M-KMA Sikanni Valley Region

Evaluating the Environmental Impacts of Well Site and Access Road Construction Methods

Submitted to:

Ministry of Sustainable Resource Management
400-100003 110th Avenue
Fort St. John, BC
Attention: Howard Madill

Prepared by:

EBA Waberski Darrow Consulting Ltd.
Fort St. John, BC

April, 2005

British Columbia

Muskwa-Kechika Management Area

eba

MSRM REVIEW DRAFT
April 13, 2005

FINAL REPORT:

EVALUATING THE ENVIRONMENTAL IMPACTS OF WELL SITE AND ACCESS ROAD CONSTRUCTION METHODS WITHIN THE M-KMA SIKANNI VALLEY REGION

Submitted To:

MINISTRY OF SUSTAINABLE RESOURCE MANAGEMENT
400-10003, 110 Avenue
Fort St. John, BC
V1J 6M7
Attention: Howard Madill

Prepared by:

EBA WABERSKI DARROW CONSULTING LTD.
Fort St. John, BC

EBA Waberski Darrow Project No. 305-03944

This document is formatted for double-sided printing.

Blank pages are intentional.

Suggested citation:

EBA Waberski Darrow Consulting Ltd. (EBA Waberski Darrow) 2005. Final Report: Evaluating the Environmental Impacts of Well Site and Access Road Construction Methods within the M-KMA Sikanni Valley Region. Prepared by EBA Waberski Darrow for the Ministry of Sustainable Resource Management, Fort St. John, British Columbia.

EXECUTIVE SUMMARY

This document is EBA Waberski Darrow Consulting Ltd.'s (EBA Waberski Darrow) Final Report to the Ministry of Sustainable Resource Management (MSRM) related to a project entitled: "*Evaluating the Environmental Impacts of Well Site and Access Road Construction Methods within the M-KMA Sikanni Valley Region*".

The Muskwa-Kechika Management Area (M-KMA) is being managed to ensure that wilderness characteristics, wildlife and its habitat are maintained over time, while at the same time, allowing carefully planned and conducted resource development and use, including oil and gas exploration and development, and its associated infrastructure. This infrastructure includes the placement of well sites and their access roads, but there is a strong commitment by the MSRM and others that such activities and developments will be closely evaluated to ensure that the impacts are minimized so that a longer-term objective, to return lands to their natural state, as much as possible, as development activities are completed, can be achieved.

The objective of this project was to conduct site impact assessments at four recently constructed access road and well site developments. The work program that EBA Waberski Darrow designed and undertook involved an objective, unbiased evaluation of the relative vegetational, wildlife habitat (terrestrial and aquatic), hydrological and geomorphical site impacts that were observed in association with the four site developments, in relation to the various construction methods and approaches that were followed for each.

EBA Waberski Darrow's multidisciplinary team examined potential environmental and engineering implications of the four approaches. The four sites that were evaluated in this project have a number of distinct differences among them – mode of construction, general features of the local environment, the extent and manner in which road construction was planned and conducted, the timing of installation, and the geotechnical, construction and environmental challenges that generally face them. The project has assessed the impacts as a part of this investigation, however strengths or weaknesses of the various approaches were considered more generally, to help identify some "lessons learned" from all four approaches.

The general approach taken in this project was as follows:

1. Conduct a field reconnaissance survey to understand and initially document the environmental and other effects associated with the four projects;

2. Review site biophysical and geomorphologic characteristics using previous reports and surveys and via consultations with MSRM staff and local oil and gas operators;

3. Compile and review existing regulatory requirements and applicable best practice criteria for undertaking construction and reclamation activities in similar regions;

4. Involve an "expert systems" approach to summarize those key biophysical, geomorphic, and construction/reclamation practice effects that are associated with the four projects, and devise project-specific "effects assessment matrices" to help summarize the issues regarding the four projects;

5. Develop a framework for deriving a site assessment protocol/tool and long-term monitoring program based on criteria used to develop the matrices; and,

6. Make recommendations for future directions / next steps and related to suitable best management practices within the M-KMA for well site and access road construction and reclamation.

This Final Report includes the following sections:

- Background and general context (Sections 1 and 2).

- Summaries of field investigations, including "alignment diagrams" from representative field sites, and summaries of observations / results based upon field visits to the four well site and access road projects (Section 3);

- Summaries of office-based investigations, including cost breakdowns related to construction and reclamation activities for the four projects, and interviews with contractors involved with the construction of each of the four projects (Section 4);

- A preliminary consideration of the four projects in relation to existing practices, associated degree of environmental impact, and in relation to various environmental and other factors (Section 5); and,

- Interpretation of the findings (Section 6), in particular to:

a. Critically assess what are the "lessons learned" from the projects examined;

b. Identify what key aspects should be included within a longer-term environmental monitoring activity for these four projects; and,

c. Make some preliminary observations / recommendations regarding preferred (environmentally, and in relation to cost effectiveness) techniques that should be employed going forward.

- A number of recommendations relating both to next steps for the current investigation, as well as (and based mainly upon field observations by EBA Waberski Darrow staff) effective construction and reclamation practices that should be encouraged and promoted within the M-KMA (Section 7)

The methodology used for this project focused on identifying those environmental, geotechnical and construction / reclamation effects that were associated with each of the four projects. EBA Waberski Darrow developed a methodology and approach that provided a retrospective assessment of conditions at the four sites, in a stand-alone format, as a key deliverable of the Year One work. The design also involved the identification of some suitable locations that could serve as a basis for monitoring future success of reclamation and recovery.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Background

1.1.1 General

The Muskwa-Kechika Management Area (M-KMA)[1] is a remote wilderness area in northeastern British Columbia (BC), and one of the few remaining vast, intact and largely unroaded areas south of the 60th parallel. The M-KMA includes some 1.58 million hectares of provincial parks and protected areas surrounded by 4.78 million hectares of special resource management areas (see http://www.luco.gov.bc.ca/nrockies/home.htm). Because of its striking environmental uniqueness and exceptional wilderness quality, the M-KMA is being very carefully managed to ensure that these environmental and wilderness features are being fully addressed and properly maintained over time.

Over the past several years, there has been a dedicated effort by land managers working in Fort Nelson, Fort St. John and elsewhere to reach consensus on how approaches to land-use in the M-KMA can occur and in what manner such activities will be permitted, managed and assessed. The M-KMA Act and various Management Plans and Pre-Tenure Plans have been developed specifically for the purpose of managing the M-KMA in the most responsible manner (see http://srmwww.gov.bc.ca/rmd/lrmp/mk/index.htm, and http://www.em.gov.bc.ca/subwebs/oilandgas/ptp/MKMA.htm).

Following much consideration, BC regulators are allowing for a limited program of carefully planned and conducted resource development and use, in particular in relation to oil and gas exploration and development. Such development, where and when approved, involves the installation of associated infrastructure such as the placement of well sites and their access roads. There is a strong commitment by the Ministry of Sustainable Resource Management (MSRM) and other regulatory agencies that such activities and developments will be closely scrutinized and monitored to ensure that any impacts are minimized and mitigated. Where environmental effects may occur, there is a firm longer-term

[1] Section 2.1 of this document provides an overview description of the M-KMA

objective to return lands to their natural state, to the greatest degree possible, as development activities are completed.

With the recent initiation of oil and gas exploration and development activities within the M-KMA Sikanni Valley Region, it is now important to "take stock" of the initial outcomes. There is a specific need to characterize and critically assess how some of the first few well sites and access road installations in this area have performed in relation to their stated objectives of minimizing environmental impacts.

There is also strong interest on the part of M-KMA land managers to determine how different construction methods and installation protocols have performed, in a comparative manner, so that any "lessons learned" can be extracted and used as a basis for directing future oil and gas development activities. As a result, the current project considers environmental effects of well site and access road development within the Sikanni Valley Region, in relation to the following:

- A limited number of well site and access road construction and reclamation projects have now been completed within the Sikanni Valley Region of the M-KMA, using different approaches, and they provide some bases for assessing what environmental practices are potentially effective / ineffective;

- These recently completed projects represent "test cases" that can now be used to help to guide how long-term monitoring strategies should be established for such projects, in order to meet terms and requirements that are laid out, for example, in the M-KMA Act and the Upper Sikanni Management Plan; and,

- There is also a growing body of scientific and technical literature that provides various environmental guidelines, Best Management Practices (BMPs) and operational standards for well site and access road construction and reclamation, and these need to be critically examined to determine which may be most applicable to the environmental management of well site and access roads in northeastern BC.

Drawing upon these three aspects, there is also a need to design some straightforward tools and strategies that will assist with appropriate long-term environmental management of well sites and access roads within the M-KMA.

1.1.2 Rationale

In 1995, the Upper Sikanni Management Plan[2] (USMP; MELP and MEMPR 1995) was the first Pre-Tenure Plan to be developed for the M-KMA. The USMP was created to ensure that impacts to sensitive wildlife and habitat from oil and gas exploration and resource developments are minimized. In 2002/2003, additional Pre-Tenure Plans were created for other regions in the M-KMA, including the Halfway-Graham, Muskwa-West, Sulphur/8 Mile and Besa-Prophet Pre-Tenure Plans. In May 2004, the "Pre-Tenure Plan for Oil and Gas Development in the Muskwa-Kechika Management Area" was implemented, and supersedes all Pre-Tenure Plans except the USMP (see: http://srmwww.gov.bc.ca/rmd/ecdev/mog/ptp/index.htm).

The regulatory framework within the M-KMA has evolved over the past few years so as to address the unique environmental conditions and challenges associated with strong development pressures. The May 2004 Pre-Tenure Plan for the M-KMA focused on result-based management that hinged on setting "Objectives" and the measurement of "Indicators" to reach a pre-described "Target". The Target is a means to quantify the acceptable future state of the Indicators.

Monitoring is viewed, in particular, within the May 2004 M-KMA Pre-Tenure Plan as a basis for adaptive management "feedback loops", and is conducted at both the operational and strategic levels of planning. The adaptive management process is critical, as it is the basis for adaptively implementing and continually improving Pre-Tenure Plan outcomes and managing for cumulative effects of multiple operations.

As part of the well site and access road evaluations conducted in the current evaluation, EBA Waberski Darrow applied the May 2004 result-based management principles and adaptive management strategy based on initial testing and implementation trials performed within the M-KMA (i.e. the Besa-Prophet area). Within the USMP, key objectives for site reclamation within the Upper Sikanni Management Area are to return sites to a condition where self-sustaining native vegetation is established (MELP and MEMPR 1995), such that the following is provided:

[2] see: http://srmwww.gov.bc.ca/rmd/ecdev/mog/docs/USMP_Final_Plan.pdf

- Wildlife habitat capabilities equal to or greater than initial conditions; and,
- Erosion control equal to or greater than conditions found on adjacent undisturbed sites.

1.1.3 Report Layout

This document includes the following key components:

- Background and general context (Sections 1 and 2).

- Summaries of field investigations, including “alignment diagrams” from representative field sites, and summaries of observations / results based upon field visits to the four well site and access road projects (Section 3);

- Summaries of office-based investigations, including cost breakdowns related to construction and reclamation activities for the four projects, and interviews with contractors involved with the construction of each of the four projects (Section 4);

- A preliminary consideration of the four projects in relation to existing practices, associated degree of environmental impact, and in relation to various environmental and other factors (Section 5); and,

- Interpretation of the findings (Section 6), in particular to:

    - Critically assess what are the “lessons learned” from the projects examined;

    - Identify what key aspects should be included within a longer-term environmental monitoring activity for these four projects; and,

    - Make some preliminary observations / recommendations regarding preferred (environmentally, geotechnically, and in relation to cost effectiveness) techniques that should be employed going forward.

In particular, project-related results, observations and recommendations are presented, with particular consideration given to how to best manage oil and gas operations and site reclamation to achieve the intent of the M-KMA Act (that is, to accommodate the development of the oil and gas industry while at the same time maintaining wildlife and wilderness values in perpetuity).

1.2 Objectives and Scope of Work

1.2.1 Objectives

The objective of this project was to conduct site impact assessments for four recently constructed well site and access road projects within the Upper Sikanni Management Area, in relation to both construction and, where applicable, reclamation activities. For the field component, the focus was upon environmental aspects of the projects, in particular those key deficiencies and successes demonstrated by each project in terms of wildlife habitat, vegetation, hydrology and geomorphology / geotechnical considerations.

It was identified at the outset of the project that EBA needed to involve a multidisciplinary team, so that evaluations / interpretations could be made in relation to the spectrum of potential environmental and engineering aspects that were involved.

Despite the fact that they were all constructed for the same purpose and in the same general geographic location, the four well site and access road projects that are evaluated here were each faced with different sets of unique conditions. These differences were related to a range of factors, including (but not limited to) the following:

- The size and extent of each project;
- The environmental and landscape features that were specifically associated with each project;
- The seasonal timing of installation / reclamation activities and the associated weather-related challenges during the field programs;
- The funding level, equipment, capabilities, experience and other strengths that each construction team / company brought to the project;
- The regulatory constraints and requirements that were placed upon each of the projects, and the net effects of these constraints / requirements upon the mode and manner in which road construction was planned and conducted for each; and,

- The net effects of prioritizing among the various construction, geotechnical and environmental challenges that each project presented.

Since factors such as those noted above are involved, EBA Waberski Darrow's approach to assessment was to generally observe the net results of each project, in relation to both positive and negative environmental effects, and to then use these observations to generally rank the projects in terms of net environmental effects, using a matrix approach. An overall aim of this exercise was to identify some overall "lessons learned" and to then use these to help design some tools to assess and monitor future success of reclamation and recovery. Ideally, in terms of future monitoring, it was recognized that what was needed is a straightforward system that can accomplish the following:

- Characterize the accuracy of impact predictions;
- Predict the ease/extent of reclamation activities that are needed; and,
- Generally assess the expected/eventual success of reclamation activities.

As part of the finalization of Year One activities, EBA Waberski Darrow designed and applied a methodology and evaluation program that, when tested and improved in future years, can be used as a basis for longer-term monitoring.

1.2.2 Scope

EBA Waberski Darrow's approach compared the relative vegetative, habitat (terrestrial and aquatic), hydrologic and geomorphic site impacts of the four site developments (Table 1, Figure 1).

Since a variety of construction methods and general approaches were used, as indicated below, the Year One assessment included an investigation that effectively ranked the "treatments" in order of overall increasing impact based upon agency and industry interviews, field investigations of the types and extents of impacts, and assessment using an evaluation matrix approach that employs an objective point-rating approach.

Table 1. Names, Operators and Locations for the Four Well Site Projects.

Well Authorization #	Operator	Project Name	Location
10759	Amoco	Amoco Sidenius	C-092-G/094-G-04
12592	CNRL	CNRL Sikanni	C-033-J/094-G-03
14570	Marathon (Husky)	Husky Sikanni	C-040-J/094-G-03
12706	Murphy (CNRL)	Murphy Chicken Creek	B-094-B/094-G-06

Following are brief summary descriptions of the four well site construction projects. As well, example field photos from each of the four projects are included in Figure 2.

- The *Amoco Sidenius* (also referred to as "Northstar Et Al Sidenius") well site C-92-G/94-G-04 was drilled in 1998. This well used part of the access that was built in 1993 for Amoco well site d-46-L/ 94-G-3. The first well in 1993 was completed prior to the USMP, however it still specifically addressed a range of environmental concerns that were identified to the industry ahead of its construction. In particular, for this project, some attention was focussed on a "choke point" topographic constraint that existed along the access road to the 1993 well site, and which was subsequently reused for access to the Amoco Sidenius well site during 1998. This well and access road is partially reclaimed.

- The *CNRL Sikanni* (also referred to as "CNRL PC Sikanni") well was drilled in February 2003 and forms the smallest footprint of the four locations. This well is currently listed as "confidential" in the Oil and Gas Commission database, therefore access to information is limited on the construction techniques used to construct this well site or reclamation plans.

- The *Husky Sikanni* (also referred to as "Husky (Marathon) Sikanni") well was originally licensed to Marathon and drilled in January 2002. This location utilized some of the same techniques of the Murphy Chicken Creek location for access. The Marathon well site included cut and fill construction techniques while the Murphy Chicken Creek was a padded well site.

- The *Murphy Chicken Creek* (also referred to as "Murphy Et Al Chicken Creek") well was drilled in January 2001. This project employed some innovative construction techniques (in particular to traverse wetlands) that have been referred to as "a model of acceptable environmental methods" by some, and as a cost-prohibitive construction approach by others. This well is listed as abandoned, however no post-construction reclamation has been undertaken.

As outlined above, each of the four well sites involved different construction techniques, site conditions and physical constraints that affected the environmental effects of the projects, as well as the total costs to complete the project. As a result, the focus of this investigation needs to take into account the range of physical constraints and environmental effects, but also the associated construction techniques and construction costs for each project. These factors collectively are important in terms of how to best proceed in the future.

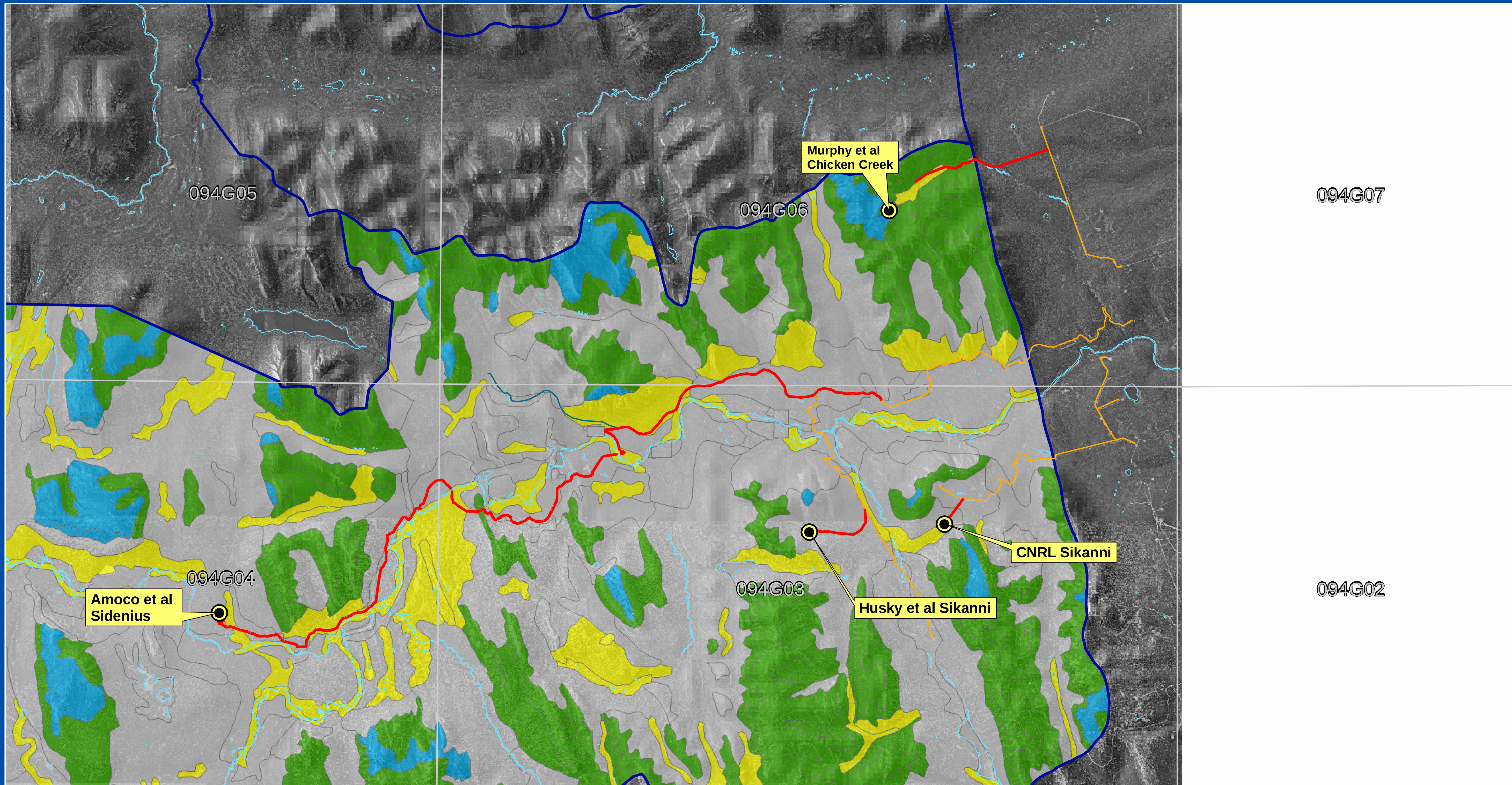
The current investigation involved a multidisciplinary team that brought the following areas of expertise to the project:

- Vegetation ecology, in particular, the characterization of vegetation impacts in terms of time frames for reclamation/rehabilitation within the M-KMA;

- Wildlife ecology and habitat quality evaluation, particularly in relation to habitat values of key species as well as species of concern within the Sikanni Valley region of the M-KMA;

- Fisheries ecology, particularly in relation to impacts of stream crossings, surface water changes (e.g., redirection or impoundment), and time frames for reclamation/rehabilitation within the M-KMA; and,

M-K Well Site Evaluation



Legend

- High Sensitivity
- Medium Sensitivity
- Low Sensitivity
- No Sensitivity
- WELLSITE ACCESS
- HIGHGRADE ACCESS

Scale 1:160,000

0 1,000 2,000 4,000 6,000 Meters

UTM Zone 10, NAD 83

M-K Well Site Evaluation

BRITISH COLUMBIA

MUSKWA-KECHIKA MANAGEMENT AREA

Well Locations

Prepared by:
EBA Waberski Darrow Consulting Ltd.

April, 2005
Version 2

Figure 1

03944_Figure1.mxd

M-K Well Site Evaluation

Amoco Sidenius

Seepage from upslope onto access road.

Erosion on slope down centre of access road.

Husky Sikanni

Removed surface duff layer along upland section of access road.

Coarse woody debris within right of way of access road.

CNRL Sikanni

Water impundment within access road.

Pipeline trench within an open fen wetland.

Murphy Chicken Creek

Low vegetation within upland portion of access road.

Erosion gully within access road down a slope, exposing rocks and cobbles.

M-K Well Site Evaluation

BRITISH COLUMBIA

MUSKWA-KECHIKA MANAGEMENT AREA

Example Field Photographs of the Four Well Site and Access Road Projects

Prepared by:
EBA Waberski Darrow Consulting Ltd.

April, 2005
Version 1

Figure 2

03944_Figure2.mxd

- Terrain, geomorphology and soils in relation to effects of construction (e.g., mineral soil exposure, slope stability, hydrogeological issues, riparian features); and,

- Geotechnical engineering and construction monitoring/evaluation of geotechnical issues, particularly in relation to timing constraints/options, equipment-related effects, and geotechnical impacts of road and well pad construction.

The team also focused upon integration of all of the above, so that overall effects or impacts can be considered within a multidisciplinary framework. The following were integrated into the project's treatments of individual subject areas / disciplines:

- Knowledge regarding the history of land use, issues of land development and the pre-development conditions that were associated with each of the sites.

- An understanding of oil and gas contractor and remote installation/camp operation issues, in particular in relation to constraints in the field, timing of operations, use and integration of available information, concerns regarding worker safety, productivity and expertise, and construction costs associated with terrain, grade and stability; and,

- An understanding of the oil and gas exploration industry's operational and construction environment so that effective recommendations are made based upon the evaluations conducted; and

As part of the work, inputs were incorporated from agency contacts (e.g. the M-KMA Board, MSRM and the Ministry of Energy and Mines (MEM)) and interviews were undertaken with members of each of the four exploration teams involved in the construction / reclamation of these well sites and access roads.

2.0 BACKGROUND / APPROACH

2.1 Regional Setting

The Muskwa-Kechika Management Area (M-KMA) is a remote wilderness area in northeastern BC and one of the few remaining vast, intact and largely unroaded areas south of the 60th parallel (Shultis and Rutledge 2003, Anon. 2004, MSRM 2004).

A regional map of the MKM-A can be accessed at the following website: http://srmwww.gov.bc.ca/rmd/ecdev/mog/docs/Final%20Fig1.pdf. The M-KMA is composed of 1.58 million hectares of provincial parks and protected areas surrounded by an additional 4.78 million hectares of special resource management areas (for additional general information regarding the M-KMA, see the Land Use Coordination Office's website at http://www.luco.gov.bc.ca/nrockies/home.htm.

The M-KMA was formally established in 1998 with the passing of the Muskwa-Kechika Management Area Act. Situated in the Cassiar Mountains and northern Rocky Mountains, the MKMA is an immense and diverse region. Northern limits of the M-KMA are the Liard River. The western limits are in the Stikine Ranges (see Holland 1976) of the Cassiar Mountains east of Dease Lake. The major watershed in this portion of the MKMA is the Turnagain River. From the Cassiar Mountains, the MKMA boundary extends eastward across the Kechika River in the Rocky Mountain Trench into the Muskwa Ranges of the northern Rocky Mountains. Southern limits in the Rocky Mountains are east of the Ospika River and north of the Ospika Arm of Williston Lake near Laurier Pass and the Graham River.

Major watersheds on the eastern slope of the Rocky Mountain portion of the M-KMA include: the Sikanni Chief, Prophet, Muskwa, and Toad Rivers. No communities or settlements occur within the boundaries of the M-KMA. Fort Nelson on the Alaska Highway and Dease Lake on the Stewart Cassiar highway are the closest communities. The only highway that traverses the MKMA is the Alaska Highway.

In terms of ecological diversity, the M-KMA includes portions of three Ecoprovinces and 11 associated Ecosections (Demarchi 1996). The greater part (about 88%) of the area lies in the Northern Boreal Mountains Ecoprovince, which is generally made up of areas of mountains and high plateaus separated by wide valleys and lowlands. The remaining portion of the M-KMA is split roughly equally between the northern fringe of the Sub-Boreal Interior and eastern edge of the Taiga Plains Ecoprovinces. The biological, climatic and landbase diversity of the area is also exemplified by the variety of biogeoclimatic units occurring within the M-KMA; there are three biogeoclimatic zones and 10 associated subzones associated with the M-KMA (DeLong 1990, Meidinger and Pojar 1991).

The Upper Sikanni Management Area sits within the M-KMA and includes a land area of approximately 1,832 sq km. It includes the Upper Sikanni – Chief River watershed and is an area that is considered highly significant in terms of wildlife specis groupings, remoteness, sensitive environmental conditions, and a known need for minimal disturbance (MELP and MEMPR 1995).

The Upper Sikanni Management Area is a broad ecotonal feature, with extensive boreal plains and muskeg forming its easternmost portion, and Rocky Mountains forming its westernmost portion; as a result, the western part of the Upper Sikanni is characterized by a varied terrain with some significant relief and alpine, upper elevation (e.g., spruce-willow-birch) and boreal vegetation / climatic elements predominantly. The eastern part is relatively flat, consisting of broad open valleys, and a mosaic of mainly boreal vegetation conditions including low-lying forest and wetland conditions. A more detailed description of the landscape and environmental characteristics of the Upper Sikanni Management Area are provided in the USMP (MELP and MEMPR 1995).

2.2 Project Methodology / Approach

Overall, the methodology used for this project focused on comparing the environmental (and geotechnical) cost/benefits of the various construction practices.

The project methodology / general approach is described in Sections 2.2.1 to 2.2.4. The project consisted of four phases:

1. Pre-Field (consisting of project initiation, and initial conceptualization / design of a site impact assessment methodology and the long-term monitoring program) (Section 2.2.1);

2. Field (field observations at the four sites, conduct of a baseline field investigation protocol that can be used as a basis for future monitoring) (Section 2.2.2);

3. Office / Analytical (analysis and evaluation of results from the field survey, interpretation in terms of monitoring and future directions) (Section 2.2.3); and,

4. Identification of Next Steps / Future Directions (consideration of appropriate next steps, derivation of recommendations and key findings and recommendations, finalization of a long-term monitoring program using suitable site assessment criteria) (Section 2.2.4).

2.2.1 Pre-field

As part of the startup phase of the Project, project leads for EBA Waberski Darrow met with MSRM staff and contacts for the project to conduct a start up meeting/conference call. The meeting was conducted to review the project's work plan, reporting conventions, background information and data that MSRM or others were able to provide, and to discuss the schedule of activities that were planned for the work. The meeting was used as a basis for identifying and clarifying roles and responsibilities and information availability.

Background materials were organized and synthesized regarding the four sites. EBA Waberski Darrow undertook an office-based review of aerial photos, existing airborne video, maps and project description information that was available for the four sites.

Logistics and planning was conducted, including the development of map base materials for the field and initial selection of survey sites for visit and study during the brief field program. Contacts were also established with key individuals, agencies and companies who were in a position to contribute to the project.

2.2.2 Field

The field component was undertaken within a very short timeframe, during October 8 to 12, 2004. Timing and budget constraints allowed only limited field efforts, but it was possible to visit, on the ground, all of the well sites and key locations along all of the access roads. During these visits, the field team collected general notes, both from an aerial reconnaissance and selected ground locations.

Field work was undertaken by a 3-person team, consisting of a vegetation / terrestrial ecologist, a fisheries /aquatics biologist and a geotechnical engineering specialist. The team worked together to complete the following key activities during the brief field program:

- General environmental effects were systematically examined along the access roads and at the well sites for each of the four projects. Timing did not allow for the collection of specific quantitative data, but overview observations were critical so that the team could gain a clear understanding of the range of environmental impacts or effects that were associated with each project. In the field, key aspects observed – from the air and on the ground – were the extent of exposed mineral soils, ditch line erosion, vegetation alteration, potential for wind throw or other secondary effects.

- Digital photographs, notes on wildlife / wildlife sign or other appropriate field observations, and site sketches were acquired at key locations along each access road and at each well site.

- During the field work, specific observations were made to identify a number of suitable locations where longer term monitoring activities could be established and undertaken. In particular, sensitive sites and representative river crossings were identified as suitable long-term monitoring sites (see Section 6 of this report for further discussion).

- GPS-positioned airborne video coverage of the access roads and well sites for all four projects was obtained during helicopter overflights.

- Other general observations were recorded as field notes and/or as air photo annotations.

Results of field-based overviews are summarized in Section 3.

2.2.3 Office / Analytical

Following the field work, several office-based activities were undertaken, as follows:

- Field information / observations were organized and summarized. As already noted in Section 2.2.2, the budget and timing allowed only a reconnaissance overview during the field work, and as a result, direct data workup and interpretation was limited. Nonetheless, we considered the rapid field reconnaissance to be highly effective, as it resulted in good overview perspectives on the environmental effects of the four projects.

- Alignment sheets were constructed for some example locations associated with each of the projects. The alignment sheets include position and profile information (derived from provincial basemapping). The access road segment or well site location is positioned on an enlarged section of an orthophoto-registered basemap. The alignment sheet also includes annotated air or ground photos that were collected during the October 2004 field work. Coordinates are provided, and these may be used to cross-reference the alignment sheet's location to the GPS-registered video coverage. Several example alignment sheets are provided in Section 3.

- The project team interviewed individuals who were directly involved in the construction and reclamation of the four projects, and also had several conversations with MSRM staff who were familiar with regulatory and other aspects in relation to projects. The interviews and discussions helped to project team to develop additional context and understanding of the projects, their operational constraints and other issues that were "drivers" during the completion of the field construction programs. In particular, EBA Waberski Darrow assembled costing information to develop a general comparison among the four projects of overall construction and reclamation costs.

Results of the office-based investigations are summarized in Section 4. Section 4 includes summaries of office-based investigations, including cost breakdowns related to construction and reclamation activities for the four projects, and interviews with contractors involved with the construction of each of the four projects.

2.2.4 Identification of Next Steps / Long-Term Monitoring

In Sections 5 to 7, results and observations from the field and post-field investigations are then used to help identify appropriate next steps and long-term monitoring aspects related to well site and access roads in the M-KMA.

Section 5 provides a preliminary consideration of the four projects in relation to existing practices, associated degree of environmental impact, and other factors.

In Section 6, findings and observations from the field and post-field investigations were used to derive preliminary matrix-based summaries relating to environmental, geotechnical and project-related constraints associated with the four projects. This matrix approach represents a suitable first step towards the development of tools for long-term monitoring.

Section 7 provides project-related recommendations / conclusion, and in particular:

- Identifies what key aspects should be included within a longer-term environmental monitoring activity for these four projects; and,
- Critically assesses what are the "lessons learned" from the projects examined, in relation to effective construction and reclamation practices that should be encouraged and promoted within the M-KMA.

Section 8 includes a list of Literature Cited, Appendix A includes profile (elevational) plan diagrams for the access roads associated with the four projects, and Appendix B is a DVD of the video flightlines that were acquired as part of the field work in October, 2004.

3.0 SUMMARY OF FIELD OBSERVATIONS

3.1 Amoco Sidenius

3.1.1 General Characteristics

The Amoco Sidenius C-92-G/94-G-4 well site and access road was field visited on October 11, 2004 by the 3-person team. The well site's GPS coordinates are: N 6335360 / E 0461275. The Amoco Sidenius well site is accessed by way of a 37.5 km road (this was the longest access road of the 4 projects examined).

The Amoco Sidenius well site was the oldest of the four projects. The well used part of the access that was built in 1993 for another well site, Amoco D-46-L/94-G-3 (Anon 1997a, b).

There has been extensive historical vehicle access along the road located on the N side of the Sikanni River (motorized vehicles are excluded from the road once it crosses the River). There is considerable evidence of use of trucks and Quads / ATVs on the access road surface, and these effects have created water management and ground disturbance problems at various locations, particularly along lower-lying parts of the road. The portion of the access road S of the River, however, has not been accessed by vehicles and Quads / ATVs and there is an associated marked reduction of surface disturbance effects.

One particular concern with the access road's construction was a geotechnical "choke point" topographic constraint that existed along the access road to the 1993 well site, and which was subsequently reused for access to the Amoco Sidenius well site during 1998. This choke point was visited during the October 2004 field work.

This well and access road is partially reclaimed and evidence of this was observed during the October 2004 field work.

3.1.2 Alignment Sheets

Alignment sheets have been assembled for all four projects to illustrate example locations where longer-term monitoring activities of environmental effects or recovery could be appropriate (see Figures 3 to 10).

Three alignment sheets were assembled for the Amoco Sidenius project (see Figures 3 to 5). Figure 3 shows a location where there has been water impoundment and channelling problems on the surface of the access road, and provides a potentially suitable location for the longer-term monitoring of recovery or continued degradation of the road bed at this location. Figure 4 shows some of the effects that can be attributed to continuing use of the access road, N of the Sikanni River, by vehicles and Quads / ATVs. Figure 5 identifies a location where river-related erosion effects on the S side of the Sikanni River have continued to modify the access road surface as well as the routing of an oxbow channel along the River.

3.1.3 Key Deficiencies

3.1.3.1 General

The following general observations were made at the Amoco Sidenius site, in relation to overall deficiencies of the project:

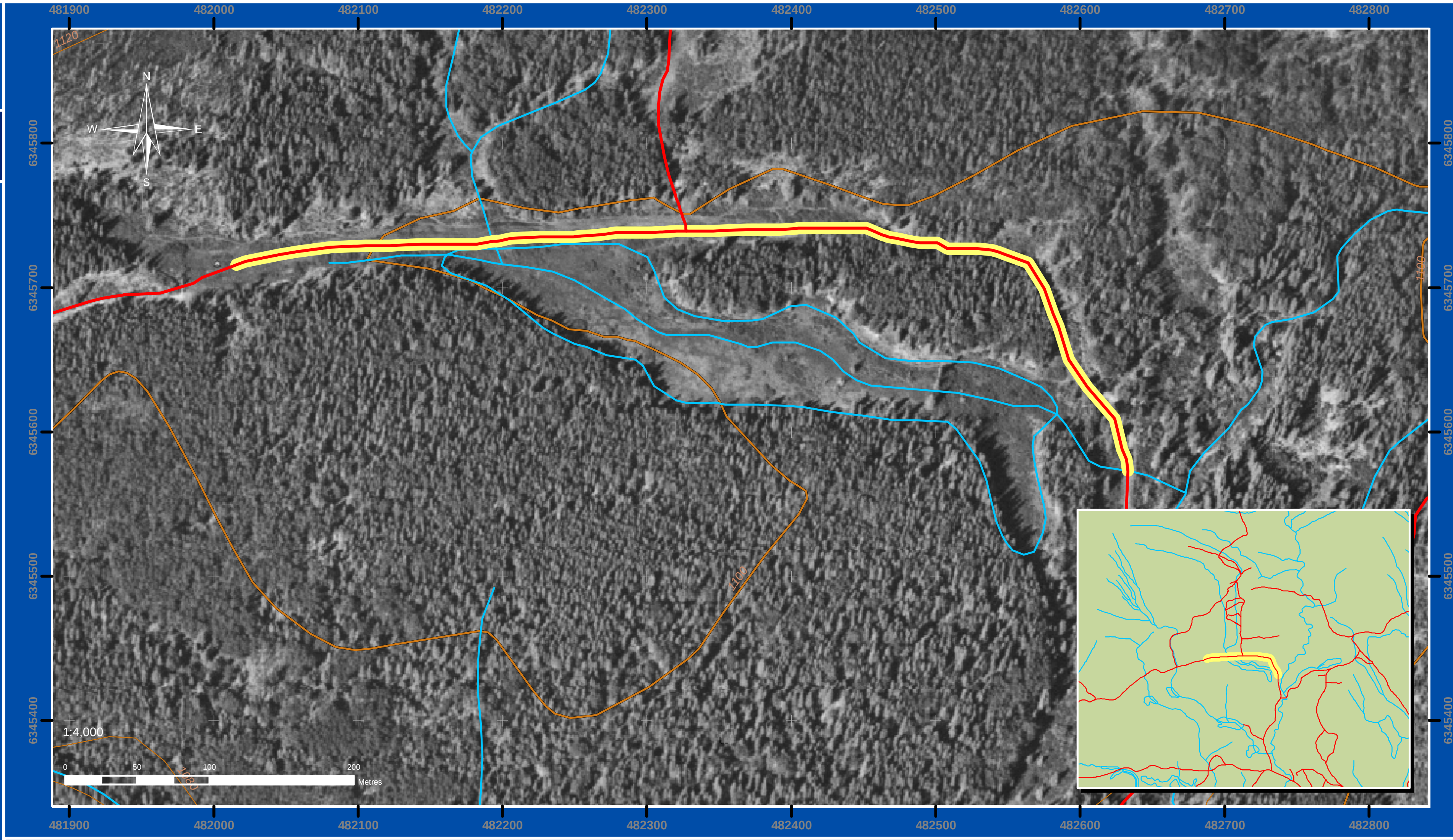
- Poor management of water drainage;
- Poor route selection through fens and other wetlands when it appears higher ground was reasonably close to selected route;
- Significant erosion from quad access;
- Blowout of access road along Sikanni - Chief River creating a large (75 – 100 m long) oxbow;
- Pack trail/game trail along reclaimed portion of road south of river showing preferential pathway for water channelling; and,
- Sections of deactivated road poorly vegetated due to low topsoil cover/rocky material.

M-K Well Site Evaluation

Amoco Sidenius

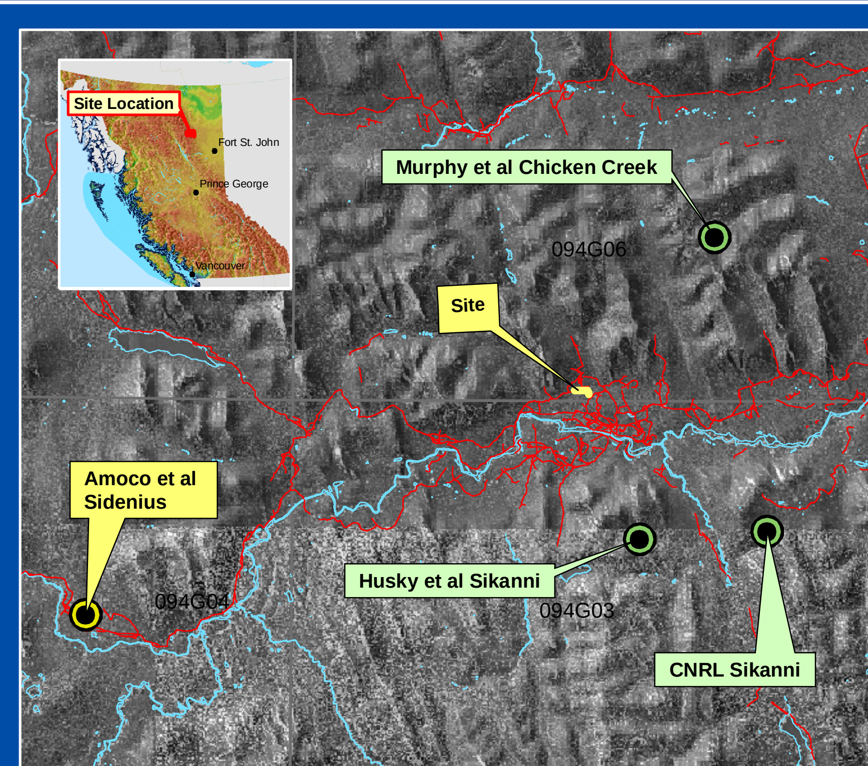
Example of water channelling down road which is used as access for recreational users. Road runs through fen resulting in drainage issues.

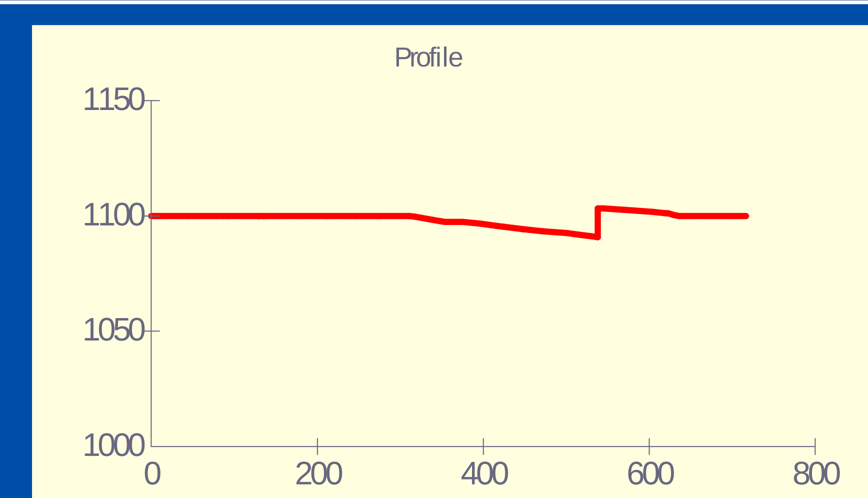
Upland location adjacent to wetland site.



Coordinates (UTM Zone 10 NAD 83)

Start: 6345567.32 N, 482653.63 E End: 6345737.07 N, 482010.78 E





M-K Well Site Evaluation

BRITISH COLUMBIA

MUSKWA-KECHIKA MANAGEMENT AREA

Amoco Sidenius

Prepared by:
EBA Waberski Darrow Consulting Ltd.

April, 2005
Version 2

Figure 3

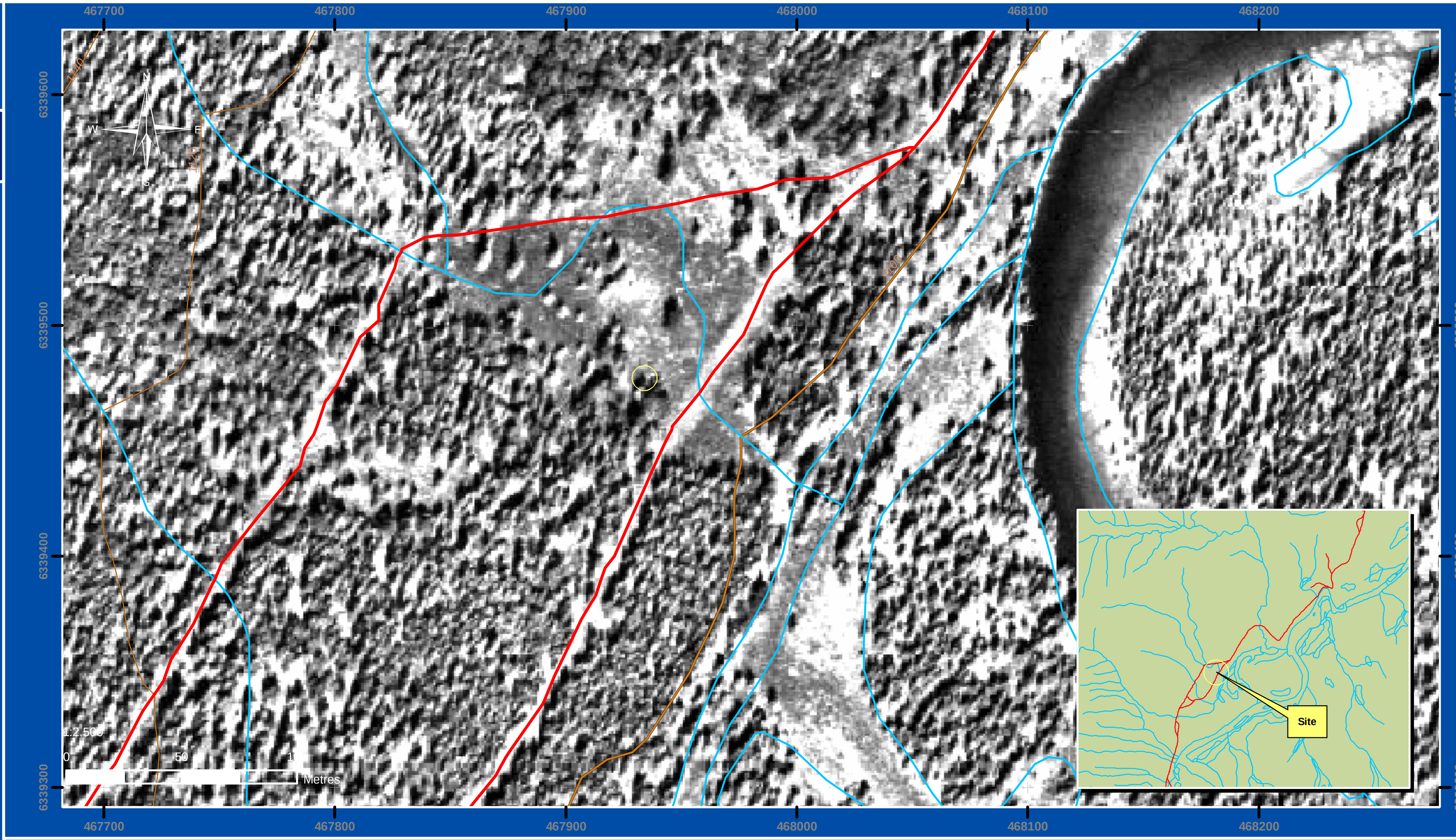
03944_Figure3.mxd

M-K Well Site Evaluation

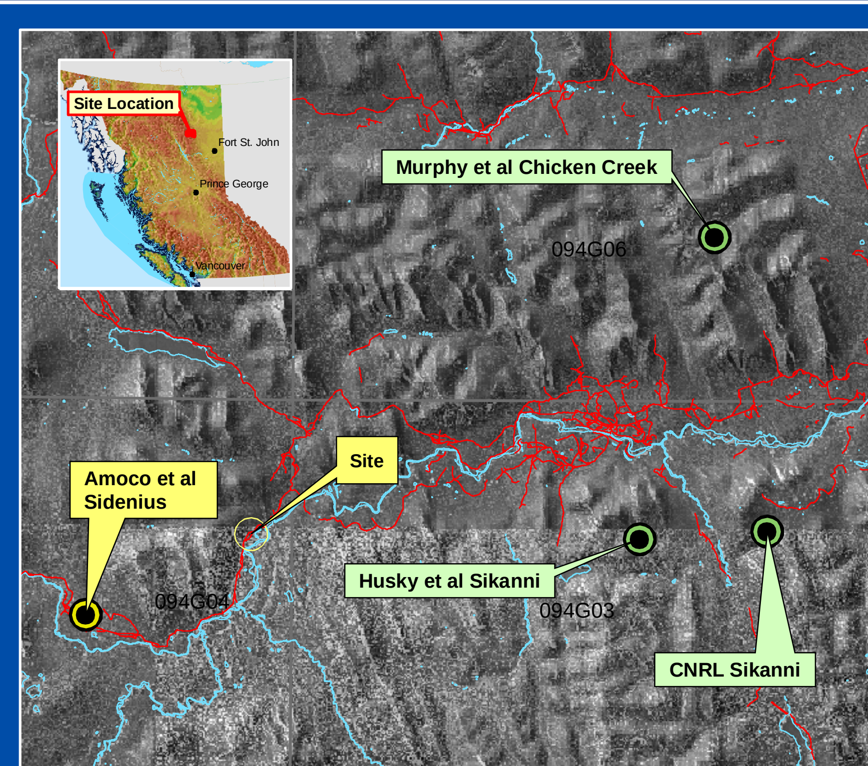
Amoco Sidenius

Example of road route selection through wetland when adjacent drier upland area would result in less ground disturbance (particularly with regard to ATV use).

Effects of recreational access on road crossing dry stream bed.



Coordinates (UTM Zone 10 NAD 83)
6339477.31 N, 467934.14 E



Profile

No profile available

M-K Well Site Evaluation

British Columbia

Muskwa-Kechika Management Area

Amoco Sidenius

Prepared by: EBA Waberski Darrow Consulting Ltd.	April, 2005 Version 2	**Figure 4**

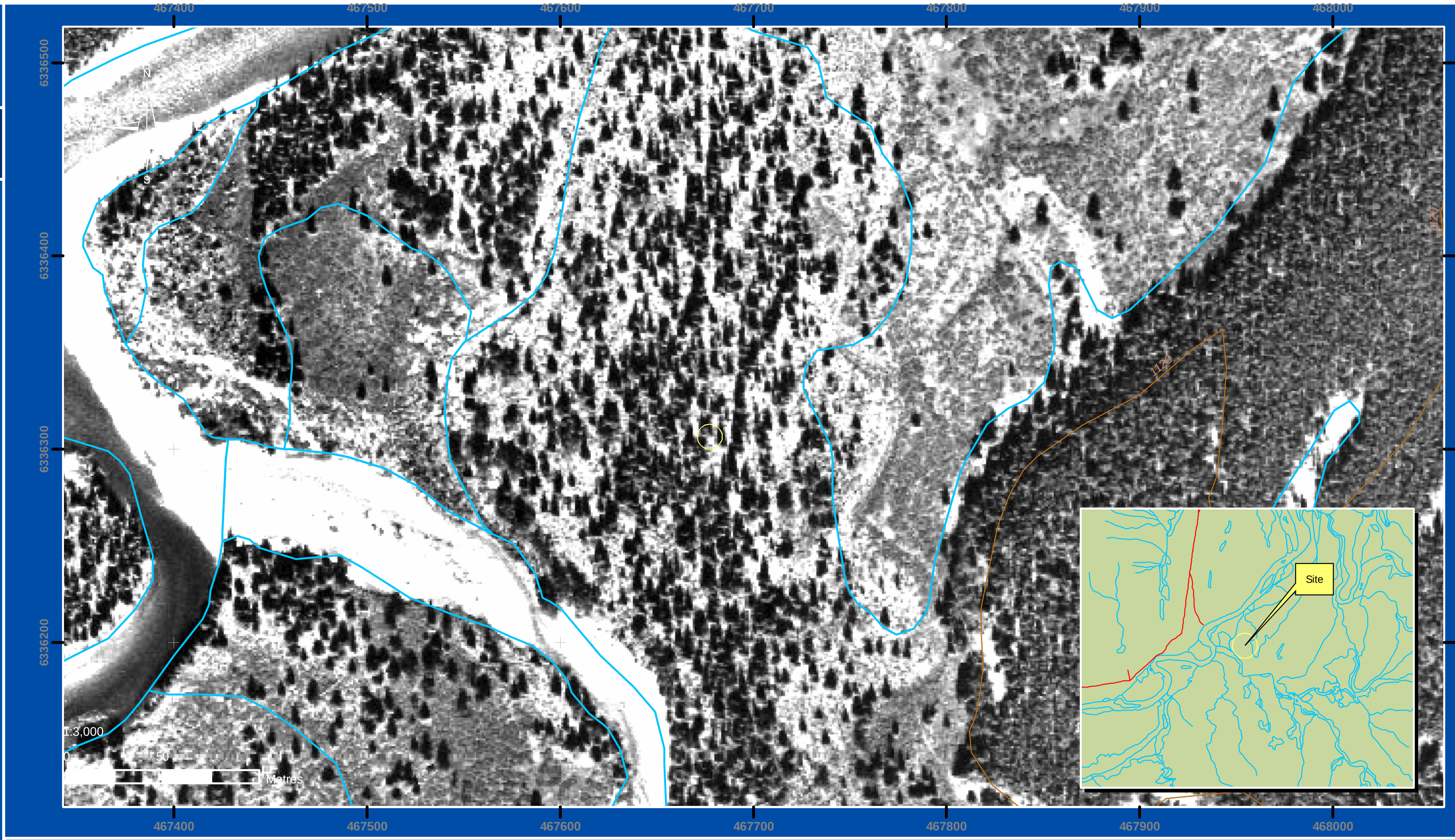
03944_Figure4.mxd

M-K Well Site Evaluation

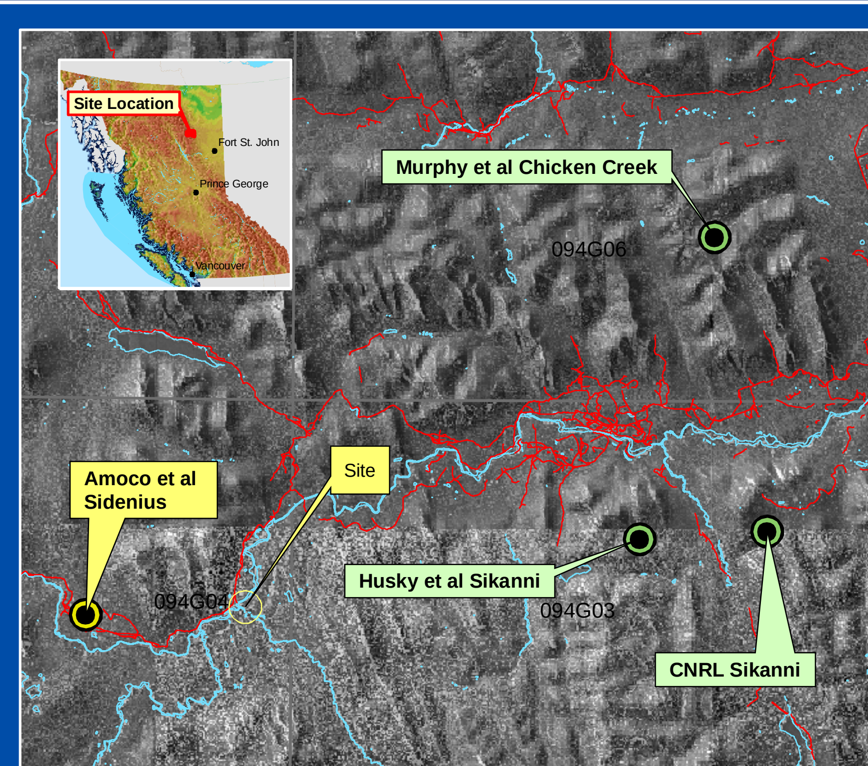
Amoco Sidenius

Aerial photo showing proximity of access road to Sikanni River. Note river erosion on access road.

Aerial view of access road near river.



Coordinates (UTM Zone 10 NAD 83)
6336306.60 N, 467677.63 E



Profile

No profile available

M-K Well Site Evaluation

BRITISH COLUMBIA

MUSKWA-KECHIKA MANAGEMENT AREA

Amoco Sidenius

Prepared by:
EBA Waberski Darrow Consulting Ltd.

eba

April, 2005
Version 2

Figure 5

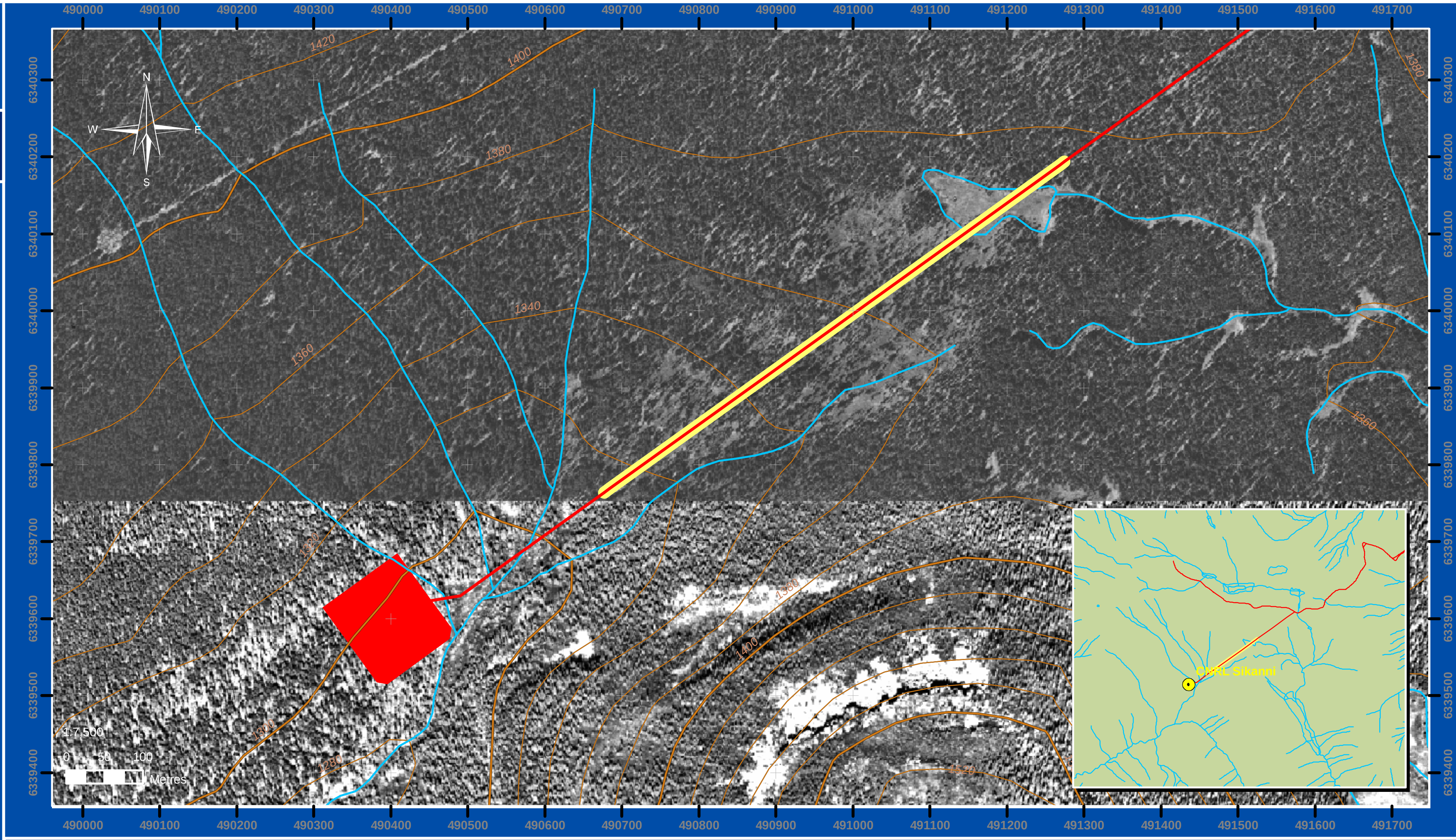
03944_Figure5.mxd

M-K Well Site Evaluation

CNRL Sikanni

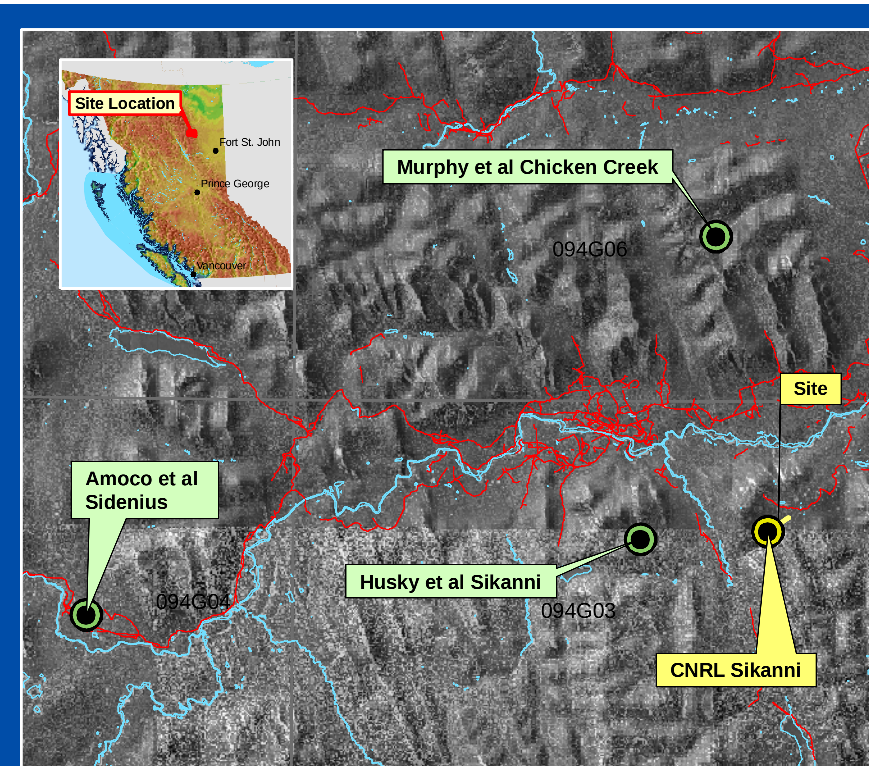
Ponding along access/pipeline due to poor drainage control. Foam berm used for drainage control ineffective and not properly installed.

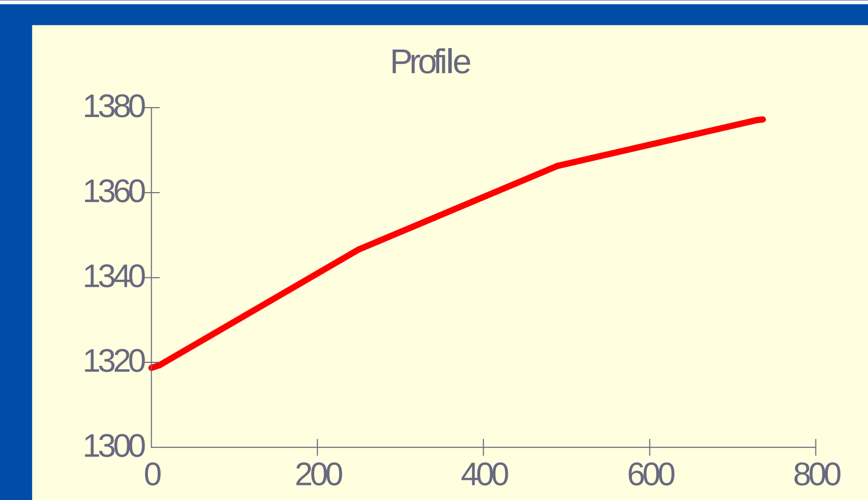
Installation of pipeline through fen without proper drainage management.



Coordinates (UTM Zone 10 NAD 83)

Start: 6340196.640 N, 491270.220 E End: 6339752.644 N, 490685.214 E





M-K Well Site Evaluation

British Columbia | Muskwa-Kechika Management Area

CNRL Sikanni

Prepared by:
EBA Waberski Darrow Consulting Ltd.

April, 2005
Version 2

Figure 6

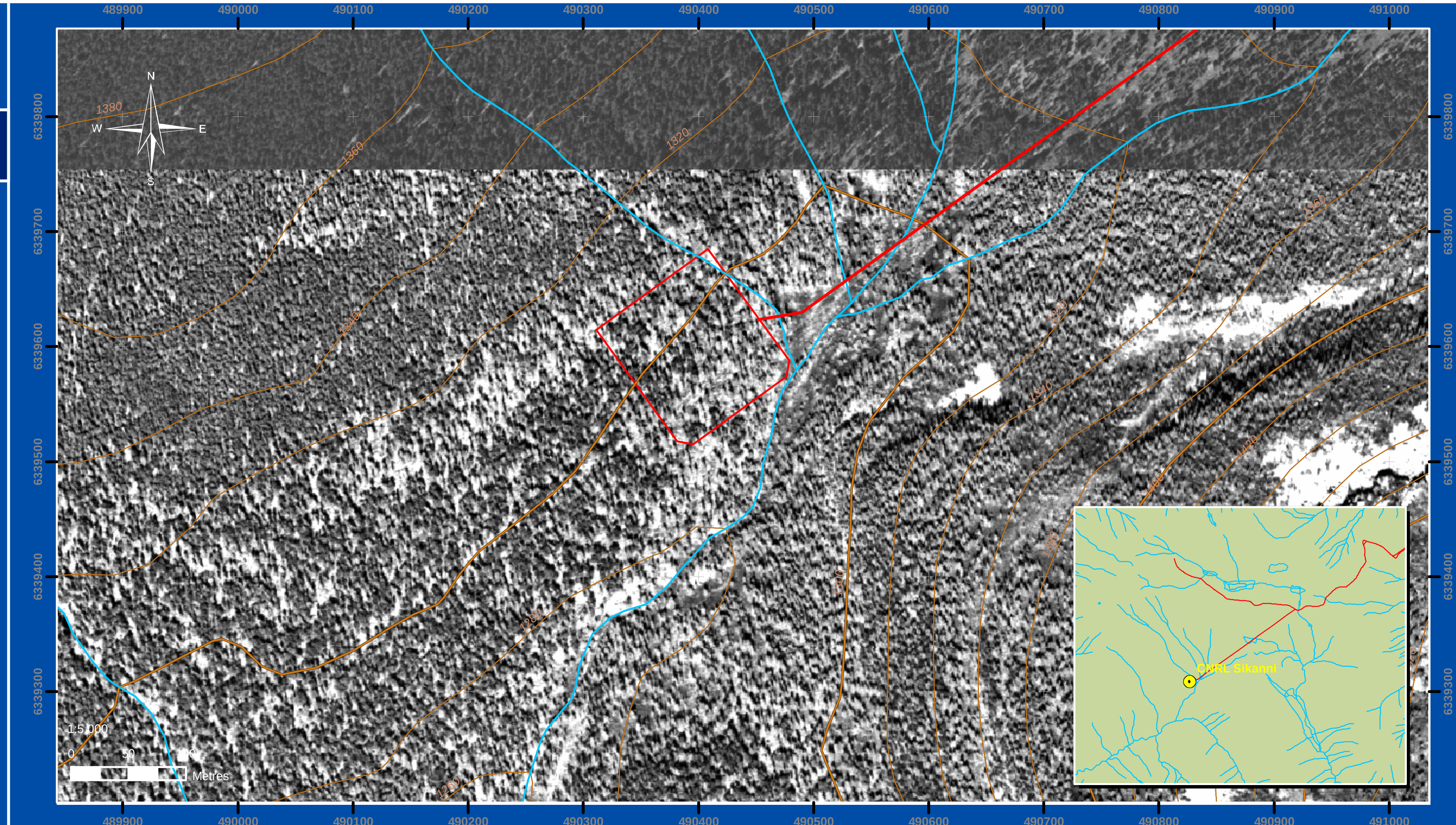
03944_Figure6.mxd

M-K Well Site Evaluation

CNRL Sikanni

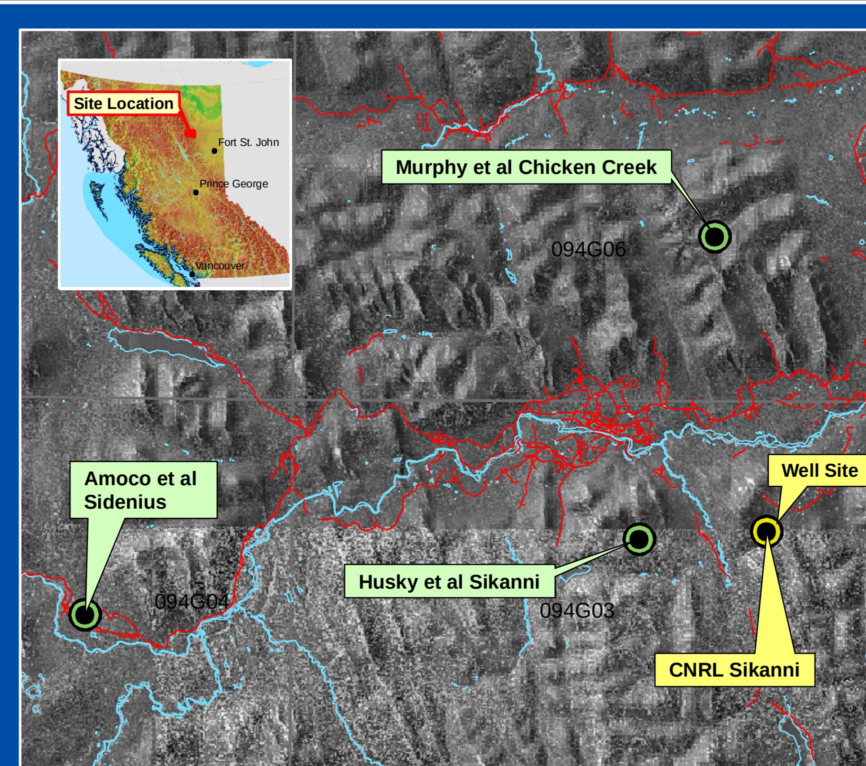
Well site showing cut and fill technique; including indication of groundwater seepage. Ungulate tracks present in wet areas.

Upper slope failure, in spite of cutoff ditch being present. This suggests slope failure not due to surface runoff. Slope failure likely due to permeable soils and groundwater seepage.



Coordinates (UTM Zone 10 NAD 83)

6339660.131 N, 490574.231 E



Profile

No Profile Available

M-K Well Site Evaluation

BRITISH COLUMBIA

Muskwa-Kechika Management Area

CNRL Sikanni

Prepared by:
EBA Waberski Darrow Consulting Ltd.

eba

April, 2005
Version 2

Figure 7

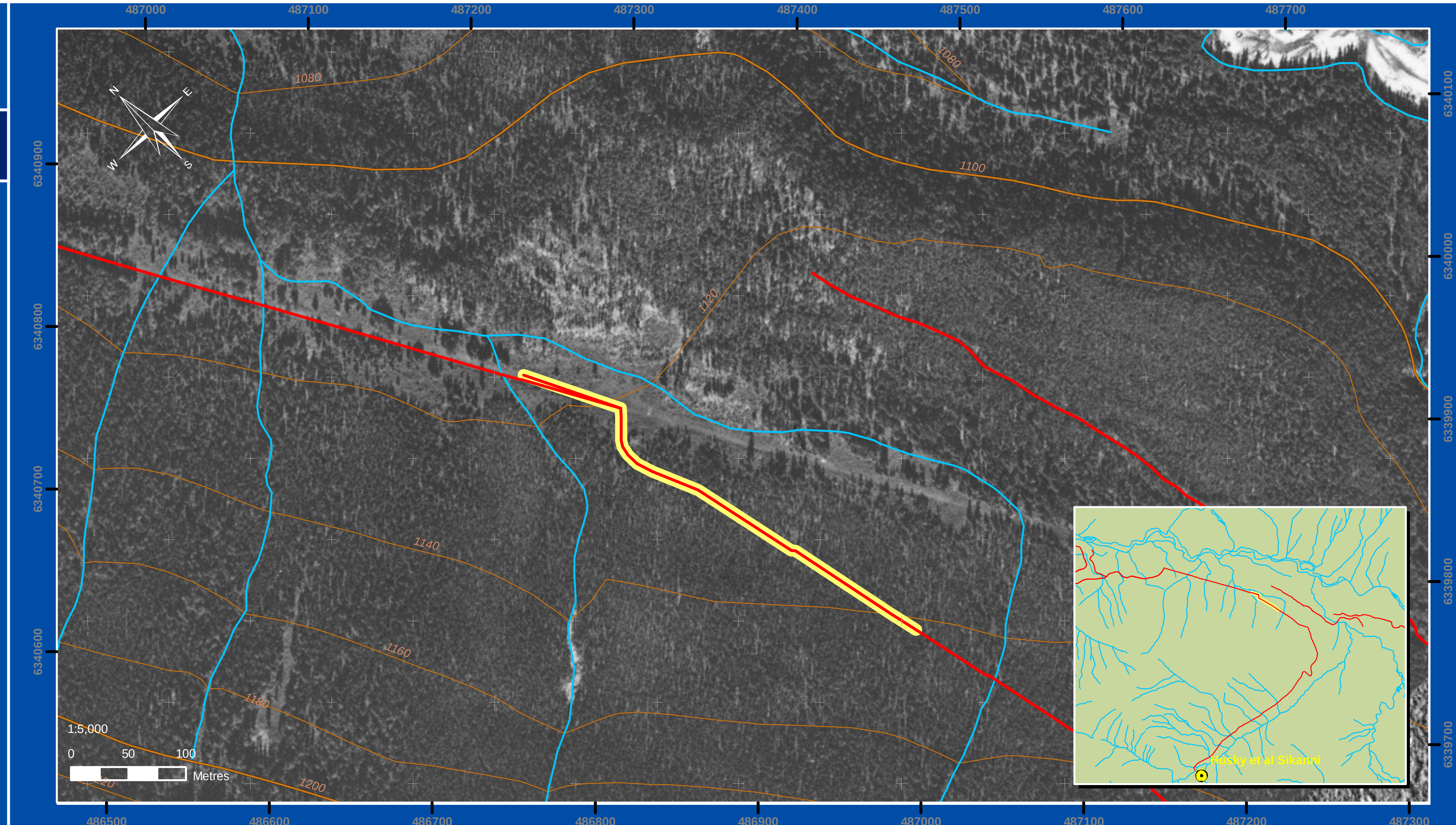
03944_Figure7.mxd

M-K Well Site Evaluation

Husky Sikanni

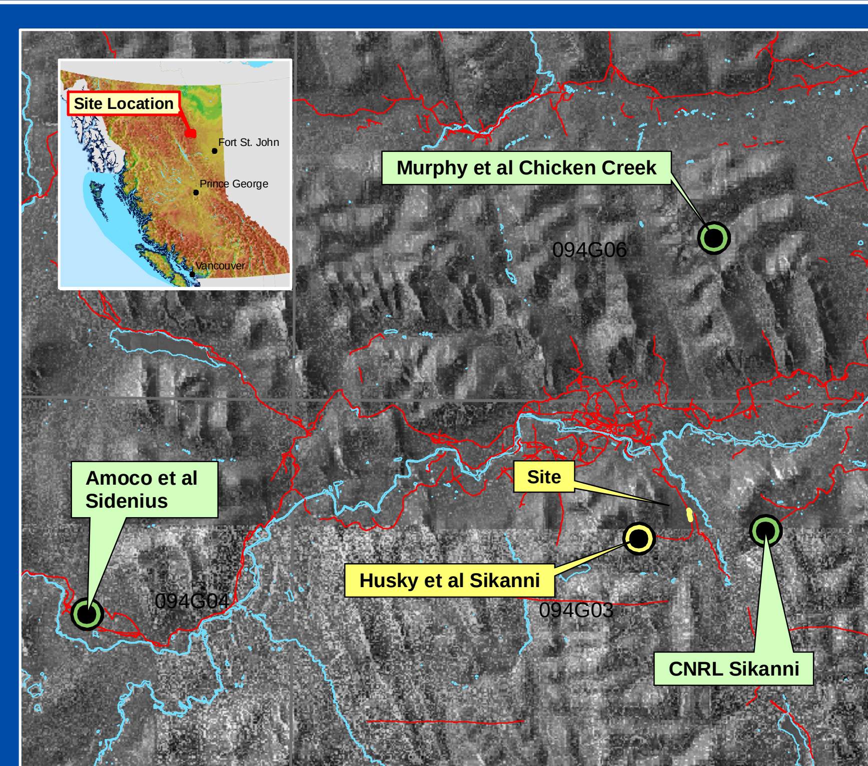
Example of low-impact road construction. Only noticeable disturbance is associated with vegetation clearing.

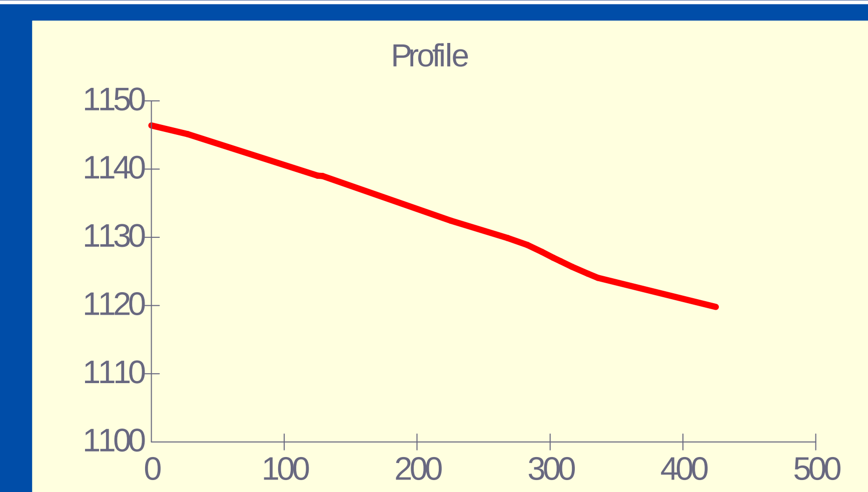
Ground surface of access road.



Coordinates (UTM Zone 10 NAD 83)

Start: 6340486.137 N, 487022.006 E End: 6340077.716 N, 487101.274 E





M-K Well Site Evaluation

British Columbia

Muskwa-Kechika Management Area

Husky Sikanni

Prepared by:
EBA Waberski Darrow Consulting Ltd.

eba

March, 2005
Version 1

Figure 8

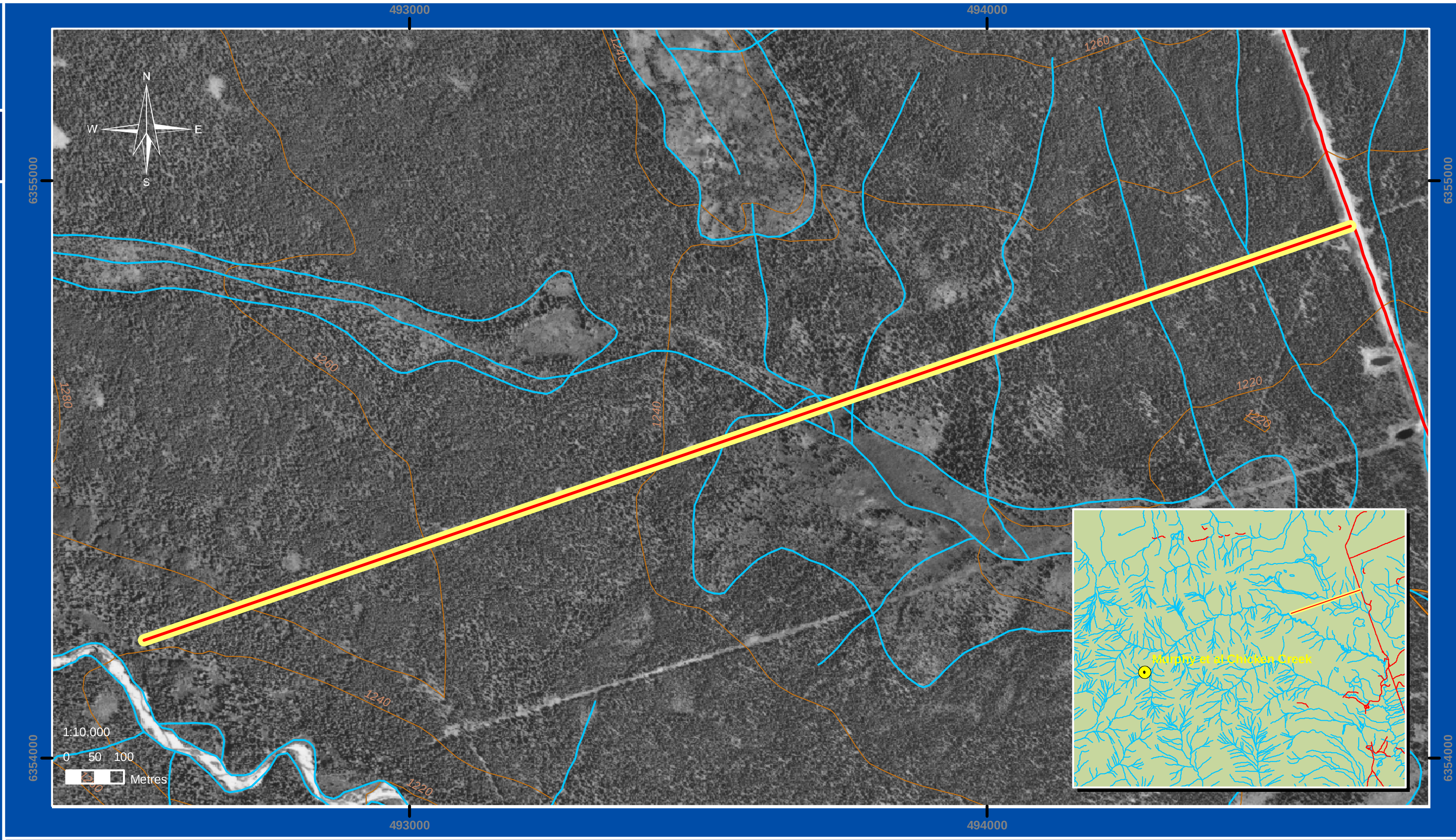
03944_Figure8.mxd

M-K Well Site Evaluation

Murphy Chicken Creek

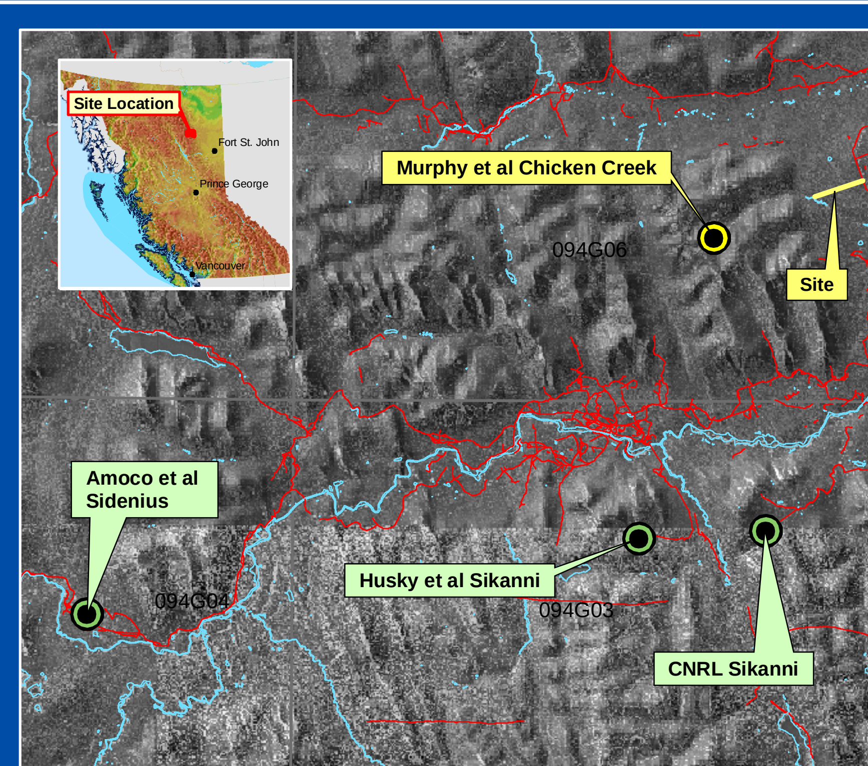
Conventional access via cutline. Slash placed to inhibit ATV access along cutline.

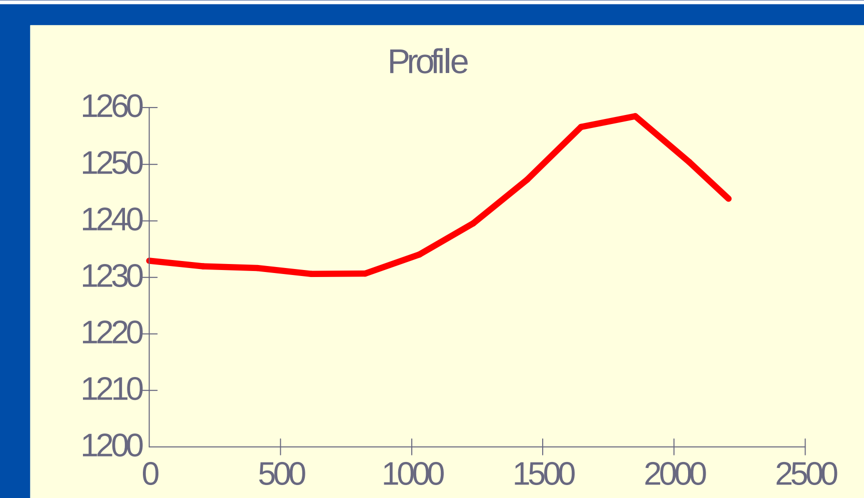
Use of existing cutline for access reduces footprint in the region. Cutline is very wet due to placement through forested wetland.



Coordinates (UTM Zone 10 NAD 83)

Start: 6354922.285 N, 494622.363 E End: 6354257.649 N, 492524.268 E





M-K Well Site Evaluation

British Columbia

Muskwa-Kechika Management Area

Murphy Chicken Creek

Prepared by:
EBA Waberski Darrow Consulting Ltd.

April, 2005
Version 2

Figure 9

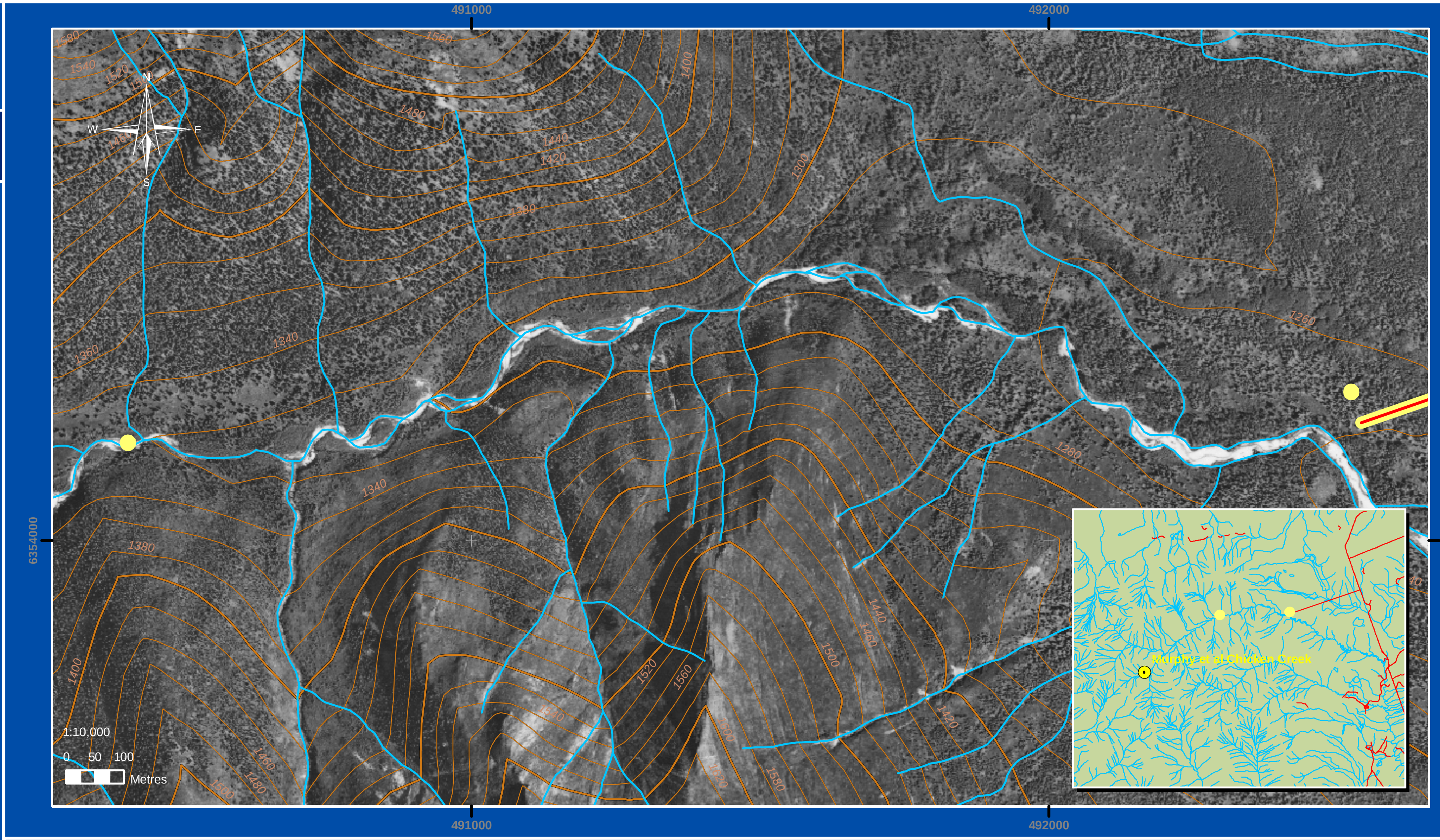
03944_Figure9.mxd

M-K Well Site Evaluation

Murphy Chicken Creek

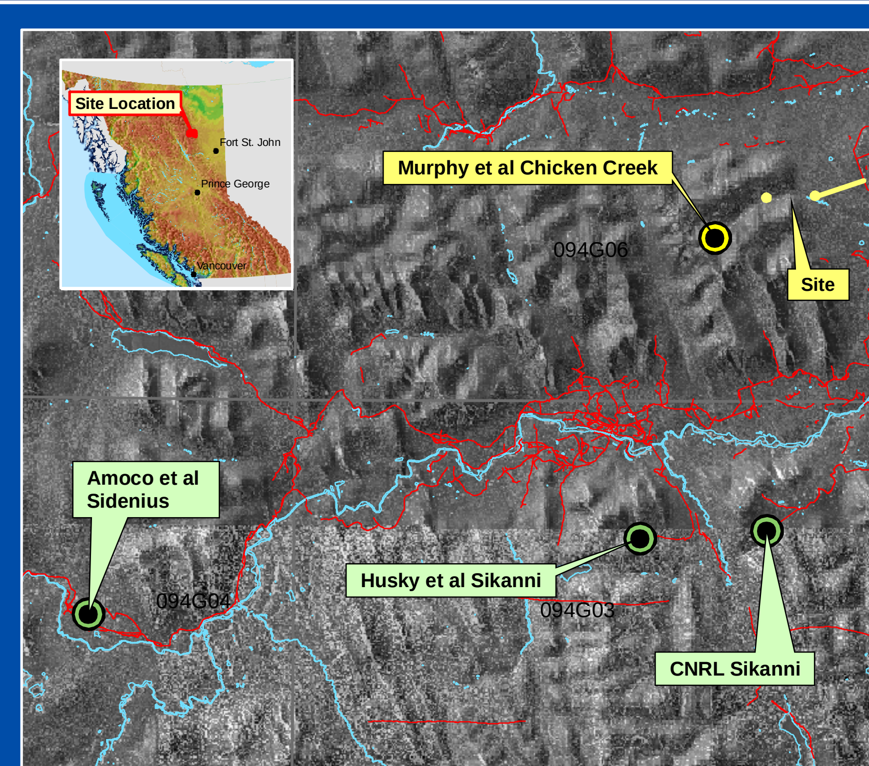
Clearing associated with access road construction in riparian area adjacent to Chicken Creek. Difficult to pick route without prior knowledge.

Location where access road crossed Chicken Creek . Minimal impacts through creek bed and along the bank.



Coordinates (UTM Zone 10 NAD 83)

Start: 6354257.649 N, 492524.268 E End: 6354169.289 N, 490406.765 E



Profile

No Profile Available

M-K Well Site Evaluation

BRITISH COLUMBIA

MUSKWA-KECHIKA MANAGEMENT AREA

Murphy Chicken Creek

Prepared by:
EBA Waberski Darrow Consulting Ltd.

April, 2005
Version 2

Figure 10

03944_Figur10.mxd

3.1.3.2 Habitat

From a wildlife habitat-perspective, the location and length of the Amoco Sidenius access road presents some issues in regards to wildlife. While not related specifically to the construction practices, the increased access into relatively pristine areas (i.e., for potential hunters and recreational users) poses potential long-term issues for wildlife management in the area.

The access road itself was constructed, though not entirely, in areas rated as highly sensitive from a wildlife-perspective (shrub/grass lowlands, riparian) (MELP and MEMPR 1995; see also those areas of higher and medium habitat sensitivity that are identified in Figure 1 of the current document). Typically these areas should be avoided when possible.

The route taken during several stages of the access road construction appeared to be linear and did not have to cross fens, skirt lakes, or be as close to the Sikanni River. The linear nature of the road in sections is also not appropriate from a wildlife perspective as it allows sightlines from predators. Decommissioning of the road did not appear to attempt to inhibit wildlife movement down the road overall, except in certain sections where snags were placed within the road.

3.1.3.3 Vegetation

The major issues from a vegetation perspective along the Amoco Sidenius access road relate to revegetation / reclamation, in particular vegetation effects within wetlands.

In some areas along the Amoco Sidenius access road, the construction of the road across fens and other open wetlands was potentially unnecessary, as there were nearby alternative routes that would have kept the road at a higher gradient by staying closer to mature forest areas that encompassed such areas. The construction practices in wetlands have resulted in some destruction and long-term alteration of fens and other wetlands (also see comments under Section 3.1.3.4). The maintenance of the access road in such areas has required additional mechanical maintenance to be undertaken, and this has resulted in higher maintenance costs, particularly where it was then necessary to redirect the road to alternative routes through adjacent areas.

In terms of revegetation issues, the volume of traffic along the access road the natural succession of grasses and shrubs in the immediate areas of stream crossings and along the entire road appears to be limited. Some sections of road have incurred excessive top soil removal along roads, thus impeding with the natural re-vegetation of the area. In addition, high use by ungulates on the access road (in particular Bison) will likely impede regrowth of shrubs and trees. Because of the high ungulate movement along the road, it is expected that shrub and tree re-establishment will be severely impeded.

3.1.3.4 Hydrologic

3.1.3.4.1 Wetlands

There were identifiable environmental effects associated with the construction of the Amoco Sidenius access road in the vicinity of wetlands. In several locations, the access road construction – when crossing fens or other wetlands where no alternative routes existed – did not include the installation of suitable diversion channels along the sides of the road. In some locations, this practice resulted in the erosion of road surfaces or the alteration of natural drainage and wetland function. Sedimentation and impoundment of water has indirectly caused the loss of additional habitat as alternative road routes were later installed to re-route the access road around these “watered up” locations.

Construction activities at several wetland locations did not include the installation of suitable culverts, which were needed to maintain the equilibrium in the water flow above and below the roadway. Altered lowland hydrology resulted in some notable degradation to several wetland habitats. In a few locations, impoundment of riparian areas by insufficient culverting resulted in the death of groups of mature conifer trees.

3.1.3.4.2 Riparian Areas and Stream Issues

From an ecological perspective, the loading of sediments into the Sikanni River is a major concern as the river is an important sport fishing river, which is home to several species of salmonids, such as the artic grayling (*Thymallus arcticus*), and bull trout (*Salvineus confluentus*) which is a “Blue Listed” species in British Columbia. In some instances, the location of the road has resulted in wetlands that have become significant sources of sedimentation, and this has a potential direct effect upon the Sikanni River.

One small section of the access road, for example, has been breached by the Sikanni River. This has a continuing effect of increasing sediment loads directly to the Sikanni River, particularly during freshet. This section of the river should be armoured and reinforced to prevent further erosion and/or the access road needs to be modified and moved away from the river at this location.

The Amoco Sidenius access road employed ice bridges for many stream crossings, as has been the practice for most other access roads as well. Many of these stream crossings however show evidence of long-term effects, in particular localized increased erosion, water gullying and channelling, and evidence of altered water flow. In addition, stream crossings showed distinct impacts by recreational vehicles and Quads / ATVs, and there are locations where distinct tire tracks have contributed to the degradation of stream banks and riparian areas at stream crossings.

There is also potential for riparian wetlands below the stream crossings to experience reduced water flows. Fens and other wetlands affected by altered flow patterns can become hydraulically altered over the longer term, affecting nutrient and water temperature regimes locally, and affecting habitat reclamation efforts.

3.1.3.4.3 Other Drainage Issues

There was a lack of drainage ditches and/or culverts along the deactivated section of the Amoco Sidenius access road. The lack of such drainage management has resulted in what appears to be mineral soil erosion, gullying and water impoundment at certain locations along the road. Sedimentation effects are of particular note, as several of the small intermittent streams and drainageways that are affected then drain into streams that directly connect to the Sikanni River.

In several wet low-lying areas, in both mineral soil and organic soil surfaces, the surface alterations that result from vehicles, particularly Quads / ATV's are clearly evident. In some locations, the longitudinal rutting effects in the road surface are creating localized areas of sedimentation / erosion and alteration of natural water flows.

3.1.3.5 Geomorphic

Environmental effects along the Amoco Sidenius access road are more numerous and extensive than were observed at the other sites. Most of the observed impacts are drainage-related, some are attributed to concentrated game use, and some are the result of Quad / ATV access, in particular, in sensitive low-lying areas; vehicle-related effects are particularly visible on open organic (wetland) surfaces and on steeper creek banks, where rutting is visible on fluvial sediments, in particular. There are some effects that can be related to fill slope and cut slope, in particular related to over-steepened cut slopes in granular soils which have then undergone some longer-term shallow sloughing. Key deficiencies on the access road are listed in Table 2.

The portion of the Amoco Sidenius road south of the Sikanni River was not travelled by ground during the October 2004 field work. However, as observed from the air, steeper sections of this section of the road were deconstructed by pulling back the fill wedge to re-establish the original slope and by placing large woody debris on the surface. There was no evidence of game trails in these areas, probably due to the bouldery and cobbly nature of the pullback material in these areas.

South of the Sikanni River, the access road is located primarily in the bottom of the Sikanni River valley, primarily in flat to gently rolling terrain, with no visible cuts or fills. At isolated locations along this stretch of the access road, there are cut and fill slopes where the topography constrained the road between steeper slopes and the Sikanni River. At these locations, ongoing ravelling of coarse grained soil such as sand or cobbly sand and gravel was observed. The root mat at the crest of such slopes was generally overhanging the slope, indicating regression of the slope crest. Such coarse grained soils are probably alluvial or fluvial and are well drained.

In general, south of the Sikanni River, no significant disturbances were observed (from the air) at most creek and river crossings associated with the Amoco Sidenius access road.

The last kilometre of access road, with a natural cross slope of 25 to 30 degrees, had been decommissioned by pulling back the road fill and covering the surface with large coarse woody debris. We judged decommissioning to have been successful at this location, as there was little evidence of ongoing erosion or preferential drainage paths in the immediate area.

3.1.4 Key Successes

3.1.4.1 General

The following general observations were made for the Amoco Sidenius project, in relation to overall positive environmental aspects of the project:

- Some sections of the deactivated road were well vegetated / well reclaimed;
- Some good route selection was included in the overall design, and where this was done, there are few potential issues regarding water drainage; and,
- The abandoned well site, in particular, is appropriately levelled and well graded.

3.1.4.2 Habitat

The presence of the access road does not seem to be inhibiting wildlife movement within the valley, as indicated by abundance of wildlife sign that was observed along the entire access road. It is possible that the road may be contributing to some altered behaviour or movement patterns, as we observed ungulates to be heavily using the road. However, the overall effect may not be significant, as it also appears that the road is not providing easy or direct access for ungulates to important habitat, such as the shrub/grass lowlands.

3.1.4.3 Vegetation

Vegetative cover, specifically graminoid and forb species, have extensively established along many portions of the access road. Such pioneering and invasive species can be particularly effective in terms of stabilizing the soil and creating conditions that are favourable for successional species to then establish.

3.1.4.4 Hydrologic

It is evident that mitigative measures were undertaken to avoid some of the major issues with respect to wetland avoidance and water management in lowland areas. Overall, however, there are many locations where this was not adequately practiced.

3.1.4.5 Geomorphic

Drier and better-drained uplands exhibited relatively few environmental effects due to access road construction. Most water crossings were minimally impacted. There were no reported terrain stability or erosion issues on flat river terraces.

It is acknowledged that some sections of the access road's route were chosen to avoid areas of potential drainage concerns. Some fen areas were crossed without ground or vegetation disturbance using winter access, and natural drainage was therefore not affected. Re-establishment of vegetation has been successful in some areas south of the Sikanni River. Many stream crossings appear to have had negligible impact from development. Key successes identified along the access road are summarized in Table 2.

Table 2. AMOCO Sidenius (c-92-G, 94-G-4), Terrain Impacts and Geotechnical Issues

ISSUE	**CAUSE or EFFECT**
Deficiencies – Well Site	
None	
Successes – Well Site	
Well site regraded	Well site recountoured, covered with large woody debris, some revegetation taking place
Deficiencies – Road	
Increase in surface water levels on one side of the road	Damaged culverts, blocked drainage in one of the fen/peat areas Exposed cobbles and boulders on road surface through this area indicate fen was bridged with coarse grained borrow material
Severe gullying; oversteepened cutslope from toe erosion; ditch scouring; ongoing erosion, high likelihood of stream siltation.	Road follows deep gully on edge of terrace; 2 m to 3 m wide ditch has destabilized cut slope; There is no evidence that measures were implemented to control what appear to be large flows on steep road profile within the gully and parallel to the road.
Poor fill slope construction with toe support by trees	Oversteepened road fill up to 2 m high supported at the toe by trees located on the bank of the Sikanni River. Loss of toe support when trees fall would likely result in failure of the fill slope into the river.
Rutting and disturbance of sensitive soils in fens by ATV's, bison and horses.	This is not a direct result of road construction but a result of ongoing use of the road by recreational users. Use of road since has resulted in some rutting of banks causing siltation. Such effects could be reduced by creating barriers to such vehicles.
Soft, wet soil on road shoulders	Inadequate drainage management; inadequate ditching; possible plugged culvert.
Standing water in ditch	; Some ditches appear to have been excavated subsequent to road construction and have inadequate gradient, culverts, ditches too low to drain away from road.
Ruts on road surface; saturated topping;	Inadequate drainage management; inadequate fill and culverts; road design is inadequate to sustain access and all season recreational use by ATV's.
Ditch overflow onto road surface	Inadequate drainage management such as ditch depths, culverts, road grade too low in low spots; inadequate fill depth; inadequate fill placement; absence of geotextile under fill;
Road soft, wet for 200 m	Road traverses, flat, wet, low lying area at toe of slope to north; road constructed for winter use only (no granular fill; clearing only); subsequent unintended all weather use causing rutting.
Ravelling cut slope	Inadequate cut slope design for long term stability; oversteepened cut slope for soil conditions; slope will not revegetated without slope flattening or other remediation measures.
Local channel migration at stream crossing	Inadequate management and protection of stream banks and channel

Table 2. AMOCO Sidenius (c-92-G, 94-G-4), Terrain Impacts and Geotechnical Issues

ISSUE	CAUSE or EFFECT
Access road washout along Sikanni river	Road is washed out as a result of natural river channel movement at a developing meander. Road construction at this location appeared to consist of little more than brush clearing and minor fill placement, and it is unlikely that the road impede the meander development.
Successes – Road	
Stream crossings essentially unaffected by road	Likely winter road construction AMOCO is unique in that it is the only road of the four being used for hunting etc
No issues in river terrace areas (flat).	
No issues in decommissioned areas such as the last 0.5 kilometre to the well site from the main road (including the well site).	The fill has been pulled back, woody debris spread on the surface and water bars created
Absence of major scouring from surface run-off on road	Cross ditching is effective on sloped sections.
Decommissioning on south side of river where road crossed steep gradient slopes appears stable	Fill slopes have been pulled back on sections of road that cross steep gradient side hill slopes.
Natural drainage of fen areas undisturbed	Did not have culverts and were likely crossed during winter
Vegetation established on some sections	Adequate seeding and road deactivation
Chosen alignment avoided some areas with potential drainage issues.	Good route planning and selection

3.2 CNRL Sikanni

3.2.1 General Characteristics

The CNRL Sikanni C-33-J/94-G-3 well site and access road was field visited on October 10, 2004 by the 3-person team. The well site's GPS coordinates are: N 6339636 / E 0490488. The CNRL Sikanni well site is accessed by way of a short (1.56 km) access road.

The CNRL Sikanni was drilled in February 2003. The associated short access road includes a trenched pipeline within its right of way. There has been no continuing historical vehicle access, as was the case for the Amoco Sidenius road. As noted in Section 1, the well site is currently active, and so access to information about construction aspects is confidential and limited. The well pad was built using conventional cut and fill techniques.

3.2.2 Alignment Sheets

Two alignment sheets were assembled for the CNRL Sikanni project (see Figures 6 and 7). Figure 6 shows ponding effects along a portion of the access road and its associated buried pipeline, and the overall effects of poor drainage control. Figure 7 shows an upper slope failure that occurred at the well site, despite a cutoff ditch having been constructed during the cut and fill operations to help avoid such an event.

3.2.3 Key Deficiencies

3.2.3.1 General

The following general observations were made in relation to the CNRL Sikanni project's overall deficiencies:

- The well pad was constructed on a slope that was characterized by significant fill depth, and which appeared to be subjected to subsurface water flows;

- Slope gradients are quite high in some locations, and associated silt fencing has sloughed and become sediment filled; and,

There are slope stability issues; for example, there are locations where sloughing of upslopes has been continuing and there is an area where a stream bank is currently exhibiting considerable lateral seepage, and a future failure of this slope may occur.

3.2.3.2 Habitat

The installation of the access road / pipeline does not seem to be affecting the movements of wildlife and there is considerable wildlife sign observed along the road. As for the Amoco Sidenius road, there is evidence of browsing and movement by ungulates in particular.

3.2.3.3 Vegetation

The location of the pipeline is very distinct as indicative of the roach pile[3], and this suggests that reclamation of the pipeline has not been completed. The depth at which the pipe is located, coupled with the channelling of water along the pipe, has resulted in frost heaving effects that are evident along the full length of the pipeline. Annual events of frost heaving activities at surface may continue to impede natural re-vegetation along the pipeline, including once reclamation is completed.

A lack of proper backfilling along the pipeline has resulted in exposed mineral/organic soil in many locations (e.g., particularly around trench dams and directly above the pipeline), which has allowed establishment of invasive plant species.

[3] Typically, soil / fill is piled on top of a pipeline after installation and allowed to settled over a few seasons; this convention of piling of soil / fill materials is called a “roach”.

3.2.3.4 Hydrologic

3.2.3.4.1 Wetlands

From the well site, the access road then runs up a slope; a fen wetland is located in a depression at the crest of this slope. The consequence of having a weltand ecosystem at the crest is that the spruce forest along the entire slope is very wet, such that it is characterized by some well developed surface organic horizons. The presence of this wet forest on a slope where it might not otherwise be expected appears to have created some water management problems. Inadequate water diversion practices were taken in this area, and the effect has precipitated down the slope, such that the pipeline length in this area exhibits associated water channelling. There is standing water in the channels as well as adjacent subsurface water percolation. The overall effect at this location is that the natural water flows have been altered, to the point where structural integrity of the substrate supporting the actual pipeline may, in time, be affected. The redirection and impoundment of waters on this sensitive slope may also have some negative consequences for the fen wetland at the crest of the slope, which may be in the process of becoming deprived of water flow.

In addition, groundwater flow redirection is potentially influencing the size of the fen wetland complex that is at the base of the CNRL Sikanni well pad. This could undermine slope stability, and later, influence patterns of vegetation succession at this location.

A general observation is that better construction practices need to be implemented in areas that contain ecosystems with high water tables (e.g., wetlands), especially when such ecosystems occur on slopes, as is the case here.

Construction of the well pad has had a measurable effect on the wetlands surrounding it. The slope gradient of the drill pad is relatively severe, and is a potential source of sedimentation into the adjacent wetland. In addition, the slope along the edge of the well pad is becoming increasingly unstable and could potentially slump, further encroaching upon the ecologically-sensitive wetland. The use of organic material to build berms / windrows at the base of the well pad appears to have influenced groundwater flow into the fen wetland that exists to the south of the well site.

3.2.3.4.2 Other Drainage Issues

There are drainage issues that are specifically attributable to the presence of the buried pipeline. The use of insulation foam as a water dyke/berm along the pipeline has proven to be ineffective, and the material is not biodegradable. As already noted, the pipeline was built through a very wet area with significant water infiltration from adjacent upslope areas. In addition, very poor drainage of water, resulting in the blockage of culverts and water ponding, was found along the length of the pipeline in wet areas.

3.2.3.5 Geomorphic

Geomorphic effects of construction by the CNRL Sikanni project were particularly evident at the well site itself. Slope stability, groundwater seepage and surface erosion effects were observed; in particular, there were tension cracks, gullying, cut slope failures and unmanaged drainage including ponded water at the well site. Stability issues at the well site are consistent with the effects of inappropriate cut and fill slope gradients for the soil type and groundwater conditions.

There are some geotechnical concerns at the well pad, in relation to localized fill and cut slope failures. This well site was active at the time of the site inspection. A pipeline has been constructed along the middle of the access road.

The CNRL Sikanni access road traverses a broadly sloping flank of a mountain, with minimal slope perpendicular to the road alignment and grades of up to 15 degrees along the alignment. The access road was constructed in winter using typical winter snow fills and, therefore, no cut or fill was observed. Groundwater control measures were implemented during pipeline construction, with foam insulation trench dams and cross ditches at regular intervals. At the time of the site inspection, water was observed flowing along the disturbed trenchline (i.e., trench of the pipeline alignment), despite the presence of cross ditches. The ground within the road alignment was generally wet with standing water in locations flatter than about 5 degrees.

The natural slope of the well site was downward, from northwest to southeast. Cut slopes up to 10 m in height and fill slopes of 8 m in height were estimated during our October 2004 field visit. It was observed at that time that the cut slope to the northwest of the site had undergone a large post construction failure. Sand and gravel were exposed on the cut slope. Seepage from the middle third of the cut slope probably contributed to the failure. Tension cracks have continued to form, as a result of lateral movement, at the downslope edge of the fill, which will likely lead to fill slope failures at some point in the future.

Natural groundwater levels appear much higher along the CNRL Sikanni access road than along the Amoco Sidenius access road, despite the fact that the Sidenius site access is predominantly in a valley bottom. Elevated groundwater flows contributed to the failures observed at the pad and the drainage issues along the pipeline.

This is the only active well site of the four projects. To this point in time, the CNRL Sikanni well site and access road have not been subjected to any reclamation work or revegetation efforts. With respect to construction activities and geotechnical considerations, key deficiencies are summarized in Table 3, but the predominant causal factors are impoundment of slow-flowing waters and the effects of frost heaving.

3.2.4 Key Successes

3.2.4.1 General

No key successes are identified.

3.2.4.2 Habitat

The CNRL Sikanni well pad surface contains several potential “new” mineral licks (as evidenced from high concentration of ungulate tracks around the well site). This suggests that ungulates are not avoiding the well site, at least not during periods of low human activity in the vicinity. Overall, wildlife use along right-of-way does not seem as high as other areas (lower pellet densities, presence of tracks), but also does not seem impeded (numerous game trails were observed, mainly oriented perpendicular to the right-of-way).

Another "success" of this access road is that it is relatively short compared to others examined, and it is somewhat more isolated. As such, it does not provide significant recreational access into this area.

3.2.4.3 Vegetation

While there was some weedy vegetation present along the access road / pipeline right-of-way, overall vegetation cover along the length of the pipeline right-of-way is relatively good, except around the trench dams and the immediate area of the buried pipeline.

3.2.4.4 Hydrologic

There are no hydrologic successes associated with this well site.

3.2.4.5 Geomorphic

Despite the cut slope failures at the well site; well operations do not appear to have been adversely affected. The disturbance to vegetation along the access does not appear to have been entirely related to road construction during drilling. Disturbance and drainage issues along the access are almost entirely due to trench backfill placement after pipeline installation. These issues include ponding and flow of water within the trench backfill.

Table 3. CNRL Sikanni (C-33-J, 94-G-3), Terrain Impacts and Geotechnical Issues

ISSUE	CAUSE
Deficiencies – Well Site	
Cut slope failures	Reduced soil shear strength due to groundwater seepage at depth; inadequate management of drainage and slope;
Water standing in low areas	Likely from cut slope seepage and surface runoff from upslope
Water flowing across well pad	Poor management of drainage; inadequate assessment of cut slope impact;
Large cut slope failure created over-steepened, concave shaped slide scarp approximately 6 m high by 20 m in length.	The cut slopes are oversteepened for the soil type. Seepage concentrated about 3 m below the crest of the head scarp likely contributed to the failure mechanism.
Tension cracks are evident at the crest of the fill slope Gullying in loose fill near the base of the slope	Lack of compaction of fill slope; oversteepened fill slope;
Eroded material deposited beyond toe of slope	Sloughing /rilling / shallow sliding
Poor Visual Quality	Poor drainage management; lack of revegetation; disruption of surficial soils by frequent ungulate use.
Successes – Well Site	
Operations	Well operation seems to be unaffected by the fill, cut slope and drainage issues.
Deficiencies – Access (Pipeline access)	
Standing water; Frost heaving	Water collection from upslope and across the slope; the route involved crossing a saddle between relatively steep slopes. Alternative routing was not available or uneconomical. Location of the alignment here was problematic and requires special drainage control and erosion protection measures. Drainage management measures implemented during construction have had marginal success. Use of the saddle for the alignment should have triggered a geotechnical investigation to recommend special construction techniques or measures to manage water issues.
Maintenance	One of the trench dams (foam) has popped out of the ground due to either buoyancy from high groundwater or from frost action.
Erosion on slope from failing surface water control structures.	Cross ditches with berms to intercept run-off in pipeline trench on a long slope with near surface groundwater were a good idea and necessary to avoid large flows and high flow velocities in trench backfill; cross berm construction was inadequate and some are failing. Some surface water is bypassing settled parts and ends of the cross ditch berms to follow the trench down the slope.

Table 3. CNRL Sikanni (C-33-J, 94-G-3), Terrain Impacts and Geotechnical Issues

ISSUE	CAUSE
Successes – Access	
Disturbance	No visual evidence of ground disturbance other than the pipeline trench. Likely winter road access for well drilling.

3.3 Husky Sikanni

3.3.1 General Characteristics

The Husky Sikanni C-40-J/94-G-3 well site and access road was field visited on October 10, 2004 by the 3-person team. The well site's GPS coordinates are: N 6339267 / E 0484879. The Huskey Sikanni well site is accessed via a 9.24 km access road on south side of Sikanni Chief River.

The Husky Sikanni well was originally licensed to Marathon and drilled in January 2002 (OGC 2001). This project involved the use of some of the same low-impact approaches that were also employed along the Murphy Chicken Creek access road. The Marathon well site included cut and fill construction techniques while the Murphy Chicken Creek was a padded well site.

Some additional features of the Husky Sikanni project include:

- There is no historical vehicle access (as for Amoco Sidenius);
- The project employed a mixture of low impact and conventional construction techniques on different portions of the access road;
- Some of the access road and the well site are located in a historical burn area;
- The Husky Sikanni well site is capped, possibly for later re-entry, or Husky may be waiting to start production;
- The well pad was built using a cut and fill technique, and fill was placed on filter fabric for future lower-impact reclamation; and,
- The well pad fill slope gradients are relatively severe (approximately 45%), and as a result there was evidence of recent damage to the sediment fences at the well site, by soil and rock colluvium. The sediment fences are located too close to the toe of the well pads to be as effective as possible.

3.3.2 Alignment Sheets

One alignment sheet was assembled for the Husky Sikanni project (Figure 8). Figure 8 shows the effects of the low-impact road construction work that was completed on a section of the access road.

3.3.3 Key Deficiencies

3.3.3.1 General

The following general observations were made of the Husky Sikanni project, in relation to overall deficiencies:

- In general, there is relatively good management of water drainage;
- There are no identified issues in relation to routing of the access road; and,
- There is some sloughing of stream banks on the downslope / fill slope along the access road.

3.3.3.2 Habitat

The access road occurs partly within an area of higher quality wildlife habitat, in particular, a portion of the road that is within an area that was burned in the recent past. There are otherwise no deficiencies noted in the field with respect to this project, in relation to wildlife habitat quality.

One aspect that could be considered problematic is the presence of long sightlines in exposed habitat (i.e., within the burned area) which may benefit predators. From the field visit, it was noted that carnivores were using the access road in addition to ungulates.

3.3.3.3 Vegetation

In relation to vegetation, since the access road and well have not been reclaimed (the well is currently capped), we were not in a position to examine or assess reclamation success in relation to this project. A general observation is that the portion of the access road that was subjected to conventional construction techniques also is currently poorly vegetated and will need to be reclaimed in future.

We considered that the use of large woody debris in restoring / deactivating the access road at the well pad was done in excess of what was required. The considerable amount of woody debris deposited at this location potentially impedes any natural succession of grasses and shrubs in this area. However, considering that the well site was located adjacent to a relatively recent wildfire, the placement of downed snags might be considered by some to be "locally" appropriate. In other locations where well sites would be constructed adjacent to mature forests, this overabundance of woody debris would be inappropriate.

3.3.3.4 Hydrologic

3.3.3.4.1 Riparian Areas and Stream Issues

Since the access road was constructed in an area with few wetlands (except near the start of access road), there are few hydrologic issues. The well pad was constructed right adjacent to an intermittent stream (north east side), and it might have been appropriate to relocate it a distance away from this drainage channel.

As already noted, large woody debris was placed along the road near the well pad. Distributing large woody debris in an area that encompasses an intermittent stream could cause a log jam. This could also alter the natural flow of the channel during heavy rains, where the channel would start to expand into the well pad area. Typically, construction of well pads should allow more distance from intermittent channels to avoid excessive erosion of the well pad, and to avoid potential sediment transfer in areas close to wetlands or open water channels.

3.3.3.4.2 Other Drainage Issues

The culvert construction methodology employed cobble and boulder riprap to decrease water velocity at culvert outlets. This approach is appropriate, but we observed that the technique was only partially effective, and resulted in some erosion. The materials were placed in a cluster too close to a few of the culverts, and this resulted in a restriction of flow (rather than the culverts serving their intended purpose as a gradual energy reducer). Where riprap was installed in this densely clustered manner, we observed (minor) erosion that resulted in damage to adjacent sediment fences.

3.3.3.5 Geomorphic

Development impacts along the Husky Sikanni access road and well site are low. Some sections of the road were built with conventional cut and fill techniques and others with low impact methods. Minor erosion was observed at a few culvert outlets on the access road but it was not considered to be a significant deficiency. Deficiencies are summarized in Table 4.

3.3.4 Key Successes

3.3.4.1 General

The following general observations were made for the Husky Sikanni project, in relation to overall positive environmental aspects of the project:

- Organic layers were stripped and piled on the side of the conventional road for future deactivation; and,
- Low-impact portions of the access road construction work were highly effective in achieving objectives of reducing long-term environmental effects.

3.3.4.2 Habitat

The presence of the well site and access road does not seem to be inhibiting wildlife activity in the area.

It was noted that wildlife are using mineral licks on the well site surface, though not as extensively as at the CNRL well pad. The presence of game trails at the base of the well site possibly indicates that ungulates in particular are not risking exposure on well site surfaces. Browse activities / evidence observed within the fen surrounding the well site, on the east side of the well pad, indicates that ungulates are potentially not exhibiting significant avoidance behaviour.

Wildlife movement along the access road was quite evident (presence of tracks, pellets, high use game trails adjacent to) during our field visit in October 2004, likely due to the ease of travel as compared to the relatively dense adjacent mature forests. Carnivores (e.g., wolves, coyotes) are also using the Husky Sikanni access road, which in some sections provides relatively good sightlines.

3.3.4.3 Vegetation

Road construction techniques that promoted the retention of native vegetation worked very well, but were limited to ecosystems that had high grass/shrub cover (e.g., burned stands, fens), as opposed to within stands with higher moss ground cover. Where used, this technique resulted in very little exposed soil and the retention of a high vegetation cover.

Along the access road portion that was constructed with gravel/mineral soil, there was a low presence of weeds and overall low vegetation cover. The slope of the road along this portion was relatively steep, but since the surrounding forest was dry, there was little evidence of surface or near surface water redirection or impoundment.

3.3.4.4 Hydrologic

Overall, appropriate culvert placement was undertaken by the Husky Sikanni project along cut-fill section of the access road, and this served to minimize erosion and erosion-related impacts. Overall the landbase is relatively well drained and generally dry, and this served to minimize the occurrence of hydrological effects.

3.3.4.5 Geomorphic

Few terrain stability and erosion issues were noted. The Husly Sikanni well site was observed to have stable cut and fill slopes, a noted absence of drainage problems, low impact to vegetation cover, and no significant ditch erosion or sloughing effects. Table 4 summarizes geo-environmental issues at the site.

The Husky Sikanni well pad had cut slopes up to 8 m in height with up to 25 degrees at the southwest corner. Slopes on the fill side of the pad were also approximately 25 degrees. Overall, these slopes are stable. Minor ravelling, and some accumulation of fine sand and silt from slopewash on the cut slope was observed in the ditch surrounding the pad. The cut slopes are likely too steep to be revegetated without bioengineering. The subgrade soil consisted of silty sand with some gravel and the occasional cobble and boulder.

The well pad was located entirely within a forested area that had burned at some point in the recent past.

Table 4. Husky Sikanni (C-40-J, 94-G-3), Terrain Impacts and Geotechnical Issues

ISSUE	**CAUSE or EFFECT**
Deficiencies – Well Site	
Minor accumulation of fine sand and silt in cut-off ditch on upslope side of well site	Slope wash
Successes – Well Site	
Stable cut and fill slopes	Cut and fill slopes were 2:1 (H:V), which was adequate based upon site observations.
Increased stability of base	Well site fill was placed on filter cloth; advantage for decommissioning
Stock pile is stable	
Deficiencies – Road	
Minor accumulation of fine sand and silt in cutoff ditch on upslope side of well site	Excess flow directed to culvert; lack of armouring at culvert outlet.
Generally low impact	
Successes – Road	
Absence of drainage problems with conventional construction across slopes	Numerous cross culverts to channel ditch flow from upslope to down slope; breaks in organic windrow at culvert outlets,
Low impact to vegetation	Low impact road sections left vegetation relatively undisturbed
	Organics windrowed to down slope side of road
No significant ditch erosion or sloughing	Ditch slopes adequate; good drainage management;

3.4 Murphy Chicken Creek

3.4.1 General Characteristics

The Murphy Chicken Creek B-94-B/94-G-6 well site and access road was field visited on October 12, 2004 by the 3-person team. The well site's GPS coordinates are: N 6353882 / E 0489725. The Murphy Chicken Creek well site is accessed by way of a 5.34 km access road that is partially built along Chicken Creek.

The Murphy Chicken Creek well was drilled in January 2001. The project employed low-impact construction techniques that were designed, in particular, to lower the potential environmental impacts that could result from wetland / lowland disturbances. Low impact practices were undertaken for the road construction (mainly use of winter snow roads, no cut and fill work, and a portion of the road made winter use of the Chicken Creek route) and well pad (it was built using snow placed on filter fabric, for low impact reclamation). The Murphy Chicken Creek well site is now listed as abandoned.

3.4.2 Alignment Sheets

Two alignment sheets were assembled for the CNRL Sikanni project (see Figures 9 and 10). Figure 9 shows how conventional access was established along the road, by way of a cutline that was then snow-filled for winter only access; the approach resulted in minimal disturbance to the natural vegetation ground cover. entional access via cutline. Minimal disturbance. Figure 10 shows the access road's route along Chicken Creek, which resulted in very low disturbance, such that it is difficult to find the route without prior knowledge of where it was.

3.4.3 Key Deficiencies

3.4.3.1 General

No key overall deficiencies are identified; however, some specific issues are noted in Sections 3.2.3.2 to 3.2.3.5.

3.4.3.2 Habitat

While methods were used to minimize the impact of road construction, there is still a relatively distinct footprint observed along the Chicken Creek valley bottom where road access was constructed with snow-blowing machines.

Overall, the heavy wildlife use in riparian areas along Chicken Creek indicates a problem beyond just focusing on construction methods. While constructing access roads along valley bottoms and dry creek beds with low-disturbance techniques is mitigative against potential impacts, construction in a high use/high sensitivity wildlife zone is more difficult to mitigate. If the well had been productive, seasonal access into this area would have been required and may have had an impact on wildlife movement within the valley; it is difficult to speculate, but had the well been productive, the routing may not have been particularly appropriate from a wildlife habitat management perspective.

3.4.3.3 Vegetation

The use of snow-blowing machines to construct a temporary road along Chicken Creek had minor impacts to the riparian ecosystem. The removal of top soil cover during snow removal may have potentially disturbed naturally-occurring seed sources. There may have been an influence upon the degree of grass and shrub re-vegetation along the entire access road that was constructed using this construction methodology. The snow-blowing method may also have had some effect upon the top layer of nutrient-bearing soils (e.g., LFH and A horizons in particular, where boreal soil nutrients are highly concentrated) and perhaps organic and mineral soil surface substrates within riparian areas.

The access road above the Chicken Creek section followed an existing cut-line. While no soil was disturbed during its use and construction, removal of the tree canopy has changed the ground vegetation due to rising of the water table level. Along this cut-line, the heightened water table promoted the dominance of sedges from the naturally occurring moss layer. Since the Murphy Chicken Creek project used an existing cut-line for this portion of the access road, impacts associated with the cut-line should not be directly attributed to this well site.

3.4.3.4 Hydrologic

3.4.3.4.1 Riparian Areas and Stream Issues

Although there is no clear evidence from the current field survey, the natural morphology of Chicken Creek may have been potentially compromised in several sections following the removal of the ice / snow road, which subsequently formed new channels that encroached into riparian zones, causing increased erosion and sedimentation.

3.4.3.4.2 Other Drainage Issues

As mentioned previously, the section of the access road above the valley bottom was very wet due to the removal of the tree canopy. Quad / ATV traffic has subsequently occurred in this area, and has contributed to some significant (although localized) surface disturbance, in particular rutting.

3.4.3.5 Geomorphic

There was no evidence of earthworks on the access road or wellsite, and vegetation – other than tree removal – was generally undisturbed throughout. Geotechnical concerns were negligible and no drainage, cut slope/fill slope, or revegetation issues were identified.

There was little evidence of construction activity, either along the access road or at the well site, other than tree clearing. There were several areas of standing water on the upland portion of the access from the main access road to Chicken Creek. There was no cut, even at the crest of the 10 to 12 degree slope down to the Chicken Creek Valley from the north side. The former access road followed Chicken Creek, which has a relatively flat valley floor in cross section, and road clearing resulted in minimal disturbance, other than tree removal. There was no evidence of cut at the crest of a 10 m high slope where the access road ascended from the valley floor to the pad located on a terrace. The pad was revegetated with grasses and there was no evidence of active erosion. Flat gradient terrain at the site precluded the need for cut slopes or fill slopes. The Murphy Chicken Creek well pad area included several swales. The perimeter boundaries of the well site conformed to the natural ground elevation of the adjacent terrain.

3.4.4 Key Successes

3.4.4.1 General

The project resulted in very low impact overall.

3.4.4.2 Habitat

Overall, we observed no significant environmental issues in relation to the access road construction for the Murphy Chicken Creek project. Wildlife use along the valley bottom is still very high. In some locations, historical game trails are still being used, more so than the area that was cleared for the access road.

3.4.4.3 Vegetation

Access road and well site construction, while noticeable, fit nicely into the landscape from a visual perspective. Low vegetation disturbance should promote relatively quick revegetation. The only impeding factor would be the overall coarseness of the soil substrates, and potential low nutrient value. Overall, vegetation cover was well maintained during construction and this served to minimize water redirection / impoundment, erosion or sedimentation effects.

3.4.4.4 Hydrologic

While some minor hydrological effects were observed along the Chicken Creek channel, due to snow road construction and removal, there was little effect overall. Road construction along the creek bed resulted in minimal effects on the natural fluvial processes.

3.4.4.5 Geomorphic

The chief success at this site is the significant lack of observed slope stability or drainage impacts as a result of construction. The upland road alignment from the main access road to Chicken Creek is stable. The sloped access road section that was constructed down to the Chicken Creek crossing was particularly well preserved and minimally impacted. Stream banks and channels at stream crossings and approaches were adequately designed to minimize impact.

Geomorphic observations and impacts are summarized in Table 5.

Table 5. Murphy Chicken Creek (b-94-B, 94-G-6), Terrain Impacts and Geotechnical Issues

ISSUE	CAUSE or EFFECT
Deficiencies – Well Site	
No major deficiencies observed; stable site	
Successes – Well Site	
No evidence of disturbance;	Site gradient is flat and revegetated with grasses; environmentally effective site selection including setback from creek
Deficiencies – Road	
No observed geotechnical impact	Rumoured that construction was expensive
Successes – Road	
Significant lack of observed impacts, erosion, instability or drainage problems	Well planned route; signs of environmentally effective route selection;
Stable road alignment on upland	Trail was cut but not cleared and is vegetated with grass
No disturbance to surficial soil or ground vegetation on sloped (10^{o} -12^{o} gradient) water crossing access	Vegetation preserved; low impact techniques used to clear route
Negligible impact to stream banks and channel	Environmentally effective route selection; appeared to utilize unvegetated gravel bars where possible; evidence of hand-clearing within riparian zone; no cut/fill where access ascends creek channel to well site on terrace.

4.0 OFFICE-BASED OVERVIEW ANALYSIS OF WELL SITE AND ACCESS ROAD CONSTRUCTION

As background to the current investigation, an office-based overview analysis was also conducted. The overview analysis was undertaken specifically to clarify construction issues and costs related to each of the well sites and access roads. Results are presented and compared in the following report sections, and provide some insight into some of the key construction issues and approximate levels of effort and expenses associated with the four projects.

4.1 Information Assembly

The overview analysis was undertaken to provide some general context in relation to the environmental effects associated with the four projects, and also as a basis for considering general cost/benefit issues in relation to well site and access road construction within the M-KMA. The investigation involved two aspects:

- Interviews with individuals involved in the original construction projects; and,
- A review of costing data provided by the current operators.

Interviews were carried out with individuals involved in each of the projects (Table 6) to better understand some of the project-specific construction issues and, in addition, how the costs were determined and whether there were any additional extenuating factors involved in the costs associated with each project. The feedback obtained from interviews is provided in Section 4.2. In general, the interviews identified a number of notable issues that were associated with the planning, construction and reclamation activities that were conducted in relation to the four projects.

Table 6. Individuals Contacted / Interviewed Regarding Project-Specific Construction Issues and Project Costing for Each of the Four Well Site and Access Road Projects

Well Site	Contact	Affiliation	Contact Phone No.
AMOCO Sidenius	Colleen Jennings	Logistics Superintendent – Wells Team, BP Canada Energy Company	(403) 233-5642 (Office)
	Roland Koecher	Construction Consultant	(250) 784-5858 (Cell)
	Andrew Purdey	Ruskin Construction Ltd (Bridges)	(250) 563-2800 (Office)
CNRL Sikanni	Dwayne Werle	Surface Land, Canadian Natural Resources Limited	(250) 785-3085 ext. 2 (Office)
	Don Mulek	Construction Consultant	(780) 625-5018 (Cell)
Husky Sikanni	Peter Daunhauer	Husky Oil Operations Limited	(403) 298-7334 (Office)
	Tom Fulton	Construction Consultant	(780) 814-2452 (Cell)
	Darrell Roddick	Construction Consultant	(780) 721-5405 (Cell)
	Andrew Purdey	Ruskin Construction Ltd. (Bridges)	(250) 563-2800 (Office)
Murphy Chicken Creek	Dwayne Werle	Surface Land, Canadian Natural Resources Limited	(250) 785-3085 ext. 2 (Office)
	Dennis Campbell	Construction Consultant	(780) 618-5705 (Office)

In addition, the current operators were contacted and asked to supply costing and level of effort data to EBA Waberski Darrow. This information was subsequently received, but all in different formats and with varying levels of detail. This is understandable since data had been summarized and maintained in different ways by the different operators associated with each of the projects. Ownership changes were also involved; data relating to Husky Sikanni and Murphy Chicken Creek projects were obtained from files that had been transferred from the previous owners (Marathon and Murphy, respectively) to the current operators (Husky and CNRL, respectively).

The interviews also identified that the assembled costing information, as presented in Section 4.3, must be considered only as provisional. The costing data are useful in terms of providing a general overview, but a more detailed or forensic review would be required – which is beyond the scope of the current project – to undertake a comprehensive comparison of the costing associated with the four projects. The costing data contained in Section 4.3 should be considered as anecdotal, and should be used mainly to initiate discussions, or as a basis for further study of detailed construction costs.

4.2 Feedback from Interviews

The following key points were identified based upon the interviews. It is clear from the following observations made by individuals interviewed, that each project was faced with a unique set of constraints and operational restrictions. This mix of issues resulted in specific and unique impacts upon each project, a situation that contributes to the difficulty of making simple interpretations or generalized overall comparisons.

4.2.1 AMOCO Sidenius

- This project required 10 bridges including two major crossings of the Sikanni River (Anon 1997a, b). In order to offer direct comparisons, an attempt was made to isolate and remove bridge costs from this project's cost summary. This was done by reviewing the details of the construction report as well as obtaining a cost summary directly from the bridge supplier.
- This project employed heli-logging in an effort to gain time on the construction schedule. These costs are included in the summary.
- The project also required the opening of the existing trail from the highway to the project start (approximately 37km), including placement of a bridge over Chicken Creek. These costs (not including the bridge) are estimated a $50,155.00.
- Costs associated with retention of Environmental Monitors and a Gate Monitor are included in the cost summary for Amoco Sidenius (Section 4.3.1).

4.2.2 CNRL Sikanni

- The well site and access road were constructed mainly during January 28 to February 11, 2003. The rig started to drill but was then removed early, as time to complete the drilling was insufficient.
- Access (i.e., a snow road) was rebuilt in winter 2003/2004, so that drilling could then be completed.

- The construction of the well site and road was originally approved to Petro Canada in January 2000, however the original well was not drilled, and the authorizations were transferred, with new approval, to CNRL in 2003.

4.2.3 Husky Sikanni

- The hours of operation for construction was restricted from start up (November 22) along the existing trail to avoid any conflict with a Limited Entry Hunt (LEH) for bison in the region.
- One major constraint on the construction phase of the project was as a result of the following permit condition: “any works (freeze-down) to the existing trail including the recreational trail must occur during night hours (2000 hours to 0600 hours)”.
- A bridge was required to cross the Sikanni River. The installation of the bridge was subject to the same construction operating hours, and this resulted in a similar impact on costs. These “lost costs” are not directly quantifiable and are not included in the summary in Section 4.3.3, but they were considerable amounts given that equipment and personnel remained on standby each day, given the restricted period of work.
- The direct bridge cost was removed from the analysis (as best as could be determined) i.e., including related rentals, mob/demob and crane installation costs.
- Costs associated with the retention of a Gate Monitor are included in the cost summary (Section 4.3.3).

4.2.4 Murphy Chicken Creek

- This project did not require any bridges as the access was entirely made of snow.
- The AFE for b-94-B was designed in conjunction with well site c-76-B located an additional 2.2 km further up the valley.

4.3 Summary of Construction / Reclamation Costs

Sections 4.3.1 to 4.3.4 provide breakdown costs of construction, and where appropriate, reclamation, for the four well site projects. The breakdowns provided in each section are as follows:

a) Length of Access Trail
b) Original Estimate for Construction
c) Original and Final AFE for Total Project
d) Construction Costs
e) Reclamation Costs
f) Total Cost Construction and Reclamation

Section 4.3.5 rolls up the information in earlier sections to provide a summary comparison of the four projects. One means of comparing unit costs is to examine the wellsite and remote sump costs among projects, while another is to review access road construction cost, estimated on a per km basis (Table 7).

With respect to the information summarized in Sections 4.3.1 to 4.3.4, there are a few clarifications that should be noted:

- Where possible, items such as survey costs and environmental reporting costs were separated out, however this was not possible for all of the well sites.

- Total costs also include camp costs for construction. In all cases, remote sumps were utilized and where possible, itemized separately.

- An attempt to isolate well site costs from access costs and remote sump costs was made, however, it was not possible to make this separation for all projects.

- Environmental Monitor and Gate Security were required at Amoco Sidenius and Husky Sikanni and are included in the costing for these projects.

- Bridge costs were “removed” from the two projects that required them.

4.3.1 AMOCO Sidenius

a) Length of Access Trail:

Existing Trail	10.85
Reopened	6.54
New	20.14
Total	37.50

b) Original Estimate for Construction – December 5, 1997

Access	$ 974,910
Wellsite	$ 539,000
Total	$1,513,910

Notes:

- Included $20,000 for manned gate
- Four bridges and two piers
- Blasting at Wellsite
- Blasting at several points along Access

c) Original AFE for Total Project $ 7,183,000

Final AFE for Total Project $ 8,885,093

d) Construction Costs – Year 1 (1997/1998)

Construction		Cleanup	Total Year 1
Access Total	$1,825,716		
Less Existing Access	$ 50,155		
Less Bridges	$ 401,699		
Access	$1,373,862	$ 291,418	$1,665,280
	($36.64/m)	($7.77/m)	
Well site	$ 163,091	$ 7,870	$ 170,961
Remote Sump	$ 52,115	$ 35,178	$ 87,293
Subtotal	$1,589,068	$ 334,466	$1,923,534
Survey & Engineering /Studies	$ 169,450	$ 0	$ 169,450
Total	$1,758,518	$ 334,466	$2,092,984

Notes:

- Problems freezing in swamp areas
- Heli-Logging used to gain construction time
- Project included ten bridges (19 m, 25 m, 25 m and 25 m to cross Sikanni plus 6 other bridges 6 m to 9 m each)

- Access included winter improvements to an additional 37.5 km to start of project including a bridge over Chicken Creek from November 12-16, 1997, estimated cost $50,155
- Included clean up of fuel spill
- Bison/game fence around remote sump

Access Total Cost Year 1	$1,665,280 ($44.41/m)
Lease	$ 170,961
Sump	$ 87,293

e) Reclamation Costs (2001/2002)

	Construction	Reclamation	
Access Total	$435,555		
Less Bridges	$176,677		
Access	$258,878 ($6.90/m)	$307,410 ($8.20/m)	$566,288
Well site	0	$197,148	$197,148
Remote	0	$ 54,782	$ 54,782
Surface Acquisition	$ 38,526	0	$ 38,526
Total	$297,404	$559,340	$856,744

Access	($15.10/m)
Wellsite	$197,148
Remote	$ 54,782

f) Total Cost Construction and Reclamation

Access	$2,231,568	($59.51/m)
Well site	$ 368,109	
Remote	$ 142,075	
Survey/Engineering/Surface	$ 207, 979	
Total Project	$2,949,731	
	÷37.5 km	**= $78,659/km**

4.3.2 CNRL Sikanni

a) Length of Access Trail: 1.56 km

b) Original Estimate for Construction – ?? (2002)

Access	n/a
Well site	n/a
Total	n/a *

c) Original AFE Total Project $2,898,685

Final AFE Total Project $3,131,248

d) Construction Costs (Year 1) 2003 n/a

e) Reclamation Costs (Year) n/a

f) Total Cost Construction and Reclamation
n/a (~**$80,000**)*

* Mike Waberski investigated construction costs for the four projects but was unable to obtain specific details regarding CNRL's costing associated with the CNRL Sikanni project; however, based upon the information that was reviewed and the project team's general understanding of the issues and general costs associated with the construction aspects of the CNRL Sikanni, it is estimated that costs were in the range of approximately $80,000 per km, or about $125,000 for the entire (1.56 km) access road and well site.

4.3.3 Husky Sikanni

a) Length of Access Trail: 9.24 km

b) Original Estimate for Construction – October 5, 2001

Access Construction (3200m New, 6000m Existing) $323,000

Access Filter Fabric/Matting	$ 85,000
Access Snow Making	$ 47,500
Subtotal	$455,500
Bridge	$ 95,500
Well site/Sump	$ 95,500
Supervision	$ 25,500
Camp for Construction	$ 90,000
Total	$762,000

c) Original AFE for Total Project $5,831,000

Final AFE Total Project unknown

d) Construction Costs – Year 1 (2001,2002)

	Construction	Cleanup	Total Year 1
Access	$803,348 ($86.94/m)	$387,406 ($41.92/m)	$1,190,754
Well site	$ 95,500 (estimate)	$ 0	$ 95,500
Remote	$ 50,000 (estimate)	$ 33,873	$ 83,873
Survey	$ 32,000	$ 0	$ 32,000
Totals	$980,848	$421,279	$1,402,127

Cost Report March 27th	$2,190,500
Plus Sump Cleanup (June 10-15)	$ 33,873
Total per Cost Report	$2,224,373
Less Incorrect Coding	$ 634,356
Total Construction/Cleanup	$1,590,017
Less Bridge	$ 187,890
Total Cost (no bridge)	$1,402,127
Less Cleanup (Mar 17 – 27)	$ 387,406
Less Sump Cleanup (June 10 – 15)	$ 33,873
Less Sump (estimated)	$ 50,000
Less Well site (estimated)	$ 95,500
Less Survey	$ 32,000
Access Construction Cost	$ 803,348

Access Total Cost Year 1	$1,190,754 ($128.87/m)
Lease	$ 95,500
Remote Sump	$ 83,873

e) Reclamation Costs (not reclaimed to date)

Estimate (for Well Site and Access)

Winter	$1,797,385	(less bridge @$100,000)	= $1,697,385
Summer	$1,351,460	(less bridge @ $95,500)	= $1,155,960

Using Summer Estimate of $1,155,960

Estimate Well Site	$ 200,000	
Access	$ 955,960	($103/m +/-)

f) Total Cost Construction and Reclamation

Access	$2,146,714	($249/m)
Well Site (estimate)	$ 295,000	
Remote	$ 83,873	
Survey/Engineering	$ 32,000	
Total Project	$2,557,587	
	÷ 9.24 km	**= $276,795/km**

4.3.4 Murphy Chicken Creek

a) Length of Access Trail: 5.34 km

b) Original Estimate for Construction – August 29, 2000

Lease Licence, Survey	$ 400,000
Wellsite & Access	$ 500,000
Supervision	$ 40,000
Total	$ 940,000
Cleanup	$ 100,000
Total	$1,040,000

c) Original AFE for Total Project $4,913,000

Final AFE for Total Project $8,272,815

d) Construction Costs – Year 1 (2000/2001)

	Construction	Cleanup	Total Year 1
Access			
Wellsite			
Remote Sump			
Total	$2,214,271	$100,000 (est.)	$2,314,271

Total AFE cost for Construction August 30, 2001	$2,326,271
Less Conductor (estimate)	$ 12,000
	$2,314,271

e) Reclamation Costs

	Construction	Reclamation
Access	n/a	n/a
Well Site	n/a	n/a
Remote	n/a	n/a

f) Total Cost Construction and Reclamation

$2,314,271
÷ 5.34 km **= $433,384/km**

4.3.5 Comparison of the Four Projects

The summary comparison in Table 7 provides a means of considering all four projects in relation to one another. One means of comparing unit costs is to examine the wellsite and remote sump costs among projects, while another is to review access road construction cost, estimated on a per km basis (Table 7).

Table 7. Total Estimated Project Costs (Including Construction and Reclamation)

Well Site	Project Component	Estimated Costs	Access Road Length (km)	Cost Per Km
AMOCO Sidenius	Construction/Cleanup	$2,092,984		
	Reclamation	$ 856,744		
	Total	**$2,949,728**	37.5	**$78,659**
CNRL Sikanni	Construction/Cleanup	?		
	Reclamation	?		
	Total	?	1.56	**(?) $80,000***
Husky Sikanni	Construction/Cleanup	$1,402,127		
	Reclamation (estimate)	$1,155,960		
	Total	**$2,558,087**	9.24	**$276,849**
Murphy Chicken Creek	Construction/Cleanup	$2,314,271		
	Reclamation	n/a		
	Total	**$2,314,271**	5.34	**$433,384**

* Estimated; see Section 4.3.3 for further discussion.

The greatest cost was incurred by the Amoco Sidenius project ($2.9M), because of the construction and reclamation costs ($2.2M or over ¾ of the total cost (see Section 4.3.1)) of the long access road. At $1.2M, the Husky Sikanni project had the greatest reclamation costs.

In terms of the total (construction and reclamation) costs, expressed in relation to the total length of the access road, the rankings were – from greatest to least – Murphy Chicken Creek ($433K), Husky Sikanni ($276K, or 64% of the cost of Murphy Chicken Creek), CNRL Sikanni (~$80K, 18%), and Amoco Sidenius ($79K, 18%) (Table 7).

4.4 Access Road Profile Diagrams

A set of overall profile plans were assembled for each of the four projects. The profile plans provide additional characterization of the elevational variations that were associated with each of the four projects, in particular in relation to the construction challenges that were faced during installation of the access roads. Profile plan figures are included in Appendix A.

5.0 EXISTING GUIDELINES & BEST MANAGEMENT PRACTICES

5.1 General Overview

As part of the office-based exercises for the project, the following review was compiled of relevant guidelines, regulations and legislation that potentially apply to management of environmental aspects of oil and gas exploration and development within the Upper Sikanni Management Area. A summary listing was assembled of those guidelines, regulations and legislation that are related to the four projects, and to other projects of a similar nature that are carried out within the M-KMA (Table 8). Included in Table 8 are regulatory requirements that are identified at both the Federal and Provincial levels, and where applicable, for both BC and Alberta (for the sake of comparison).

Sections 5.1.1 to 5.1.4 provide further summaries and discussion of existing guidelines and best management practices that are most relevant to the M-KMA.

5.1.1 The Upper Sikanni Management Plan (1995)

The Upper Sikanni Management Plan (1995) (USMP) was developed to ensure that impacts to sensitive wildlife and habitats from resource development are minimised. The two main components of the USMP are:

- The categorization of broad habitats types, a description of the environmental values and sensitivities of each type and specific management strategies for each, and

- Operational Guidelines for works within the Upper Sikanni drainage.

With respect to wildlife, the USMP the Operational Guidelines provide specific considerations for the assessment of wildlife habitat for development plans occurring within the Upper Sikanni Management Area (USMA). The Habitat Impact Assessments require a certain level of detail to evaluate the impacts of a proposed activity or development.

Table 8. Guidelines, Regulations and Legislation Related to Environmental Management in Oil and Gas Development Areas within the Muskwa-Kechika Management Area

Government Body or Agency	Type	Title	Description
Federal Government	Legislation	Species at Risk Act (SARA)	Protects wildlife found on federal lands as well as their critical habitat. However, Federal government looking to provinces for joint protection on all lands.
	Legislation	Fisheries Act	Protects fisheries capability within waterbodies found in Canada.
	Legislation/ Regulation	Migratory Birds Convention Act and Regulation	Protect migratory birds from indiscriminate harvesting and destruction. Relates most to hunting and other uses of birds. Contravention of the act is not likely to occur.
BC Provincial Government	Guideline	Fish-stream Crossing Guidebook (Forest Practices Code of B.C.)	Designed to help forest and other resource managers and practitioners plan, prescribe, and implement sound forest practices for fish-stream crossings that comply with both the Forest Practices Code and the federal *Fisheries Act*.
	Legislation	Wildlife Act	Prohibits damage/destruction to wildlife. Relevant portions state that it is illegal to: damage beaver dams; capture an animal without license; feed dangerous wildlife; destroy a bird's egg or the nest of an eagle, peregrine falcon or gyrfalcon.
	Legislation	Muskwa-Kechika Management Area Act	"*… to maintain in perpetuity the wilderness quality, and the diversity and abundance of wildlife and the ecosystems on which it depends while allowing resource development and use……. including ……. oil and gas exploration and development*."
	Regulation	Muskwa-Kechika Management Plan	Based upon the MKMA Act
	Guidelines / Regulations	Pre-tenure Plans for Oil and Gas Development in the Muskwa-Kechika Management Area	Designed to encourage and guide environmentally-responsible development of oil and gas resources by providing results-orientated management direction that ensures oil and gas activities are consistent with the M-KMA Act.

Government Body or Agency	Type	Title	Description
	Regulation	Upper Sikanni Management Plan	Developed to ensure that impacts to sensitive wildlife and habitat from oil and gas exploration and resource developments are minimized within the Upper Sikanni drainage.
BC Oil and Gas Commission (OGC)	Guideline	Oil and Gas Commission Planning and Construction Guide – for Oil and Gas Operations in British Columbia	Describes typical maximum disturbance allowances fro the development of wellsites, access routes, right of way for pipelines, and other associated project requirements.
	Regulation	Fish and Wildlife Timing Windows	Fish and wildlife timing windows for O&G operations designed to reduce the impacts of disturbances on fish and wildlife species during sensitive lifecycle stages.
	Guideline	Stream Crossing Planning Guide (Northeast B.C.)	Guide to assist planning for, installing, removing or deactivating access and/or pipeline crossings on watercourses in order to protect fish and fish habitat values and maintain the functionality of aquatic and riparian ecosystems.
	Guideline	Caribou Management Guidelines	Currently under development. Likely to be released in the near future.

As required by the USMP (MELP and MEMPR 1995), all assessments methodology and reporting must meet government and professional requirement standards and are expected to address the following issues:

1. An analysis of site and access selection and construction procedures, with options;

2. Baseline environmental conditions including the current status, habitat use, behaviors of wildlife and plant communities with a specific focus on blue and red listed species, direct and indirect impacts of the project on species, and coordination measures that could reduce/eliminate adverse impacts to species;

3. Impact mitigation options and plans to mitigate impacts;

4. Monitoring and reporting plans;

5. Results of public consultation programs and details of any future programs; and,

6. Plans for reclamation of all disturbed areas with the primary objective of returning the site to wildlife capability as close as possible to previous levels prior to disturbance.

It some cases, it may be necessary to conduct an environmental baseline analysis to determine site-specific sensitivities and to aid in mitigation planning. This assessment should include studies on wetlands and riparian resources, critical wintering habitat, impacts on alpine habitat and fisheries, and direct impacts on specific wildlife species. Critical lambing and calving grounds and critical rutting will be verified by proponent-funded assessments/inventories

Specific guidelines covered in the USMP include:

- Topsoil Salvaging
- Flight Patterns/Distances
- Timing/Seasonal Restrictions
- Fisheries
- Water and Water Crossings

- Geophysical Operations Roads
- Exploratory Wells/Drilling/Well Pads
- Pipelines
- Waste
- Facilities/Power Lines
- Personnel and Camp Management

5.1.2 OGC Planning and Construction Guide – for Oil and Gas Operations in British Columbia

The Planning and Construction Guide is a tool to provide guidelines for oil and gas construction contractors and service firms conducting business in British Columbia (OGC n.d.). The purpose of the Planning and Construction Guide is to describe preferred maximum disturbance allowances for the development of:

- Well sites;
- Access routes;
- Right of ways for pipelines; and,
- Other associated project requirements such as remote sumps, decking sites, camp sites and borrow pits.

The Planning and Construction Guide provides recommendations regarding:

- Planning strategies and application preparation;
- Size and spacing of new disturbance; and,
- Construction techniques.

5.1.3 OGC Fish and Wildlife Timing Windows

As a means of providing guidance for oil and gas operations in regards to minimizing impacts on wildlife and fish, the OGC released a document in 2003 entitled the “Fish and Wildlife Timing Windows for Oil and Gas Exploration and Development in Northeast British Columbia” (OGC 2003).

These timing windows are in place to help reduce impacts to fish and wildlife during sensitive lifecycle stages. For species considered being ecosystem indicators, of special management concern and more susceptible to disturbance, various levels of timing restrictions throughout the year are provided.

In certain instances, mitigation measures would be required, particularly if an application was made that requested a variance in an identified timing window. In such cases, a mitigation plan explaining potential adverse impacts to wildlife would be minimized would need to accompany the application (OGC 2003).

5.1.4 OGC Stream Crossings

The Oil and Gas Commission (OGC) provides regulatory review and approval for petroleum roads (including design and layout of roads, which includes stream crossing) under the *Petroleum and Natural Gas Act*. However, petroleum road construction, maintenance and deactivation are subject to the *Forest Practice Code of British Columbia Act* under the provisions of the Forest Road Regulations.

The *Forest Practice Code of British Columbia Act* also covers fish – stream crossing, which includes the design, construction, maintenance, and deactivation of stream crossings on forest roads. Federally, any potentially fish bearing watercourses are subject to the Federal *Fisheries Act* under the following sections:

- Obstruction to fish migration (refer to section 22 and 26);
- Destruction of fish or fish habitat (refer to section 32);
- Harmful alteration, disruption, or destruction (HADD) to fish or fish habitat (refer to section 35) unless authorized; and,
- Depositing of substances deleterious to fish in waters frequented by fish (refer to section 36).

Within the OGC application area, any watercourses can be assessed using a "Fish Stream Identification Risk Management Flow Chart" and stream crossing construction methodology can be determined by using the OGC "Stream Crossing Matrix – Summer Construction" and "Stream Crossing Matrix – Winter Construction". The construction methodology (summer or winter) is determined by the field assessment and classification of the stream (i.e. fish bearing or non-fish bearing), and the stream width rating which is classified as follows:

- S1 (>20 m),
- S2 (>5 < 20),
- S3 (1.5 – 5 m),

- S4 (< 1.5 m),
- S5 (no fish > 3 m), and
- S6 (no fish < 3 m)

5.2 Geotechnical Factors

In general, the intent of present OGC practices appears to provide some direction to guide well site access road construction. Many stability and erosion issues could be overcome if OGC guidelines were carefully followed, backed-up with recognized best industry practices and retaining qualified professionals for drainage prescriptions and specialized techniques for construction on sensitive terrain.

The incidence of terrain stability, erosion and drainage issues may possibly reflect inadequate enforcement or insufficient will to follow OGC or other suitable guidelines.

The four well sites are compared in relation to their compliance with established environmental guidelines as laid out in the Upper Sikanni Management Plan, (USMP; MELP and MEMPR 1995) as well as the OGC Planning and Construction Guide, (P & C) undated. Requirements extracted from the USMP and P & C are summarized in the left columns of Table 9. Conformance of the historical practices at the four well sites and related access roads with these requirements was determined from field observation and are summarized in Table 9.

There are also best management practices in the OGC Stream Crossing Planning Guide for Northeast BC, Version 1.0, dated March 26, 2004. These practices relate to snowfill crossings, ice bridges, and removable clearspan bridges. The construction and remediation of these structures obviously cannot be evaluated once they have been decommissioned. These practices are therefore not included in the following table. The OGC Stream Crossing Planning Guide does refer to culverts for stream crossings and requires that they be removed immediately from access roads.

Table 9. Comparison of the Four Projects in Relation to Their Meeting Environmental Guidelines Established in the Upper Sikanni Management Plan (MELP and MEMPR 1995) and the OGC Planning and Construction Guide.

Ratings
○ - Yes
● - No
N/A – does not apply

			Amoco Sidenius	**CNRL Sikanni**	**Husky Sikanni**	**Murphy Chicken Creek**
Upper Sikanni Management Plan Guidelines						
Topsoil Salvaging	Topsoil Stockpiling	well site	N/A	●	○	N/A
		access	○●[1]	N/A	○N/A	N/A
	Large woody debris stockpiling	well site	N/A	●	○	N/A
		access	●○[1]	N/A	○	N/A
Water Crossings	Snowfill of smaller creeks may be accepted	well site	N/A	N/A	N/A	N/A
		access	N/A	N/A	N/A	N/A
	No development within 500 m of Sikanni Chief River (roads will be permitted but should be avoided if possible)	well site	○	N/A	N/A	N/A
		access	●	N/A	N/A	N/A
Roads	Winter access only for exploratory wells	access	○	○	○	○
	All significant stream crossings by removable clear span bridges	access	○	N/A[2]	○	N/A[2]
	Long lines of sight avoided.	access	●	●	●	●
	Steep cutslopes serrated, roughened or benched	access	●	N/A	●	N/A
Exploratory wells/ Drilling / Well Pads	Remote monitoring of well sites (no permanent access).	well site	N/A	○	N/A	N/A
	Use geotextile matting	well site	N/A	●	○	○
	Wellsites to be located to minimize cut and fill slopes	well site	○	●	●	N/A
	Perimeter diversion channels	well site	N/A	○	○	N/A
	Areas on pads with successful wells not required for production to be reclaimed	well site	N/A	●	N/A	N/A
Reclamation – subsequent to abandonment of road, wellsite.	Cuts recontoured	access	○●[1]	N/A	○●[1]	N/A
		well site	○	N/A	●	N/A
	Spread previously stockpiled topsoil	access	N/A	N/A	N/A	N/A
		well site	N/A	N/A	N/A	N/A
	Seed after spreading topsoil	access	N/A	N/A	N/A	N/A
		well site	N/A	N/A	N/A	N/A
	Construct cross ditches/waterbars	access	○	N/A	○	N/A
		well site	N/A	N/A	N/A	N/A
	Implement erosion control measures as required.	access	○●[1]	N/A	○	N/A
		well site	○	N/A	○	N/A
Bridges	Remove all structures	access	○	N/A	○	N/A
	Recontour/restore banks	access	N/A	N/A	N/A	N/A
	Remove all culverts	access	○	●	●	N/A

Ratings ○ - Yes ● - No N/A – does not apply			**Amoco Sidenius**	**CNRL Sikanni**	**Husky Sikanni**	**Murphy Chicken Creek**
OGC Planning and Construction Guide						
Roads	Use existing seismic lines where possible	access	○	○	N/A	○
Roads/Well sites	Where gradient is 60% and/or there is potential for slope instability a Terrain Stability Field Assessment is required.	well site	N/A	N/A	N/A	N/A
		access	N/A	N/A	N/A	N/A

Notes:

1 – portions of the road were recontoured and decommissioned, others were not, therefore a dual symbol is used.

2 – no significant streams along access therefore does not apply.

The N/A designation in Table 9 was applied to elements where the requirement does not apply, for example, the CNRL Sikanni site has an active well, therefore most of the reclamation requirements do not apply.

The N/A designation in Table 9 was also applied to situations where it could not be determined whether or not the requirement had been implemented or where the particular feature was not present. For example, the well site at Murphy Chicken Creek was revegetated at the time of the site reconnaissance, preserving the existing vegetation by covering the pre-existing ground with geotextile prior to fill placement, therefore, N/A is indicated in the 'Topsoil Stockpiling' row of the table for this well.

6.0 EFFECTS ASSESSMENT MATRICES & SITE ASSESSMENT TOOL

6.1 Background

Observations obtained from the field work, as well as the findings of post-field activities were assembled in order to develop three effects assessment matrices that relate to environmental, geotechnical and project-related constraints associated with the four projects (Section 6.2). These matrix based summaries represent a first step towards the development of a first approximation site assessment tool (Section 6.3) that will be suitable for longer-term monitoring (Section 6.4).

Due to various project constraints, such as the time and budget available to complete the field survey, the diversity of site and environmental conditions represented among the four projects, and other variables / issues such as regulatory and construction constraints, it was not possible to formally populate a ratings system and derive a site assessment tool as had been envisioned at the outset of the project. As a result, the current assessment of effects and impacts is relatively subjective and based mainly upon professional judgement – there was not the time in the field or the baseline information in place to base evaluations upon quantitative bases. Future assessments need to take the requirements for quantitative measurements into consideration so that appropriate field survey design is devised. This is particularly true when a program is established that requires re-measurements that will assist in the determination of directions and rates of recovery. Adaptive management principles are also clear in that they require a strong quantitative basis upon which to determine how course corrections and adjustments can be best implemented and incorporated into long-term objectives.

Based upon the initial foundation of the 2004/2005 observations and scoping activities, however, a conceptual framework can now be identified as a suitable basis for development / population of a data-based quantitative approach. Once implemented, it will serve as a baseline against which longer-term measurements can be assessed.

Figure 11 provides a conceptual outline of the approach taken to derive initial environmental effects matrices for the four projects that were examined.

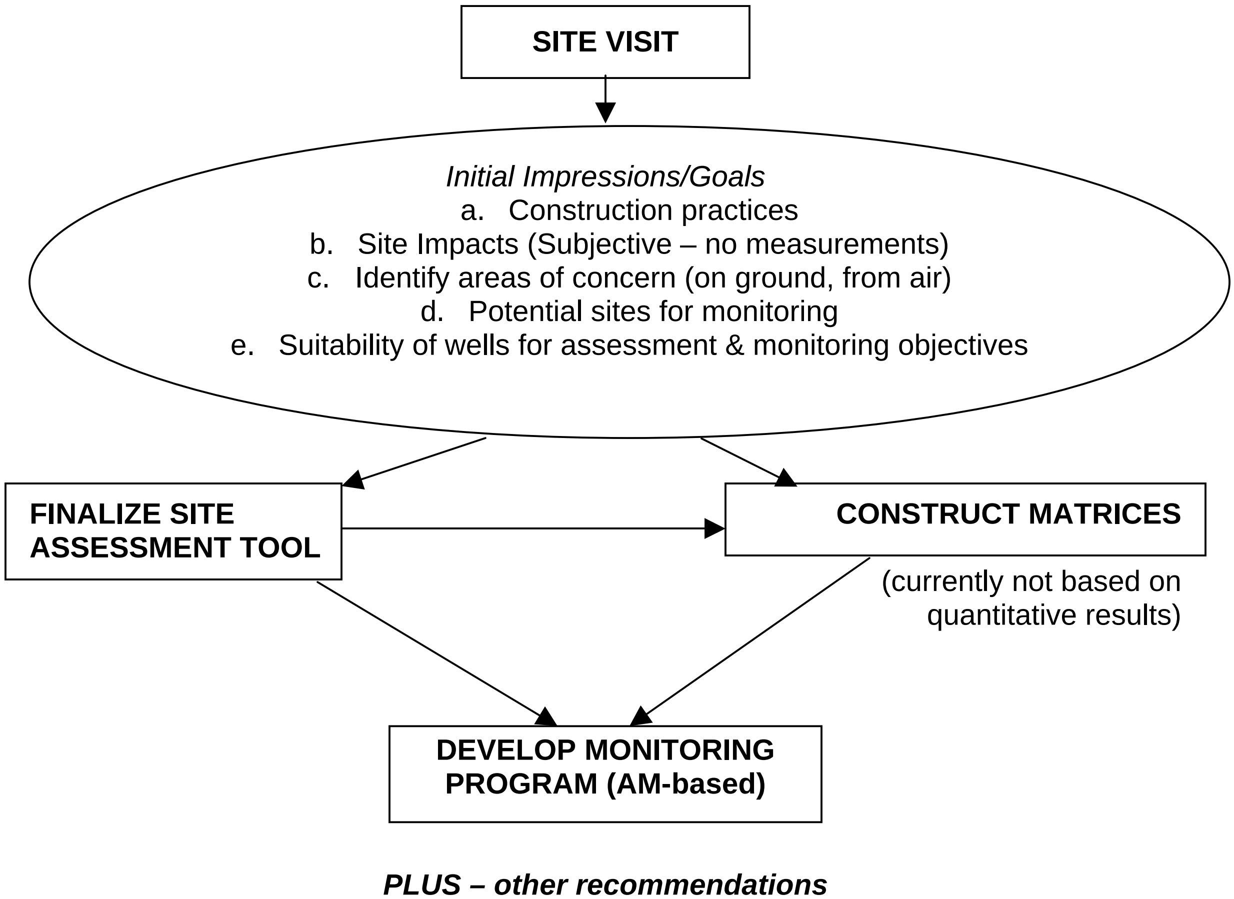


Figure 11. Derivation of Preliminary Effects Assessment Matrices as a Basis for Development of a Longer-Term Site Assessment Tool

6.2 Assembly of Preliminary Effects Assessment Matrices

6.2.1 Approach

A simple methodology is adapted here to provide an overall assessment of the "environmental suitability" of construction and reclamation practices associated with the four projects. This is important as a basis for guiding the adoption of suitable guidelines and best management practices, and to determine "which parts" of each project may have had an overall positive effect in terms of minimizing longer-term environmental effects.

Observations obtained from the field work, as well as the findings of post-field activities were assembled in order to develop three effects assessment matrices that relate to environmental (Section 6.2.2), geotechnical (6.2.3) and project-related (6.2.4) constraints associated with the four projects.

The matrices are assembled based upon expert opinion / qualitative interpretation of the projects. As such, they are useful for general interpretations only. More quantitative bases would provide more objective means of undertaking this assessment but would require a considerable and perhaps inordinate effort in terms of additional field investigations. For example, a more data-based biophysical assessment would need to include data elements such as the following:

- Scalar measurements of plant species diversity, cover and structure;
- Vegetation health/vigour;
- The determination of the percentage occurrence within unit areas of invasive or non-native species;
- Similar area-based measures of the abundance of coarse woody debris; and,
- Specific measures of wildlife habitat usage within different ecosystem units, both undisturbed and as affected by the projects.

The matrices outlined in Sections 6.2.2 to 6.2.4 provide a proactive approach to evaluating, in a simple manner, currently-applied construction methodologies for well site and access road construction and reclamation. The objective of the matrices is to document and provide a basis for making some preliminary recommendations, with the recognition that environmental effects are the result of variable issues – for example, pertaining to road stability / geotechnical issues, the selection of the route and incorporation of construction costing and operational constraints, and wildlife, vegetation and aquatic/riparian concerns.

6.2.2 Environmental Effects Matrix

Table 10 summarizes key environmental effects (in relation to wildlife habitat, vegetation and hydrological / aquatic) that were identified and discussed, in particular in Sections 3 and 4 of this document, in relation to the four projects. Table 10 also rates the overall acceptability of access road and well site construction (in terms of a 3-class general qualitative rating of poor, acceptable or good) for the four projects in relation to each of the identified environmental effects.

Table 10. Environmental Effects in Relation to Access Road and Well Site Construction and Reclamation for the Four M-KMA Well Site Projects.

Ratings ○ - **Good** ● - **Acceptable** 🔴 - **Poor**		**Amoco Sidenius**	**CNRL Sikanni**	**Husky Sikanni**	**Murphy Chicken Creek**
Wildlife Habitat					
Wildlife Movement & Behaviour		●○	●○	●○	●○
Access Management, i.e., use of existing ROW		●	●	●	●
Presence of Critical Wildlife Habitat / Sensitive Ecosystems		🔴○	🔴○	●○	🔴
Line of Sight / Route Selection		●	🔴●	●	●
Vegetation					
Revegetation / Reclamation Success (e.g., vegetation cover)	well site	●	N/A[1]	N/A[1]	○
	Road	●	N/A[1]	N/A[1]	●○
Presence of Non-native Species[2]	well site	●	●	●	○
	Road	●	●	●	○
Extent of Ground Surface Disturbance		●	🔴	●	●○
Hydrologic / Aquatic					
Extent of Construction in Wetlands (e.g., avoidance, and/or measures to control alterations in water level due to effects on vegetation and substrate)	well site	○	🔴	●	○
	Road	🔴○	🔴	○	🔴○[3]
Construction in Riparian	well site	○	○	🔴●	○

Ratings ○ - **Good** ● - **Acceptable** 🔴 - **Poor**		**Amoco Sidenius**	**CNRL Sikanni**	**Husky Sikanni**	**Murphy Chicken Creek**
Areas	Road	🔴●	○	🔴●	🔴
Stream Crossings (e.g., erosion damage to stream bank)		🔴○	○	●	🔴○
Effective use of Culverts / Drainage Ditches, etc.		🔴○	🔴	○	N/A
Maintenance of Local Hydrology		🔴●	🔴	○	🔴○[3]
Management of In-stream Habitats		🔴●	○	●○	●○

Notes:
1 – well site and road not yet decommissioned.
2 – would need to conduct vegetation survey at appropriate time of year to confirm / document.
3 – cut line portion of access road exhibits notable changes in wetland hydrology

Based on the summary in Table 10, and recognizing that this is a highly simplified overall ranking of complex projects, the following are noted:

- All four projects exhibited some weaknesses in terms of addressing effectively the range of environmental effects listed;
- A higher number of "poor" ratings were applied to the Amoco Sidenius and CNRL Sikanni projects, 6 and 7, respectively, as compared to the Husky Sikanni and Murphy Chicken Creek projects which had 2 and 4, respectively;
- A similar pattern was exhibited by the distribution of "acceptable" ratings; and,
- In terms of overall suitability, the highest overall rating was associated with the Husky Sikanni project, followed by the Murphy Chicken Creek project.

6.2.3 Geotechnical Effects Matrix

In the same manner as outlined above, Table 11 identifies those geotechnical conditions / effects that were observed / encountered in the field, in relation to access road and well site construction and reclamation.

Overall acceptability of construction / reclamation activities applied in the four projects is also ranked in Table 11 for the geotechnical effects identified, using the same 3-class system as used in Table 10 for environmental constraints.

Table 11. Geotechnical Effects in Relation to Access Road and Well Site Construction and Reclamation for the Four M-KMA Well Site Projects.

Ratings
○ - Good
●- Acceptable
🔴- Poor

		AMOCO Sidenius	**CNRL Sikanni**	**Husky Sikanni**	**Murphy Chicken Creek**
Slope stability	well site	N/A[1]	🔴	○	○
	Road	●	●	○	○
Fill slope construction	well site	N/A[1]	🔴	○	N/A[2]
	Road	●	N/A[2]	○	N/A[2]
Drainage	well site	N/A[1]	🔴	○	○
	Road	🔴○	🔴	○	○
Ditches and culverts	well site	N/A[1]	🔴	○	N/A[2]
	Road	🔴○	N/A[2]	○	N/A[2]
Stream crossings	well site	N/A	N/A	N/A	N/A
	Road	○	N/A[2]	N/A	○
Route selection	well site	○	🔴	○	○
	Road	●	●	○	○
Revegetation success	well site	○	N/A	N/A	N/A[2]
	Road	🔴○	N/A[2]	○/ N/A[2]	N/A[2]
Rutting and disturbance of sensitive soils in fens / wetlands by ATVs, bison and horses.	well site	N/A[1]	None	None	None
	Road	🔴	None	None	None
Visual quality objective	well site	○	🔴	○	○
	road	○	●	○	○

Notes:
1 – well site recontoured.
2 – winter road construction, no cut, fill or culverts, surface vegetation left in place.

A few notes / clarifications regarding Table 11 are in order:

- Techniques of road reclamation cannot be meaningfully commented upon for Amoco Sidenius and Husky Sikanni, since these roads did not appear to have been reclaimed (with the exception of a short section leading to the Amoco Sidenius well site, and some low impact road sections of the Husky Sikanni project which will not require reclamation).

- CNRL Sikanni has an active well so discussion of reclamation does not apply. Although reclamation of unused areas of successful well sites is part of the recommended practice, this reclamation work has not been carried out yet for the CNRL Sikanni project.

- At Murphy Chicken Creek, the well site and access reclamation were completed at some point prior to our October 2004 field visit. It is difficult to comment on the methods used, but reclamation at the Chicken Creek road was observed to have been effective.

There are some key overall deficiencies identified within Table 11 that should be highlighted further:

- Long lines of sight on access roads are common to all four sites. Recommendations for use of seismic lines are also in effect, which contradicts the recommendation to avoid long site lines.

- Serration, benching or roughening of cut slopes to limit erosion was not observed in unreclaimed road cuts.

- It appears possible that the CNRL Sikanni and Husky Sikanni well sites could have been better located to reduce fill and cut slopes. This is particularly significant in the case of CNRL Sikanni, although the natural slopes that existed prior to well site levelling were unlikely to have triggered a terrain assessment. It is also possible that any site reconnaissance work would not have indicated the significant groundwater seepage problems that were exposed during earthwork construction.

- Reclamation has been the most successful in the Murphy Chicken Creek project. However, with respect to the Murphy Chicken Creek site, the methods of reclamation in Table 11 cannot be commented upon in detail, as the reclamation was essentially complete at the time of the site reconnaissance. There was no apparent disturbance of ground cover along the access road or at the Murphy Chicken Creek well site, which either indicates that construction methods did not include removal of surface vegetation or that recontouring and revegetation have obscured any visual evidence of earthwork.

Based on the summary in Table 11, and recognizing that this is a highly simplified overall ranking of complex projects, the following is noted:

- In terms of effectively addressing the range of geotechnical effects listed in Table 11, there was a clear division between the Amoco Sidenius and CNRL Sikanni projects, for which a number of “poor” ratings were identified, and the Husky Sikanni and Murphy Chicken Creek projects, neither or which had any “poor” ratings;

6.2.4 Project (Construction and Reclamation) Effects Matrix

Table 12 identifies a few key project-related effects that also need to be considered, as they have an effect on the overall ability of a contractor or proponent to execute a project effectively. There are likely to be, in addition to those effects identified in Table 12, others that will arise in relation to other projects that are undertaken. Those effects included in Table 12 are preliminary and are rated provisionally based upon information that was gathered and reported, mainly in Section 4 of this report.

Table 12. Project (Construction and Reclamation) Effects in Relation to Access Road and Well Site Construction and Reclamation for the Four M-KMA Well Site Projects.

Ratings ○ - **Good** ● - **Acceptable** 🔴 - **Poor**		**AMOCO Sidenius**	**CNRL Sikanni**	**Husky Sikanni**	**Murphy Chicken Creek**
Time Window for Construction / Reclamation		🔴	●	●	○
Timeliness of Reclamation following Construction		🔴●[1]	🔴●[1]	N/A[2]	N/A[2]
Estimated Cost Per Kilometer		○	○	🔴	🔴
Difficulty of Access in Reln to Route selection		🔴	●	○	●
Total Cost of Construction	well site	●	●	🔴	🔴
	Road	●	●	🔴	🔴
Total Cost of Reclamation	well site	🔴●[1]	🔴●[1]	N/A[2]	N/A[2]
	Road	●	●	N/A[2]	N/A[2]

Notes:
1 – As described in Section 3, portions of the project were assessed as being “poor”, while portions were “acceptable”
2 – N/A – reclamation not completed at Husky Sikanni and Murphy Chicken Creek

Based on the summary in Table 12, and recognizing that this is a highly simplified overall ranking of complex projects, the following is noted:

- All four projects faced difficulties with respect to logistics and the costing out of construction and reclamation activities. Compressed or restricted timing windows, and objectives that focused upon achieving “low impact” results forced the cost of construction for projects, and for the Murphy Chicken Creek project in particular, to very high (perhaps prohibitive from an industrial perspective) levels.
- The length of the access road and the difficulty of the terrain through which it must be installed and maintained is a key factor in terms of determining the overall constraints on timing and costing that will come into play for both construction and reclamation;
- In terms of construction costs and timing constraints, there is no clear “winner” for the four projects – all were ranked as “poor” in at least two of the six categories.

6.2.5 Discussion

There are confounding / complicating aspects in terms of evaluating the “levels of impacts or effects” from an environmental / geotechnical perspective in particular. There is considerable variability among the methods employed in each of the four projects and this makes the evaluation of overall levels of impacts somewhat problematic. These confounding / complicating aspects include the following:

- Some roads are used in other seasons than winter, for example, those that are accessed in summer.

- Some roads have had motor vehicle access, particularly in the past, while others have restricted to non-motorized. With respect to the latter, backpackers/outfitters can contribute to continued signs of use / wear and tear.

- Effects of wildlife in some areas are considerable, and separation of wildlife effects versus the effects of horses from backpackers/outfitters is sometimes very difficult to determine.

- One place where distinctions can be made between motorized / non-motorized is along the Amoco Sidenius access road, where it is possible to compare the N and S side of the river (the S side has had no ongoing / continuing vehicle access).

- Restoration vs. revegetation is a significant distinction – e.g. not putting contours or surface soil materials back in place. In general, restoration should be moved ahead more quickly but this is confounded by the issue of closed-down versus active roads, the latter where well heads are installed and there is the possibility of the road being reactivated or used in future.

- Water diversion techniques – diversion trenches sometimes evidence over time that there has been subsurface water movement which can undercut and erode beneath the channel, can be resolved with better geotechnical approaches and better consideration of slopes / subsurface materials / water movements at peak flows, etc.

- Distinguishing between the impacts associated with the various construction techniques at each location is difficult due to the variety in ecosystems encompassing each project. In addition, each project is at a different stage in its operations (e.g., active, capped but not reclaimed, decommissioned).

6.3 Site Assessment Tool

EBA Waberski Darrow devised a preliminary weighting system to be applied to the various criteria that were introduced in Section 6.2 (see Table 13). The weighting / ranking approach is intended to apply additional significance / scoring to those criteria that are greater contributors to environmental "success" for a given project. In this way, the cost/benefits of the construction techniques and other aspects are placed in a better balance. As well, the scores obtained from the matrices are then better interpreted in relation to the more cost-effective and successful techniques that can be employed to manage oil and gas operations and site reclamation within the M-KMA.

The system, as outlined in Table 13, involves the application of component scores and then integrated scores to arrive at overall scores for each effect rated. The intent is that the ranking would be applied to individual effects such as those currently identified as rated variables within Tables 10 to 12.

However, it was not possible to finalize or to apply the site assessment tool at this point. The qualitative assessment results obtained to this point in the investigation are not considered to be rigorous enough such that a refined weighting tool can currently be applied. The next appropriate step will be to assemble more quantitatively-based baseline data, particularly quantitative environmental data, upon which to base this preliminary site assessment tool, and as a basis for more precisely determining trends over the longer term (i.e., long-term monitoring).

Table 13. A Preliminary Ranking System for the Site Assessment Tool for the Four M-KMA Well Site Projects.

Component Rankings

Magnitude

Rating	Code	Category	Description
0	N	Nil	No effect or very temporary
1	L	Low	
2	M	Moderate	
3	H	High	

Duration

Rating	Code	Category	Description
1	S	Short	Less than 1 year or duration of operation
2	L	Long	Over 1 year or beyond duration of operation

Scope

Rating	Code	Category	Description
1	L	Local	Confined to well site and adjacent.
2	R	Regional	Beyond the well site to valley and beyond

Integrated Ratings (#1)

Rating	Code	Magnitude	Duration	Scope
0	N	Nil	-	-
1	LSL	Low	Short	Local
2	LSR	Low	Short	Regional
3	LLL	Low	Long	Local
4	LLR	Low	Long	Regional
5	MSL	Moderate	Short	Local
6	MSR	Moderate	Short	Regional
7	MLL	Moderate	Long	Local
8	MLR	Moderate	Long	Regional
9	HSL	High	Short	Local
10	HSR	High	Short	Regional
11	HLL	High	Long	Local
12	HLR	High	Long	Regional

Integrated Ratings (#2)

Rating	Code	Magnitude	Duration	Scope
0	N	Nil	-	-
1	LSL	Low	Short	Local

Assumptions:

-- Effects are weighted more strongly in relation to Duration than Magnitude.

-- For Short Duration, Local and Regional Duration are assumed to be similar.

-- Regional Scope is Weighted as more important for Long Duration.

2	LSR	Low	Short	Regional
3	MSL	Moderate	Short	Local
4	MSR	Moderate	Short	Regional
5	HSL	High	Short	Local
6	HSR	High	Short	Regional
7	LLL	Low	Long	Local
8	MLL	Moderate	Long	Local
9	HLL	High	Long	Local
10	LLR	Low	Long	Regional
11	MLR	Moderate	Long	Regional
12	HLR	High	Long	Regional

At a later date, finalization of a site assessment tool and the protocols for long-term monitoring for the Upper Sikanni area will need to adhere to an Adaptive Management approach (as identified in the M-KMA Pre-Tenure Plan, May 2004). As such, the site assessment tool and monitoring protocols will need to consider both impacted and control areas in and around each well site and at key locations along the access roads for each project. By comparing control conditions relative to the various construction treatments, management prescriptions can be better formulated for future development.

When completed, the site assessment tool will address the following:

- Reporting will involve summarizing and analyzing the field data and include the rankings of the treatments and a discussion of the results.

- Assessing the accuracy of impact predictions will involve comparing predictions in previous environmental assessments performed prior to construction and comparing them to current conditions. Because sampling designs employed within the various sites will be different, only a qualitative assessment can be undertaken.

- Within the site assessment protocol and field study design described previously, this deficiency will be addressed so that impact predictions can be quantitatively and statistically analyzed. Incorporating adaptive management-based principles into long-term monitoring would require that a rigorous protocol be established.

6.4 Long Term Monitoring Program

6.4.1 General Context

Due to various logistical constraints (e.g., timing of field surveys outside of growing season, timing and budget for initial reconnaissance work, and the need to undertake and complete an initial stratification of the four projects from environmental, geotechnical and construction/reclamation perspectives), EBA Waberski Darrow determined that initiating the monitoring program during the fall of 2004 was not appropriate. Since we were unable to establish baseline data/implement the monitoring program during last year's field visit, EBA Waberski Darrow modified their approach so that the field survey was used to steer the development of tools used for assessing and monitoring overall effects as opposed to collecting quantitative data.

Section 6.4 focuses on recommendations for next steps and long-term monitoring. The field and post-field activities of the current investigation provide a basis for the consideration of how adaptive management-based principles, and results-based management can be applied in future.

The following are suitable next steps:

1. Continue to review site biophysical and geomorphologic characteristics using previous reports and surveys and through discussions with MSRM staff and local oil and gas operators, and use this as a basis for designing a more rigorous data gathering exercise in 2005;
2. Continue to compile and review applicable best practice criteria for undertaking construction and reclamation activities in similar regions;
3. Continue to refine the project-specific "effects assessment matrices" and site assessment tool, to develop a refined rating system that addresses a wide range of well site and access road projects within the M-KMA; and
4. Establish long-term monitoring, using the matrices, the site assessment tool and baseline data collected at a set of identified monitoring locations.

6.4.2

Long-term monitoring is essential to track rates of recovery and overall persistence of key environmental conditions that are associated with well site and access road projects. As such, conditions at environmentally impacted locations are compared to control conditions immediately outside the development area. Site impacts are then assessed relative to control conditions and compared across the treatments (i.e., construction methods *within and* between the various well sites).

Potential components of the long-term monitoring program and site assessment include:

- Use of photo-monitoring approach (including higher quality and more precisely-positioned airborne video than was obtained during the October 2004 field surveys);
- Establishment of permanent plots, and completion of follow-up field visits; and
- Application of the effects matrices ratings, weightings from the site assessment tool, and – over time – characterization of the changes that are occurring.

The following components are also identified as useful and important for the refinement and further development of a suitable longer-term monitoring program:

- Roll up vertical assessment of the techniques that were used in the four sites, how they differ and what the issues were;
- Report on "overall status" regarding environmental impacts associated with the four well site projects;
- Specifically address constraints and issues associated with slopes and road grades, for example, how slope and road grade factors are to be handled, and how stratifiers, constraints, thresholds are identified and dealt with in relation to slope issues;
- Linkages to cross-link the results and monitoring plan to M-KMA Performance Based Criteria;
- Regional implications of the results and evaluation, and consider how future projects might be influenced by regional considerations, i.e., what the environmental and geographic limits of potential application may be;
- Future adjustments to the system, for example, perhaps a more complex evaluation tool once a greater number of parameters are better known in terms of their longer-term;
- How adaptive management might be addressed as a concept over time, i/.e, a mechanism to revisit approaches and implement any experience-based enhancements; and,
- Consider, as part of the assessment and monitoring component, what the logical next steps are regarding the future evaluation of new well sites that are established, and how this can logically lead to the development, iterative improvement and general widespread acceptance of "Well Site Construction Best Management Practices".

6.4.3 Locations for Long-Term Monitoring

One objective of the reconnaissance program undertaken in October 2004 was to identify suitable locations associated with each of the four projects that could be established and used over time for monitoring of environmental recovery and change. As the field work was conducted, sites that represented the range of environmental issues encountered were identified and GPS-positioned. Several of the candidate locations are illustrated in Figures 3 to 10 within this report.

Table 14 identifies a total of 24 locations that would be suitable candidates for long-term monitoring. Of the 24 locations, 17 are located within the Amoco Sidenius project, and the remainder are associated among the other 3 projects. As indicated in the summary descriptions and other comments / notes sections of Table 14, all of the locations are established to represent various identified effects (and including both positive and negative environmental aspects of the projects). It is recommended that all of these locations now be worked up in a quantitative manner, and with precisely positioned photo-documentation work, so that they may be used as a key part of a long-term monitoring program for the four M-KMA well site projects.

Table 14. Selected Locations for the Establishment of a Long-Term Monitoring System for the Four M-KMA Well Site Projects.

Well Site Project	Site #	Location (Lat / Long)	Summary Description	Other Comments / Notes	Fig #[1]
Amoco Sidenius	AS – 1	5714.64N to 5714.67N / 12311.10W to 12311.28W	Road widening at bend / mud hole as a result of vehicle use	Road rerouted left of low poorly drained area, cleared road width to right but no visual evidence that the road was built. Seismic cut has been used as short-cut for Quads / ATVs, evidence of use. Extensive run-off channeling on south side of road that originates from rut in road at top of hill.	
	AS – 2	5714.92N / 12314.16W	Old sump or lease on upslope of road with water channeling / impoundment	Channeling evident along south side of road. Water flowing across and also standing on road.	

Well Site Project	Site #	Location (Lat / Long)	Summary Description	Other Comments / Notes	Fig #[1]
	AS – 3	5715.15N to 5715.25N / 12316.33W to 12316.55W	Example of access road section through a poorly drained lowland / wetland area	Road traverses an open fen wetland for about 200m; segment of the road is under water. Rutting is evident as are alternative motor vehicle paths (ATVs, etc…) that were established to go around the wetter segments of the road.	
	AS – 4	5715.10N / 12317.17W	Example of creek crossing that has been widened as a result of continued vehicle access		
	AS – 5	5715.17N to 5715.26N / 12317.25W to 12317.89W	Example of a location where water has created ruts and drainage channels down the access road	Evidence of erosion and channeling in the surface of the road, in the vicinity of a seepage zone. Quad / ATV tracks can been seen going around a large mudhole. Road section is wet where it passes adjacent to a wetland.	3
	AS – 6	5714.99N / 12319.46W	Creek crossing area	Some localized channel changes can be seen in the river, possibly as a result of road building in the vicinity of the crossing.	
	AS – 7	5713.15N / 12322.79W	Crossing of the Sikanni River	There appears to be a widening of the north bank of the river, right at the road crossing location.	
	AS – 8	5713.46N to 5713.29 N / 123.00W to 12323.60W	South side of the Sikanni River, at the point where no motorized vehicle access is allowed on the access road	This location is a good example of successful reclamation.	
	AS – 9	5712.97N to 5712.95 N / 12324.12W to 12324.72W	A deactivated stretch of access road	Note the existence of a pack trail through the road access, and its relatively low impact relative to Quad / ATV effects on the N side of the River.	
	AS – 10	5712.00N / 12326.57W	A deactivated stretch of acess road that passes through a complex of rocky slope conditions and a low-lying open fen wetland	There appears to be good reclamation / revegetation success at this location. In particular, there is minimal erosion or other effects within the fen wetland area.	
	AS – 11	5712.04N to 5712.19N / 12327.84W to 12328.51W	A deactivated stretch of access road	This location includes some areas where blast rock was pulled back.	
	AS – 12	5712.19N / 12328.51W	Location where there is considerable erosion on both sides of the access road, and significant impacts from water runoff and pack trail use	Clearly evident at this site are the areas of erosion that exist along both margins of the road. There are significant effects here as a result of water impoundment / redirection. Impacted areas where pack trails have compacted and rutted the surface.	

Well Site Project	Site #	Location (Lat / Long)	Summary Description	Other Comments / Notes	Fig #[1]
	AS – 13	5711.84N / 12331.84W	Location on the N side of the Sikanni River that clearly shows effects of Quads / ATVs on the access road	This location should be compared to the much improved conditions at Site # AS – 8 which is on the S side of the Sikanni River, where Quads / ATVs have been excluded. Suitable reclamation activities and some means to exclude Quads / ATVs at this site would help to resolve rutting, erosion and compaction effects.	4
	AS – 14	5711.05N / 12332.31W	Effects of pack trail on erosion of surface of the access road		
	AS – 15	5710.13N / 12332.7W	Location where river erosion is affecting the access road		5
	AS – 16	5709.87N to 5709.69N / 12339.00W to 12338.87W	Example of road deactivation results right near the well site	Pullback of course granular soil, limited revegetation and too much woody debris.	
	AS – 17	5709.83N / 12338.89W	This site shows poor revegetation / reclamation results to date at the AS well site		
CNRL Sikanni	CS – 1	5712.29N to 5712.05N / 12308.67W to 12309.25W	Example of ponding effects along the access road / pipeline, as a result of insufficient drainage controls	Water that has become impounded and channelled along the entire length of pipeline trench at this site.	6
	CS – 2	5712.00N / 12309.36W	Well site showing cut and fill techniques that were used during construction, and an upper slope failure at the well pad	The upper slope failure at this location has occurred in spite of a cut off / drainage ditch having been constructed to help avoid this situation. Likely the slope failure is not due to surface runoff (since a drainage channel was designed) but rather it likely occurred as a result of groundwater seepage through permeable soils.	7
Husky Sikanni	HS – 1	5712.44N to 5712.22N / 12312.89W to 12312.81W	Example of access road conditions in an area where low-impact road construction techniques were used	Portion of the Husky Sikanni well site access road was constructed using low impact techniques. Results here indicate that the approach was relatively successful in achieving minimal impacts.	8

Well Site Project	Site #	Location (Lat / Long)	Summary Description	Other Comments / Notes	Fig #[1]
	HS – 2	5712.22N to 5711.83N / 12312.81W to 12314.81W	Example of access road conditions in an area where conventional road construction techniques were used	Where conventional techniques were used, it was evident that there were more significant effects. At this location, topsoil stripped and stockpiled on the downslope side of road. Ditching on upslope side of road and cross ditching / culverts were used to control drainage.	
	HS – 3	5711.85N / 12314.93W	Location is the HS well site, where there were minimal environmental effects	Relatively minor effects, however some trees along the cutslope have overturned either from cutslope ravelling or from windthrow effects.	
Murphy Chicken Creek	CC – 1	5720.23N to 5719.87N / 12305.36W to 12307.45W	Example of the access road, where conventional access consisted of a cutline / low impact construction	There are minimal effects / signs of disturbance.	9
	CC – 2	5719.87N to 5719.82N / 12307.45W to 12309.56W	Portion of the access road where the access was along an existing stream	Minimal disturbance; no clear environmental effects are evident from this approach. Stream access appears very successful in terms of impacts, and in fact it is difficult to identify the access road route without having the air photos and prior knowledge of its location.	10

Notes:
1 For those site numbers for which there is a constructed alignment sheet, Fig # refers to the Figure number (Fig, 3 to 10) within this project report.

7.0 RECOMMENDATIONS AND CONCLUSIONS

7.1 Recommendations

7.1.1 Regarding Next Steps Identified by this Project

The work summarized in this Final Report is preliminary in nature, and EBA Waberski Darrow recommends that a carry on phase be established, so that further investigations are conducted. There are a few key recommendations regarding next steps:

- As outlined in Section 6, there is a need to conduct further work to refine the effects assessment matrices, the site assessment tool and the long-term monitoring programs for the four projects.

- The field work completed to date should now be succeeded by a further field program in 2006 which establishes a set of field monitoring stations (for long-term monitoring purposes), as identified in Section 6.4.2. There needs to be an objective set of baseline data obtained so that clear measurements can be made regarding recovery and changes with respect to environmental and geotechnical effects associated with the four projects.

- Input and feedback from MSRM and the OGC are also in order, so that agency input is obtained as more detailed aspects of the next phase of the investigation are designed. It is recommended that MWRM and OGC input be obtained as a component of the planning process related to carry-on investigations.

7.1.2 Specific Recommendations Related to Access Road and Well Site Construction

The four projects all employed different access road and well site construction methods, and this resulted in distinct variations that were further reflected in the ways that environmental and geotechnical effects developed and occurred.

Road construction practices, for example, have continued to change over the years, partly in response to regulatory requirements but also based on contractor knowledge and practices, operator skill, cost effectiveness, and even the changing capabilities that result from new equipment. In this regard, it is important to note that road construction practices prior to 1999 are sub-standard if compared against the present road construction and environmental due diligence standards being maintained by today’s oil and gas industry. In discussing the overall observations relating to pre and post 1999 road construction standards it is very apparent that the priorities associated with road construction standards (and other aspects) have been significantly improved.

If compared against the access road construction standards and guidelines that are currently in effect, the road construction standards dating back to 1997 (i.e. Amoco Sidenius) and the degree of impact to aquatic and riparian habitat is not permissible by today’s standards for well site and access road developments and/or restoration requirements (i.e. CNRL Sikkani, Husky Sikkani, Murphy Chicken Creek projects).

Specific recommendations are provided in the following sections in relation to appropriate construction and reclamation practices for well site and access roads in the M-KMA. The specific recommendations are grouped by subject area, and are based on combined field observations / office-based analysis relating to all four projects. The recommendations provided in the following sections are also provided in context with existing regulatory frameworks, such as the Oil and Gas Commission’s Planning and Construction Guide (OGC n.d.), Geophysical Guidelines (OGC 2004a) and Stream Crossing Planning Guide (OGC 2004b).

7.1.2.1 General Construction Practices

- Where possible, it is recommended that low impact clearing of access roads should be adopted. This would help maintain the integrity of the road, and would help mitigate any surface water flow concerns, particularly if the road grade varies.

- It is recommended that the Standard for well sites or access road deactivation follow that which was applied in completing the deactivation of the Amoco Sidenius well site and the final section of the well access road. The Standards applied in the remediation of this section of road prevented any erosion and reduced the potential for any sediment transfer.

- The construction activities did not reasonably address drainage concerns along sections of the road, particularly in area that lacked any form of drainage ditches along sections of road with increased grade. This was particularly evident on the Amoco Sidenius access road, and along sections of the CNRL Sikanni access road. It is suggested that more emphasis should been applied on surface water flow, and erosion containment to account for drainage management during spring, summer and fall. It is recommended that additional emphasis be placed on developing standards that address potential long term, and/or seasonal impacts that could occur outside of the winter season. A good example of this was evident in the planning and construction of the Husky Sikanni project.

- A common theme throughout the field work was one of “water drainage management”. It is clear that, in terms of environmental and geotechnical effects, there are significant hardships in terms of maintaining natural water flows over time, after the access road and well site have been constructed, and this is not necessarily readily resolved by using lower impact / lighter touch approaches during construction. Fens and other small wetlands are readily affected quickly and over the longer term by water flowing down roads, water redirected or impounded.

- Restoration activities have the potential to minimize environmental and geotechnical effects, and should continue to be required as an important environmental practice within the M-KMA. For example, rehabilitation efforts at Murphy Chicken Creek appear to have been effective (although this may be more attributable to the implementation of low impact construction techniques). The limited areas of rehabilitation at Amoco Sidenius, for example at the well site and along the adjoining access road, as well as some steep sidehill sections of the Amoco Sidenius access road, also appear to have been suitably and effectively restored.

7.1.2.2 Culvert Design and Installation

- The planning and installation of access roads that use low impact clearing where possible, appropriate culverts and ditches to manage surface water flow as per the “Husky Sikanni” well site was very effective, and should be considered.

- The placement of boulders on the outlet of culverts was not as effective when placed to close to the outlet. Therefore it is recommended that the placement of cobbles and boulders at the outlet of culverts should generally be extended out further from outlets (>1.5 < 3m). If possible, two lines of rocks would further reduce the velocity of the water flow and help trap sediments.

- The positioning of culverts is an important tool in preventing the uncontrolled transfer of sediments in areas where the road grade is > 5 %, and empties into fen or other sensitive wetland ecosystems.

7.1.2.3 Sediment Fences and Berms to Control Sediment / Erosion

- Sediment fences need to be positioned further down slope from the lines of boulders (>1.5 < 3m), if positioned to close to culvert outlets the force of the water was knocking them down.

- The construction of berms (on the down slope side of a road) with material obtained while bulldozing the road access, and the placement on ditches on the up slope side of the road was very ineffective in managing surface water flow. This practice should be adopted as a standard practice if having to cut an access road.

7.1.2.4 Wetland and Riparian Conservation / Management

- It is recommended that winter access roads should avoid crossing fens/swamp areas and should try to stay on the edges of these areas where possible. This is suggested as this would prevent the unnecessary clearing or alteration of the area, particularly in areas where there is high recreational activity as this can result in high habitat destruction/alteration.

- It is recommended that portable road sections be used when traversing river flat areas (i.e. Murphy Chicken Creek). This is suggested as the impact to the riparian areas along the creek, following the removal of the snowfall also resulted in the stripping of important topsoil which contained both important nutrients and seed deposits for the locally occurring flora, resulting in a distinct footprint along the river flat section. If portable road sections are used in similar scenarios this would prevent any habitat alteration/destruction. Although the cost of the portable roads is high, this would greatly reduce the associated costs involved in restoring such areas at the completion of drilling activities.

- Environmental sensitivity in relation to fens and other wetlands needs to be anticipated ahead of time, in relation to what effects are appropriate if the well will be established over the long-term. For the Murphy Chicken Creek project, for example, it is difficult to determine how effective the routing would have been if it had been a producing well site that required ongoing access. So the question to pose, at the outset of route planning, is “if the well becomes a producer, and you need to access in summer on the ground, then will crossing wetlands and traveling creek beds be appropriate for continued or long-term access?”

7.1.2.5 Winter / Snow Road Management

- Low-impact snow-making techniques for winter road construction are well accepted as the best means of minimizing environmental effects, and these practices are generally being followed for winter road construction in BC, Alberta, the NWT and Yukon. Within the M-KMA there is a need to continue to use, wherever possible and practical, low-impact snow making approaches. The Murphy Chicken Creek project clearly demonstrates that these practices can work well, and in other access road situations, and with more widespread use of this approach, it should become more cost effective. Certainly, it appears to greatly reduce the overall costs of subsequent reclamation / revegetation.

- The standard practice of completely removing all the snow pack is potentially causing a reduction in the re-vegetation within the immediate area of the stream crossing. The lack of these vegetative covers results in the weakening of the stream banks, and potentially increasing erosion and sediment transfer to important fish bearing habitat located downstream. It is suggested that this is occurring as surface seeds and nutrients have been removed along with the snow pack, thus impeding any natural regeneration of the local flora.

- It is suggested that when deactivating winter access roads on river crossing that a prior assessment of the flora be determined, this would enable an accurate replanting program to be conducted. This is suggested, as the river flat areas impacted by the access road on Murphy Chicken Creek did not appear to have been replanted upon the deactivation of the road.

- Stream channel crossing which used snow bridges during winter access commonly showed increased erosion, wide spread channelling, and altered water flow pathways. It is suggested that the current deactivation guidelines regarding the complete removal of snow pack from stream crossing is potentially causing additional impact to both the riparian and down stream aquatic habitat. It is recommended that further consultation between the industry and the Oil and Gas Commission conduct a review of these present practices.

7.1.2.6 Recreational Access to Well Site Access Roads

- Although the amount of recreational vehicles that travel the roads designated as winter access roads vary as to the location it is suggested that where possible the access road be made to follow the contour of the land, and where possible, to avoid crossing fens/swamps. This is suggested because the destruction/impact to fen wetlands in particular is a common occurrence along the access roads (e.g., see Amoco Sidenius). This has caused erosion and is a potential source of sedimentation, and the alteration of natural water flow in the immediate vicinity. The alteration and/or destruction to the access roads require that a more effective deactivation plan be developed to avoid further destruction due to the volume of recreational vehicles that have accessed these roads. Thus, if a road is to be deactivated, this would be a substantial decrease in the restoration costs associated with the road.

7.1.2.7 Other Issues

- The review of these four projects indicates that there are negative environmental and geotechnical effects associated with all of the projects, despite high expenditures to undertake, for some of the projects, low impact practices. For some well site projects in future, it is recommended that ground-heli-portable drilling be considered seriously as an alternative (see Anon. 2002). Particularly where wetland or watercourse crossings will present construction challenges, the use of heli-portable systems could provide a low-impact alternative that would still allow well site installation but would avoid unnecessary damage (that is, if the well site is not a producer).

- Use of coarse woody debris, especially larger logs, provides an effective surface treatment of access roads under suitable conditions. In the field, there was some evidence of effective use of woody debris within rights-of-ways to help as water runoff / water diversion tools on steeper slopes (especially when laid in a herringbone fashion down the slope line), and as small mammal / ground cover maintenance on areas of lower relief. As well, the use of coarse woody materials can also act as a deterrent to Quad / ATV use, thereby avoiding surface damage effects that result from such access. This practice should be encouraged, particularly in light of the fact that access road / well site permits typically require that "all marketable timber be appropriately used".

7.2 Conclusions

This document is EBA Waberski Darrow Consulting Ltd.'s (EBA Waberski Darrow) Final Report to the Ministry of Sustainable Resource Management (MSRM) related to a project entitled: "*Evaluating the Environmental Impacts of Well Site and Access Road Construction Methods within the M-KMA Sikanni Valley Region*". The project's objective was to conduct initial site impact assessments at four recently constructed access road and well site developments. The work program that EBA Waberski Darrow designed and undertook involved an objective, unbiased evaluation of the relative vegetational, wildlife habitat (terrestrial and aquatic), hydrological and geomorphical site impacts that were observed in association with the four site developments, in relation to the various construction methods and approaches that were followed for each.

The general approach taken in the project was as follows:

1. Conduct a field reconnaissance survey to understand and initially document the environmental and other effects associated with the four projects;
2. Review site biophysical and geomorphologic characteristics using previous reports and surveys and via consultations with MSRM staff and local oil and gas operators;

3. Compile and review existing regulatory requirements and applicable best practice criteria for undertaking construction and reclamation activities in similar regions;
4. Involve an “expert systems” approach to summarize those key biophysical, geomorphic, and construction/reclamation practice effects that are associated with the four projects, and devise project-specific “effects assessment matrices” to help summarize the issues regarding the four projects;
5. Develop a framework for deriving a site assessment protocol/tool and long-term monitoring program based on criteria used to develop the matrices; and,
6. Make recommendations for future directions / next steps.

This Final Report has provided the following outputs:

- Background and general context (Sections 1 and 2).

- Summaries of field investigations, including “alignment diagrams” from representative field sites, and summaries of observations / results based upon field visits to the four well site and access road projects (Section 3);

- Summaries of office-based investigations, including cost breakdowns related to construction and reclamation activities for the four projects, and interviews with contractors involved with the construction of each of the four projects (Section 4);

- A preliminary consideration of the four projects in relation to existing practices, associated degree of environmental impact, and in relation to various environmental and other factors (Section 5); and,

- Interpretation of the findings (Section 6), in particular to:

    a. Critically assess what are the “lessons learned” from the projects examined;

    b. Identify what key aspects should be included within a longer-term environmental monitoring activity for these four projects; and

c. Make some preliminary observations / recommendations regarding preferred (environmentally, and in relation to cost effectiveness) techniques that should be employed going forward.

- A number of recommendations relating both to next steps for the current investigation, as well as (and based mainly upon field observations by EBA Waberski Darrow staff) effective construction and reclamation practices that should be encouraged and promoted within the M-KMA (Section 7)

8.0 REFERENCES

Anon. 1997a. Amoco et al Sidenius c-92-G, 94-G-4, Winter Wellsite Access Alignment, Geo-engineering, September, 1997.

Anon. 1997b. Land Use Permit, W.A. #10759 Amoco et al Sidenius c-92-G/94-G-4, C Ministry of Employment and Investment, November 10, 1997.

Anon. 2002. Muskwa-Kechika Management Area – Heliportable Drilling Feasibility Study. Prepared by TERA Consultants and others, Calgary, Alberta, for BC Ministry of Sustainable Resource Management, MK Advisory Board and the BC Oil and Gas Commission. June, 2002.

Anon. 2004. Conserving Canada's Natural Capital: The Boreal Forest – Muskwa-Kechika Case Study. Prepared for the National Round Table on the Environment and the Economy, Ottawa, Ontario, by R. McManus Consulting Ltd. and Salmo Consulting Inc., Calgary, Alta. July 2004. 74 pp.

DeLong, C. 1990. A field guide for identification and interpretation of ecosystems of the northeast portion of the Prince George Forest Region. Land Management Handbook no. 22. Ministry of Forests, Research Branch, Province of British Columbia.

Holland, S. 1976. Landforms of British Columbia. A physiographic outline. Bulletin 48. British Columbia Department of Mines and Petroleum Resources. Province of British Columbia.

Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. Ministry of Forests, Victoria, B.C. 330 pp.

Ministry of Environment, Lands and Parks and Ministry of Energy, Mines and Petroleum Resources (MELP and MEMPR). 1995. Upper Sikanni Management Plan. November, 1995. Province of British Columbia. Victoria, B.C. 46 pp.

Ministry of Sustainable Resource Management (MSRM). 1997. Fort St. John Land and Resource Management Plan. Prepared by Fort St. John LRMP Working Group October 1997.

Ministry of Sustainable Resource Management (MSRM). 2004 M-KMA Pre-Tenure Plan (May 2004). Province of British Columbia.

Oil and Gas Commission (OGC). 2001. Permit Appendix A, Marathon Sikanni c-40-J,94-G-3, November 15, 2001.

Oil and Gas Commission (OGC). n.d. OGC Planning and Construction Guide For Oil and Gas Operations in British Columbia, undated.

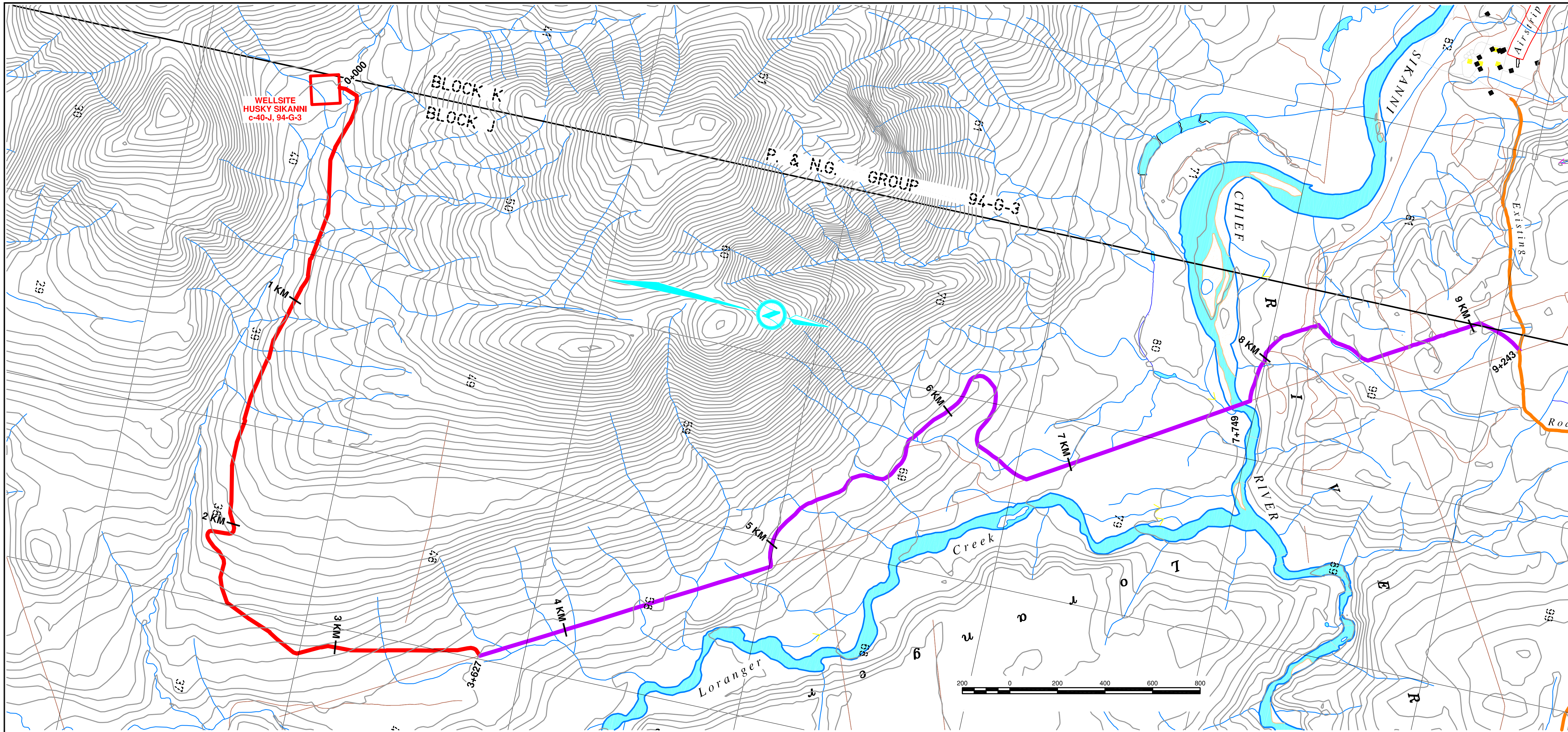
Oil and Gas Commission (OGC). 2004a. Stream Crossing Planning Guide (Northeast BC). Version 1.0, March 26, 2004.

Oil and Gas Commission (OGC). 2004b. Geophysical Guidelines for the Muskwa-Kechika Management Area. May 18, 2004. 16 pp.

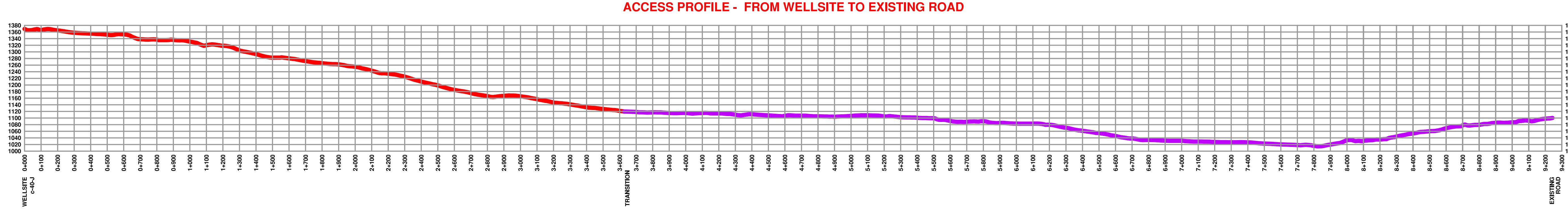
Shultis, J. and R. Rutledge. 2003. The Muskwa-Kechika Management Area – A Model for the Sustainable Development of Wilderness? Internat. J Wilderness 9 (3): 12-17.

APPENDIX A

Access Road Profile Plan Diagrams for the Four M-KMA Well Site Projects



ACCESS PROFILE - FROM WELLSITE TO EXISTING ROAD



Rev	Revision Description	Date(Y/M/D)	By
0	Original Plan Prepared	2005/02/09	TP
1	Updated Plans	2005/03/15	TP

Note:
Contour Interval = 10m

NOTES:

All underground facilities shown were located with electronic locators and may be be subject to error. Actual locations should be verified independently by the contractor in field prior to any crossings.

Existing Roads shown thus:
Drainages shown thus:
Proposed New Cut Access shown thus:
Proposed Access Along Cut Lines shown thus:

MUSKWA KECHIKA STUDY

PROFILE PLAN SHOWING
ACCESS FOR WELLSITE
HUSKY SIKANNI c-40-J, 94-G-3

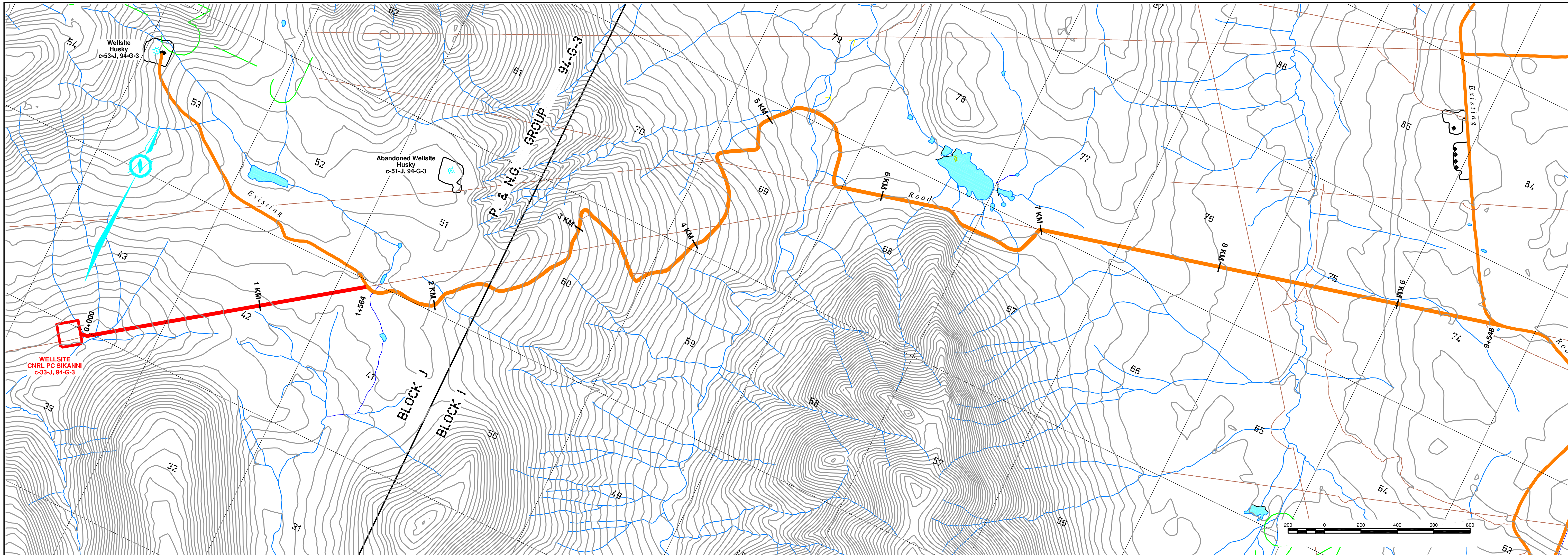
Unsurveyed Crown Land, Peace River District

200 0 200 400 600 800

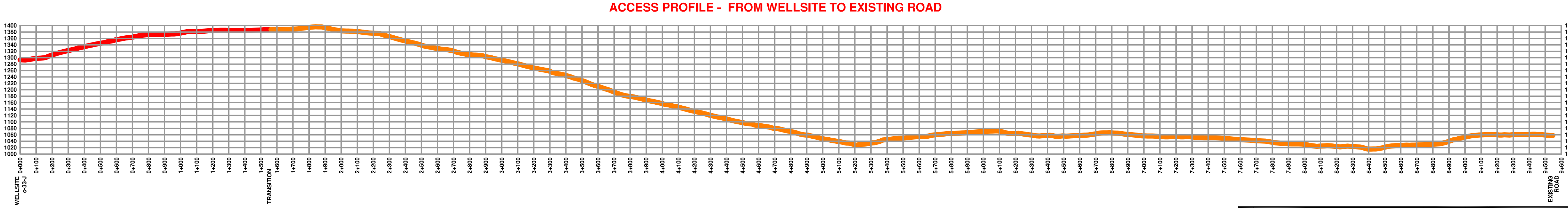
B.C.G.S. 94G.014, 94G.024

WABERSKI DARROW SURVEY GROUP
10720 - 100th Avenue,
Fort St. John, B.C., V1J 1Z3
Ph. (250)787-0300 Fax (250)787-1611

WDSG Job No.: 041288ST01R0
Client File No.:
EBA File No.:
REV. 1



ACCESS PROFILE - FROM WELLSITE TO EXISTING ROAD



Note:
Contour Interval = 10m

Rev	Revision Description	Date(Y/M/D)	By
0	Original Plan Prepared	2005/02/09	TP
1	Updated Plans	2005/03/15	TP

NOTES:

All underground facilities shown were located with electronic locators and may be be subject to error. Actual locations should be verified independently by the contractor in field prior to any crossings.

Existing Roads shown thus:
Drainages shown thus:
Proposed New Cut Access shown thus:
Proposed Access Along Cut Lines shown thus:

MUSKWA KECHIKA STUDY

PROFILE PLAN SHOWING
ACCESS FOR WELLSITE
CNRL PC SIKANNI c-33-J, 94-G-3

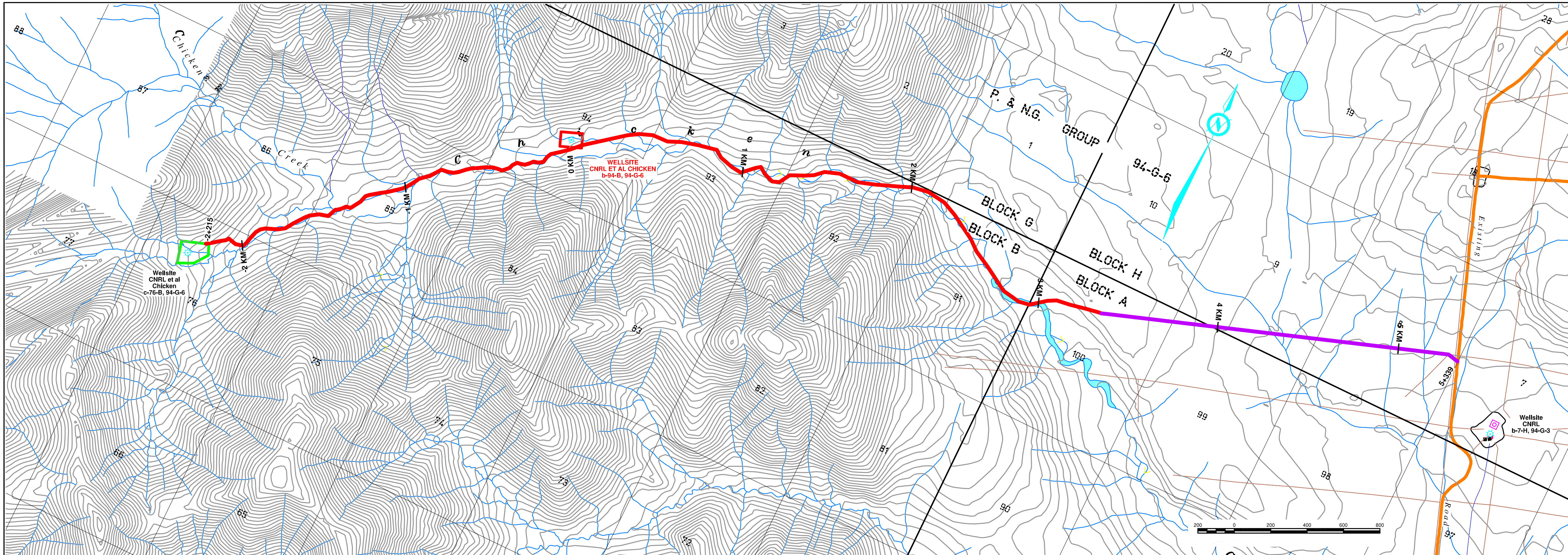
Unsurveyed Crown Land, Peace River District

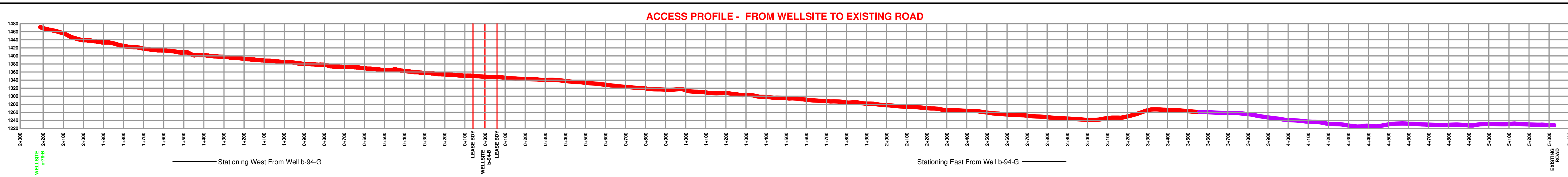
200 0 200 400 600 800

B.C.G.S. 94G.015, 94G.025

WABERSKI DARROW SURVEY GROUP
10720 - 100th Avenue,
Fort St. John, B.C., V1J 1Z3
Ph. (250)787-0300 Fax (250)787-1611

WDSG Job No.:	041288ST01R1	**REV.**
Client File No.:		1
EBA File No.:		





Note:
Contour Interval = 10m

Rev	Revision Description	Date(Y/M/D)	By
0	Original Plan Prepared	2005/02/09	TP
1	Updated Plans	2005/03/15	TP

NOTES:

All underground facilities shown were located with electronic locators and may be be subject to error. Actual locations should be verified independently by the contractor in field prior to any crossings.

Existing Roads shown thus:
Drainages shown thus:
Proposed New Cut Access shown thus:
Proposed Access Along Cut Lines shown thus:

MUSKWA KECHIKA STUDY

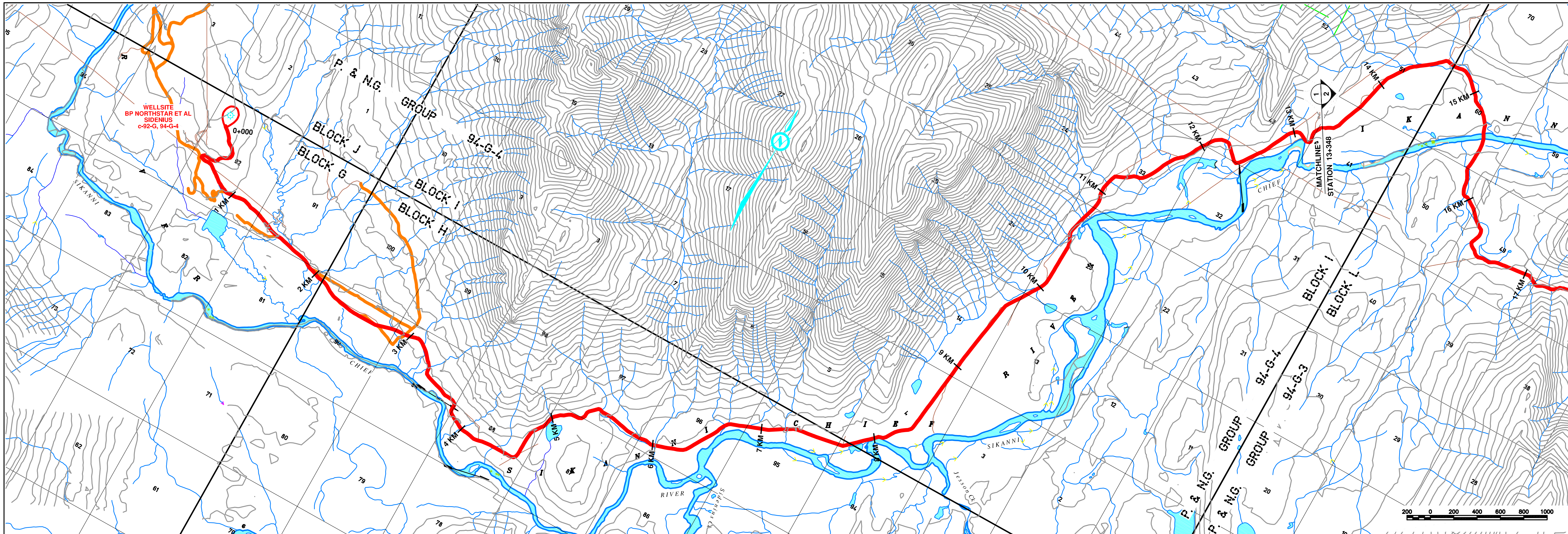
PROFILE PLAN SHOWING
ACCESS FOR WELLSITE
CNRL ET AL CHICKEN c-76-B & b-94-B, all in 94-G-6
Unsurveyed Crown Land, Peace River District

200 0 200 400 600 800

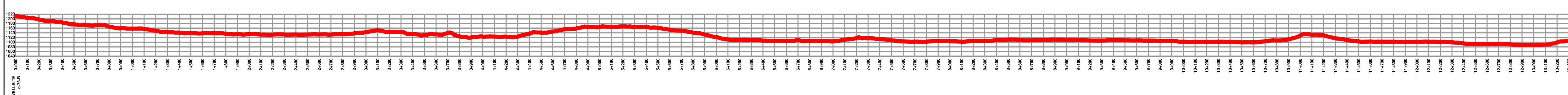
B.C.G.S. 94G.035

Waberski Darrow
WABERSKI DARROW SURVEY GROUP
10720 - 100th Avenue,
Fort St. John, B.C., V1J 1Z3
Ph. (250)787-0300 Fax (250)787-1611

WDSG Job No.: 041288ST01R0
Client File No.:
EBA File No.:
REV. 1



ACCESS PROFILE - FROM WELLSITE TO EXISTING ROAD



SHEET 1 OF 3

Note:
Contour Interval = 10m

Rev	Revision Description	Date(Y/M/D)	By
0	Original Plan Prepared	2005/02/09	TP
1	Updated Plans	2005/03/15	TP

NOTES:

All underground facilities shown were located with electronic locators and may be be subject to error. Actual locations should be verified independently by the contractor in field prior to any crossings.

Existing Trails shown thus:
Drainages shown thus:
Proposed New Cut Access shown thus:
Proposed Access Along Cut Lines shown thus:

MUSKWA KECHIKA STUDY

PROFILE PLAN SHOWING
ACCESS FOR WELLSITE
BP NORTHSTAR ET AL SIDENIUS c-92-G, 94-G-4

Unsurveyed Crown Land, Peace River District

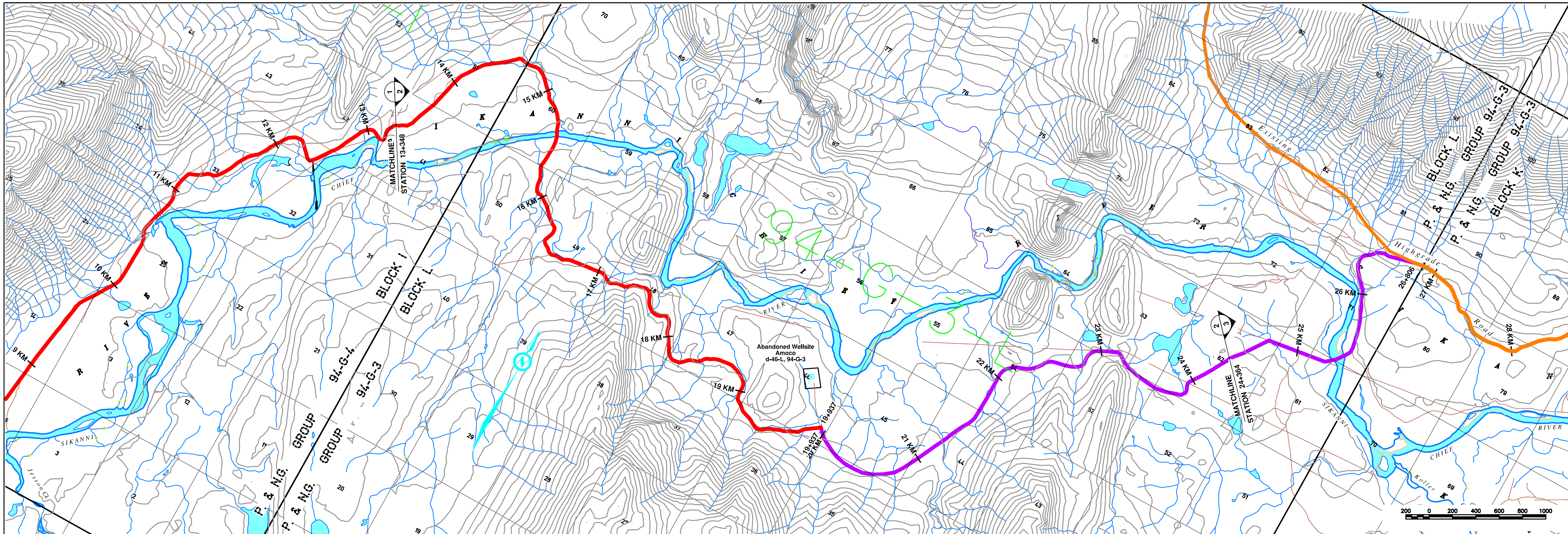
200 0 200 400 600 800 1000

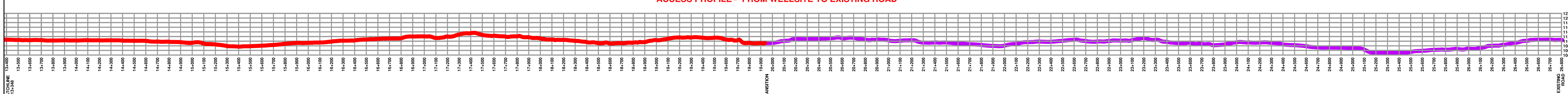
B.C.G.S. 94G.012,013,023,024

SHEET 1 OF 3

WABERSKI DARROW SURVEY GROUP
10720 - 100th Avenue,
Fort St. John, B.C., V1J 1Z3
Ph. (250)787-0300 Fax (250)787-1611

WDSG Job No.: 041288ST01R1
Client File No.:
EBA File No.:
REV. 1





SHEET 2 OF 3

Rev	Revision Description	Date(Y/M/D)	By
0	Original Plan Prepared	2005/02/09	TP
1	Updated Plans	2005/03/15	TP

NOTES:

All underground facilities shown were located with electronic locators and may be be subject to error. Actual locations should be verified independently by the contractor in field prior to any crossings.

Existing Trails shown thus:
Drainages shown thus:
Proposed New Cut Access shown thus:
Proposed Access Along Cut Lines shown thus:

Note:
Contour Interval = 10m

MUSKWA KECHIKA STUDY

PROFILE PLAN SHOWING
ACCESS FOR WELLSITE
BP NORTHSTAR ET AL SIDENIUS c-92-G, 94-G-4
Unsurveyed Crown Land, Peace River District

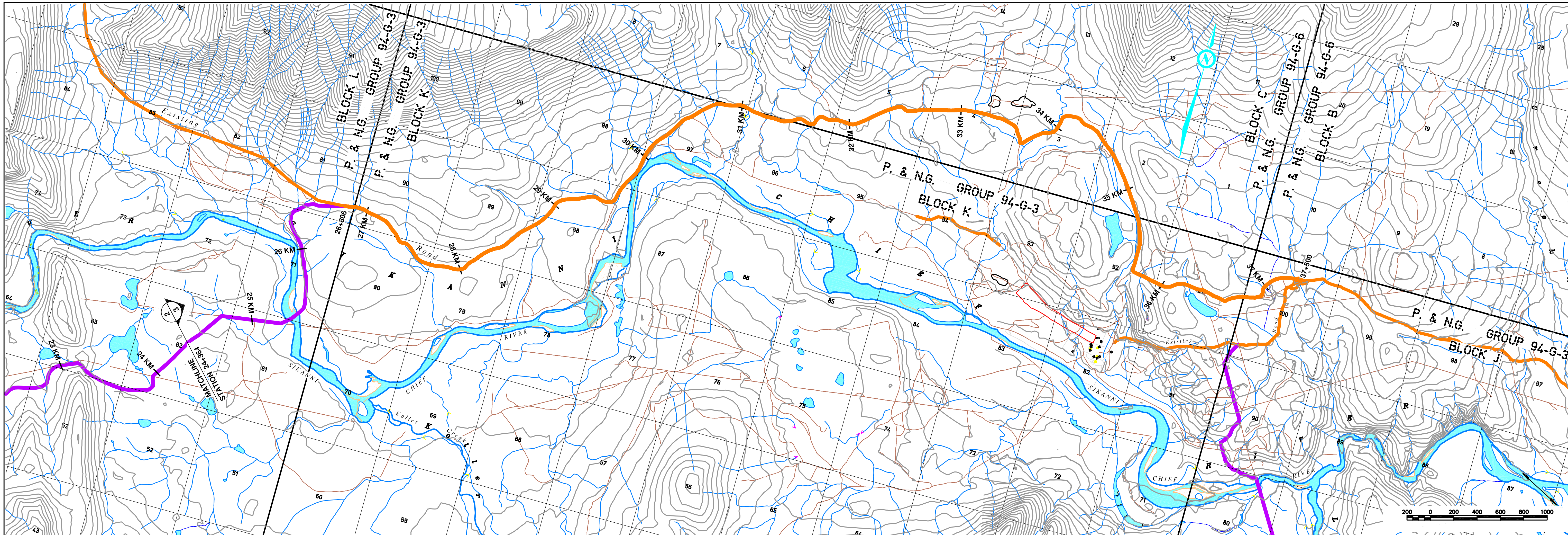
200 0 200 400 600 800 1000

B.C.G.S. 94G.012,013,023,024

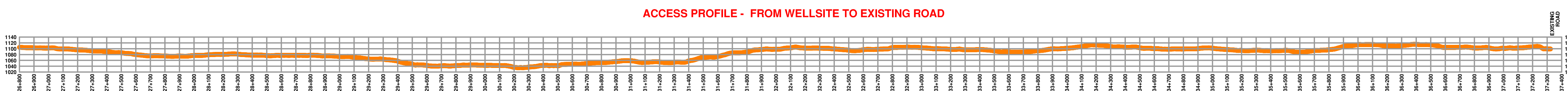
SHEET 2 OF 3

WABERSKI DARROW SURVEY GROUP
10720 - 100th Avenue,
Fort St. John, B.C., V1J 1Z3
Ph. (250)787-0300 Fax (250)787-1611

WDSG Job No.: 041288ST01R1
Client File No.:
EBA File No.:
REV. 1



ACCESS PROFILE - FROM WELLSITE TO EXISTING ROAD



SHEET 3 OF 3

Rev	Revision Description	Date(Y/M/D)	By
0	Original Plan Prepared	2005/02/09	TP
1	Updated Plans	2005/03/15	TP

NOTES:

All underground facilities shown were located with electronic locators and may be be subject to error. Actual locations should be verified independently by the contractor in field prior to any crossings.

Existing Highgrade Roads shown thus:

Drainages shown thus:

Proposed New Cut Access shown thus:

Proposed Access Along Cut Lines shown thus:

Note:
Contour Interval = 10m

MUSKWA KECHIKA STUDY

PROFILE PLAN SHOWING
ACCESS FOR WELLSITE
BP NORTHSTAR ET AL SIDENIUS c-92-G, 94-G-4

Unsurveyed Crown Land, Peace River District

200 0 200 400 600 800 1000

B.C.G.S. 94G.012,013,023,024

SHEET 3 OF 3

WABERSKI DARROW SURVEY GROUP
10720 - 100th Avenue,
Fort St. John, B.C., V1J 1Z3
Ph. (250)787-0300 Fax (250)787-1611

WDSG Job No.: 041288ST01R1		**REV.** 1
Client File No.:		
EBA File No.:		

APPENDIX B

Airborne Video Coverages of the Four M-KMA Well Site Projects (as a DVD)