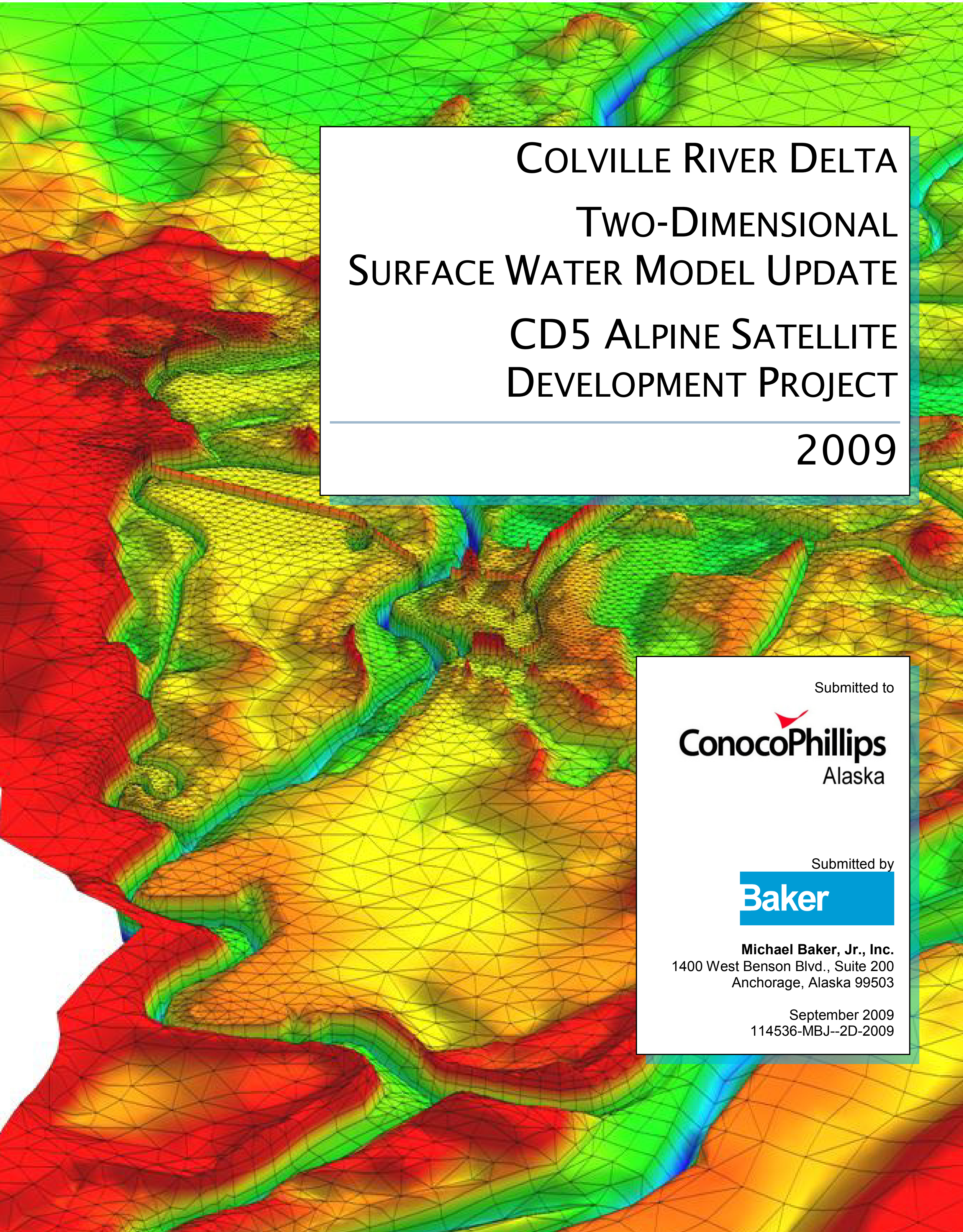

Colville River Delta Two-Dimensional Surface Water Model Update CD5 Alpine Satellite Development Project

2009

Submitted to

ConocoPhillips Alaska

Submitted by

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EXECUTIVE SUMMARY

The proposed CD5 Satellite Facility is located west of the Colville River Delta in the NPRA. A road and pipeline are proposed to connect CD5 to Alpine, which is located in the Colville River Delta. The proposed road crosses the Nigliq Channel, the smaller of the two main Colville Delta channels, with a proposed 1,450-foot combined road and pipeline bridge. Two smaller bridges will span Lake L9341 (approximately 320-foot bridge) and the Nigliagvik (approximately 280-foot bridge) located west of the Nigliq Channel. The location of the existing CD facilities and the proposed CD5 facility are shown on Figure 1.

The Colville River Delta two-dimensional surface water model was originally created in 1997 to predict design flood conditions for the original Alpine CD1/CD2 facilities. In 2002, the model was updated to include the CD3/CD4 facilities. The model was again updated in 2004 as part of the CD5 engineering and NEPA analysis. In 2006, the model was updated to include the Qannik extension of the CD2 pad.

In 2009, the two-dimensional model was enhanced to include additional mesh and topographic detail. The improvements were made due to increases in computing power, software upgrades, and additional available data. The 2009 model enhancements were much more complex than previous model updates. Essentially, the entire model mesh was regenerated. Detail of the model enhancements is discussed in Section 3. No major changes in the overall modeling results for the 50- and 200-year flood events occurred. There were increases on the order of 1 foot in predicted water surface elevations east of the CD4 road and along the Sakoonang Channel. In two locations, the increases in predicted water surface elevations cause sections of gravel road to be lower than the design criteria of Q50 plus 3 feet of free board if the design criteria were based on the new model. The sections of road are the CD2 road east of the CD4 intersection and the CD4 road south of the CD5 intersection.

The enhanced model was then updated to include the proposed CD5 road and bridges in order to evaluate the impacts of the facilities. Water surface elevation increases are predicted upstream of the proposed CD5 road for both the 50- and 200-year design events. Although the bridges span the entire bank-to-bank width of the crossings, overbank flows during these large and infrequent flood events will be diverted into the bridge openings and resulting backwater does occur. Smaller more frequent flood events, 10-year return interval or less, are not predicted to have notable backwater associated with the CD5 road. Predicted water surface elevations for the pre- and post-CD5 conditions during the 50- and 200-year return intervals (Q50, Q200) at selected locations are presented in Tables 1 and 2, respectively. The location ID is shown on Figure 1.

TABLE 1 Q50 WATER SURFACE ELEVATION CHANGES DUE TO CD5

Point	Location	Pre-CD5	Post-CD5	Difference
1	Nigliq Bridge (Downstream 500')	12.4	12.4	0.0
2	Nigliq Bridge (Upstream 500')	12.7	12.7	0.0
3	L9341 Bridge (Downstream 500')	12.8	13.3	+0.5
4	L9341 Bridge (Upstream 500')	12.9	13.3	+0.4
5	Nigliagvik Bridge (Downstream 500')	12.7	12.6	-0.1
6	Nigliagvik Bridge (Upstream 500')	12.8	13.1	+0.3
7	CD2 Pad - Adjacent to Nigliq	11.5	11.5	0.0
8	Alpine Swale Upstream (PSG#3)	11.9	11.9	0.0
9	Alpine Swale Downstream (PSG#4)	10.1	10.1	0.0
10	Alpine Pad South	13.2	13.2	0.0
11	CD4 - Adjacent to Nigliq	14.3	14.3	0.0
12	CD3 - Adjacent to Channel	7.0	7.0	0.0
13	Nigliq Channel at Nuiqsut	19.0	19.0	0.0

TABLE 2 Q200 WATER SURFACE ELEVATION CHANGES DUE TO CD5

Point	Location	Pre-CD5	Post-CD5	Difference
1	Nigliq Bridge (Downstream 500')	14.5	14.4	-0.1
2	Nigliq Bridge (Upstream 500')	14.9	14.9	0.0
3	L9341 Bridge (Downstream 500')	14.9	15.1	+0.2
4	L9341 Bridge (Upstream 500')	14.9	15.5	+0.6
5	Nigliagvik Bridge (Downstream 500')	14.9	14.5	-0.4
6	Nigliagvik Bridge (Upstream 500')	15.0	15.5	+0.5
7	CD2 Pad - Adjacent to Nigliq	13.4	13.3	-0.1
8	Alpine Swale Upstream (PSG#3)	14.0	13.9	-0.1
9	Alpine Swale Downstream (PSG#4)	11.7	11.7	0.0
10	Alpine Pad South	15.4	15.5	+0.1
11	CD4 - Adjacent to Nigliq	16.3	16.5	+0.2
12	CD3 - Adjacent to Channel	8.0	8.0	0.0
13	Nigliq Channel at Nuiqsut	21.0	21.1	+0.1

Water surface elevations are predicted to increase the greatest just upstream of the CD5 access road west of the Nigliq Channel and near the CD4 facility pad. Backwater impacts are less pronounced at the Nigliq Channel bridge. Although water surface elevations are predicted to increase at certain existing gravel facilities, none of the original design criteria with respect to flooding has been compromised from inclusion of the CD5 facilities in the model; 200-year water surface elevation plus 1 foot of freeboard for facility pads and 50-year water surface elevation plus 3 feet of freeboard for roads. The overall area of inundation in the Delta changes little due to the CD5 road.

Water velocities increase through the three bridges during the 50- and 200-year model predictions. The increase in velocity through the bridges will increase the scour in the channel during flood events greater than the 10-year event. Scour, due to the access road and bridges, is not predicted during the 10-year event because bridge spans are in excess of the open water conditions and do not influence flows. Downstream of the proposed road, water velocities on the floodplains generally decrease, although the area of inundation remains the same.

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2009 2D MODEL
EXECUTIVE SUMMARY
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1 INTRODUCTION

In 1997, a two-dimensional surface water model was developed for the Colville River Delta to predict water surface elevations and velocities throughout the Delta. The model has proven to be a reliable tool and source of design criteria for the Alpine Oil Field (Alpine). Alpine facilities are owned and operated by ConocoPhillips, Alaska (CPAI). CPAI plans to expand into the National Petroleum Reserve-Alaska (NPRA) with the development of the CD5 Satellite Facility, located west of the Colville River Delta. The expansion is part of the Alpine Satellite Development Project (ASDP).

The CD5 road originates at the CD4 access road approximately 4,000 feet north of the CD4 pad and traverses west across the Delta into NPRA to the CD5 pad location. Three bridges are proposed along the access road. The first crosses the Nigliq Channel, the second crosses Lake L9341, and the third crosses the Nigliagvik.

Figure 1 is an area map showing features and locations discussed in this report.

Over the years the two-dimensional surface water model (two-dimensional model) has been updated with new survey data and proposed facilities expansion. It was originally created to provide peak water surface elevations and velocity magnitudes for the design of the Alpine CD1 and CD2 facilities and pipelines. The model was then updated in 2002 to reflect the addition of CD3 and CD4 facilities. In 2005 and 2006 the model was again updated with new survey data in an effort to model the proposed CD5 access road alignment located west of CD2. Though this initial proposal for the CD5 alignment has since been abandoned, the survey data which included the as-built configuration of CD3 and CD4 facilities was retained in the model. The model was again updated for the Qannik expansion of CD2 in 2006. The model has been used not only to provide design criteria but also to estimate the impact of facilities on the environment with respect to large spring floods.

This report presents Michael Baker Jr., Inc. (Baker)'s update of the two-dimensional model for the newly proposed CD5 Satellite Facility. Baker has been involved with the model since its development in 1997. Aside from the adjustments described above no major update of the model mesh had been performed. Building on elevation point data used to define topography of the 2006 model a refined mesh was developed for the entire Colville River Delta (Delta). The updated model was used to estimate water surface elevations and velocity magnitudes for the 2-, 10-, 50-, and 200-year spring breakup floods. Model output was used in support of bridge design and will be used to set design criteria for the minimum elevation of the proposed CD5 access road and pipelines with respect to floodwater.

The intent of this report is to provide the reader with an understanding of how the original model was developed, what the major milestone updates have been, how the new model was developed, as well as present and discuss recent modeling results. A discussion of the two-dimensional model and the update adjustments is presented in Section 2. Recent reconstruction of the model mesh and modifications to associated components is discussed in Section 3. The modeling results for pre-CD5 (existing) and post-CD5 (proposed facilities) conditions are compared and described in Section 4. A bank migration analysis is contained in Section 5. Data from the modeling results were used to develop design scour estimates for the three proposed bridge crossings. A discussion of bridge scour methods and results is presented in Section 6. Appendices A and B present the tables and figures illustrating these results and discussions.

Predictions presented here are for open water conditions assuming no ice or snow impacts. Though the presence of ice and snow can have localized effects on floodwaters, these conditions have a much lower impact on overall water surface elevations for large design flood events.

All elevations presented in this report are in feet and referenced to the British Petroleum Mean Sea Level (BPMSL).

2 BACKGROUND

1997. The two-dimensional model of the Colville River Delta was originally developed in 1997 to predict peak water surface elevations and velocities for 50-, 100-, and 200-year flood events as part of the original Alpine facilities (CD1 and CD2) design. The original report was published in 1997 (Shannon & Wilson).

1998. CD1 and CD2 In the fall of 1997, field surveys conducted in the area of the proposed Alpine facilities showed that a portion of the ground surface elevations used to develop the original finite element mesh did not match the project datum (BPMSL). Consequently, the ground surface elevations were adjusted to match the 1997 field survey. In addition to the revised topography, the finite element mesh along the proposed CD2 access road was updated to reflect the March 1998 proposed alignment. This included the addition of the proposed 440-foot bridge with spill-through abutments (only one bridge was anticipated at the time). The model was rerun and the analysis presented in a project update report (Baker 1998b). The data from this publication became the hydrology design basis for the CD1 and CD2 facility design.

2001. CD1 and CD2 Model runs for the 2- and 10-year floods were completed in the spring of 2001 (Baker 2001). The purpose of this analysis was not for design but to address permit stipulations required by the Army Corps of Engineers regarding floodwater monitoring around CD1 and CD2 facilities. The 1998 mesh was used to model pre-Alpine conditions during the 2- and 10-year events. The mesh was then modified to reflect as-built configurations at Alpine, including the addition of a second smaller bridge and the widening of the larger bridge to account for vertical abutments. The modified model was then run to simulate 2- and 10-year flood conditions with facilities in place.

2002. CD3 and CD4 The model was updated again in 2002 to incorporate the proposed CD3 (CD-North) and CD4 (CD-South) satellite developments. The model was used to evaluate the impacts of the proposed facilities on water surface elevations and velocities near existing (CD1 and CD2) and proposed facilities. Model runs for the 10-, 50-, and 200-year flood events were completed. Modifications to the model included new topography at the CD3 and CD4 facility locations and modifications to the mesh to include the proposed facilities. Topography changes were made only on the floodplains; no channel modifications were made. Boundary conditions were not changed for the 2002 model (see Section 3 for a description of boundary conditions). The update results were published in May 2002 (Baker 2002).

2004. CD5 In March of 2004, another modeling report was published to support the original proposed CD5 access road and bridge alignment (Baker 2004). The modeling was conducted during the early stages of the CD5 design. Modeling supported both the engineering design process as well as the development of the ASDP environmental impact statement (EIS) (BLM 2004). New channel topography at the originally proposed bridge crossing (near CD2) was added to the model as well as updates for the finite element mesh to simulate the proposed road. Three bridge lengths were modeled to evaluate the hydrologic and hydraulic effects of the CD5 road and bridge on existing facilities. Eleven model runs were completed for the different bridge lengths at the 10-, 50-, and 200-year flood events.

2006. Updated CD5 At the time of the 2004 analysis, the CD5 project was still in the conceptual design stages and the initial results were published to support the EIS analyses. The proposed CD5 Nigliq Channel Bridge was located due west of the CD2 pad. The 2006 design had the Nigliq Bridge approximately 1,000 feet north of the initial location. The 2006 bridge location, modified road alignment, and the inclusion of 2005 survey data at the new bridge site were the only changes made to the model since the 2004 publication. The updated results were published in February 2006 (Baker 2006a).

2006. CD2 Qannik Extension In June of 2006, the model was slightly adjusted to accommodate the proposed gravel extension of the CD2 pad; Qannik Project. Mesh geometry and scatter data were only modified to reflect the proposed Qannik extension. As expected, the resulting model runs revealed no impact to flood waters near existing and proposed facilities. The results of this modeling effort were published as a project note (Baker 2006b).

2009. Updated CD5 In 2008, a new CD5 access road alignment was proposed. The new alignment has been moved upstream, to a location approximately 4,000 feet north and west of the CD4 pad. The proposed CD5 access road originates at the CD4 access road and traverses west 6.0 miles across the Delta into NPRA to the CD5 pad location. Three bridges are currently proposed; Nigliq Channel, Lake L9341, and Nigliagvik Bridges.

Advances in computing power, modeling capability, and available data warranted the development of a refined two-dimensional mesh for the Colville Delta. The new mesh has more definition and will result in more detailed simulation results. The new mesh was developed from updated topographic and bathymetric survey data to reflect existing and proposed facilities within the Delta as accurately as practical. The development of the new mesh and resulting model simulations are described in detail throughout this report.

TABLE 2.1 OVERVIEW TWO-DIMENSIONAL MODEL NOMENCLATURE

Year	Alpine Facilities	Model referred to as
1998 / 2001	CD1 and CD2	original CD1/CD2 models
2002	CD3 and CD4	CD3/CD4 model
2004 / 2006	CD5 and Qannik	Old CD5 model
2009	CD5	New CD5 model

3 2009 MODEL UPDATE AND ENHANCEMENTS

3.1 MODELING SOFTWARE

The two-dimensional model is the product of two computer programs. The finite element mesh is developed using a pre- and post-processing software titled Surface Modeling System (SMS) developed by Brigham Young University. The original model was developed using version 4.1. Subsequent analyses were developed using versions 6.0, 7.0, 8.0, and 9.0. The current model update used the most recent update to SMS, version 10.0. SMS is not only used to create the finite element mesh, but also to review and analyze the results and generate output graphics.

The numerical computations of the model have been performed by the software Finite Element Surface-Water Modeling System (FESWMS): Two dimensional Flow in a Horizontal Plane, developed by the U.S. Geological Survey. FESWMS version 2 (modified specifically for the original model by David Froehlich, one of the original authors, to handle a greater number of elements) was used for the original analysis and subsequent analyses through April 2001 (Froehlich 1996). Version 3.2 of FESWMS supplied by EMS-I (the supplier of SMS) was used for all other historic analyses. The 2009 model update used the recent FESWMS: Depth-Averaged Flow and Sediment Transport Module (FST2DH) version 3.3.2, available through SMS 10.0 and provided by EMS-I.

3.2 TOPOGRAPHIC BASE MAP

Several areas of the topographic base map developed as part of the old CD5 model (Baker 2006a) were enhanced in the vicinity of the proposed bridge crossings and the west floodplain of Nigliq Channel near the CD2 Pad. The extent of new topography is presented in Figure B 1 and Figure B 2.

Bathymetric and topographic survey data were collected by LCMF in the fall of 2008 at each of the proposed CD5 bridge crossings (Nigliq Channel, Lake L9341, and Nigliagvik) (LCMF 2008a). Additional survey data was collected upstream of the proposed Nigliq Bridge crossing in support of the model update (LCMF 2008b). The data were provided in vertical datum BPMSL and horizontal datum NAD83, Alaska State Plane, Zone 4. The original model and subsequent updates were in NAD27, Alaska State Plane, Zone 4 horizontal datum. The model was converted to NAD83 using the coordinate conversion tool in SMS 10.0. The vertical datum was unchanged. All model runs and reporting are now in the NAD 83 horizontal datum.

Photogrammetric survey data provided by Aero-Metric Inc. was used to enhance the area north of the Nigliagvik and west of the CD2 pad. Photogrammetric data was based on aerial imagery collected in 2004 (AeroMap U.S. 2005). Survey data used to update the 2006 model from the area west of the Nigliq Channel was used to check accuracy of photogrammetric data. Stated vertical accuracy of the photogrammetric survey was approximately one half of the two foot contour interval. A comparison of the photogrammetric data and the survey data showed the photogrammetric data was within the stated one foot accuracy and used as part of the basemap.

Data points were added to the topographic basemap in areas where ground surface interpolation to the mesh would cause abnormal surface features in the model. This was most common in-channel where point data along banks falsely influenced contour interpolation of the channel thalweg. Supplemental data points were linearly interpolated between existing points to provide a smooth transition in areas of increased mesh density.

3.3 Finite Element Mesh

The finite element mesh was originally generated in 1997 and has since undergone a number of modifications to incorporate proposed and subsequently constructed facilities within the Delta. The initial mesh was limited in nodal density due to computational limitations of computers at the time and the ability of the FESWMS program to handle a large number of nodes. Though the FESWMS code was modified by one of the original authors (Froehlich) to handle an increased number of nodes specifically for the 1997 model, mesh refinement was still limited to areas of hydraulic importance. Typical mesh modifications consisted of increasing nodal density at proposed facilities to provide greater local definition.

With increased computing power, enhanced mesh generation tools, and a revised finite element modeling code, the development of a highly refined mesh is possible. The existing mesh was updated and enhanced for the new CD5 model. Mesh design is extremely important in the modeling process because the mesh controls the resolution or detail of the numerical computations and results.

A number of methods can be employed to generate a mesh, including manual, triangulation, and automated methods. The new CD5 mesh was created using both automated and manual methods. Because of the size and desired resolution of the final mesh, a master mesh was constructed from the sequential addition of smaller mesh areas. The shape, size, and location of these feature objects were based on georeferenced topographic base maps, raster images, and AutoCAD DWG and DXF files. Polygons are created to define each feature type (e.g., river, overbank, road) and land use type. Land use types are classified into material properties which are assigned specific hydraulic roughness and kinematic eddy viscosity values. Once feature objects are defined, a mesh of elements can be created.

The updated topographic base map, aerial imagery (AeroMap U.S. 2004 and 2006), as-built DWG files for existing facilities, DWG files for proposed facilities, and material boundaries from the old CD5 model were all used for mesh generation. The initial mesh was generated from feature objects using automated tools available in SMS. The resulting two-dimensional mesh consists of nodes which are connected by nodestrings to define an element; an assemblage of which should accurately represent pertinent topographic features of the modeled area. To best maintain the accuracy of the topographic base map, referred to in SMS as a scatter set, nodes are typically placed at established scatter points. The automated mesh generation feature will generally place nodes at scatter points; however, the number and location of these nodes typically does not adequately represent local topography. Mesh nodes were manually moved, added, or deleted to provide the best distribution possible after automated mesh generation. The "best distribution" of nodes and associated nodestrings is rather subjective and dependent on a wide range of variables specific to local conditions. However, there are a number of guidelines that help the finite element analysis converge at a better solution.

Because an element can only be assigned one material property value, each element should conform to a region of homogeneous roughness (lake, vegetation type, sand dune, etc.). Various aspects of an element's shape must also be considered; interior angles, aspect ratio, size, linear or curved sides, triangular or quadrangular shape. The resulting network of elements should yield smooth contours and boundaries that allow flow to progress without interruption. Elements must transition in size gradually as mesh detail changes. Steep slopes and banks should be represented by smaller elements, particularly at flow boundaries, to accurately model water surface elevations, horizontal flood limits, and cross sectional flow areas. Mesh quality was consistently checked using the *Mesh Quality* visualization tool in SMS. Elements were adjusted to maximize adherence to established guidelines.

The final mesh of the new CD5 model is presented in Figure B 3.

Mesh density increased nearly two-fold between the old and new CD5 models. In-channel mesh density increased both across channel and in the direction of flow. Cross channel mesh density was greatest near banks to capture the rapid transition in topography of steep banks. Nodal wetting and drying can significantly impact water surface elevation, flow area, and model convergence particularly when flow is confined within the channel. Allowing more elements to "turn on" (see Section 3.5) provides a better spatial distribution of flow and in turn more accurate water surface elevations and velocities. Increased mesh density in the direction of flow was most common at bends, bifurcations, contractions, and expansions where velocity magnitude and orientation can change rapidly.

Once the final mesh had been generated, material properties were assigned to each element. The number of material properties and associated design parameters (roughness and eddy viscosity) did not change between models. The distribution and limits of each material property changed slightly due to changes in mesh density and topography, and enhanced aerial imagery. Material properties distribution changed little between the first 1997 model and the 2008 model. Distribution of material properties of the new CD5 model is presented in Figure B 4.

3.4 Boundary Conditions

Downstream and upstream boundary conditions were unchanged. The following sections summarize the boundary conditions used.

3.4.1 Downstream Boundary

The downstream boundary condition was set at a constant water surface elevation of 3.0 feet (BPMSL) for all modeled flood events. The water surface elevation of 3.0 feet was based on conditions observed during the 1996 breakup and thought to be conservative. Water surface elevation measurements made near the coast since 1996 suggest the downstream boundary condition is still reasonable. No field observations to date suggest a change in the downstream boundary condition is necessary.

3.4.2 Upstream Boundary

The upstream boundary condition is based on a steady state discharge. Discharge values are based on design flood frequency estimates for the Colville River (Baker and Hydroconsult 2002). A flood frequency analysis performed in 2006, supplemented with recent discharge data, supported the 2002 estimates (Baker 2007). A summary of design flood frequency estimates is presented in Table A 1. Discharge due to spring flooding is generally not a steady state condition and flood peaks are attenuated by natural features of the Delta (i.e., temporary floodwater storage). As a result, the steady state conditions of the two-dimensional model are considered to be somewhat conservative.

3.5 Modeling Parameters

Element Status. The extent of flow across the mesh is dependent upon the status of elements within the mesh. Elements are either turned "on" or "off." Elements that are turned off are generally those that are dry or only partially covered with water and are not considered in the numerical computations. In some cases, an element may be completely covered with water yet it is turned off. The on/off status of an element is dependent on a user-defined depth tolerance and a user-defined storativity depth.

The depth tolerance indicates the required depth of water to rewet a dry node. Typically, a depth tolerance greater than zero is used to avoid computationally unstable oscillations in the wet/dry status of an element. The depth tolerance has been changed to 0.5 feet from 1.0 foot used in previous models. In effect, an element that is turned off would not be turned on unless the local water surface elevation was at least 0.5 feet above the highest corner node in that element.

The storativity depth allows an element to remain wet and computationally active even though the highest node of the element is dry. This is particularly useful for large elements that represent varied terrain. If these elements were turned off, the removal of such large volumes of water could significantly impact the resulting flow distribution. Element size relative to local relief in the new CD5 model and a sensitivity analysis of varied storativity depths did not warrant deviating from the default storativity depth of 0.0 feet established in SMS. As a result, elements were turned off if water dropped below the highest node in the element.

3.6 Model Validation

To validate the new CD5 model, various attributes and model solutions from the old and new CD5 models were compared. In all cases, existing "pre-CD5" conditions were evaluated, i.e., simulations without the proposed CD5 infrastructure in the model. Predicted water surface elevations and flow distribution across the Delta were compared between the old and new model. Variations in modeled ground surface elevations were a result of new topographic scatter data, increased mesh density, and node placement. Changes in predicted water surface elevations occurred in various locations as a result of changes in the ground topography data and node status. The validation exercise was to ensure the model output wasn't significantly different, or if it was, to verify why.

3.6.1 Water Surface Elevations

Water surface elevations for the 200-, 50-, and 10-year flood conditions using the old and new CD5 models were compared. The greatest significant difference for all flood conditions was an increase in overbank floodwater coverage. Figure B 5, Figure B 6, and Figure B 7 show the difference in water surface elevation between the new and old CD5 models for the 200-, 50-, and 10-year conditions, respectively. Dark red regions identify floodwater coverage in the new model that was not captured in the old CD5 model. The greater overbank floodwater coverage in the new model was due to the greater density of elements and the lowering of the depth tolerance from 1 to 0.5 feet. This caused elements to "turn on" which were off in the previous model.

The most pronounced differences in water surface elevation occurred under the 10-year flood condition. The 1997 model was originally designed to provide insight into open water flooding conditions for large magnitude floods (200- and 50-year events). Computational and program limitations required that a limited number of nodes and elements be used to represent the 574 square mile model. The limited number of nodes and associated elements provided little detail to model low magnitude floods with significant confidence. Subsequent models increased in detail near proposed facilities where the scatter had been updated but the mesh changed little overall. The new model provides far more detail, both in the floodplain and within channels, providing a better platform on which low magnitude floods can be modeled. Therefore, it is not surprising that differences in floodwater coverage are more pronounced for the lower magnitude flood models.

Increases in predicted water surface elevations were noted along the east side of the CD1 and CD4 pads, and the CD4 access road. Water surface elevations were 0.5 feet (200-year), 0.6 feet (50-year), and 1.0 feet (10-year) higher than the old model had predicted in this region. The increase in predicted water surface elevation was due to better topographic detail and a denser mesh which caused more conveyance of water toward this area, particularly out of the Sakoonang Channel.

West of the Nigliq Channel near CD2, overall predicted water surface elevations changed little; however, increases in floodwater distribution were evident. The model mesh was improved considerably in the area with both new topography and a denser mesh design.

Water surface elevations at discrete locations across the Delta and around facilities from the 1998, 2002, and 2009 pre- and post-CD5 models are presented in Appendix A. A comparative discussion of this data is presented in Section 4.

3.6.2 Flow Distribution

Observation arcs were used in SMS to approximate flow in the East, Nigliq, Sakoonang, Tamayagiaq, and Ulamnigiaq channels (Figure B 8). Flow distribution was estimated immediately downstream of the divergence of the channel where flow was confined on the right and left overbank. For example, flow distribution was extracted for the East and Nigliq channels immediately downstream of the Putu Channel.

To estimate discharge at defined locations, flow area and velocity were pulled from the model at no less than 20 points along each cross section. This method is similar to standard USGS discharge measuring techniques. Table 3.1 presents the distribution of flow as a percent of the total design discharge for the 200-, 50-, and 10-year flood events from the old and new CD5 models. Flow distribution at specified locations varied by no more than 1% of the respective design discharge between the old and new CD5 models. Table 3.2 compares the calculated discharge directly between the old and new models. These locations are identical to those presented in Table 3.1.

Overall flow distribution varied little throughout the Delta relative to the design discharge. Differences in predicted discharge through the Sakoonang and Tamayagiaq channels were greater when comparing discharge directly. Changes in this area are not surprising based on the revised topography and more defined mesh. These results also corroborate the rise in water surface elevation east of CD1 and CD4 discussed in the previous section.

No major changes in flow patterns were observed and no major variations in water surface elevations were observed to indicate the new model is significantly different than the old. The topographic updates and improvements to the mesh improve the model and provide a better representation of the likely conditions during high flood events.

TABLE 3.1 COMPARISON OF FLOW DISTRIBUTION ACROSS COLVILLE RIVER DELTA FOR 200-, 50- AND 10-YEAR FLOOD EVENTS FROM OLD CD5 (2006) AND NEW CD5 (2009) MODELS

Location (1)	200-year (2)		50-year (3)		10-year (4)	
	Old	New	Old	New	Old	New
East Channel	77%	76%	78%	79%	81%	80%
Nigliq Channel	23%	24%	22%	21%	19%	20%
Sakoonang Channel	3%	3%	3%	3%	1%	2%
Tamayagiaq Channel	6%	6%	6%	5%	6%	5%
Ulamnigiaq Channel	2%	2%	3%	2%	3%	3%

Notes:
1. The location of measurement is immediately downstream of the respective channel's divergence from upstream channels or as it is confined by bridge abutments (CD2 Long and Short Bridges).
2. The 200-year design discharge is 1,000,000 cubic feet per second.
3. The 50-year design discharge is 730,000 cubic feet per second.
4. The 10-year design discharge is 470,000 cubic feet per second.
5. Percent distribution is the estimated discharge relative to the total discharge.

TABLE 3.2 COMPARISON OF FLOODWATER DISCHARGE AT SELECT LOCATIONS FOR 200-, 50- AND 10-YEAR FLOOD EVENTS FROM OLD CD5 (2006) AND NEW CD5 (2009) MODELS

Location (1)	200-year		50-year		10-year	
	Old	New	Old	New	Old	New
East Channel	746,700	756,200	547,100	574,700	372,100	370,900
Nigliq Channel	227,700	234,500	151,400	153,400	88,600	92,900
Sakoonang Channel	32,100	32,500	20,000	19,400	4,600	11,200
Tamayagiaq Channel	60,100	59,200	43,300	34,000	29,700	22,700
Ulamnigiaq Channel	19,500	21,100	18,300	16,100	13,300	13,700

Notes:
1. The location of measurement is immediately downstream of the respective channel's divergence from upstream channels or as it is confined by bridge abutments (CD2 Long and Short Bridges).

4 RESULTS AND DISCUSSION

The new CD5 model was used to complete model runs for the 200-, 50-, 10-, and 2-year flood events for both existing conditions and post-CD5 conditions. The finite element mesh was constructed to simulate the proposed CD5 facilities including the proposed bridges and gravel road (PND 2008a and 2008b). For post-CD5 conditions, the height of the gravel road was set to prevent water from flowing over it at any point. CD5 roadway openings were placed at the Nigliq Channel, Lake L9341, and Nigliagvik crossings to represent bridges placed in these locations. The left and right bank limits of bridge openings were based on preliminary bridge designs. Culverts for local drainage were not included in the model as they would not affect the overall hydraulic conditions being represented.

The new CD5 modeling results are divided into five groups for reporting. These groups are based on past modeling exercises. The grouping allows comparisons to past results and provides a segregation of data for specific facilities. The groupings are:

- Colville River Delta,
- CD1 and CD2 facilities and Alpine pipeline,
- CD3,
- CD4, and
- CD5 facilities.

Discussions of each are presented in the following sections. Related tables and figures are located in Appendix A and Appendix B, respectively. Within each group, results are divided into three subsets where applicable.

- Model Upgrade: CD3/CD4 & 2009 Pre-CD5 Model Conditions presents a comparison of results from the CD3/CD4 model mesh (2002) and new 2009 Pre-CD5 model mesh. This comparison presents changes in predicted existing conditions as a direct result of the new refined mesh, building on data presented in the model validation section (3.6).
- CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions identifies the hydrologic changes from the CD5 facilities by presenting a direct "pre" and "post" comparison. This provides a clear understanding of the predicted impacts due only to proposed facilities, rather than those associated with the refined mesh.
- Facilities Design Criteria: Impacts of 2009 Model Conditions is presented to provide the cumulative impact of facilities construction and model development where data has historically been used to provide flood design criteria. Predicted water surface elevations from the 2009 post-CD5 model conditions are used to establish new flood design criteria, which are compared with historic flood design criteria and existing as-built conditions to confirm adequate construction of existing facilities as it pertains to floodwater.

4.1 COLVILLE RIVER DELTA

Predicted water surface elevations for the 10-, 50-, and 200-year floods in the main channels throughout the Delta are presented in Table A 2 through Table A 4. In addition to presenting the new modeling results with existing pre-CD5 and proposed post-CD5 facilities, these tables present the results from the original CD1/CD2 model runs, and CD3/CD4 model runs. The tables present data at identical locations used in past studies. Channel locations and mile indicators are presented on Figure B 9.

Model Upgrade: CD3/CD4 & 2009 Pre-CD5 Model Conditions

The most significant changes occurred for the 10-year flood event. Predicted water surface elevations increased as much as 1.3 feet at mile 9.80 of the Sakoonang Channel, likely as a result of the more defined mesh at the Sakoonang bifurcation allowing more flow into the channel. Near the downstream boundary of the model, water surface elevations changed little. Differences in water surface elevation were less pronounced for the 50-year and 200-year flood events. Predicted water surface elevations increased in all channels except near the downstream boundary for the 50-year event. Water surface elevations increased by as much as 0.5 feet near mile 15.07 of the Nigliq Channel and decreased by as much as 0.2 feet near mile 8.20 of the Tamayigiaq Channel. For the 200-year event, elevations increased by as much as 0.3 feet at mile 9.47 of the Nigliq Channel and decreased by as much as 0.3 feet near the downstream boundary in the Nigliq, Sakoonang, and Tamayigiaq channels.

CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions

Little change occurred in the main channels of the Delta as a result of the proposed CD5 facilities. Water surface elevation predictions increased on the Nigliq Channel upstream of the proposed Nigliq crossing; however, these increases are relatively local. Predicted water surface elevation increases are less than 0.1 feet on the Nigliq Channel during the 50- and 10-year flood events.

4.2 CD1 AND CD2 FACILITIES AND ALPINE PIPELINE

4.2.1 ALPINE PIPELINE

Peak water surface elevations from the CD1/CD2 model, CD3/CD4 model, and the 2009 pre-CD5 (existing facilities) and post-CD5 (proposed facilities) models along the Alpine pipeline for the 50- and 200-year floods are presented in Table A 5 and Table A 6, respectively. The locations of the CD1 and CD2 facilities are presented in Figure B 10.

Model Upgrade: CD3/CD4 & 2009 Pre-CD5 Model Conditions

Predicted water surface elevations increased at all but two locations (PI 13A and PI 15A) in the 2009 pre-CD5 model for both the 50- and 200-year flood events. Values typically increased by 0.4 feet and 0.2 feet for the 50- and 200-year events, respectively. Maximum increases of 0.6 feet

(PI 07) and 0.3 feet (PI's 10 through 12A) were predicted for the 50- and 200-year flood events, respectively.

CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions

A maximum increase of 0.1 feet in predicted water surface elevation for the 50-year flood event was observed at PI 08 and PI 09. A maximum increase in predicted water surface elevations for the 200-year event of 0.2 feet occurred at PI 07 and a typical increase of 0.1 feet at all locations north of PI 13A. No change was observed at PI's 13A through 15A.

4.2.2 Permanent Staff Gages

The peak water surface elevations resulting from the CD3/CD4 model and the 2009 pre- and post-CD5 models for the 10-year flood event at Alpine permanent staff gage locations are presented in Table A 7. Locations of permanent staff gages are shown in Figure B11. The permanent staff gages were installed to monitor water surface elevations during spring floods.

Model Upgrade: CD3/CD4 & 2009 Pre-CD5 Model Conditions

The 10-year flood event yielded the greatest change in water surface elevations across the Delta between the CD3/CD4 model and 2009 pre-CD5 model. Water surface elevations increased at all staff gages but one which had a decrease of 0.2 feet (Staff Gage 7). All other locations increased from 0.2 feet (Staff Gage 8) to 1.2 feet (Staff Gages 9 and 10). An increase of 1.0 feet was predicted at Staff Gage 1 located on the bank of the Sakoonang Channel near CD1.

CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions

Predicted water surface elevations at the permanent staff gages did not change between the 2009 pre- and post-CD5 models for the 10-year flood event.

4.2.3 Gravel Facilities

Changes in peak water surface elevation between the CD3/CD4 model results and the 2009 pre- and post-CD5 model conditions along the CD1/CD2 gravel facilities for the 50- and 200-year floods are presented in Table A 8 and Table A 9, respectively. Stationing along the CD2 access road is shown on Figure B 12.

Model Upgrade: CD3/CD4 & 2009 Pre-CD5 Model Conditions

Predicted 2009 pre-CD5 water surface elevations for the 50-year condition on the upstream (south) side of the CD2 access road increased 0.3 feet and 0.4 feet west and east of the CD4 access road, respectively. Downstream (north) of the CD2 access road predicted water surface elevations increased by no more than 0.1 feet. The 200-year 2009 pre-CD5 condition yielded a maximum water surface elevation increase of 0.3 feet west and 0.2 feet east of the CD4 access road on the upstream side of the CD2 access road. Downstream water surface elevations remained constant or dropped 0.1 feet. Around the CD1 pad water surface elevations increased as much as 0.5 feet and 0.2 feet for the 50- and 200-year events, respectively. The greatest increases occurred at the southwest corner of the CD1 pad; this area is influenced by the increased flow in the Sakoonang Channel. The CD2 pad saw a maximum increase of 0.2 feet at the southeast corner for both the 50- and 200-year flood events. These changes are representative of those predicted in the Nigliq and Sakoonang channels.

CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions

There was little change in predicted water surface elevations around CD1 and CD2 gravel facilities due to the proposed CD5 facilities. No changes in water surface elevation were predicted for the 50-year flood event between the 2009 pre- and post-CD5 models. The 2009 post-CD5 model predicted 200-year water surface elevations approximately 0.1 feet lower than predicted by the pre-CD5 model upstream of the CD2 access road and west of the CD4 access road. Water surface elevations did rise 0.1 feet east of the CD4 access road. These changes are due to the backwater effect of the proposed road, diverting water around CD4 to the east. Downstream of the CD2 access road water surface elevations remained constant between 2009 pre-CD5 and post-CD5 model conditions.

Facilities Design Criteria: Impacts of 2009 Model Conditions

Design elevations of the original CD1/CD2 facilities and subsequent CD3/CD4 facilities were based on three criteria; design flood elevations, thermal design conditions, and wind wave requirements. The greatest elevation based on these criteria ultimately determines the design heights of the facilities. The two-dimensional modeling provided the design flood elevations.

Facility pads were designed for flood elevations based on the 200-year flood event plus 1 foot of freeboard. The CD1 design elevation was 19.0 feet (Baker 1998a) and is generally governed by thermal design. As-built elevations of the CD1 pad range from 17 to 20 feet around its periphery (LCMF 2000). The highest predicted 200-year flood elevation at the CD1 pad is 15.8 feet for the post-CD5 condition. Including the 1 foot of freeboard the minimum CD1 pad elevation remains above the design flood elevation criteria and current as-built elevation. The CD2 pad design elevation was 15.9 feet (Baker 1998a) and as-built elevations ranged from 15.6 to 16.0 feet (LCMF 2001) near the pad's periphery. The maximum predicted flood elevation near the CD2 pad for the 200-year event is 14.1 feet during the 2009 post-CD5 condition. Adding the 1 foot of freeboard puts the CD2 design elevation criteria at 15.1 feet. The CD2 pad remains above the flood elevation criteria.

Design criterion for the CD2 access road, with the exception of the Swale Area (portion of road containing the long and short swale bridges), was the 50-year flood elevation plus 3 feet of freeboard based on the 1998 model. The design elevation for the road established in 1998 was 15.9 feet (Baker 1998a). The 2009 predicted 50-year water surface elevation is 13.4 feet east of the CD4 access road along the south side of the Alpine airstrip. Design criteria established in 1998 is 2.5 feet above the 2009 post-CD5 design elevations east of the CD4 tie-in. West of the CD4 tie-in, the highest predicted 50-year water surface elevation along the CD2 road is 12.2 feet based on the 2009 model. Design criteria established in 1998 is 3.7 feet above the predicted water surface elevation.

The Swale Area of the CD2 access road was designed to a lower elevation than the rest of the road and did not have the same criteria with respect to flood elevations. The low cord of the swale bridges (design elevation 10.8 feet) were designed lower than the 50-year flood elevation and the bridge deck (design elevation 13.0 feet) was designed to be overtopped by the 200-year flood event, but not the 50-year event. A maximum increase of 0.4 feet is predicted in the Swale Area by the post-CD5 model for the 50- and 200-year flood events. Based on predictions from the 2009 model runs and design elevations, the bridges will not be overtopped during the 50-year flood event (maximum water surface elevation of 12.0 feet in Swale Area), but will be during the 200-year event (water surface elevation of 14.0 feet). While the water surface elevation increases by 0.4 feet during the 200-year flood event, there is no change in the Swale Area design conditions.

4.3 CD3 Facilities

4.3.1 Gravel Facilities

The peak water surface elevations and water velocities for the 200-year flood event predicted by the CD3/CD4 model and 2009 pre- and post-CD5 models are presented in Table A 10. The differences between CD3/CD4 and 2009 post-CD5 model results are also presented. Only the 200-year flood conditions are provided since the pad and airstrip are based on 200-year design criteria and no major roads are present. The CD3 pad and stationing along the CD3 pipeline is shown on Figure B 13.

Model Upgrade: CD3/CD4 & 2009 Pre-CD5 Model Conditions

Water surface elevations decreased as much as 0.3 feet and increased as much as 0.5 feet between the CD3/CD4 model and 2009 pre-CD5 condition during the 200-year event. Predicted water surface elevations dropped from 7.9 to 7.6 feet at the southwest corner of the CD3 pad. Near the mid-point of the airstrip, on the south side, predicted water surface elevations increased from 7.8 to 8.3 feet. The maximum predicted velocity is 2.5 feet per second at the southwest corner of the pad during the 200-year event. The CD3 area is heavily influenced by the Sakoonang and Tamayigiaq channels which diverge off the East Channel. Water surface elevation changes in the Sakoonang, Tamayigiaq, and Ulamnigiaq channels (Section 4.1) suggest the difference in predicted water surface elevations around CD3 are a result of increased mesh density at the bifurcation of these channel.

CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions

The proposed CD5 development had little to no impact on the hydrology at CD3. The facilities are far enough downstream not to be influenced significantly by the proposed CD5 facilities.

The only difference in water surface elevation was an increase of 0.1 feet at the runway, which is likely exaggerated from rounding values to the nearest 0.1 feet.

Facilities Design Criteria: Impacts of 2009 Model Conditions

The CD3 pad and airstrip sit on the floodplain between the West and East Ulamnigiaq channels. Water depths in this area are predicted to be less than 2.5 feet during the 200-year event. As-built elevations (LCMF 2005a) of the CD3 road and airstrip range from 12.5 feet (north side of pad) to 14.8 feet (airstrip). The CD3 facilities are no less than 4.1 feet above the maximum 200-year flood elevation, satisfying the flood design criteria of Q200 plus 1 foot of freeboard.

4.3.2 CD3 Pipeline

Peak water surface elevations and water velocities for the 200-year flood event along the CD3 pipeline are presented in Table A 11 and the location of and stationing along the pipeline is presented in Figure B 13.

Model Upgrade: CD3/CD4 & 2009 Pre-CD5 Model Conditions

Decreases in water surface elevations are predicted at all but a few locations along the entire length of the pipeline. The difference in water surface elevations range from a decrease of 0.5 feet (Station 160+00) to an increase of 0.6 feet (Station 200+00). Flow velocities increased by as much as 0.5 feet per second (Station 320+00) and decreased by as much as 1.7 feet per second (Station 70+00).

CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions

The influence of the CD5 facilities on the CD3 pipeline is limited to stations near CD1. Water surface elevations do not change north of the Sakoonang crossing (approximately Station 260+00). South of the Sakoonang channel water surface elevations increase on the order of 0.1 feet. Velocities remain constant along the entire length of the CD3 pipeline.

4.4 CD4 Facilities

4.4.1 Gravel Facilities

The peak water surface elevations and velocities for the 50- and 200-year flood events for the CD3/CD4 model and 2009 pre- and post-CD5 models along the CD4 gravel road and pad are presented in Table A 12 and Table A 13, respectively. The location and stationing of the CD4 access road is presented in Figure B 14.

Model Upgrade: CD3/CD4 & 2009 Pre-CD5 Model Conditions

The average water surface elevations during the 200-year flood event (the design event for the pad) in the vicinity of the CD4 pad changed from 16.1 feet to 16.4 feet and the maximum predicted water surface elevation changed from 16.4 to 16.7 feet. Velocities remained relatively constant except for those near the southeast corner of the pad, where they increased from 0.3 feet per second to 0.7 feet per second.

The CD4 access road alignment was changed after the CD3/CD4 model had been developed. The new 2009 model contains the actual CD4 road alignment so a direct comparison of values south of Station 145+00 is not possible. Water surface elevations range from 11.9 feet near the north terminus to 14.2 feet near the southern end of the road. Along the west side of the road, water surface elevations range from 11.9 feet near the north terminus to 14.7 feet near the southern end. Predicted velocities changed little on either the east or west side of the CD4 access road. The greatest increase in velocity occurred near the CD2 access road on the west side, going from 0.2 feet per second to 0.5 feet per second.

CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions

The post-CD5 model condition predicted an average water surface elevation of 16.6 feet for the 200-year event near the CD4 pad with a maximum predicted water surface elevation of 16.9 feet at the southeast corner. This accounts for a maximum increase in water surface elevation of 0.2 feet resulting from backwater generated by the proposed CD5 facilities. Predicted velocities remain relatively unchanged at the corners of the CD4 pad.

The greatest change in water surface elevations occurs along the west side of the CD4 access road in the vicinity of the CD5 road tie-in. Water surface elevations during the 50-year flood event on the west side of the CD4 road decrease by as much as 1.4 feet north (downstream) of the proposed CD5 road tie-in. Water surface elevations increased south (upstream) of the CD5 road 0.1 feet. Water surface elevations ranged from 11.9 feet near the CD2 access road to 14.3 feet near the CD4 pad. Predicted water surface elevations on the east side of the CD4 road changed little with a maximum increase of 0.1 feet. Velocities varied by no more than 0.1 feet per second on both the west and east sides of the CD4 road, with the exception of the maximum estimated velocity of 0.8 feet per second immediately north (downstream) of the proposed CD5 access road. Flow was entirely eliminated from this location as a result of the CD5 road, reducing velocity from 0.8 to 0.0 feet per second.

Facilities Design Criteria: Impacts of 2009 Model Conditions

A review of the CD4 As-Built Survey (LCMF 2005b) shows the average pad elevation at approximately 19.5 feet. The maximum predicted water surface elevation near the CD4 pad during a 200-year event for post-CD5 conditions is 16.9 feet. With the addition of 1 foot freeboard, the CD4 pad remains well above the minimum design flood elevation (17.9 feet).

The proposed CD4 road alignment used in the 2002 CD3/CD4 model varied from the constructed alignment south of Station 145+00. The modeled road continued straight south crossing Lake L9323 at a constriction between the eastern and central lobes of the lake. The constructed road was diverted around the east side of lake with culvert batteries positioned north and south of the lake. The maximum 50-year water surface elevation predicted by the 2002 post-CD3/CD4 model was 13.8 feet along the proposed CD4 access road, dictating a design criteria with 3 feet of freeboard of 16.8 feet. According to the CD4 As-Built Survey (LCMF 2005b), a minimum road elevation of 16.9 feet occurs at the south culvert battery, meeting the 2001 design criteria. Maximum water surface elevations predicted by the 2009 post-CD5 model for the 50-year flood event occur near the south culvert battery at an elevation of 14.8 feet. Current road elevations at the south culvert battery are 2.1 feet above design flood elevations. At the north culvert battery, the post-CD5 design elevation (50-year water surface elevation of 14.3 feet) is 2.7 feet above the finished road elevation of 17.0 feet. Current as-built survey elevations for the CD4 access road north of the CD5 road tie-in are above the 2009 post-CD5 design elevations plus 3 feet freeboard criterion.

4.4.2 CD4 Pipeline

The peak water surface elevations and velocities along the CD4 pipeline for the 200-year flood event from the CD3/CD4 model and 2009 pre- and post-CD5 models are presented in Table A 14. The location and stationing of the CD4 pipeline is presented in Figure B 14.

<u>Model Upgrade: CD3/CD4 & 2009 Pre-CD5 Model Conditions</u>

Predicted water surface elevations along the CD4 pipeline increased at all but two locations; stations 50+00 and 60+00 remained constant. Water surface elevations typically increased 0.2 feet, with a maximum predicted increase of 0.4 feet near the CD4 pad. Changes in predicted velocities varied along the pipeline, decreasing as much as 0.8 feet per second (from 1.2 to 0.4 feet per second) and increasing as much as 0.6 feet per second (from 0.8 to 1.4 feet per second).

<u>CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions</u>

Predicted water surface elevations increased along the entire length of the CD4 pipeline by as much as 0.2 feet due to backwater from the CD5 facilities. Predicted velocities remained relatively constant changing by no more than 0.1 feet per second.

4.5 CD5 Facilities

4.5.1 Gravel Facilities and Bridges

Predicted peak water surface elevations for the 50- and 200-year flood events for the CD3/CD4 and 2009 pre- and post-CD5 model conditions are presented in Table A 15 and Table A 16, respectively. Water velocities for the 50- and 200-year events are presented in Table A 17. The location and stationing of the CD5 access road is presented in Figure B 15.

<u>CD5 Impacts: 2009 Pre-CD5 & Post-CD5 Model Conditions</u>

The presence of the CD5 access road blocks flow across the floodplain west of the CD4 access road to the bluff defining the western boundary of the Colville River Delta. Backwater from the proposed road causes an increase of water surface elevations for both the 50- and 200-year design discharges upstream (south) of the road. Predicted flood extents and velocity distribution for the pre- and post-CD5 conditions during the 200-, 50-, 10-, and 2-year design flood events are presented in Figure B 16 through Figure B 31. Water surface elevations and velocities were extracted from model solutions approximately 50 feet upstream and downstream of the CD5 road centerline. The maximum increase in water surface elevation for the 50-year event is 0.7 feet and the maximum increase for the 200-year event is 1.0 feet. In both cases, the maximum rise in water surface elevation occurs between the Lake L9341 and Nigliagvik bridges. Predicted water surface elevations immediately upstream of the Nigliq Bridge are lower due to the draw-down of water as it accelerates through the bridge. Water surface elevation increases on the Nigliq Channel further upstream of the bridge do occur but are less than those predicted on either the right or left overbank floodplain. Impacts from the CD5 road and bridges are negligible for the 10-year flood event. Flooding extents for the 10-year event are generally within the main channel of proposed crossings and the presence of bridges does not cause additional backwater.

Water surface elevations downstream of the CD5 road decrease with the inclusion of the CD5 access road. The road blocks flow on the floodplains diverting it to the three bridge openings. Consequently, water surface elevations on the floodplain downstream of the bridge are reduced. Water continues to inundate the floodplain but water surface elevations are as much as 0.3 and 0.7 feet lower during the 50- and 200-year events, respectively.

Predicted velocities increase at the outlet of each bridge as flow accelerates to accommodate the concentrated flow. Predicted velocities reach as high as 9.5, 5.2, and 7.9 feet per second at the outlet of the Nigliq, Lake L9341, and Nigliagvik bridges, increasing by 1.1, 3.9, and 5.0 feet per second, respectively.

4.5.2 CD5 Pipeline

Predicted water surface elevations, velocities, and water depths for the post-CD5 model conditions for the 50- and 200-year flood events are presented in Table A 18. The location and stationing of the CD5 pipeline is presented in Figure B 15. The proposed CD5 pipeline is located on the downstream side of the CD5 access road to protect vertical support members (VSMs) from large floating ice pans and the pipelines cross the channels on the proposed bridges.

Predicted water surface elevations average 12.7 feet and 14.5 feet for the 50- and 200-year flood events, respectively. The maximum predicted velocities in the floodplain where VSMs would be impacted are 0.8 feet per second and 1.1 feet per second for the 50- and 200-year flood events, respectively. Predicted water depths in the floodplain range from 0.1 feet to 5.3 feet during the 50-year flood event. Water depths during the 200-year event range from 2.0 feet to 7.8 feet in the floodplain.

5 Bank Migration Analysis

5.1 Methods

Aerial photography was used to compare long-term bank migration between 1948 and 2006 channel bank locations. AeroMap U.S. and the U.S. Geological Survey (USGS) provided the photography. The 1948 USGS photography was provided as uncontrolled digital photo mosaics. The 2006 AeroMap U.S. photography was provided as a digital orthophotograph. The highest resolution on the 1948 photography was a five-foot by five-foot pixel and the 2006 was a one-foot by one-foot pixel. Portions of the 1948 and 2006 photography that covered the areas of interest were digitally cropped from the photo mosaic. The cropped 1948 photographs were then digitally rectified to the 2006 orthophotograph to match the scale and orientation of the two sets of photographic data. Aerial photographs of the three proposed bridge site taken in 1948 and 2006 are shown on Figure B 32 through Figure B 34. The 1948 and 2006 bank locations are superimposed on the respective images.

Channel bank lines near the bridge crossing were digitized on all sets of photography. Channel bank lines represent the interpreted edge of vegetation. The edge of vegetation may not always coincide with what would be surveyed in the field as the top of the bank, particularly in areas such as point bar complexes on the inside of meander bends. Topographic survey data from the summer of 2008 in the vicinity of the proposed crossings was used to validate channel bank lines (LCMF 2008a). However, in the absence of digital contour data upstream and downstream of the bridge alignments, vegetation lines are felt to provide the best representation of bank lines. Both the left and right banks were digitized in the areas of interest.

Positive values of bank migration denote erosion while negative values denote accretion. The resulting bank migration measurements are felt to be accurate to ±10 feet (plus or minus the width of two pixels on the 1948 photography) when differences in resolution, color, and quality between the two sets of photography are considered.

Average erosion rates were estimated for each bank. In this analysis, accreting banks are those that are interpreted to have been stabilized by the growth of vegetation (inboard of the 1948 vegetation line). Average bank migration and bank erosion rates were used to calculate predicted 30-year average bank migration and maximum erosion magnitudes.

5.2 Results

The road and bridge centerlines, 1948 and 2006 bank lines, and analysis results are presented in Figure B 32, Figure B 33, and Figure B 34. An assessment of historic and potential future river patterns and bank erosion is outlined in detail within the table sidebar on the respective figures.

5.2.1 NIGLIQ CHANNEL

Unlike the majority of channels in the Colville Delta, the erosional bank on the Nigliq Channel at the proposed bridge site is the left bank, and thus thawing or thermoerosion is not the driving erosive mechanism. Rather, erosion is due to the fact that the left bank at the bridge site is immediately downstream and on the outside of a meander bend. The western (left) bank at the point of the proposed Nigliq Channel Bridge has experienced 50 feet of erosion over the 58-year analysis period with an average rate of 0.9 feet per year. Given the location on the outside of a bend, this trend is expected to continue over the life of the project. The eastern (right) bank at the point of the proposed bridge has experienced a total accretion of 270 feet over the analysis period. The right bank, defined by established vegetation, is located on an old point bar and will likely fluctuate, eroding and migrating, over the life of the project. However, it is unlikely that the right bank will erode to the extent at which it will impact the proposed abutment.

5.2.2 LAKE L9341

Lake L9341 is the remnant of a paleo-channel which has become isolated from the main channel of the Nigliq. The western (left) bank at the point of the proposed bridge has experienced 16 feet of erosion over the 58-year period, averaging 0.3 feet per year. It is likely that the observed erosion was the result of spring ice floes scouring the shallow sloping west bank. The eastern (right) bank has experienced neither erosion nor accretion over the analysis period. Given the hydraulic isolation of the lake, predicted overbank flow patterns, and potential for ice floes, these trends are likely to continue over the life of the project.

5.2.3 NIGLIAGVIK

The Nigliagvik is bound on the western (left) bank by a bluff which marks the western limits of the Colville River Delta. The left bank at the bridge site forms the outside of a large radius meander bend and flow is directed along the west bank in that area. The left bank is perched on the bluff approximately 18 feet above the right bank. The eastern exposure suggests that thawing or thermoerosion is not the driving erosive mechanism. No undercutting has been documented to date at the proposed crossing. The western bank at the point of the proposed Nigliagvik bridge has experienced 6 feet of erosion over the 58-year analysis period with an average rate of 0.1 feet per year. This trend is expected to continue over the life of the project. However, there is potential for accelerated erosion during large flood events with high flood stages and high flow velocities along the left bank resulting from the proposed access road and bridge. The eastern (right) bank at the point of the proposed bridge has experienced a total accretion of 42.2 feet over the analysis period. Given the already small cross sectional flow area and limited rate of left bank erosion, this rate of accretion is expected to be less during the life of the project.

Historic erosion at the proposed crossings is a sound indicator of potential future bank erosion. Channel changes typical of meander bends several miles upstream of the proposed Nigliq

Channel and Nigliagvik crossings could increase erosion potential of the left (west) bank by increasing the attack angle of flow into the banks. Other important design factors such as floodwater heights, ground elevations, ice floe movements, and impact to flow caused by bridge abutments may govern final erosion distances. A 2.0 factor of safety is suggested to estimate maximum potential erosion at the three sites. Predicted erosion rates of left banks at the Nigliq Channel, Lake L9341, and Nigliagvik bridge crossings are 54, 18, and 6 feet, respectively.

6 BRIDGE SCOUR

6.1 INTRODUCTION

Bridge scour estimates were made for the three proposed bridges (Nigliq, Lake L9341, and Nigliagvik) to determine potential scour elevations for the design of bridge foundation members. Design scour elevations are based on the cumulative effects of contraction scour and local scour at bridge piers and abutments. All scour recommendations are based on the 200-year design flood conditions. Contraction scour estimates of lower magnitude floods at the three crossings are presented to illustrate the effect the bridge has on the natural scour of the respective channel.

All elevations are presented in the vertical datum feet BPMSL.

6.2 METHODS

Hydraulic data for the scour computations were obtained from the updated 2009 two-dimensional surface water model of the Colville River Delta. A one-dimensional HEC-RAS model of the Delta west of CD4 facilities was also developed as an independent method to estimate scour in the Nigliq Channel.

Bed Material

Determination of the D50 (diameter for which 50% of the soil particles are finer as determined from sieve analysis) was compiled from Duane Miller & Associates geotechnical investigations conducted along the proposed Nigliq Channel crossing in 2009 (Duane Miller 2009). The primary intent of these geotechnical investigations was to examine the deeper soils for bridge pier design purposes and limited D50 laboratory analysis was performed for samples collected near the surface. Available data provides a conservative estimate of particle sizes and was considered adequate for the analysis.

The shallowest sampling depths collected within the active channel ranged from 25 feet to 48 feet below ground surface (bgs). D50 values ranged between 4.2 mm and 6.8 mm at 25 feet to 48 feet bgs, respectively. Boring logs classified this material as sandy gravel. Silty sand and sand were recorded in boring logs above the sandy gravel at all in-channel locations from ground surface to depths of 15 feet to 34 feet bgs. Samples collected within the sand layer at a depth of 33.5 feet bgs near the east bank (boring A09-12) were identified as sand having a D50 value of 0.2 mm. A D50 of 0.2 mm was used for all computations as a representative value of channel bed material.

All channel sediment was considered non-frozen fine-grained sand and silt. These scour analyses do not take into account any scour protection measures and do not consider layering of coarser gravels that would be encountered at greater depths.

6.2.1 HEC-18

Contraction and local scour estimates were calculated using the methods presented in HEC-18, *Evaluating Scour at Bridges Fourth Edition*, developed by the U.S. Federal Highway Administration (FHWA 2001). Hydraulic data for the scour computations were obtained from the updated 2009 two-dimensional surface water model (Section 4) for pre- and post-CD5 conditions.

Contraction scour was determined assuming either live-bed scour or clear-water scour. The type of scour was dependent on a comparison of the average flow velocity upstream of the bridge and the critical velocity at which sediment is transported. A critical velocity below the average flow velocity suggests a live-bed condition. The location of setbacks and characteristics of overbank flow were also considered to account for vegetation and reduced flow. Live-bed scour is assumed in the main channel of the Nigliq and Nigliagvik crossings. Clear-water scour is assumed for the overbank of all crossings, where applicable, and at the Lake L9341 crossing.

Abutment scour estimates were calculated using Froehlich's equation and the HIRE equation. The choice of resulting scour was based on the ratio of projected abutment length into the active flow path and the average depth of flow at the abutment. The HIRE equation is used when the resulting ratio is greater than 25.

Pier scour estimates were calculated using the CSU equation as presented in HEC-18. Pier scour was calculated at each pier using local data extracted from the two-dimensional model. The maximum pier scour was estimated assuming a pier in the deepest channel section and maximum expected water velocity acting on the pier. This provides the most conservative estimate and should be applied to all piers for design to account for any shifting of the channel thalweg.

6.2.2 ABSCOUR

The ABSCOUR program was developed by the Maryland State Highway Administration, Office of Bridge Development, Structure Hydrology and Hydraulics Unit, and is recommended as an alternate method in HEC-18. The program is an expanded version of Laursen's long contraction theory applied to both clear-water and live-bed scour by Chang with certain modifications developed to account for non-uniform velocity distribution in the bridge section and the nature of flow in the approach section (HEC-18, Appendix F). Equations and associated "adjustment factors" have been based on two-dimensional potential flow theory and laboratory flume tests. ABSCOUR was used to predict scour in the post-CD5 condition only to corroborate the initial HEC-18 predictions. Version 8, Build 1.03 of the ABSCOUR program was used.

6.3 Results

Contraction and local scour (abutment or pier) were combined to estimate the total scour depth for the abutments and piers of each crossing. The validity of values was evaluated given local

6.3 Results

Contraction and local scour (abutment or pier) were combined to estimate the total scour depth for the abutments and piers of each crossing. The validity of values was evaluated given local conditions at each crossing, limitations of the procedures used, and best engineering judgment. Design scour depths and recommended design elevations are presented below.

6.3.1 Nigliq Bridge Scour

The Nigliq Bridge was modeled with an open length 1,390 feet. The east abutment is located approximately 40 feet from the right bank, while the west abutment is located approximately 125 feet from the left bank. The bridge crosses the channel downstream of a meander bend where the channel begins to expand out of a natural constriction. Bridge abutments will be 48-inch diameter vertical pipe piles surrounded by gravel contained within vertical open sheet piles with sheet pile wing walls. Seven sets of 48-inch diameter piers will be installed to support the deck superstructure between the abutments. Five pier sets are located in-stream while the remaining two are located on a vegetated sand bar. The bridge geometry was based on drawings developed by PND Incorporated (CPA 2008).

<u>Contraction Scour</u>

Contraction or general scour occurs when the flow area of a channel is reduced, either by natural channel constriction or by the reduction of flow areas from man-made structures. General scour can occur during large floods in channels without a natural or man-made constriction. The Nigliq Channel at the proposed crossing location is in an expanding reach. Live-bed scour is assumed in the main channel and clear-water scour is assumed for the overbank.

Contraction scour was estimated at the proposed Nigliq Bridge for the 10-, 50-, and 200-year discharges to illustrate the effect the bridge has on natural scour at the channel. Results are compared and are presented in Table 6.1, Table 6.2, and Table 6.3.

TABLE 6.1 CONTRACTION SCOUR BASED ON 10-YEAR DESIGN DISCHARGE (FEET)

Nigliq Channel Crossing	HEC-18
Natural Channel Contraction Scour	1.6
Contraction Scour with CD5 Bridge	1.6
Additional Scour due to CD5 Bridge	0.0

Note: Q10 WSE = 9.8 feet

TABLE 6.2 CONTRACTION SCOUR BASED ON 50-YEAR DESIGN DISCHARGE (FEET)

Nigliq Channel Crossing	HEC-18	ABSCOUR
Natural Channel Contraction Scour	3.4	-
Contraction Scour with CD5 Bridge	3.7	3.7
Additional Scour due to CD5 Bridge	0.3	-

Note: Q50 WSE = 12.4 feet

TABLE 6.3 CONTRACTION SCOUR BASED ON 200-YEAR DESIGN DISCHARGE (FEET)

Nigliq Channel Crossing	HEC-18	ABSCOUR
Natural Channel Contraction Scour	5.2	-
Contraction Scour with CD5 Bridge	6.6	7.5
Additional Scour due to CD5 Bridge	1.4	-

Note: Q200 WSE = 14.4 feet

Abutment Scour

Abutment scour was estimated using the methods presented in HEC-18 and ABSCOUR. Abutment scour calculations assumed vertical wall sheet piles. The configuration of the multiple cell open sheet piles was considered more representative of a straight vertical wall than a wing wall. This also added some conservatism to the predictions. Overbank clear water scour was assumed at both the east and west abutments. Abutment scour was estimated at the proposed Nigliq Bridge for the 50- and 200-year discharges. Results are presented in Table 6.4 and Table 6.5.

TABLE 6.4 ABUTMENT SCOUR BASED ON 50-YEAR DESIGN DISCHARGE (FEET)

Nigliq Channel Crossing	HEC-18		ABSCOUR
	Contraction	Local	Total
West (Left) Abutment	5.2	6.0	17.2
East (Right) Abutment	10.6	12.2	8.6

TABLE 6.5 ABUTMENT SCOUR BASED ON 200-YEAR DESIGN DISCHARGE (FEET)

Nigliq Channel Crossing	HEC-18		ABSCOUR
	Contraction	Local	Total
West (Left) Abutment	7.2	18.2	24.2
East (Right) Abutment	10.6	15.6	12.8

Pier Scour

Pier scour was estimated based on the CSU equation as presented in the methods of HEC-18. The maximum pier scour should be applied to all 48 inch diameter piers for design to account for any shifting of the channel thalweg. Pier scour was calculated for both the 50- and 200-year discharges and are presented below (Table 6.6)

TABLE 6.6 PIER SCOUR BASED ON 50- AND 200-YEAR DESIGN DISCHARGES (FEET)

Nigliq Channel Crossing	HEC-18
200-Year	11.7
50-Year	11.1

Recommended Scour

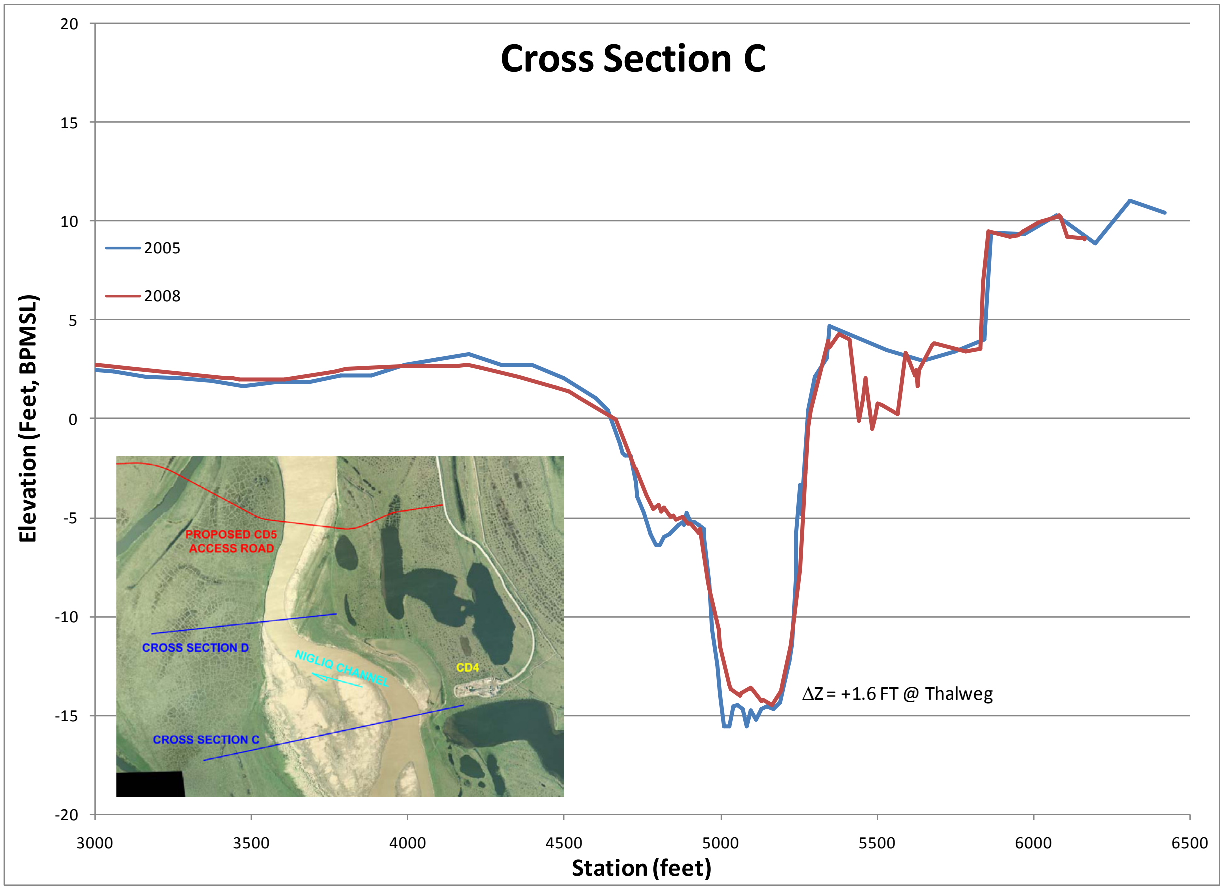
Results of the 200-year flood scour analysis are presented below (Table 6.7). All channel sediment was considered non-frozen fine-grained silt. These scour analyses do not take into account any scour protection countermeasures and do not consider layering of coarser gravels that may be encountered at deeper depths.

TABLE 6.7 RECOMEMEDED SCOUR DEPTHS BASED ON 200-YEAR DESIGN DISCHARGE (FEET)

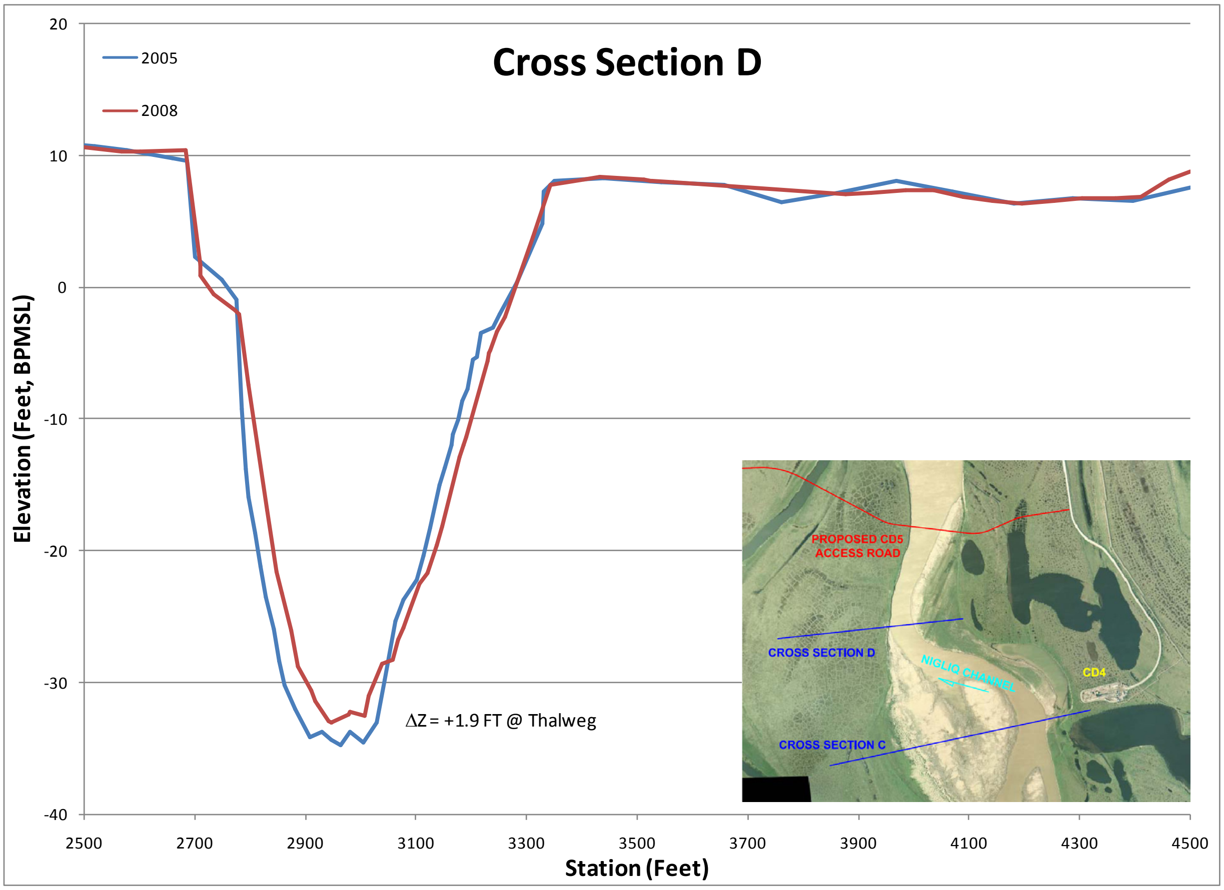
Nigliq Channel Crossing	Contraction Scour	Abutment Scour	Pier Scour	Design Scour Depth
General	6.6	-	-	6.6
Piers	6.6	-	11.7	18.3
West Abutment	7.2	18.2	-	25.4
East Abutment	10.6	15.6	-	26.2

Historic Channel Degradation/Aggradation

Long term aggradation (filling) and degradation (cutting) of a channel is considered separate from the scour which occurs during peak seasonal runoff events. There are two years of survey data on the Nigliq Channel in the vicinity of the proposed bridge to examine natural trends. Cross sectional channel geometry surveyed in 2005 (LCMF 2005c) and 2008 (LCMF 2008b) were compared upstream of the proposed CD5 Nigliq Channel bridge. Two cross sections located 6,700 feet (Cross Section C) and 2,400 feet (Cross Section D) upstream of the bridge alignment are presented in Graph 6.1 and Graph 6.2, respectively. Cross section naming was assigned in the 2005 drawing. Aggradation was observed at both sections over the brief 3-year period, with an increase in thalweg elevation of 1.6 feet and 1.9 feet. Aggradation is likely the result of low seasonal flows over the survey period. Peak discharge at the head of the Colville River Delta in 2006, 2007, and 2008 was similar to the estimated mean annual flood discharge (2-year recurrence interval).



GRAPH 6.1 2005 AND 2008 CROSS SECTION SURVEY DATA 6,700 FEET UPSTREAM OF PROPOSED CD5 NIGLIQ CHANNEL BRIDGE



GRAPH 6.2 2005 AND 2008 CROSS SECTION SURVEY DATA 2,400 FEET UPSTREAM OF PROPOSED CD5 NIGLIQ CHANNEL BRIDGE

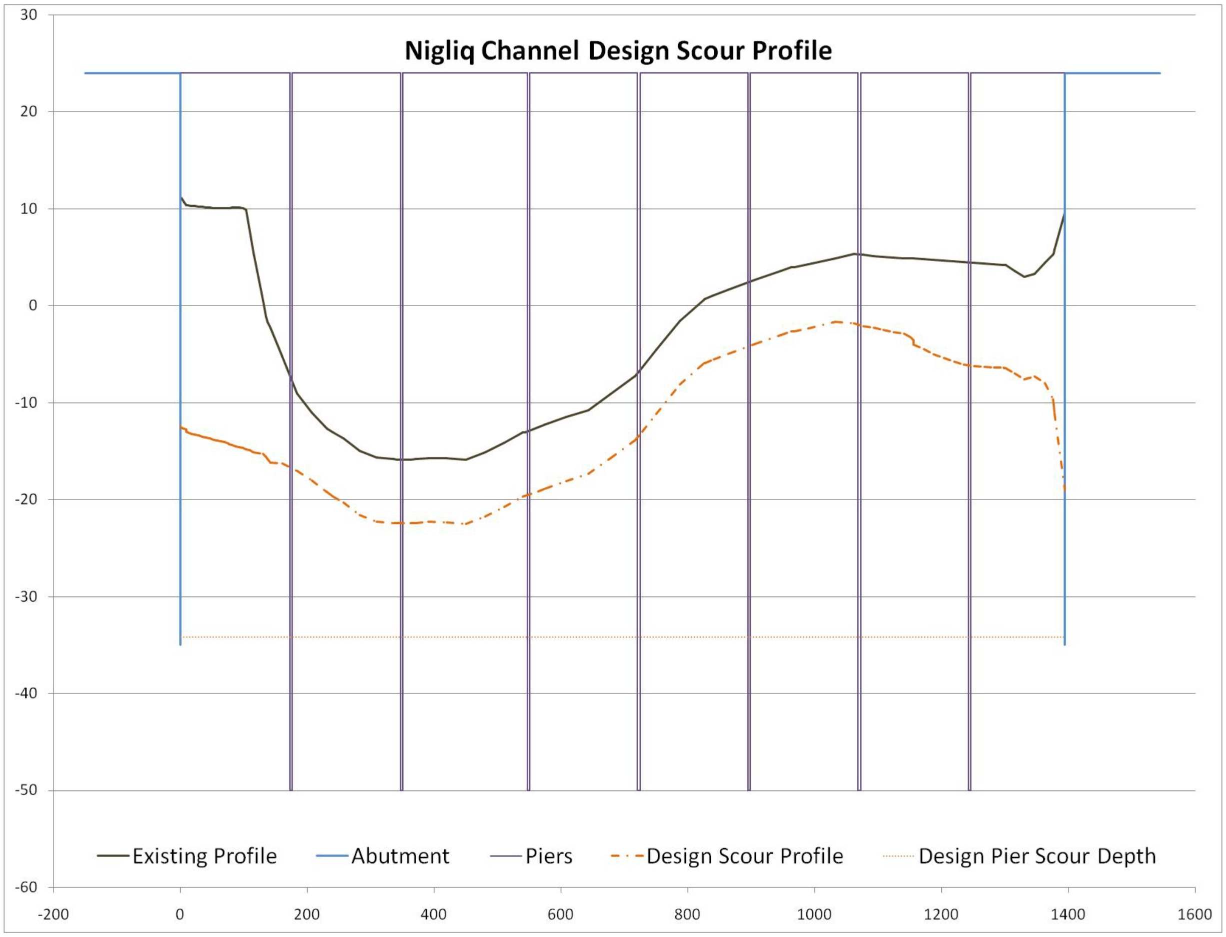
<u>Recommended Design Scour Elevations</u>

The recommended design scour elevations for the bridge foundation structures are presented in Table 6.8 and the scour profile in shown on Graph 6.3. These recommendations are based on the scour analyses and did not consider the results of the historical channel degradation/aggradations analysis because of its limited data.

The design scour elevation for all piers is recommended at -34 feet BPMSL. The design elevation assumes a total scour of 18 feet below the channel thalweg, which is at an elevation of -16 feet. Applying this design elevation to all piers considers potential movement of the thalweg and is a conservative approach, especially for the piers on the shallow eastern part of the channel. However, the bridge piers are vital structural components for the bridge and some additional conservatism is reasonable.

TABLE 6.8 RECOMMENDED DESIGN SCOUR ELEVATIONS FOR THE PROPOSED CD5 NIGLIQ BRIDGE

Nigliq Channel Crossing	Design Scour Elevation (feet BPMSL)
All Piers	-34.2
West Abutment	-15.0
East Abutment	-20.9



GRAPH 6.3 PREDICTED SCOUR PROFILE FOR THE PROPOSED CD5 NIGLIQ BRIDGE

Design scour elevations at the west and east abutments are -15.0 feet and -20.9 feet BPMSL, respectively. These elevations do not take into account the potential for lateral bank migration. The bank migration analysis using 1948 and 2006 aerial imagery revealed aggradations of the east bank. The east bank was defined by established vegetation visible in aerial imagery and supported by 2008 field surveys. Therefore, no bank erosion is expected. The recommended design scour elevation for the east abutment is the total scour subtracted from the existing ground elevation.

The same study revealed an average bank erosion rate of 0.9 feet per year over the 58-year period. Considering a design life of 30 years, 27 feet of erosion can be expected. This value compares well with the 1.1 feet of annual erosion predicted in 2002 (Baker 2002). To account for uncertainties in the predicted erosion rate, a factor of safety of 2 is recommended and 55 feet of erosion has been assumed; this is within the proposed 110 foot setback. Therefore, the recommended design scour elevation is the total scour subtracted from the existing ground

6.3.2 Lake L9341 Bridge Scour

The modeled bridge crossing Lake L9341 is 315 feet wide. Both the west and east abutments are located near their respective banks with little to no setback. The bridge crosses the long narrow lake at about mid-length. Bridge abutments will be vertical pipe piles surrounded by gravel contained within vertical open sheet piles with sheet pile wing walls. Five sets of 48-inch diameter piers will be installed to support the deck superstructure. The bridge geometry was based on drawings developed by PND Incorporated (CPA 2008). Ground geometry was based on survey data provided by LCMF (LCMF 2008a)

The bridge was modeled as a flood relief bridge spanning a wide shallow floodplain. The bridge is over a pond, but there is no established channel approaching the bridge. All scour estimates were modeled using the HEC-18 methods. The Q200 design discharge through the bridge was calculated from the two-dimensional surface water model and is 21,600 cfs.

Contraction scour estimated for the Q200 flood is 21.2 feet.

Abutment scour was estimated as 22.6 for the east abutment and 17.0 for the west abutment.

Pier scour for all piers was estimated at 9.6 feet.

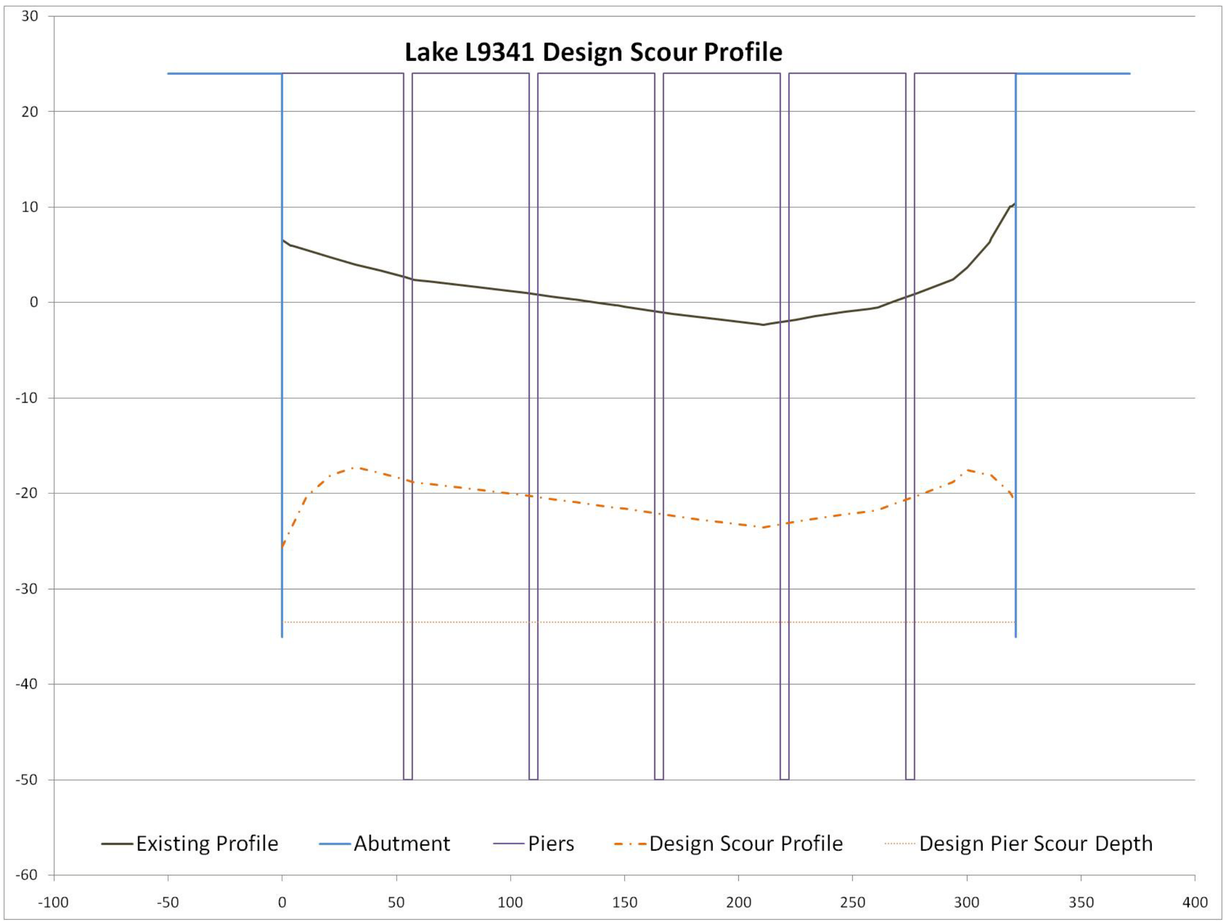
<u>Recommended Design Scour Elevations</u>

The Lake L9341 Bridge is located on a wide shallow floodplain and will act as a flood relief bridge during high magnitude flood events. Floodwaters do not reach this location during mean annual flood events. Approach velocities are low and there is no active channel where flows are being diverted. Combining both the contraction and abutments estimates for a total scour would be overly conservative. A reasonable approach is to take the greater of the contraction or abutment scour estimate and consider it the total scour. Because of the clear water conditions, it is recommended to use the predicted contraction scour, and add ½ the average abutment scour for slightly more conservatism.

The recommended design scour elevations for the bridge foundation structures are presented in Table 6.9 and the scour profile in shown on Graph 6.4. The design scour elevation for all piers is recommended at -33.5 feet BPMSL. Applying this design elevation to all piers considers potential movement of the thalweg and is a conservative approach. Design scour elevations at the west and east abutments are -25.6 feet and -21.1 feet BPMSL, respectively. These elevations do not take into account the potential for lateral bank migration.

TABLE 6.9 RECOMMENDED DESIGN SCOUR ELEVATIONS FOR THE PROPOSED LAKE L9341 BRIDGE

Lake L9341 Crossing	Design Scour Elevation (feet BPMSL)
All Piers	-33.5
West Abutment	-25.6
East Abutment	-21.1



GRAPH 6.4 PREDICTED SCOUR PROFILE FOR THE PROPOSED CD5 LAKE L9341 BRIDGE

6.3.3 Nigliagvik Bridge Scour

The modeled bridge crossing the Nigliagvik is 277 feet wide. The west abutment is perched above the Colville River Delta on a bluff outside the direct impact of design floodwater. The abutment sits at the edge of the bluff (bank). The east abutment is located at the east bank having no setback. The bridge crosses the channel at a moderate bend with little change in channel width upstream or downstream of the bridge alignment. Bridge abutments will be vertical pipe piles surrounded by gravel contained within vertical open sheet piles with sheet pile wing walls. Two sets of 48 inch diameter piers will be installed to support the deck superstructure. The bridge geometry was based on drawings developed by PND Incorporated (CPA 2008). Ground geometry was based on survey data provided by LCMF (LCMF 2008a)

All scour estimates were modeled using the HEC-18 methods. The Q200 design discharge through the bridge was calculated from the two-dimensional surface water model and is 26,300 cfs.

Contraction scour estimated for the Q200 flood is 29.7 feet.

Abutment scour was estimated as 24.9 feet for the east abutment. The west abutment is high on the bank out of the floodplain above the predicted flood elevation and no scour due to the abutment is predicted.

Pier scour for all piers was estimated at 10.4 feet.

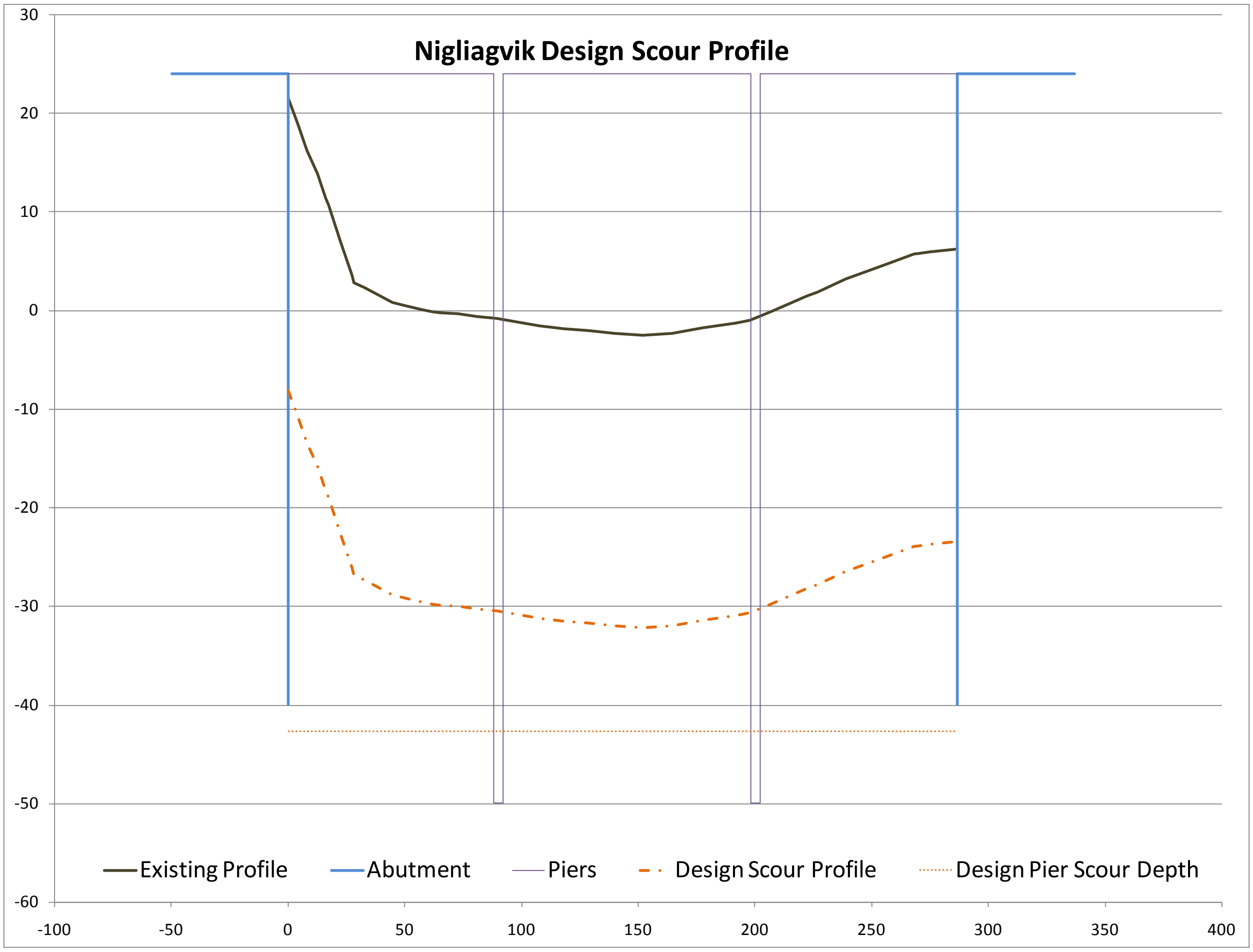
Recommended Design Scour Elevations

The Nigliagvik Bridge located on a natural channel adjacent to a wide shallow floodplain. This bridge is similar to a flood relief bridge in that channel is small in comparison to the length of adjacent floodplain. Overbank floodwaters do not reach this location during mean annual flood events, and only during large magnitude floods will the bridge see overbank flow. Combining both the contraction and abutments estimates for a total scour would be overly conservative. The recommended design scour is the larger of the contraction or abutment scour estimates. In this case, the predicted contraction scour of 29.7 feet will be used for total scour except for piers.

The recommended design scour elevations for the bridge foundation structures are presented in Table 6.10 and the scour profile in shown on Graph 6.5. The design scour elevation for all piers is recommended at -42.7 feet BPMSL. Applying this design elevation to all piers considers potential movement of the thalweg and is a conservative approach. The design scour elevation at the east abutment is -23.5 feet.

TABLE 6.10 RECOMMENDED DESIGN SCOUR ELEVATIONS FOR THE PROPOSED NIGLIAGVIK BRIDGE

Nigliagvik Crossing	Design Scour Elevation (feet BPMSL)
All Piers	-42.7
West Abutment	-8.2
East Abutment	-23.5



GRAPH 6.5 PREDICTED SCOUR PROFILE FOR THE PROPOSED CD5 NIGLIAGVIK BRIDGE

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Appendix A TABLES

Table A1: Design Flood Frequency Relationship at Head of Delta

Return Period	Design Flood-Peak Discharge (cfs)
2-Year	240,000
5-Year	370,000
10-Year	470,000
25-Year	610,000
50-Year	730,000
100Year	860,000
200-Year	1,000,000
500-Year	1,300,000

Table A2: Comparison of the 10-Year Flood Water Surface Elevations Within the Channels

Location	State Plane Coordinates (1)		Water Surface Elevation (ft)				Difference in Water Surface Elevation	
	Northing	Easting	2001 CD1 & CD2 Facilities (2)	2002 CD3 & CD4 Existing Facilities (3)	2009 Pre-CD5 Existing Facilities (4)	2009 Post-CD5 Proposed Facilities (5)	2009 Pre-CD5 vs 2002 CD3 & CD4	2009 Post-CD5 vs 2009 Pre-CD5
East Channel								
Near E27.09	5,909,392	1,525,796	19.4	19.4	19.5	19.5	0.1	0.0
Near E24.92	5,919,240	1,530,846	18.2	18.3	18.4	18.4	0.1	0.0
Near E22.75	5,929,134	1,537,837	17.2	17.3	17.5	17.5	0.2	0.0
Near E20.56	5,940,063	1,536,703	15.7	15.7	16.0	16.0	0.3	0.0
Near E18.47	5,948,830	1,540,906	14.5	14.6	15.0	15.0	0.4	0.0
Near E16.32	5,958,781	1,546,394	13.2	13.3	13.8	13.8	0.5	0.0
Near E14.32	5,969,293	1,550,080	11.8	11.9	12.6	12.6	0.7	0.0
Near E09.76	5,984,621	1,567,090	9.0	9.0	9.6	9.6	0.6	0.0
Near E03.00	6,007,167	1,596,633	4.3	4.3	4.5	4.5	0.2	0.0
Kupigruik Channel								
Near K11.65	5,988,382	1,554,649	9.5	9.5	10.1	10.1	0.6	0.0
Nechelik Channel								
Near N22.65	5,921,789	1,525,401	17.5	17.5	17.9	17.9	0.4	0.0
Near N19.95	5,933,077	1,526,053	16.5	16.6	16.8	16.8	0.2	0.0
Near N17.8	5,934,038	1,517,923	14.4	14.4	14.7	14.7	0.3	0.0
Near N15.07	5,941,261	1,513,754	12.2	12.3	12.8	12.8	0.5	0.0
Near N12.88	5,952,560	1,515,813	10.7	10.9	11.4	11.4	0.5	0.0
Near N09.47	5,967,772	1,510,988	8.6	8.6	9.4	9.4	0.8	0.0
Near N07.47	5,975,970	1,508,294	7.2	7.2	7.7	7.7	0.5	0.0
Near N05.42	5,987,368	1,507,825	5.8	5.8	6.0	6.0	0.2	0.0
Near N02.03	6,006,252	1,508,992	3.4	3.4	3.4	3.4	0.0	0.0
Sakoonang Channel								
Near S16.52	5,945,967	1,533,992	15.3	15.3	15.7	15.7	0.4	0.0
Near S13.07	5,957,692	1,525,998	11.5	11.2	12.2	12.2	1.0	0.0
Near S09.80	5,968,420	1,530,552	9.8	9.6	10.9	10.9	1.3	0.0
Near S05.07	5,985,565	1,524,730	8.2	8.2	8.8	8.8	0.6	0.0
Near S01.38	5,991,587	1,517,723	7.1	7.1	7.0	7.0	-0.1	0.0
Tamayayak Channel								
Near T12.62	5,972,148	1,537,826	11.3	11.3	11.8	11.8	0.5	0.0
Near T08.20	5,992,002	1,531,706	8.9	8.9	9.3	9.3	0.4	0.0

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update*, Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
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5. Proposed CD5 Facilities water surface elevations based on model output: Q10_PostCD5_2009_final.flo.

Table A3: Comparison of the 50-Year Flood Water Surface Elevations Within the Channels

Location	State Plane Coordinates (1)		Water Surface Elevation (ft)				Difference in Water Surface Elevation	
	Northing	Easting	1998 CD1 & CD2 Facilities (2)	2002 CD3 & CD4 Existing Facilities (3)	2009 Pre-CD5 Existing Facilities (4)	2009 Post-CD5 Proposed Facilities (5)	2009 Pre-CD5 vs 2002 CD3 & CD4	2009 Post-CD5 vs 2009 Pre-CD5
East Channel								
Near E27.09	5,909,392	1,525,796	23.4	23.4	23.5	23.5	0.1	0.0
Near E24.92	5,919,240	1,530,846	22.1	22.1	22.0	22.0	-0.1	0.0
Near E22.75	5,929,134	1,537,837	20.8	20.8	20.8	20.8	0.0	0.0
Near E20.56	5,940,063	1,536,703	18.8	18.8	18.9	18.9	0.1	0.0
Near E18.47	5,948,830	1,540,906	17.6	17.5	17.7	17.7	0.2	0.0
Near E16.32	5,958,781	1,546,394	16.0	15.9	16.1	16.1	0.2	0.0
Near E14.32	5,969,293	1,550,080	14.1	14.1	14.5	14.5	0.4	0.0
Near E09.76	5,984,621	1,567,090	10.7	10.6	10.9	10.9	0.3	0.0
Near E03.00	6,007,167	1,596,633	4.9	4.8	5.0	5.0	0.2	0.0
Kupigruik Channel								
Near K11.65	5,988,382	1,554,649	11.3	11.2	11.5	11.5	0.3	0.0
Nechelik Channel								
Near N22.65	5,921,789	1,525,401	21.5	21.5	21.6	21.6	0.1	0.0
Near N19.95	5,933,077	1,526,053	19.7	19.7	19.8	19.8	0.1	0.0
Near N17.8	5,934,038	1,517,923	17.4	17.5	17.6	17.6	0.1	0.0
Near N15.07	5,941,261	1,513,754	15.0	15.1	15.6	15.6	0.5	0.0
Near N12.88	5,952,560	1,515,813	14.0	14.2	14.5	14.5	0.3	0.0
Near N09.47	5,967,772	1,510,988	11.8	11.8	12.1	12.1	0.3	0.0
Near N07.47	5,975,970	1,508,294	10.3	10.3	10.4	10.4	0.1	0.0
Near N05.42	5,987,368	1,507,825	8.1	8.2	8.1	8.1	-0.1	0.0
Near N02.03	6,006,252	1,508,992	3.9	4.0	3.9	3.9	-0.1	0.0
Sakoonang Channel								
Near S16.52	5,945,967	1,533,992	18.3	18.3	18.4	18.4	0.1	0.0
Near S13.07	5,957,692	1,525,998	14.3	14.9	15.2	15.2	0.3	0.0
Near S09.80	5,968,420	1,530,552	12.2	13.2	13.6	13.6	0.4	0.0
Near S05.07	5,985,565	1,524,730	10.2	10.7	10.8	10.8	0.1	0.0
Near S01.38	5,991,587	1,517,723	8.1	8.3	8.2	8.2	-0.1	0.0
Tamayayak Channel								
Near T12.62	5,972,148	1,537,826	13.2	13.1	13.4	13.4	0.3	0.0
Near T08.20	5,992,002	1,531,706	10.1	10.0	9.8	9.8	-0.2	0.0

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update*, Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
3. 2002Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 50_New_Facilities_c(1).flo.
4. 2009 Existing Facilities water surface elevations basedon 2009 model output: Q50_PreCD5_2009_final.flo.
5. Proposed CD5 Facilities water surface elevations based on model output: Q50_PostCD5_2009_final.flo.

Table A4: Comparison of the 200-Year Flood Water Surface Elevations Within the Channels

Location	State Plane Coordinates (1)		Water Surface Elevation (ft)				Difference in Water Surface Elevation	
	Northing	Easting	1998 CD1 & CD2 Facilities (2)	2002 CD3 & CD4 Existing Facilities (3)	2009 Pre-CD5 Existing Facilities (4)	2009 Post-CD5 Proposed Facilities (5)	2009 Pre-CD5 vs 2002 CD3 & CD4	2009 Post-CD5 vs 2009 Pre-CD5
East Channel								
Near E27.09	5,909,392	1,525,796	26.4	26.4	26.4	26.4	0.0	0.0
Near E24.92	5,919,240	1,530,846	24.9	24.9	24.6	24.6	-0.3	0.0
Near E22.75	5,929,134	1,537,837	23.4	23.4	23.2	23.2	-0.2	0.0
Near E20.56	5,940,063	1,536,703	21.0	21.0	21.0	21.0	0.0	0.0
Near E18.47	5,948,830	1,540,906	19.7	19.7	19.6	19.6	-0.1	0.0
Near E16.32	5,958,781	1,546,394	17.8	17.9	17.8	17.8	-0.1	0.0
Near E14.32	5,969,293	1,550,080	15.7	15.8	15.9	15.9	0.1	0.0
Near E09.76	5,984,621	1,567,090	11.8	11.9	11.9	11.9	0.0	0.0
Near E03.00	6,007,167	1,596,633	5.3	5.4	5.4	5.4	0.0	0.0
Kupigruik Channel								
Near K11.65	5,988,382	1,554,649	12.1	12.4	12.5	12.5	0.1	0.0
Nechelik Channel								
Near N22.65	5,921,789	1,525,401	24.3	24.3	24.3	24.4	0.0	0.1
Near N19.95	5,933,077	1,526,053	22.0	22.0	21.7	21.7	-0.3	0.0
Near N17.8	5,934,038	1,517,923	19.7	19.7	19.7	19.7	0.0	0.0
Near N15.07	5,941,261	1,513,754	17.3	17.4	17.6	17.8	0.2	0.2
Near N12.88	5,952,560	1,515,813	16.4	16.4	16.6	16.8	0.2	0.2
Near N09.47	5,967,772	1,510,988	14.1	13.9	14.2	14.1	0.3	-0.1
Near N07.47	5,975,970	1,508,294	12.3	12.3	12.3	12.3	0.0	0.0
Near N05.42	5,987,368	1,507,825	9.8	9.7	9.4	9.4	-0.3	0.0
Near N02.03	6,006,252	1,508,992	4.4	4.4	4.3	4.3	-0.1	0.0
Sakoonang Channel								
Near S16.52	5,945,967	1,533,992	20.5	20.5	20.4	20.4	-0.1	0.0
Near S13.07	5,957,692	1,525,998	16.4	16.9	17.0	17.1	0.1	0.1
Near S09.80	5,968,420	1,530,552	14.8	15.8	15.8	15.9	0.0	0.1
Near S05.07	5,985,565	1,524,730	11.9	12.4	12.2	12.3	-0.2	0.1
Near S01.38	5,991,587	1,517,723	9.5	9.7	9.4	9.4	-0.3	0.0
Tamayayak Channel								
Near T12.62	5,972,148	1,537,826	14.2	14.3	15.3	15.3	1.0	0.0
Near T08.20	5,992,002	1,531,706	10.8	10.9	10.6	10.6	-0.3	0.0

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update*, Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 200_New_Facilities_i(1).flo.
4. 2009 Existing Facilities water surface elevations based on 2009 model output: Q200_PreCD5_2009_final.flo.
5. Proposed CD5 Facilities water surface elevations based on model output: Q200_PostCD5_2009_final.flo.

Table A5: Comparison of the 50-Year Flood Water Surface Elevations Along the Alpine Pipeline

Location	State Plane Coordinates (1) Northing	State Plane Coordinates (1) Easting	Water Surface Elevation (ft) 1998 CD1 & CD2 Facilities (2)	Water Surface Elevation (ft) 2002 CD3 & CD4 Existing Facilities (3)	Water Surface Elevation (ft) 2009 Pre-CD5 Existing Facilities (4)	Water Surface Elevation (ft) 2005 Post-CD5 Proposed Facilities (5)	Difference in Water Surface Elevation 2009 Pre-CD5 vs 2002 CD3 & CD4	Difference in Water Surface Elevation 2009 Post-CD5 vs 2009 Pre-CD5
PI 01B	5,976,849	1,525,459	12.1	13.0	13.4	13.4	0.4	0.0
PI 03	5,972,807	1,522,738	12.1	13.0	13.4	13.4	0.4	0.0
PI 04	5,969,233	1,519,018	12.1	13.1	13.5	13.5	0.4	0.0
PI 05	5,962,991	1,517,932	12.5	13.1	13.5	13.5	0.4	0.0
PI 06	5,960,740	1,518,241	12.8	13.3	13.5	13.5	0.2	0.0
PI 07	5,953,916	1,522,663	14.7	14.6	15.2	15.2	0.6	0.0
PI 08	5,952,421	1,522,643	14.8	15.0	15.2	15.3	0.2	0.1
PI 09	5,950,909	1,523,516	14.8	15.0	15.2	15.3	0.2	0.1
PI 10	5,949,478	1,524,877	15.3	15.4	15.8	15.8	0.4	0.0
PI 11	5,945,936	1,532,147	15.9	15.9	16.3	16.3	0.4	0.0
PI 12A	5,944,666	1,533,174	15.9	15.9	16.3	16.3	0.4	0.0
PI 13A	5,939,498	1,533,838	18.9	19.0	19.0	19.0	0.0	0.0
PI 14A	5,939,389	1,538,708	18.8	18.6	18.9	18.9	0.3	0.0
PI 15A	5,935,265	1,541,718	20.0	20.0	19.6	19.6	-0.4	0.0

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update*, Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 50_New_Facilities_c(1).flo.
4. 2009 Existing Facilities water surface elevations based on 2009 model output: Q50_PreCD5_2009_final.flo.
5. Proposed CD5 Facilities water surface elevations based on model output: Q50_PostCD5_2009_final.flo.

Table A6: Comparison of the 200-Year Flood Water Surface Elevations Along the Alpine Pipeline

Location	State Plane Coordinates (1)		Water Surface Elevation (ft)				Difference in Water Surface Elevation	
	Northing	Easting	1998 CD1 & CD2 Facilities (2)	2002 CD3 & CD4 Existing Facilities (3)	2009 Pre-CD5 Existing Facilities (4)	2009 Post-CD5 Proposed Facilities (5)	2009 Pre-CD5 vs 2002 CD3 & CD4	2009 Post-CD5 vs 2009 Pre-CD5
PI 01B	5,976,849	1,525,459	14.4	15.5	15.7	15.8	0.2	0.1
PI 03	5,972,807	1,522,738	14.4	15.6	15.8	15.9	0.2	0.1
PI 04	5,969,233	1,519,018	14.4	15.7	15.8	15.9	0.1	0.1
PI 05	5,962,991	1,517,932	14.8	15.7	15.9	16.0	0.2	0.1
PI 06	5,960,740	1,518,241	15.2	15.8	15.9	16.0	0.1	0.1
PI 07	5,953,916	1,522,663	16.6	17.0	17.1	17.3	0.1	0.2
PI 08	5,952,421	1,522,643	16.6	17.0	17.2	17.3	0.2	0.1
PI 09	5,950,909	1,523,516	16.6	17.0	17.2	17.3	0.2	0.1
PI 10	5,949,478	1,524,877	17.4	17.6	17.9	18.0	0.3	0.1
PI 11	5,945,936	1,532,147	18.3	18.5	18.8	18.9	0.3	0.1
PI 12A	5,944,666	1,533,174	18.3	18.5	18.8	18.9	0.3	0.1
PI 13A	5,939,498	1,533,838	21.2	21.3	21.1	21.1	-0.2	0.0
PI 14A	5,939,389	1,538,708	21.0	20.9	20.9	20.9	0.0	0.0
PI 15A	5,935,265	1,541,718	22.3	22.4	21.8	21.8	-0.6	0.0

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Water surface elevations from the report: Michael Baker Jr., Inc., 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update*, Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 200_New_Facilities_i(1).flo.
4. 2009 Existing Facilities water surface elevations based on 2009 model output: Q200_PreCD5_2009_final.flo.
5. Proposed CD5 Facilities water surface elevations based on model output: Q200_PostCD5_2009_final.flo.

Table A7: Comparison of the 10-Year Flood Water Surface Elevations At Permanent Staff Gage Locations

Permanent Staff Gage Number	State Plane Coordinates (1)		Ground Surface Elevation	Water Surface Elevation (ft)			Difference in Water Surface Elevation	
	Northing	Easting		2002 CD3 & CD4 Existing Facilities (4)	2009 Pre-CD5 Existing Facilities (5)	2009 Post-CD5 Proposed Facilities (6)	2009 Pre-CD5 vs 2002 CD3 & CD4	2009 Post-CD5 vs 2009 Pre-CD5
1	5,975,695	1,526,953	1.9 [2]	8.8	9.8	9.8	1.0	0.0
2	5,974,708	1,520,339	3.6 [3]	8.2	8.8	8.8	0.6	0.0
3	5,974,767	1,519,281	5.9 [2]	8.7	9.4	9.4	0.7	0.0
4	5,974,920	1,519,255	5.0 [3]	8.1	8.5	8.5	0.4	0.0
5	5,974,778	1,519,104	5.2 [3]	8.2	8.7	8.7	0.5	0.0
6	5,974,729	1,513,588	6.4 [3]	8.9	9.6	9.6	0.7	0.0
7	5,974,879	1,513,619	7.5 [2]	8.6	8.4	8.4	-0.2	0.0
8	5,974,602	1,511,294	8.2 [2]	8.7	8.9	8.9	0.2	0.0
9	5,972,390	1,523,063	8.0 [2]	9.7	10.9	10.9	1.2	0.0
10	5,975,544	1,525,497	6.7 [2]	9.7	10.9	10.9	1.2	0.0

Notes:
1. All elevations are reported in BPMSL and coordinates are shown Alaska State Plane, Zone 4, NAD 83.
2. Ground surface elevations survey by LCMF Inc., (Doc. LCMF-018, 5/17/00).
3. Ground surface elevations are from finite element mesh dated 3/5/2009.
4. 2002 Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 10_New_Facilities_d(3).flo.
5. 2009 Existing Facilities water surface elevations based on 2009 modl output: Q10_PreCD5_2009_final.flo.
6. Proposed CD5 Facilities water surface elevations based on model output: Q10_PostCD5_2009_final.flo.

Table A8: Comparison of the 50-Year Flood Water Surface Elevations Along the Alpine Facilities Road

	State Plane Coordinates (1)		2002 CD3 & CD4 Existing Facilities Water Surface Elevations (2)		2009 Pre-CD5 Existing Facilities Water Surface Elevations (3)		2009 Post-CD5 Proposed Facilities Water Surface Elevations (4)		2009 Pre-CD5 vs 2002 CD3 & CD4		2009 Post-CD5 vs 2009 Pre-CD5	
Location	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
SW Corner CD2 Pad	5,973,863	1,511,422	11.6	-	11.6	-	11.6	-	0.0	-	0.0	-
SE Corner CD2 Pad	5,973,896	1,511,953	11.9	-	12.1	-	12.1	-	0.2	-	0.0	-
10+00	5,974,647	1,511,400	-	10.4	-	10.1	-	10.1	-	-0.3	-	0.0
20+00	5,974,753	1,512,395	11.9	10.0	12.2	10.0	12.2	10.0	0.3	0.0	0.0	0.0
30+00	5,974,834	1,513,390	11.9	9.9	12.2	10.0	12.2	10.0	0.3	0.1	0.0	0.0
40+00	5,974,467	1,514,303	11.9	9.9	12.2	10.0	12.2	10.0	0.3	0.1	0.0	0.0
50+00	5,973,866	1,515,095	11.9	9.9	12.2	10.0	12.1	10.0	0.3	0.1	-0.1	0.0
60+00	5,973,764	1,516,074	11.8	9.9	12.1	10.0	12.1	10.0	0.3	0.1	0.0	0.0
70+00	5,974,003	1,517,045	11.8	10.0	12.1	10.0	12.1	10.0	0.3	0.0	0.0	0.0
80+00	5,974,253	1,518,013	11.8	10.1	12.1	10.1	12.1	10.1	0.3	0.0	0.0	0.0
90+00	5,974,685	1,518,914	11.7	10.1	12.0	10.1	12.0	10.1	0.3	0.0	0.0	0.0
100+00	5,974,818	1,519,894	11.6	10.1	11.9	10.1	11.9	10.1	0.3	0.0	0.0	0.0
103+00	5,974,757	1,520,187	11.1	10.0	11.5	10.1	11.5	10.1	0.4	0.1	0.0	0.0
108+00	5,974,625	1,520,670	11.4	10.0	11.5	10.1	11.5	10.1	0.1	0.1	0.0	0.0
110+00	5,974,573	1,520,862	11.5	10.0	11.7	10.0	11.7	10.0	0.2	0.0	0.0	0.0
120+00	5,974,595	1,521,774	13.0	10.1	13.4	10.1	13.4	10.1	0.4	0.0	0.0	0.0
130+00	5,975,189	1,522,578	13.0	10.1	13.4	10.1	13.4	10.2	0.4	0.0	0.0	0.1
140+00	5,975,783	1,523,383	13.0	10.1	13.4	10.2	13.4	10.2	0.4	0.1	0.0	0.0
150+00	5,976,377	1,524,187	13.0	10.1	13.4	10.2	13.4	10.2	0.4	0.1	0.0	0.0
160+00	5,976,970	1,524,992	13.0	10.1	13.4	10.1	13.4	10.1	0.4	0.0	0.0	0.0
170+00	5,977,564	1,525,796	-	10.1	-	10.1	-	10.1	-	0.0	-	0.0
NW Corner CD1 Pad	5,976,893	1,526,099	13.0	-	13.4	-	13.4	-	0.4	-	0.0	-
NE Corner CD1 Pad	5,977,059	1,526,833	11.8	-	12.1		12.1		0.3	-	0.0	-
SW Corner CD1 Pad	5,975,013	1,525,229	12.9	-	13.4		13.4		0.5	-	0.0	-
SE Corner CD1 Pad	5,974,801	1,525,441	12.8	-	13.2		13.2		0.4	-	0.0	-

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. 2002 Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 50_New_Facilities_c(1).flo.
3. 2009 Existing Facilities water surface elevations based on 2009 model output: Q50_PreCD5_2009_final.flo.
4. Proposed CD5 Facilities water surface elevations based on model output: Q50_PostCD5_2009_final.flo.

Table A9: Comparison of the 200-Year Flood Water Surface Elevations Along the Alpine Facilities Road

Location	State Plane Coordinates (1)		2002 CD3 & CD4 Existing Facilities Water Surface Elevations (2)		2009 Pre-CD5 Existing Facilities Water Surface Elevations (3)		2009 Post-CD5 Proposed Facilities Water Surface Elevations (4)		2009 Pre-CD5 vs 2002 CD3 & CD4		2009 Post-CD5 vs 2009 Pre-CD5	
	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
SW Corner CD2 Pad	5,973,863	1,511,422	13.5	-	13.5	-	13.4	-	0.0	-	-0.1	-
SE Corner CD2 Pad	5,973,896	1,511,953	13.9	-	14.1	-	14.0	-	0.2	-	-0.1	-
10+00	5,974,647	1,511,400	-	12.2	-	11.8	-	11.7	-	-0.4	-	-0.1
20+00	5,974,753	1,512,395	13.9	11.8	14.2	11.7	14.1	11.6	0.3	-0.1	-0.1	-0.1
30+00	5,974,834	1,513,390	13.9	11.7	14.2	11.6	14.1	11.6	0.3	-0.1	-0.1	0.0
40+00	5,974,467	1,514,303	13.9	11.7	14.2	11.6	14.1	11.6	0.3	-0.1	-0.1	0.0
50+00	5,973,866	1,515,095	13.9	11.7	14.2	11.6	14.1	11.6	0.3	-0.1	-0.1	0.0
60+00	5,973,764	1,516,074	13.9	11.7	14.1	11.6	14.1	11.6	0.2	-0.1	0.0	0.0
70+00	5,974,003	1,517,045	13.9	11.7	14.1	11.6	14.0	11.6	0.2	-0.1	-0.1	0.0
80+00	5,974,253	1,518,013	13.9	11.8	14.1	11.7	14.0	11.7	0.2	-0.1	-0.1	0.0
90+00	5,974,685	1,518,914	13.8	11.8	14.0	11.7	13.9	11.7	0.2	-0.1	-0.1	0.0
100+00	5,974,818	1,519,894	13.7	11.7	13.9	11.6	13.8	11.6	0.2	-0.1	-0.1	0.0
103+00	5,974,757	1,520,187	13.1	11.7	13.5	11.6	13.4	11.6	0.4	-0.1	-0.1	0.0
108+00	5,974,625	1,520,670	13.4	11.7	13.5	11.7	13.4	11.7	0.1	0.0	-0.1	0.0
110+00	5,974,573	1,520,862	13.6	11.7	13.8	11.6	13.7	11.6	0.2	-0.1	-0.1	0.0
120+00	5,974,595	1,521,774	15.6	11.8	15.8	11.7	15.9	11.7	0.2	-0.1	0.1	0.0
130+00	5,975,189	1,522,578	15.5	11.8	15.7	11.7	15.8	11.7	0.2	-0.1	0.1	0.0
140+00	5,975,783	1,523,383	15.5	11.8	15.7	11.8	15.8	11.8	0.2	0.0	0.1	0.0
150+00	5,976,377	1,524,187	15.5	11.8	15.7	11.8	15.8	11.8	0.2	0.0	0.1	0.0
160+00	5,976,970	1,524,992	15.5	11.8	15.7	11.8	15.8	11.8	0.2	0.0	0.1	0.0
170+00	5,977,564	1,525,796	-	11.8	-	11.8	-	11.8	-	0.0	-	0.0
NW Corner CD1 Pad	5,976,893	1,526,099	15.5	-	15.7	-	15.8	-	0.2	-	0.1	-
NE Corner CD1 Pad	5,977,059	1,526,833	14.0	-	14.0	-	14.0	-	0.0	-	0.0	-
SW Corner CD1 Pad	5,975,013	1,525,229	15.5	-	15.7	-	15.8	-	0.2	-	0.1	-
SE Corner CD1 Pad	5,974,801	1,525,441	15.3	-	15.4	-	15.5	-	0.1	-	0.1	-

Notes:
1. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. 2002 Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 200_New_Facilities_i(1).flo.
3. 2009 Existing Facilities water surface elevations based on 2009 model output: Q200_PreCD5_2009_final.flo.
4. Proposed CD5 Facilities water surface elevations based on model output: Q200_PostCD5_2009_final.flo.

Table A10: Water Surface Elevations and Water Velocities Along the CD3 Pad, Road, and Runway During the 200-Year Flood

Location	State Plane Coordinates (1)			2002 CD3 & CD4 Existing Facilities (3)		2009 Pre-CD5 Existing Facilities (4)		2009 Post-CD5 Proposed Facilities (5)		2009 Pre-CD5 vs 2002 CD3 & CD4		2009 Post-CD5 vs 2009 Pre-CD5	
	Northing	Easting	Approximate Ground Elevation (2)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)
NW Corner of Pad	6,003,656	1,527,527	6.2	7.7	2.4	7.5	0.9	7.5	0.9	-0.2	-1.5	0.0	0.0
NE Corner of Pad	6,003,944	1,528,704	6.0	7.0	0.1	7.1	0.1	7.1	0.1	0.1	0.0	0.0	0.0
SW Corner of Pad	6,003,342	1,527,584	6.1	7.9	1.4	7.6	2.5	7.6	2.5	-0.3	1.1	0.0	0.0
SE Corner of Pad	6,003,292	1,528,923	6.0	7.0	0.1	7.1	0.0	7.1	0.0	0.1	-0.1	0.0	0.0
Access Road (south)	6,002,498	1,529,441	7.7	8.3	1.1	8.2	1.0	8.2	1.0	-0.1	-0.1	0.0	0.0
Access Road (north)	6,002,603	1,529,475	7.6	-	-	7.1	0.0	7.1	0.0	-	-	-	-
West End of Runway (south)	6,002,923	1,530,596	6.5	7.9	0.4	8.4	0.0	8.4	0.0	0.5	-0.4	0.0	0.0
West End of Runway (north)	6,003,353	1,530,293	6.6	7.0	0.1	7.1	0.1	7.1	0.1	0.1	0.0	0.0	0.0
Mid-Point Runway (south)	6,004,070	1,531,667	6.0	7.8	0.4	8.3	0.3	8.4	0.3	0.5	-0.1	0.1	0.0
Mid-Point Runway (north)	6,004,205	1,531,591	6.0	7.0	0.1	7.4	0.4	7.4	0.4	0.4	0.3	0.0	0.0
East End Runway (south)	6,005,149	1,533,276	6.0	7.7	0.5	8.2	0.8	8.2	0.8	0.5	0.3	0.0	0.0

Notes:
1. All elevations are reported in BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Ground elevations are from photogramic contour data provided by Aeromap U.S., 6/30/99.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations and velocities based on 2002 model output: 200_New_Facilities_i(1).flo.
4. 2009 Existing Facilities water surface elvations and velocities based on 2009 model output: Q200_PreCD5_2009_final.flo.
5. Water surface elevations and velocities for model results with CD5 Facilities based on model output: Q200_PostCD5_2009_final.flo.
6. Empty cells are areas where the model indicates dry ground.

Table A11: Water Surface Elevations and Water Velocities Along the CD3 Pipeline During the 200-Year Flood

	State Plan Coordinates (1)			2002 CD3 & CD4 Existing Facilities (3)		2009 Pre-CD5 Existing Facilities (4)		2009 Post-CD5 Proposed Facilities (5)		2009 Pre-CD5 vs 2002 CD3 & CD4		2009 Post-CD5 vs 2009 Pre-CD5	
Location	Northing	Easting	Ground Elevation (2)	Water Surface Elevation (6,7)	Water Velocity (ft/s) (7)	Water Surface Elevation (6,7)	Water Velocity (ft/s) (7)	Water Surface Elevation (6,7)	Water Velocity (ft/s) (7)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)
10+00	6,003,422	1,528,550	6.0	8.1	0.4	7.9	0.2	7.9	0.2	-0.2	-0.2	0.0	0.0
20+00	6,002,615	1,529,037	6.1	8.3	1.5	8.1	1.8	8.1	1.8	-0.2	0.3	0.0	0.0
30+00	6,002,120	1,529,813	4.8	8.3	1.6	8.2	1.5	8.2	1.5	-0.1	-0.1	0.0	0.0
40+00	6,001,548	1,530,556	4.3	8.5	2.0	8.4	1.4	8.4	1.4	-0.1	-0.6	0.0	0.0
50+00	6,000,843	1,531,279	7.0	8.6**	0.7**	8.5	0.5	8.5	0.5	-	-	0.0	0.0
60+00	5,999,985	1,531,691	8.0	8.6**	0.7**	8.6	0.6	8.6	0.6	-	-	0.0	0.0
70+00	5,999,202	1,532,081	4.4	8.8	3.0**	8.7	1.3	8.7	1.3	-0.1	-	0.0	0.0
Crossing 5	-	-	-	8.8	4.3	8.7	2.8	8.7	2.8	-0.1	-1.5	0.0	0.0
80+00	5,998,362	1,531,716	7.8	8.9**	1.0**	8.7	1.1	8.7	1.1	-	-	0.0	0.0
90+00	5,998,082	1,530,811	7.6	8.9**	1.0**	8.6**	1.0**	8.6**	1.0**	-	-	-	-
100+00	5,997,759	1,529,930	13.2	9.3*	-	9.1*	-	9.1*	-	-	-	-	-
110+00	5,997,155	1,529,213	8.1	9.4**	1.3**	9.2**	1.0**	9.2**	1.0**	-	-	-	-
120+00	5,996,309	1,528,798	9.5	9.5*	-	9.3*	-	9.3*	-	-	-	-	-
130+00	5,995,425	1,528,424	7.8	9.9	1.5	9.6	1.3	9.6	1.3	-0.3	-0.2	0.0	0.0
140+00	5,994,557	1,527,981	7.8	9.8	1.2	9.6	1.0	9.6	1.0	-0.2	-0.2	0.0	0.0
Crossing	-	-	-	10.1	5.0	9.8	4.3	9.8	4.3	-0.3	-0.7	0.0	0.0
160+00	5,992,878	1,527,864	7.6	10.3**	0.7**	9.8	0.1	9.8	0.1	-	-	0.0	0.0
170+00	5,991,963	1,527,644	8.7	10.3**	0.9**	9.8	0.0	9.8	0.0	-	-	0.0	0.0
180+00	5,990,969	1,527,805	9.0	10.2	0.1	9.9	0.4	10.0	0.4	-0.3	0.3	0.1	0.0
190+00	5,990,073	1,528,012	9.6	10.2**	0.1**	10.2	0.3	10.2	0.3	-	-	0.0	0.0
200+00	5,989,079	1,528,172	10.7	10.7*	-	11.3	0.6	11.3	0.6	-	-	0.0	0.0
210+00	5,988,171	1,528,320	11.6	12.1**	1.0**	12.1	0.4	12.1	0.4	-	-	0.0	0.0
220+00	5,987,215	1,528,528	12.5	12.5*	-	12.5*	-	12.5*	-	-	-	-	-
230+00	5,986,268	1,528,685	11.8	13.1**	0.9**	12.9**	0.9**	12.9**	0.9**	-	-	-	-
240+00	5,985,463	1,528,336	9.4	13.0	1.2	12.9	1.5	12.9	1.5	-0.1	0.3	0.0	0.0
250+00	5,984,815	1,527,663	4.4	13.0	2.0	12.8	2.3	12.8	2.3	-0.2	0.3	0.0	0.0
Crossing	-	-	-	13.1	4.6	13.0	4.9	13.0	4.9	-0.1	0.3	0.0	0.0
270+00	5,982,976	1,527,128	10.1	13.2	1.1	13.0	1.2	13.1	1.2	-0.2	0.1	0.1	0.0
280+00	5,982,051	1,527,145	9.9	13.3	0.8	13.2	0.8	13.2	0.8	-0.1	0.0	0.0	0.0
290+00	5,981,064	1,527,224	10.5	13.5	0.7	13.3	0.7	13.4	0.7	-0.2	0.0	0.1	0.0
300+00	5,980,095	1,527,239	11.7	13.6	0.6	13.4**	0.6**	13.5**	0.6**	-	-	-	-
310+00	5,979,164	1,527,255	11.3	13.7	0.8	13.5	0.2	13.6	0.2	-0.2	-0.6	0.1	0.0
320+00	5,978,171	1,527,337	10.3	13.9	1.2	13.6	1.7	13.7	1.7	-0.3	0.5	0.1	0.0
330+00	5,977,240	1,527,350	9.6	14.2	2.0	14.0	2.1	14.1	2.1	-0.2	0.1	0.1	0.0
340+00	5,976,347	1,527,041	10.5	14.5	1.5	14.3	1.7	14.4	1.7	-0.2	0.2	0.1	0.0

Notes:
1. All elevations are reported in feet BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Ground elevations are based on the topographical base map used to define the 2009 finite element mesh.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations and velocities based on 2002 model output: 200_New_Facilities_i(1).flo.
4. 2009 Existing Facilities water surface elevations and velocities based on 2009 model output: Q200_PreCD5_2009_final.flo.
5. Water surface elevations and velocities for model results with CD5 Facilities based on model output: Q200_PostCD5_2009_final.flo.
6. Water surface elevations with an asterisk (*) represent water surface elevations in the vicinity of the identified location and are lower than the ground elevation at this location.
7. Water surface elevations and velocities with a double asterisk (**) represent values in the vicinity of the identified location. The element at the specified location is considered turned off by the model, however the ground surface elvation is lower than the water surface elevation.
8. Empty cells are areas where the model indicates dry ground.

Table A12: Water Surface Elevations and Water Velocities Along the CD4 Access Road During the 50-Year Flood

				2002 CD3 & CD4 Existing Facilities				2009 Pre-CD5 Existing Facilities				2009 Post CD5 Proposed Facilities				2009 Pre-CD5 vs 2002 CD3 & CD4				2009 Post-CD5 vs 2009 Pre-CD5			
	State Plane Coordinates (1)			Along the Western Side of CD-South Access Road (3,5)		Along the Eastern Side of CD-South Access Road (3,5)		Along the Western Side of CD-South Access Road (4,6)		Along the Eastern Side of CD-South Access Road (4,6)		Along the Western Side of CD-South Access Road (5,6)		Along the Eastern Side of CD-South Access Road (5,6)		Along the Western Side of CD-South Access Road		Along the Eastern Side of CD-South Access Road		Along the Western Side of CD-South Access Road		Along the Eastern Side of CD-South Access Road	
Location	Northing	Easting	Approximate Ground Elevation (2)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)
10+00	5,973,470	1,521,172	12.0	11.7	0.4	13.0	0.5	11.9	0.3	13.4	0.2	11.9	0.3	13.4	0.2	0.2	-0.1	0.4	-0.3	0.0	0.0	0.0	0.0
20+00	5,972,709	1,520,549	11.8	11.8	0.4	13.0	0.4	12.1	0.3	13.4	0.4	12.0	0.3	13.4	0.4	0.3	-0.1	0.4	0.0	-0.1	0.0	0.0	0.0
30+00	5,972,080	1,519,775	9.0	11.8	0.3	13.1	0.4	12.1	0.3	13.4	0.4	12.1	0.3	13.4	0.4	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0
40+00	5,971,391	1,519,061	9.7	11.8	0.2	13.1	0.3	12.1	0.3	13.5	0.3	12.1	0.3	13.5	0.3	0.3	0.1	0.4	0.0	0.0	0.0	0.0	0.0
50+00	5,970,614	1,518,427	9.4	11.8	0.1	13.1	0.3	12.1	0.2	13.5	0.3	12.1	0.2	13.5	0.3	0.3	0.1	0.4	0.0	0.0	0.0	0.0	0.0
60+00	5,969,879	1,517,777	9.8	11.8	0.1	13.1	0.1	12.1	0.1	13.5	0.2	12.1	0.1	13.5	0.2	0.3	0.0	0.4	0.1	0.0	0.0	0.0	0.0
70+00	5,968,901	1,517,622	14.0	12.0*	-	13.1*	-	12.2	-	13.5	0.2	12.2	-	13.5	0.2	0.2	-	0.4	-	0.0	-	0.0	0.0
75+00	5,968,403	1,517,588	15.2	12.0*	-	13.1*	-	12.2*	-	13.5*	-	12.2*	-	13.5*	-	0.2	-	0.4	-	0.0	-	0.0	-
80+00	5,967,905	1,517,527	16.0	12.0*	-	13.1*	-	12.2*	-	13.5*	-	12.2*	-	13.5*	-	0.2	-	0.4	-	0.0	-	0.0	-
85+00	5,967,419	1,517,412	18.9	12.0*	-	13.1*	-	12.2*	-	13.5*	-	12.2*	-	13.5*	-	0.2	-	0.4	-	0.0	-	0.0	-
90+00	5,966,930	1,517,307	16.0	12.0*	-	13.1*	-	12.2*	-	13.5*	-	12.2*	-	13.5*	-	0.2	-	0.4	-	0.0	-	0.0	-
100+00	5,965,948	1,517,130	16.0	12.0*	-	13.1*	-	12.2*	-	13.5*	-	12.2*	-	13.5*	-	0.2	-	0.4	-	0.0	-	0.0	-
110+00	5,964,953	1,517,131	11.1	12.0*	-	13.1	0.5	12.2	0.1	13.5	0.1	12.2	0.1	13.5	0.1	0.2	-	0.4	-0.4	0.0	0.0	0.0	0.0
115+00	5,964,458	1,517,042	16.0	12.0*	-	13.1*	-	12.2	0.1	13.5	0.1	12.2	0.1	13.5	0.1	0.2	-	0.4	-	0.0	0.0	0.0	0.0
120+00	5,963,971	1,516,938	14.8	12.0*	-	13.1*	-	12.2*	-	13.5*	-	12.2*	-	13.5*	-	0.2	-	0.4	-	0.0	-	0.0	-
125+00	5,963,477	1,516,976	15.9	12.0*	-	13.1*	-	12.6*	-	13.5*	-	12.3*	-	13.5*	-	0.6	-	0.4	-	-0.3	-	0.0	-
130+00	5,962,982	1,517,051	15.0	-	-	-	-	13.7*	-	13.5	0.1	12.5*	-	13.5	0.1	-	-	-	-	-1.2	-	0.0	0.0
140+00	5,961,994	1,517,204	13.0	-	-	-	-	13.9	0.8	13.5	0.1	12.5*	-	13.5	0.1	-	-	-	-	-1.4	-	0.0	0.0
145+00	5,961,503	1,517,285	13.5	-	-	-	-	14.2	0.0	13.5	0.1	14.3	0.0	13.5	0.1	-	-	-	-	0.1	0.0	0.0	0.0
150+00	5,961,081	1,517,522	9.7	-	-	-	-	14.2	0.1	13.5	0.1	14.3	0.1	13.5	0.2	-	-	-	-	0.1	0.0	0.0	0.1
155+00	5,960,803	1,517,934	7.6	-	-	-	-	14.2	0.2	13.5	0.1	14.3	0.3	13.5	0.1	-	-	-	-	0.1	0.1	0.0	0.0
160+00	5,960,438	1,518,274	10.8	-	-	-	-	14.2	0.2	13.5	0.4	14.3	0.2	13.5	0.5	-	-	-	-	0.1	0.0	0.0	0.1
165+00	5,960,027	1,518,550	10.9	-	-	-	-	14.2	0.2	13.5	0.7	14.3	0.1	13.6	0.7	-	-	-	-	0.1	-0.1	0.1	0.0
170+00	5,959,580	1,518,784	11.4	-	-	-	-	14.2	0.2	13.7	0.6	14.3	0.1	13.8	0.7	-	-	-	-	0.1	-0.1	0.1	0.1
180+00	5,958,744	1,519,333	12.8	-	-	-	-	14.2	0.1	14.6	0.7	14.3	0.0	14.6	0.7	-	-	-	-	0.1	-0.1	0.0	0.0
185+00	5,958,244	1,519,405	11.4	-	-	-	-	14.2	0.0	14.7	0.2	14.3	0.0	14.8	0.2	-	-	-	-	0.1	0.0	0.1	0.0
190+00	5,957,771	1,519,230	10.2	-	-	-	-	14.2	0.1	14.7	0.1	14.3	0.1	14.8	0.1	-	-	-	-	0.1	0.0	0.1	0.0
195+00	5,957,446	1,518,846	15.0	-	-	-	-	14.2*	-	14.7*	-	14.3*	-	14.8*	-	-	-	-	-	0.1	-	0.1	-
NW Corner Pad	5,957,319	1,517,402	10.2	13.8	0.2	-	-	14.2	0.2	-	-	14.3	0.2	-	-	0.4	0.0	-	-	0.1	0.0	-	-
NE Corner Pad	5,957,576	1,518,513	15.0	-	-	14.0*	-	-	-	14.2*	-	-	-	14.3*	-	-	-	-	0.2	-	-	0.1	-
SW Corner Pad	5,956,953	1,517,488	10.2	13.8	0.7	-	-	14.4	1.1	-	-	14.4	1.1	-	-	0.6	0.4	-	-	0.0	0.0	-	-
SE Corner Pad	5,957,139	1,518,632	13.3	-	-	14.2	0.3	-	-	14.7	0.2	-	-	14.7	0.2	-	-	0.5	-0.1	-	-	0.0	0.0

Notes:
1. All elevations are reported in BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Ground elevations are based on the topographical base map used to define the finite element mesh, which are based on photogrammetric contour date by Aeromap U.S. 6/30/99.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations and velocities based on 2002 model output: 50_New_Facilities_c(1).flo for stations 10+00 to 150+00. Water surface elevations and velocities from stations 155+00 to the CD-4 pad from the 2002 model do not match the existing CD-4 access road alignment and have been removed since they do not represent actual conditions.
4. 2009 Existing Facilities water surface elvations and velocities based on 2009 model output: Q50_PreCD5_2009_final.flo.
5. Water surface elevations and velocities for model results with CD5 Facilities based on model output: Q50_PostCD5_2009_final.flo.
6. Water surface elevations with an asterisk (*) represent water surface elevations in the vicinity of the identified location and are lower than the ground elevation at this location.
7. Empty cells are areas where the model indicates dry ground.

Table A13: Water Surface Elevations and Water Velocities Along the CD4 Access Road During the 200-Year Flood

				2002 CD3 & CD4 Existing Facilities				2009 Pre-CD5 Existing Facilities				2009 Post CD5 Proposed Facilities				2009 Pre-CD5 vs 2002 CD3 & CD4				2009 Post-CD5 vs 2009 Pre-CD5			
	State Plane Coordinates (1)			Along the Western Side of CD-South Access Road (3,5)		Along the Eastern Side of CD-South Access Road (3,5)		Along the Western Side of CD-South Access Road (4,6)		Along the Eastern Side of CD-South Access Road (4,6)		Along the Western Side of CD-South Access Road (5,6)		Along the Eastern Side of CD-South Access Road (5,6)		Along the Western Side of CD-South Access Road		Along the Eastern Side of CD-South Access Road		Along the Western Side of CD-South Access Road		Along the Eastern Side of CD-South Access Road	
Location	Northing	Easting	Approximate Ground Elevation (2)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)
10+00	5,973,470	1,521,172	12.0	13.7	0.7	15.6	0.2	14.0	0.8	15.8	0.3	13.9	0.3	15.9	0.2	0.3	0.1	0.2	0.1	-0.1	-0.5	0.1	-0.1
20+00	5,972,709	1,520,549	11.8	13.8	0.6	15.6	0.7	14.1	0.6	15.8	0.7	14.0	0.3	15.9	0.4	0.3	0.0	0.2	0.0	-0.1	-0.3	0.1	-0.3
30+00	5,972,080	1,519,775	9.0	13.9	0.5	15.6	0.6	14.1	0.5	15.8	0.5	14.0	0.3	15.9	0.4	0.2	0.0	0.2	-0.1	-0.1	-0.2	0.1	-0.1
40+00	5,971,391	1,519,061	9.7	13.9	0.3	15.6	0.4	14.1	0.4	15.8	0.4	14.0	0.3	15.9	0.3	0.2	0.1	0.2	0.0	-0.1	-0.1	0.1	-0.1
50+00	5,970,614	1,518,427	9.4	13.9	0.2	15.6	0.4	14.1	0.2	15.8	0.4	14.0	0.2	15.9	0.3	0.2	0.0	0.2	0.0	-0.1	0.0	0.1	-0.1
60+00	5,969,879	1,517,777	9.8	13.9	0.0	15.6	0.3	14.1	0.0	15.8	0.4	14.0	0.0	15.9	0.2	0.2	0.0	0.2	0.1	-0.1	0.0	0.1	-0.2
70+00	5,968,901	1,517,622	14.0	14.0*	-	15.7	0.3	14.2	0.1	15.8	0.3	14.2	0.0	16.0	0.2	0.2	-	0.1	0.0	0.0	-0.1	0.2	-0.1
75+00	5,968,403	1,517,588	15.2	14.0*	-	15.7	0.1	14.2*	-	15.8	0.3	14.2*	-	16.0	0.0	0.2	-	0.1	0.2	0.0	-	0.2	-0.3
80+00	5,967,905	1,517,527	16.0	14.0*	-	15.7*	-	14.3*	-	15.9*	-	14.2*	-	16.0*	-	0.3	-	0.2	-	-0.1	-	0.1	-
85+00	5,967,419	1,517,412	18.9	14.0*	-	15.7*	-	14.2*	-	15.9*	-	14.2*	-	16.0*	-	0.2	-	0.2	-	0.0	-	0.1	-
90+00	5,966,930	1,517,307	16.0	14.0*	-	15.7*	-	14.3*	-	15.9*	-	14.2*	-	16.0*	-	0.3	-	0.2	-	-0.1	-	0.1	-
100+00	5,965,948	1,517,130	16.0	14.0*	-	15.7*	-	14.3*	-	15.9*	-	14.2*	-	16.0*	0.1	0.3	-	0.2	-	-0.1	-	0.1	-
110+00	5,964,953	1,517,131	11.1	14.0	0.1	15.7	0.4	14.3	0.1	15.9	0.2	14.2	0.1	16.0	0.1	0.3	0.0	0.2	-0.2	-0.1	0.0	0.1	-0.1
115+00	5,964,458	1,517,042	16.0	14.0*	-	15.7*	-	14.3*	-	15.9*	-	14.2*	-	16.0*	-	0.3	-	0.2	-	-0.1	-	0.1	-
120+00	5,963,971	1,516,938	14.8	14.0*	-	15.7	0.6	14.3*	-	15.9	0.2	14.2*	-	16.0	0.1	0.3	-	0.2	-0.4	-0.1	-	0.1	-0.1
125+00	5,963,477	1,516,976	15.9	14.2*	-	15.7*	-	14.8*	-	15.9	0.2	14.3*	-	16.0	0.1	0.6	-	0.2	-	-0.5	-	0.1	-0.1
130+00	5,962,982	1,517,051	15.0	14.9*	-	15.7	0.9	15.2	0.5	15.9	0.2	14.4*	-	16.0	0.1	0.3	-	0.2	-0.7	-0.8	-	0.1	-0.1
140+00	5,961,994	1,517,204	13.0	15.2	0.7	15.7	1.2	15.6	1.0	15.9	0.2	14.4	0.0	16.0	0.1	0.4	0.3	0.2	-1.0	-1.2	-1.0	0.1	-0.1
145+00	5,961,503	1,517,285	13.5	15.3	0.9	15.8	1.1	15.9	1.2	15.9	0.2	16.4	0.0	16.0	0.0	0.6	0.3	0.1	-0.9	0.5	-1.2	0.1	-0.2
150+00	5,961,081	1,517,522	9.7	-	-	-	-	16.1	1.1	15.9	0.2	16.5	0.1	16.0	0.2	-	-	-	-	0.4	-1.0	0.1	0.0
155+00	5,960,803	1,517,934	7.6	-	-	-	-	16.1	0.4	15.9	0.3	16.5	0.2	16.0	0.1	-	-	-	-	0.4	-0.2	0.1	-0.2
160+00	5,960,438	1,518,274	10.8	-	-	-	-	16.1	0.5	15.9	0.6	16.5	0.2	16.0	0.5	-	-	-	-	0.4	-0.3	0.1	-0.1
165+00	5,960,027	1,518,550	10.9	-	-	-	-	16.1	0.5	15.9	0.8	16.5	0.1	16.0	0.7	-	-	-	-	0.4	-0.4	0.1	-0.1
170+00	5,959,580	1,518,784	11.4	-	-	-	-	16.2	0.5	16.0	1.0	16.5	0.1	16.1	0.7	-	-	-	-	0.3	-0.4	0.1	-0.3
180+00	5,958,744	1,519,333	12.8	-	-	-	-	16.2	0.1	16.4	1.5	16.5	0.0	16.6	0.7	-	-	-	-	0.3	-0.1	0.2	-0.8
185+00	5,958,244	1,519,405	11.4	-	-	-	-	16.2	0.1	16.7	0.8	16.5	0.0	16.9	0.2	-	-	-	-	0.3	-0.1	0.2	-0.6
190+00	5,957,771	1,519,230	10.2	-	-	-	-	16.2	0.0	16.7	0.4	16.5	0.0	16.9	0.0	-	-	-	-	0.3	0.0	0.2	-0.4
195+00	5,957,446	1,518,846	15.0	-	-	-	-	16.2	0.2	16.7	0.1	16.5	0.2	16.9	0.0	-	-	-	-	0.3	0.0	0.2	-0.1
NW Corner Pad	5,957,319	1,517,402	16.0	15.9	0.2	-	-	16.3	0.3	-	-	16.5	0.2	-	-	0.4	0.1	-	-	0.2	-0.1	-	-
NE Corner Pad	5,957,576	1,518,513	12.3	-	-	16.2	0.4	-	-	16.2	0.4	-	-	16.5	0.2	-	-	0.0	0.0	-	-	0.3	-0.2
SW Corner Pad	5,956,953	1,517,488	12.3	15.9	1.6	-	-	16.3	1.5	-	-	16.6	1.5	-	-	0.4	-0.1	-	-	0.3	0.0	-	-
SE Corner Pad	5,957,139	1,518,632	15.0	-	-	16.4	0.3	-	-	16.7	0.7	-	-	16.9	0.5	-	-	-	-	-	-	0.2	-0.2

Notes:
1. All elevations are reported in BPMSL. Horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Ground elevations are based on the topographical base map used to define the finite element mesh, which are based on photogrammetric contour date by Aeromap U.S. 6/30/99.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations and velocities based on 2002 model output: 200_New_Facilities_i(1).flo for stations 10+00 to 150+00. Water surface elevations and velocities from stations 155+00 to the CD-4 pad from the 2002 model do not match the existing CD-4 access road alignment and have been removed since they do not represent actual conditions.
4. 2009 Existing Facilities water surface elvations and velocities based on 2009 model output: Q200_PreCD5_2009_final.flo.
5. Water surface elevations and velocities for model results with CD5 Facilities based on model output: Q200_PostCD5_2009_final.flo.
6. Water surface elevations with an asterisk (*) represent water surface elevations in the vicinity of the identified location and are lower than the ground elevation at this location.
7. Empty cells are areas where the model indicates dry ground.

Table A14: Water Surface Elevations and Water Velocities Along the CD4 Pipeline During the 200-Year Flood

Location	State Plan Coordinates (1)			2002 CD3 & CD4 Existing Facilities (3)		2009 Pre-CD5 Existing Facilities (4)		2009 Post-CD5 Proposed Facilities (5)		2009 Pre-CD5 vs 2002 CD3 & CD4		2009 Post-CD5 vs 2009 Pre-CD5	
	Northing	Easting	Ground Elevation (2)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)	Water Surface Elevation	Water Velocity (ft/s)
10+00	5,957,019	1,518,381	12.1	16.4	1.1	16.6	1.1	16.8	1.0	0.2	0.0	0.2	-0.1
20+00	5,957,261	1,519,406	9.3	16.4	1.2	16.7	0.4	16.9	0.5	0.3	-0.8	0.2	0.1
30+00	5,957,736	1,520,161	12.0	16.3	0.6	16.7	0.3	16.9	0.3	0.4	-0.3	0.2	0.0
40+00	5,958,558	1,519,603	13.3	16.2	0.8	16.6	1.4	16.8	1.5	0.4	0.6	0.2	0.1
50+00	5,959,438	1,519,004	12.1	16.1	0.9	16.1	1.3	16.2	1.4	0.0	0.4	0.1	0.1
60+00	5,960,183	1,518,568	11.5	15.9	1.1	15.9	0.7	16.0	0.8	0.0	-0.4	0.1	0.1
70+00	5,960,734	1,518,199	10.5	15.8	0.8	15.9	0.5	16.0	0.5	0.1	-0.3	0.1	0.0
80+00	5,962,007	1,518,050	12.0	15.7	0.6	15.9	0.1	16.0	0.1	0.2	-0.5	0.1	0.0
90+00	5,963,056	1,517,881	11.2	15.7	0.6	15.9	0.2	16.0	0.2	0.2	-0.4	0.1	0.0
100+00	5,964,003	1,518,026	11.6	15.7	0.3	15.9	0.1	16.0	0.2	0.2	-0.2	0.1	0.1
110+00	5,964,903	1,518,222	8.6	15.7	0.3	15.9	0.2	16.0	0.2	0.2	-0.1	0.1	0.0
120+00	5,965,939	1,518,381	3.2	15.7	0.2	15.9	0.2	16.0	0.2	0.2	0.0	0.1	0.0
130+00	5,966,903	1,518,537	4.0	15.7	0.2	15.9	0.3	16.0	0.3	0.2	0.1	0.1	0.0
140+00	5,967,830	1,518,740	8.0	15.7	0.2	15.9	0.4	16.0	0.4	0.2	0.2	0.1	0.0
150+00	5,968,815	1,518,886	8.9	15.7	0.2	15.8	0.2	15.9	0.3	0.1	0.0	0.1	0.1
160+00	5,969,681	1,519,373	10.3	15.7	0.4	15.8	0.4	15.9	0.4	0.1	0.0	0.1	0.0
170+00	5,970,301	1,520,073	10.1	15.6	0.4	15.8	0.4	15.9	0.4	0.2	0.0	0.1	0.0
180+00	5,970,998	1,520,767	10.9	15.6	0.3	15.8	0.3	15.9	0.4	0.2	0.0	0.1	0.1
190+00	5,971,705	1,521,474	10.4	15.6	0.4	15.8	0.3	15.9	0.3	0.2	-0.1	0.1	0.0
200+00	5,972,331	1,522,178	10.5	15.6	0.5	15.8	0.4	15.9	0.4	0.2	-0.1	0.1	0.0
210+00	5,973,038	1,522,906	8.9	15.6	0.6	15.8	0.6	15.9	0.6	0.2	0.0	0.1	0.0
220+00	5,973,671	1,523,664	5.9	15.5	0.7	15.7	0.8	15.8	0.8	0.2	0.1	0.1	0.0
230+00	5,974,246	1,524,432	8.5	15.5	0.9	15.7	1.0	15.8	1.1	0.2	0.1	0.1	0.1
240+00	5,974,605	1,525,156	10.1	15.4	1.4	15.6	1.7	15.7	1.7	0.2	0.3	0.1	0.0

Notes:
1. All elevations are reported in feet BPMSL and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
2. Ground elevations are based on the topographical base map used to define the 2009 finite element mesh.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations and velocities based on 2002 model output: 200_New_Facilities_i(1).flo.
4. 2009 Existing Facilities water surface elvations and velocities based on 2009 model output: Q200_PreCD5_2009_final.flo.
5. Water surface elevations and velocities for model results with CD5 Facilities based on model output: Q200_PostCD5_2009_final.flo.

Table A15: Comparison of the 50-Year Flood Water Surface Elevations Along the CD5 Access Road

Location (1)	State Plane Coordinates (2)		2002 CD3 & CD4 Existing Facilities Water Surface Elevations (3)		2009 Pre-CD5 Existing Facilities Water Surface Elevations (4)		2009 Post CD5 Proposed Facilities Water Surface Elevations (5)		2009 Pre-CD5 vs 2002 CD3 & CD4		2009 Post-CD5 vs 2009 Pre-CD5	
	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
10+00	5,961,518	1,516,231	13.7*	13.7*	14.0*	14.0*	14.3	12.5	0.3	0.3	0.3	-1.5
20+00	5,961,172	1,515,298	12.5*	12.4*	12.6*	12.5*	12.6*	12.4*	0.1	0.2	0.0	-0.1
30+00	5,961,150	1,514,312	12.5	12.5	12.5	12.5	12.5	12.4	0.0	0.0	0.0	-0.1
36+00	5,961,218	1,513,716	12.5	12.5	12.4	12.5	12.4	12.4	-0.1	0.0	0.0	-0.1
40+00	5,961,263	1,513,319	12.5	12.5	12.2	12.1	12.2	12.1	-0.3	-0.4	0.0	0.0
50+00	5,961,569	1,512,380	12.7*	12.7*	12.8	12.8	13.3	12.9	0.1	0.1	0.5	0.1
60+00	5,962,040	1,511,498	12.7	12.7	12.9	12.8	13.3	13.2	0.2	0.1	0.4	0.4
66+00	5,962,323	1,510,969	12.7	12.7	12.9	12.9	13.4	13.3	0.2	0.2	0.5	0.4
70+00	5,962,507	1,510,614	12.7	12.7	12.9	12.8	13.3	13.2	0.2	0.1	0.4	0.4
80+00	5,962,677	1,509,639	12.6	12.6	12.8	12.8	13.4	12.8	0.2	0.2	0.6	0.0
90+00	5,962,641	1,508,639	12.5	12.5	12.8	12.7	13.4	12.5	0.3	0.2	0.6	-0.2
100+00	5,962,605	1,507,640	12.5	12.4	12.7	12.7	13.4	12.4	0.2	0.3	0.7	-0.3
110+00	5,962,569	1,506,641	12.4	12.4	12.7	12.7	13.4	12.4	0.3	0.3	0.7	-0.3
120+00	5,962,533	1,505,641	12.4	12.3	12.7	12.6	13.4	12.4	0.3	0.3	0.7	-0.2
130+00	5,962,497	1,504,642	12.3	12.3	12.7	12.6	13.4	12.4	0.4	0.3	0.7	-0.2
140+00	5,962,461	1,503,643	12.3	12.3	12.7	12.6	13.3	12.4	0.4	0.3	0.6	-0.2
150+00	5,962,441	1,502,643	12.3	12.3	12.7	12.7	13.1	12.4	0.4	0.4	0.4	-0.3
153+00	5,962,457	1,502,344	12.4*	12.3*	12.7	12.7	12.8	12.5	0.3	0.4	0.1	-0.2
154+50	5,962,475	1,502,179	-	-	12.9	12.7	12.9	12.7	-	-	0.0	0.0

Notes:
1. Stations 155+00 through 323+00 are located west of the floodplain and are not subjected to flood water (based on 2009 mesh). Stations 30+00, 36+00, and 40+00 are located on the Nigliq Bridge. Station 66+00 is located on the Lake L9341 Bridge. Stations 153+00 and 154+50 are located on Nigliagvik Bridges. Stationing begins at CD4 Access Road tie-in.
2. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations and velocities based on 2002 model output: 50_New_Facilities_c(1).flo.
4. 2009 Existing Facilities water surface elvations and velocities based on 2009 model output: Q50_PreCD5_2009_final.flo.
5. Proposed CD5 Facilities water surface elevations based on model output: Q50_PostCD5_2009_final.flo.
6. Water surface elevations with an asterisk (*) represent water surface elevations in the vicinity of the identified location and are lower than the ground elevation at this location.
7. Station 154+50 is located outside of the Delta based on the 2002 mesh but is within the Delta based on the 2009 mesh.
8.Empty cells are areas where the model indicates dry ground.

Table A16: Comparison of the 200-Year Flood Water Surface Elevations Along the CD5 Access Road

Location (1)	State Plane Coordinates (2)		2002 CD3 & CD4 Existing Facilities Water Surface Elevations (3)		2009 Pre-CD5 Existing Facilities Water Surface Elevations (4)		2009 Post CD5 Proposed Facilities Water Surface Elevations (5)		2009 Pre-CD5 vs 2002 CD3 & CD4		2009 Post-CD5 vs 2009 Pre-CD5	
	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
10+00	5,961,518	1,516,231	15.3	15.2	15.8	15.7	16.4	14.4	0.3	0.5	0.6	-1.3
20+00	5,961,172	1,515,298	14.6*	14.5*	14.8*	14.7*	14.7*	14.3*	0.1	0.2	-0.1	-0.4
30+00	5,961,150	1,514,312	14.6	14.5	14.7	14.6	14.6	14.5	0.1	0.1	-0.1	-0.1
36+00	5,961,218	1,513,716	14.5	14.5	14.6	14.6	14.5	14.5	0.1	0.1	-0.1	-0.1
40+00	5,961,263	1,513,319	14.5	14.5	14.5	14.4	14.2	14.1	0.0	-0.1	-0.3	-0.3
50+00	5,961,569	1,512,380	14.6	14.6	14.8	14.8	15.6	14.6	0.2	0.2	0.8	-0.2
60+00	5,962,040	1,511,498	14.6	14.6	14.9	14.9	15.6	14.9	0.3	0.3	0.7	0.0
66+00	5,962,323	1,510,969	14.6	14.6	14.9	14.9	15.2	14.9	0.3	0.3	0.3	0.0
70+00	5,962,507	1,510,614	14.6	14.6	14.9	14.9	15.4	14.8	0.3	0.3	0.5	-0.1
80+00	5,962,677	1,509,639	14.6	14.6	14.9	14.8	15.7	14.5	0.3	0.2	0.8	-0.3
90+00	5,962,641	1,508,639	14.6	14.5	14.9	14.8	15.8	14.3	0.3	0.3	0.9	-0.5
100+00	5,962,605	1,507,640	14.5	14.5	14.9	14.8	15.9	14.3	0.4	0.3	1.0	-0.5
110+00	5,962,569	1,506,641	14.5	14.5	14.9	14.8	15.9	14.3	0.4	0.3	1.0	-0.5
120+00	5,962,533	1,505,641	14.5	14.5	14.9	14.8	15.9	14.3	0.4	0.3	1.0	-0.5
130+00	5,962,497	1,504,642	14.6	14.5	14.9	14.8	15.9	14.3	0.3	0.3	1.0	-0.5
140+00	5,962,461	1,503,643	14.6	14.5	14.9	14.9	15.8	14.3	0.3	0.4	0.9	-0.6
150+00	5,962,441	1,502,643	14.6	14.6	14.9	14.9	15.4	14.2	0.3	0.3	0.5	-0.7
153+00	5,962,457	1,502,344	14.6*	14.6*	14.9	14.9	14.9	14.3	0.3	0.3	0.0	-0.6
154+50	5,962,457	1,502,344	-	-	15.0	14.6	15.0	14.6	-	-	0.0	0.0

Notes:
1. Stations 155+00 through 323+00 are located west of the floodplain and are not subjected to flood water (based on 2009 mesh). Stations 30+00, 36+00, and 40+00 are located on the Nigliq Bridge. Station 66+00 is located on the Lake L9341 Bridge. Stations 153+00 and 154+50 are located on Nigliagvik Bridges. Stationing begins at CD4 Access Road tie-in.
2. All elevations are reported in BPMSL, and coordinates are reported in Alaska State Plane, Zone 4, NAD83.
3. 2002 Existing CD3 & CD4 Facilities water surface elevations based on 2002 model output: 200_New_Facilities_i(1).flo.
4.2009 Existing Facilities water surface elvations and velocities based on 2009 model output: Q200_PreCD5_2009_final.flo.
5. Proposed CD5 Facilities water surface elevations based on model output: Q200_PostCD5_2009_final.flo.
6. Water surface elevations with an asterisk (*) represent water surface elevations in the vicinity of the identified location and are lower than the ground elevation at this location.
7. Station 154+50 is located outside of the Delta based on the 2002 mesh but is within the Delta based on the 2009 mesh.
8.Empty cells are areas where the model indicates dry ground.

Table A17: Water Velocities Along the CD5 Access Road During the 50-Year and 200-Year Flood

Location (1)	State Plane Coordinates (2)		Q50 2009 Post-CD5 Proposed Facilities Water Velocity (ft/s) (3)		Q200 2009 Post-CD5 Proposed Facilities Water Velocity (ft/s) (4)	
	Northing	Easting	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities	Upstream (South) Side of Facilities	Downstream (North) Side of Facilities
10+00	5,961,518	1,516,231	0.0	0.0	0.2	0.0
20+00	5,961,172	1,515,298	0.0	0.0	0.1	0.0
30+00	5,961,150	1,514,312	2.9	3.2	4.2	4.7
36+00	5,961,218	1,513,716	8.5	8.4	9.4	9.5
40+00	5,961,263	1,513,319	4.1	4.9	5.2	4.1
50+00	5,961,569	1,512,380	0.4	0.9	0.7	1.3
60+00	5,962,040	1,511,498	0.1	0.4	0.7	0.4
66+00	5,962,323	1,510,969	1.2	1.3	4.4	5.2
70+00	5,962,507	1,510,614	0.3	0.5	1.5	0.7
80+00	5,962,677	1,509,639	0.4	1.1	1.1	1.2
90+00	5,962,641	1,508,639	0.3	0.6	0.8	0.7
100+00	5,962,605	1,507,640	0.1	0.3	0.5	0.3
110+00	5,962,569	1,506,641	0.0	0.1	0.2	0.1
120+00	5,962,533	1,505,641	0.2	0.1	0.1	0.1
130+00	5,962,497	1,504,642	0.4	0.3	0.5	0.3
140+00	5,962,461	1,503,643	0.7	0.4	1.0	0.2
150+00	5,962,441	1,502,643	1.7	0.6	2.8	0.2
153+00	5,962,457	1,502,344	4.7	4.9	6.5	7.2
154+50	5,962,475	1,502,179	5.0	5.5	6.8	7.9

Notes:
1. Stations 155+00 through 323+00 are located west of the floodplain and are not subjected to flood water (based on 2009 mesh). Stations 30+00, 36+00, and 40+00 are located on the Nigliq Bridge. Station 66+00 is located on the Lake L9341 Bridge. Stations 153+00 and 154+50 are located on Nigliagvik Bridges. Stationing begins at CD4 Access Road tie-in.
2. All coordinates are reported in Alaska State Plane Zone 4, NAD83.
3. Water velocities for Q50 model results with CD5 Facilities based on model output: Q50_PostCD5_2009_final.flo.
4. Water velocities for Q200 model results with CD5 Facilities based on model output: Q200_PostCD5_2009_final.flo.

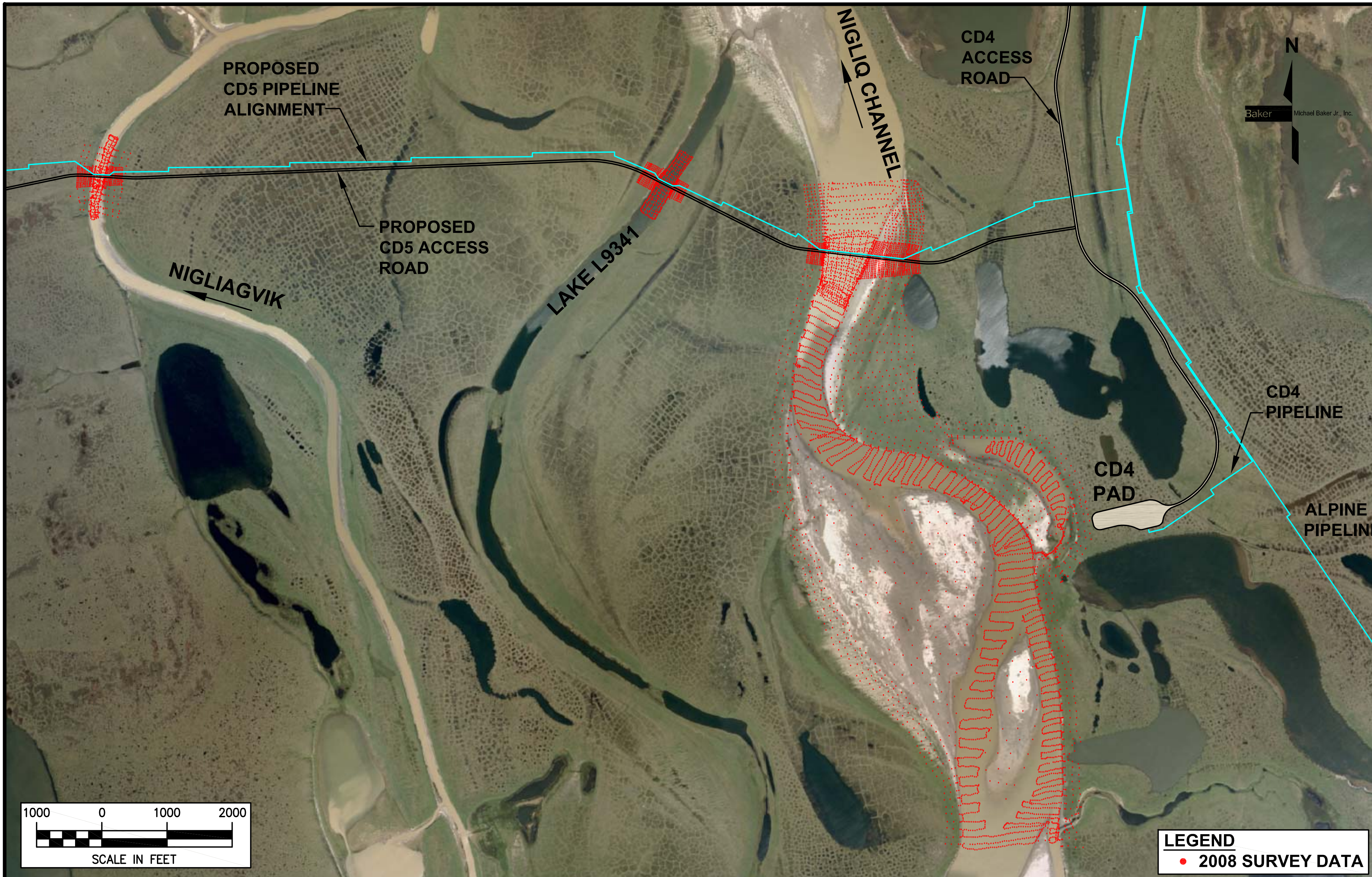
Table A18: Water Surface Elevations and Water Velocities Along the CD5 Pipeline During the 50-Year and 200-Year Flood

Location (1)	State Plan Coordinates (2)			Q50 2009 Post-CD5 Proposed Facilities (4)			Q200 2009 Post-CD5 Proposed Facilities (5)		
	Northing	Easting	Ground Elevation (3)	Water Surface Elevation	Water Velocity (ft/s)	Water Depth	Water Surface Elevation	Water Velocity (ft/s)	Water Depth
170+00	1,502,334	5,962,480	-1.9	12.6	5.2	14.5	14.4	7.6	16.3
180+00	1,503,317	5,962,530	9.2	12.4	0.3	3.2	14.3	0.1	5.1
190+00	1,504,269	5,962,598	9.8	12.4	0.4	2.6	14.3	0.3	4.5
200+00	1,505,221	5,962,666	9.8	12.4	0.2	2.6	14.3	0.2	4.5
210+00	1,506,221	5,962,675	9.9	12.4	0.0	2.5	14.3	0.0	4.4
220+00	1,507,173	5,962,743	10.0	12.4	0.2	2.4	14.3	0.2	4.3
230+00	1,508,173	5,962,752	10.2	12.4	0.5	2.2	14.3	0.5	4.1
240+00	1,509,124	5,962,820	10.6	12.6	0.9	2.0	14.4	0.9	3.8
250+00	1,510,124	5,962,828	10.3	13.0	1.0	2.7	14.6	1.4	4.3
260+00	1,510,959	5,962,361	-0.9	13.3	1.4	14.2	15.0	5.6	15.9
270+00	1,511,854	5,962,051	10.2	13.2	0.6	3.0	14.8	1.1	4.6
280+00	1,512,757	5,961,621	11.4	12.6	0.8	1.2	14.4	1.1	3.0
290+00	1,513,640	5,961,298	-15.3	12.4	8.6	27.7	14.4	9.7	29.7
300+00	1,514,631	5,961,204	4.8	12.4	1.0	7.6	14.3	1.3	9.5
310+00	1,515,528	5,961,529	14.5	12.5*	0.0	-	14.4*	0.0	-
320+00	1,516,445	5,961,928	12.4	12.5	0.0	0.1	14.4	0.1	2.0
330+00	1,517,362	5,962,173	8.2	13.5	0.1	5.3	16.0	0.2	7.8

Notes:

1. Stations 10+00 through 160+00 are located west of the floodplain and are not subjected to flood water. Station 170+00 is located at the Nigliagvik Bridge, Station 260+00 is located at the Lake L9341 Bridge, and Stations 290+00 and 300+00 arelocated at the Nigliq Bridge, where the pipeline is connected to the respective bridges. Station 330+00 is located on the east side of the CD4 access road.
2. All elevations are reported in feet BPMSL and horizontal coordinates are reported in Alaska State Plane, Zone 4, NAD83.
3. Ground elevations are based on the topographical base map used to define the 2009 finite element mesh .
4. Water surface elevations and velocities for model results with CD5 Facilities based on model output: Q50_PostCD5_2009_final.flo.
5. Water surface elevations and velocities for model results with CD5 Facilities based on model output: Q200_PostCD5_2009_final.flo.
6. Water surface elevations with an asterisk (*) represent water surface elevations in the vicinity of the identified location and are lower than the ground elevation at this location.

Appendix B FIGURES



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Alaska, Inc.

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B1
CHECKED:	JAB	SCALE:	AS SHOWN

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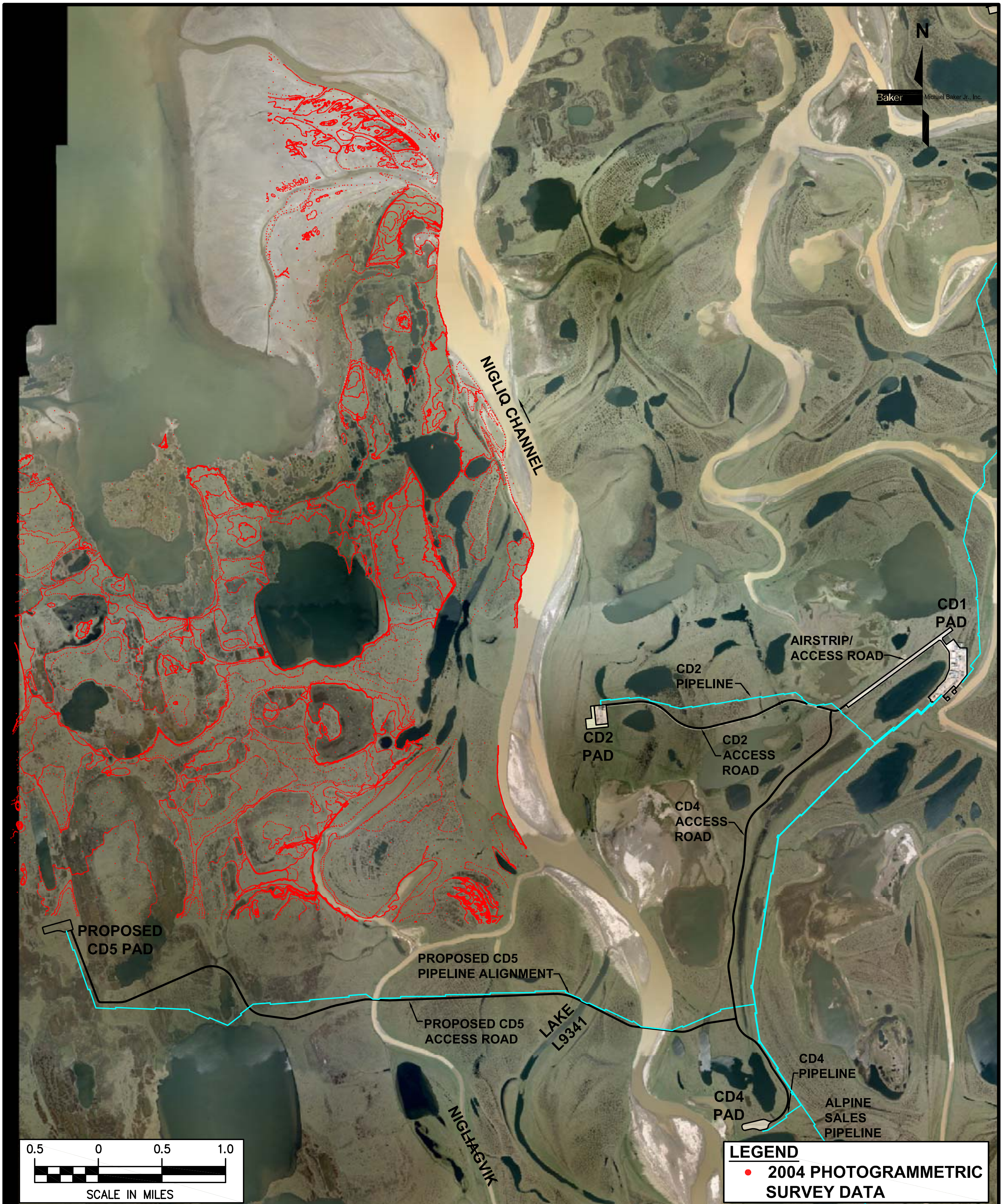
2009 2D MODEL
UPDATED TOPOGRAPHY
PROPOSED CROSSINGS

FIGURE B1
(SHEET 1 OF 1)



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2009 2D MODEL

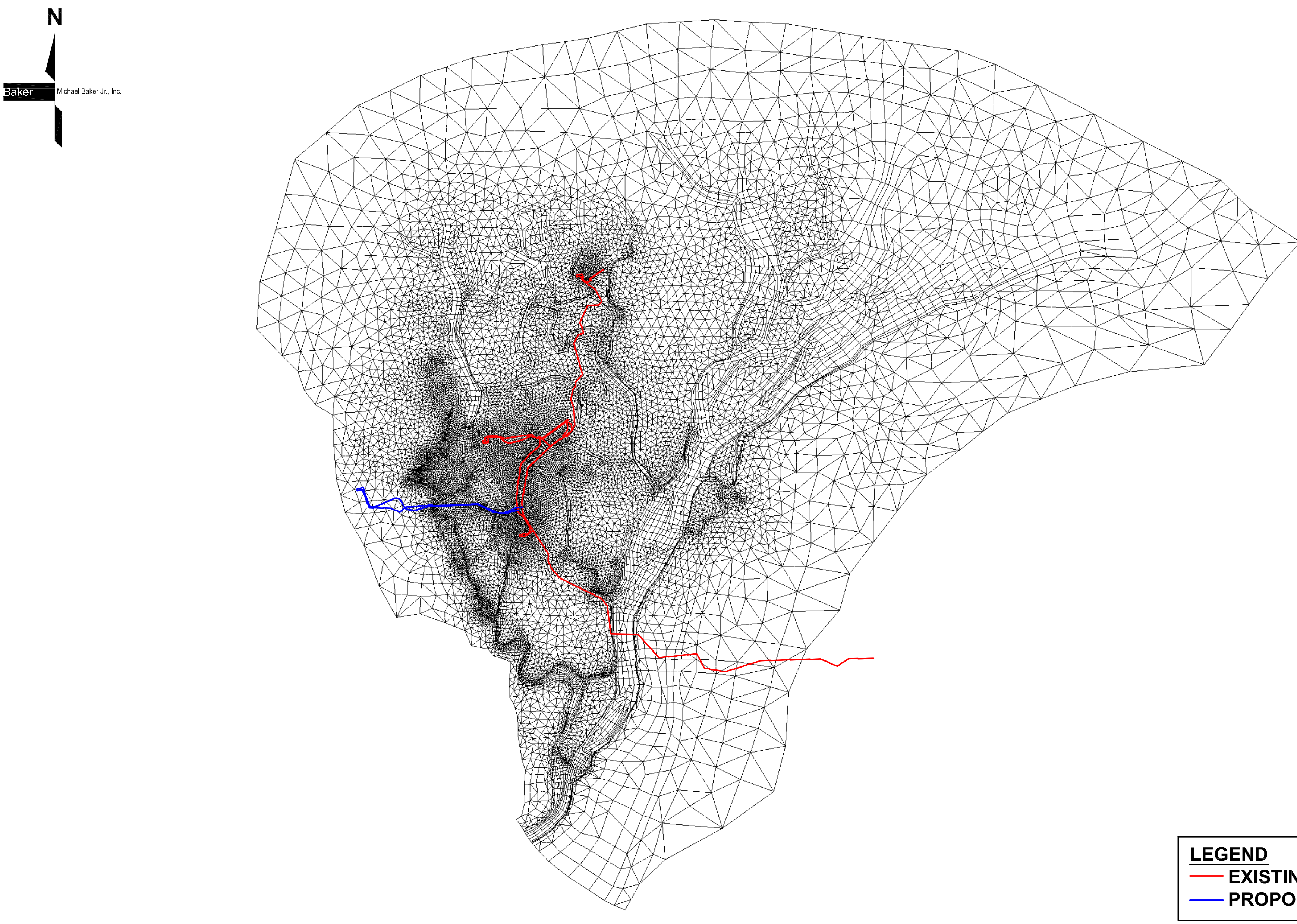
UPDATED TOPOGRAPHY

NORTH WEST DELTA

FIGURE B2

(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B2
CHECKED:	JAB	SCALE:	AS SHOWN



LEGEND
EXISTING FACILITIES
PROPOSED FACILITIES

ConocoPhillips
Alaska, Inc.

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B3
CHECKED:	JAB	SCALE:	N/A

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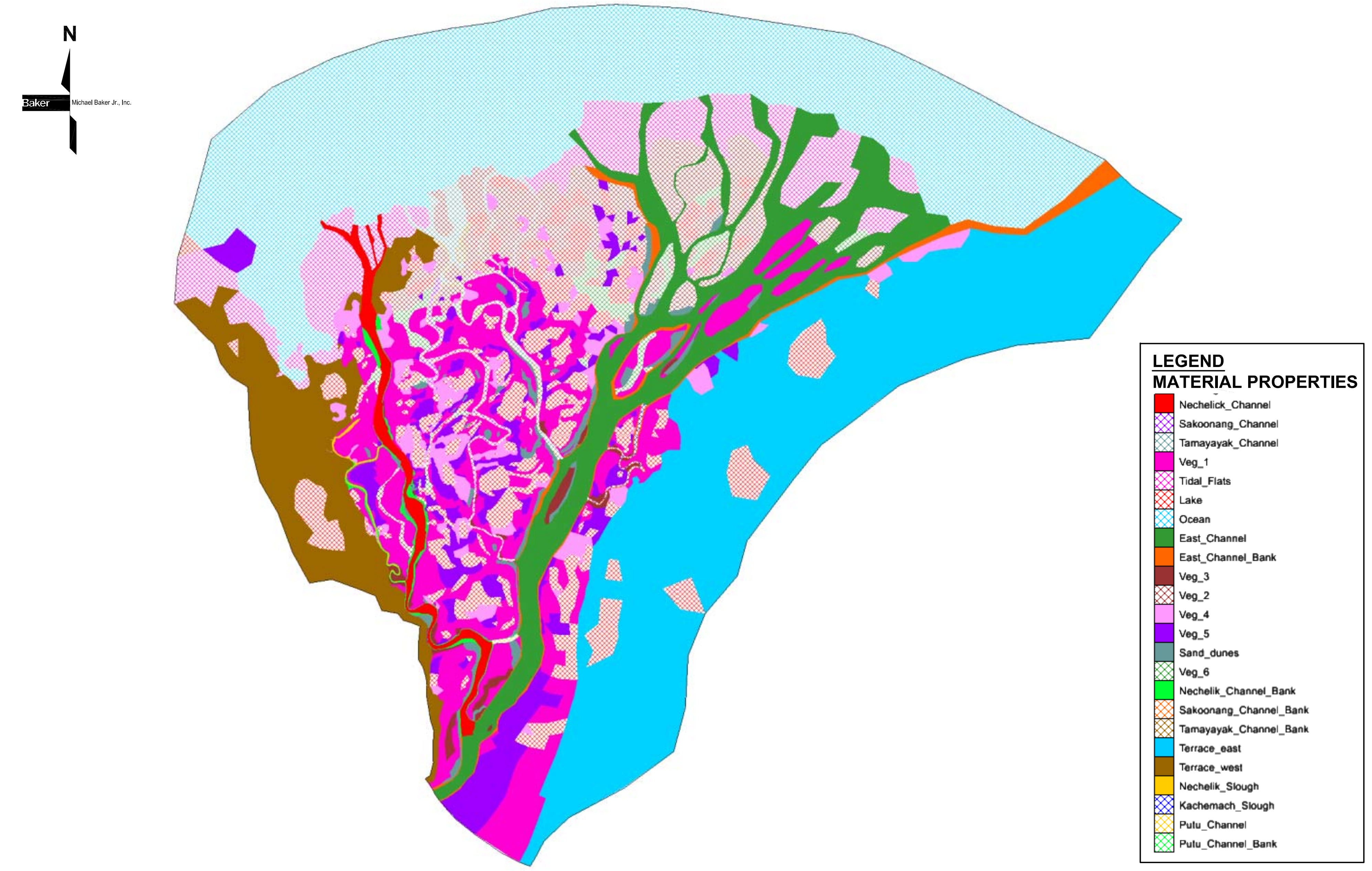
2009 2D MODEL
FINITE ELEMENT MESH
SMS 10.0 OUTPUT

FIGURE B3
(SHEET 1 OF 1)



ConocoPhillips
Alaska, Inc.

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B4
CHECKED:	JAB	SCALE:	N/A

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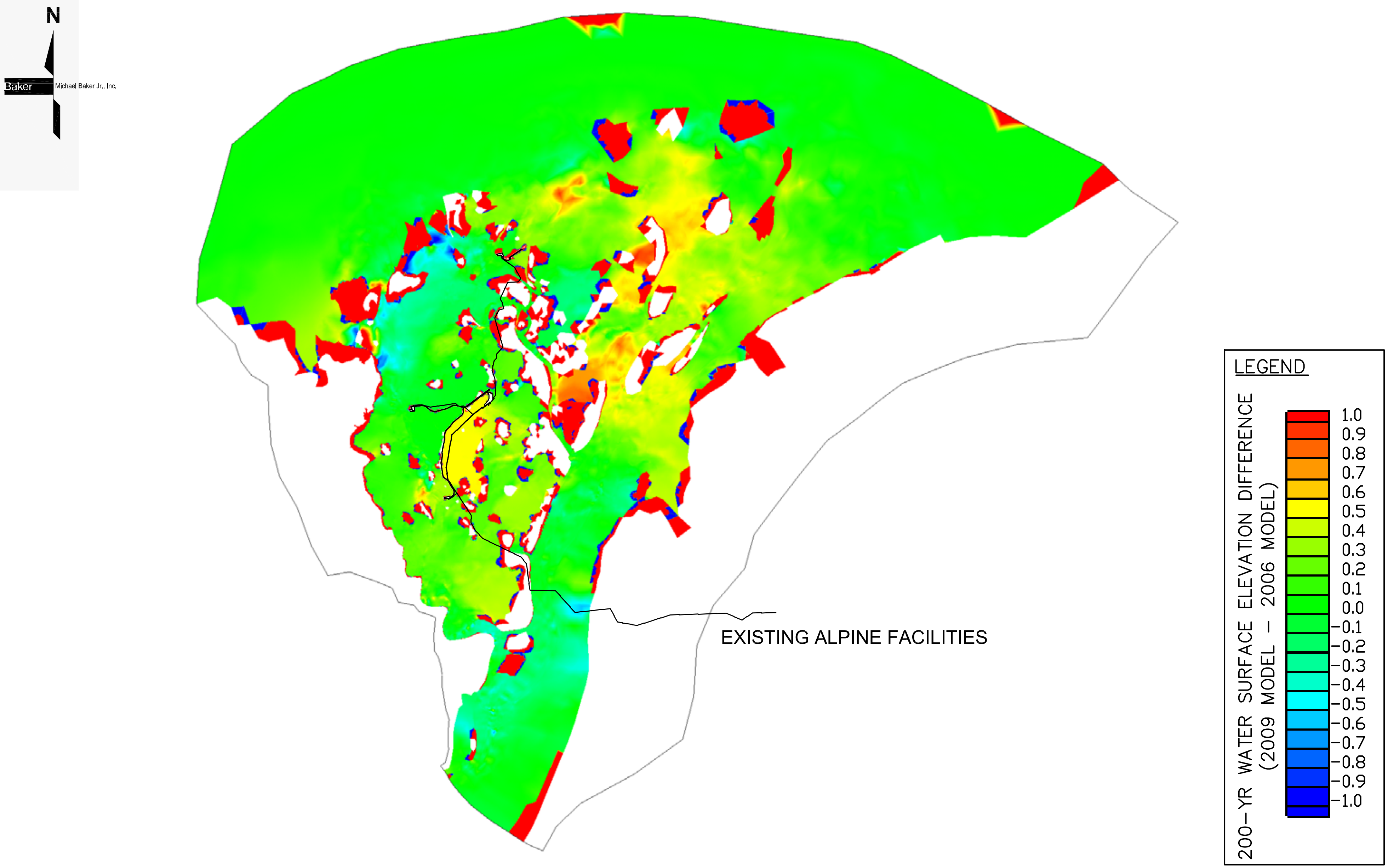
2009 2D MODEL
MATERIAL PROPERTIES
SMS 10.0 OUTPUT

FIGURE B4
(SHEET 1 OF 1)



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DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_VALIDATION.DWG
CHECKED:	JAB	SCALE:	N/A

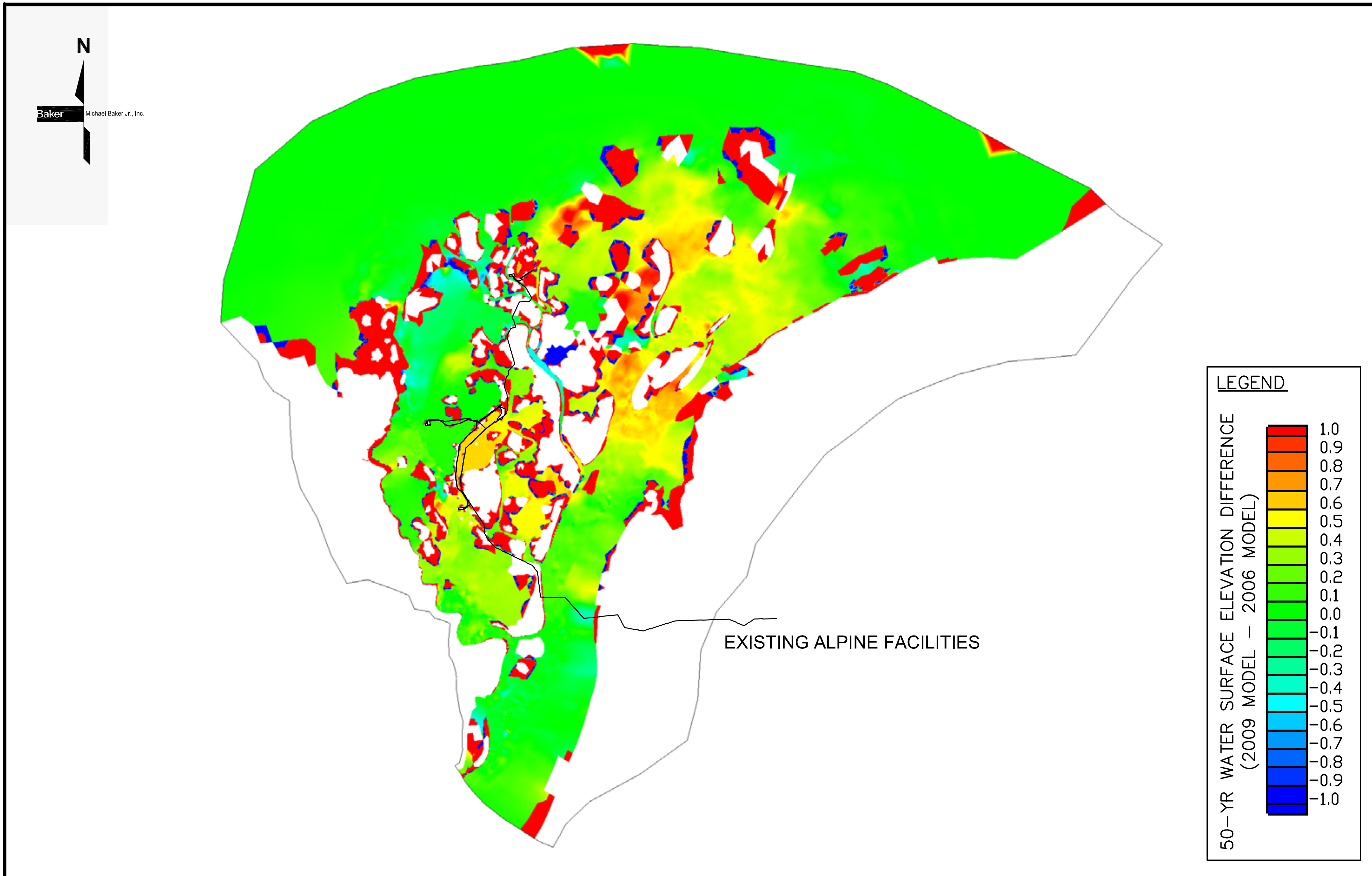
2009 2D MODEL VALIDATION

200-YR WATER SURFACE

ELEVATION DIFFERENCE

FIGURE B5

(SHEET 1 OF X)



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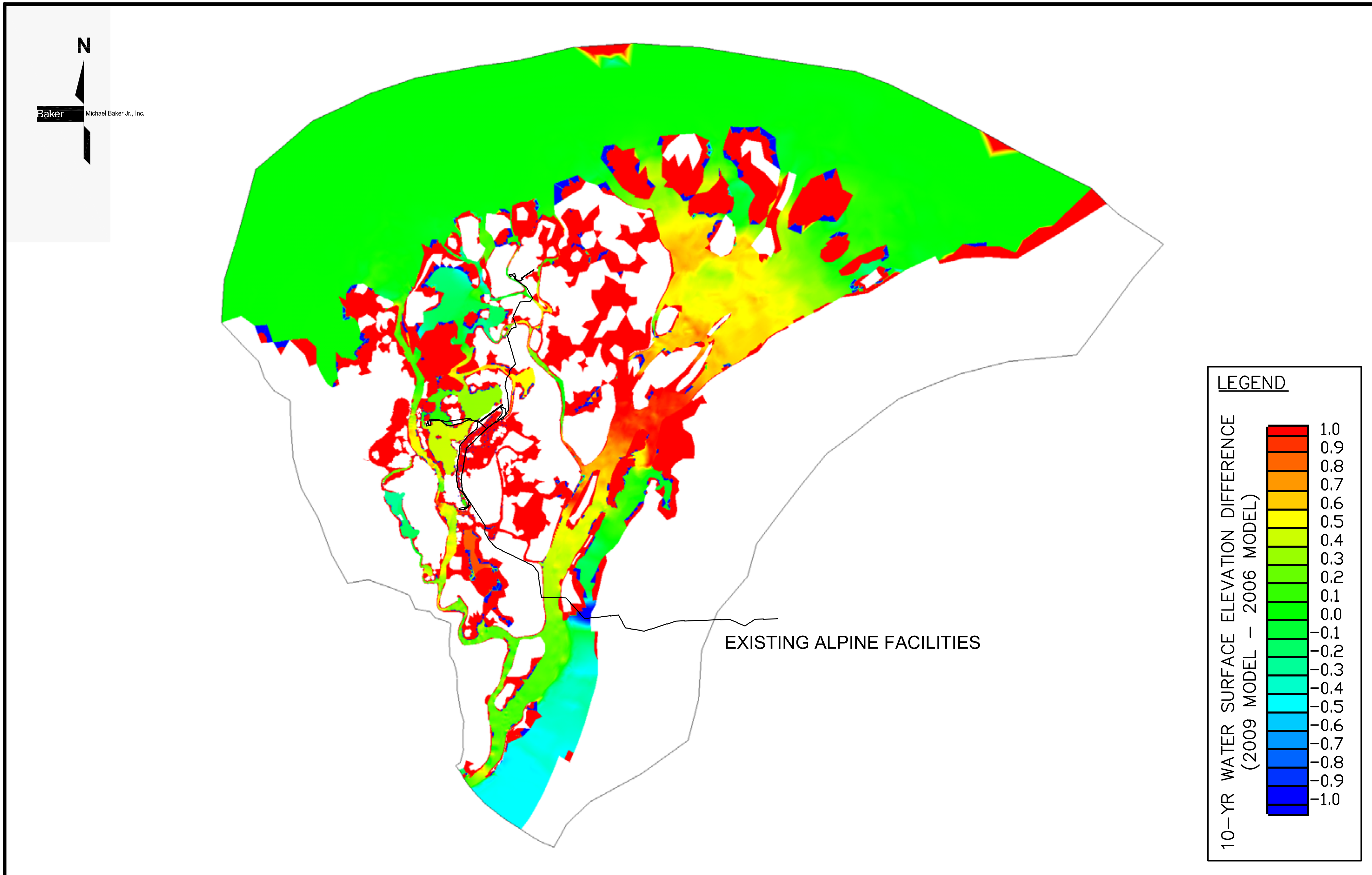
2009 2D MODEL VALIDATION
50-YR WATER SURFACE
ELEVATION DIFFERENCE

FIGURE B6
(SHEET 1 OF X)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_VALIDATION.DWG
CHECKED:	JAB	SCALE:	N/A



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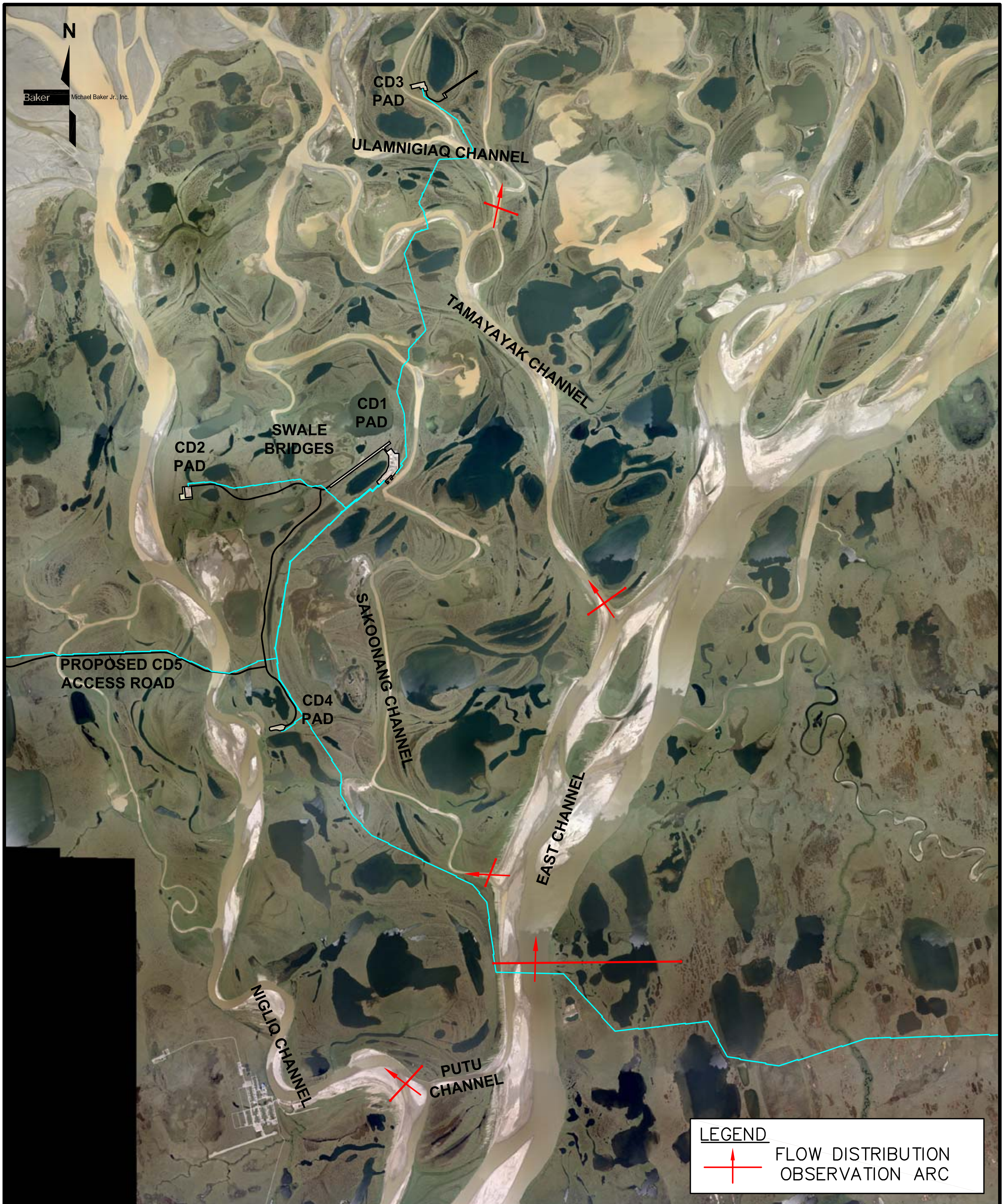
DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_VALIDATION.DWG
CHECKED:	JAB	SCALE:	N/A

2009 2D MODEL VALIDATION
10-YR WATER SURFACE
ELEVATION DIFFERENCE

FIGURE B7
(SHEET 1 OF X)



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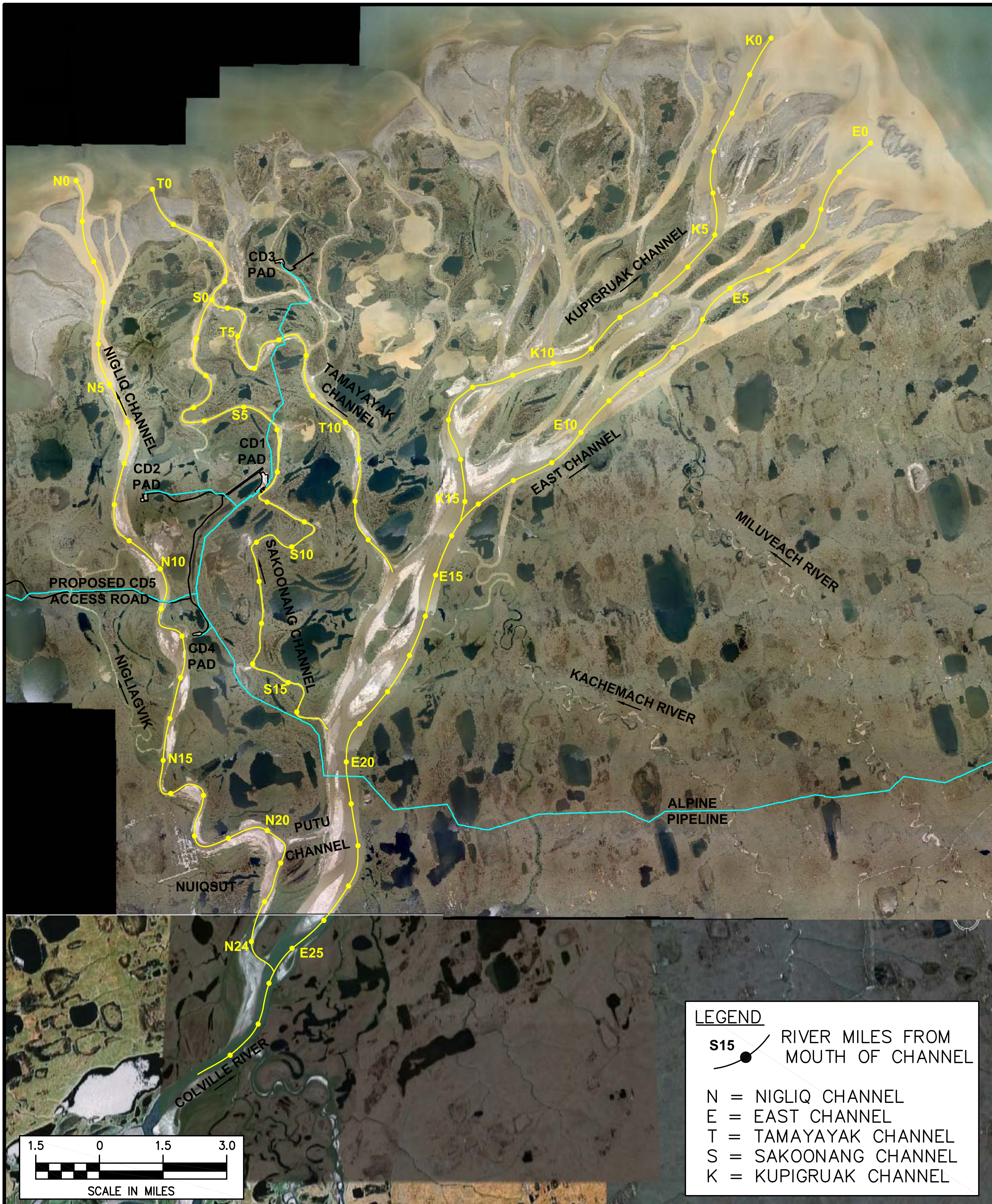
2009 2D MODEL VALIDATION
FLOW DISTRIBUTION
OBSERVATION ARCS

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B8
CHECKED:	JAB	SCALE:	AS SHOWN

FIGURE B8
(SHEET 1 OF 1)



LEGEND

S15 RIVER MILES FROM MOUTH OF CHANNEL

N = NIGLIQ CHANNEL
E = EAST CHANNEL
T = TAMAYAYAK CHANNEL
S = SAKOONANG CHANNEL
K = KUPIGRUAK CHANNEL

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2009 2D MODEL

COLVILLE RIVER DELTA

CHANNELS

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B9
CHECKED:	JAB	SCALE:	AS SHOWN

FIGURE B9

(SHEET 1 OF 1)

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DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B10
CHECKED:	JAB	SCALE:	AS SHOWN

2009 2D MODEL

ALPINE PIPELINE

PI 01B - PI 15A

FIGURE B10

(SHEET 1 OF 1)

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DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B11
CHECKED:	JAB	SCALE:	AS SHOWN

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2009 2D MODEL
ALPINE FACILITIES
PERMANENT STAFF GAGES

FIGURE B11
(SHEET 1 OF 1)

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DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B12
CHECKED:	JAB	SCALE:	AS SHOWN

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2009 2D MODEL
ALPINE FACILITIES
CD2 ACCESS ROAD STATIONING

FIGURE B12
(SHEET 1 OF 1)

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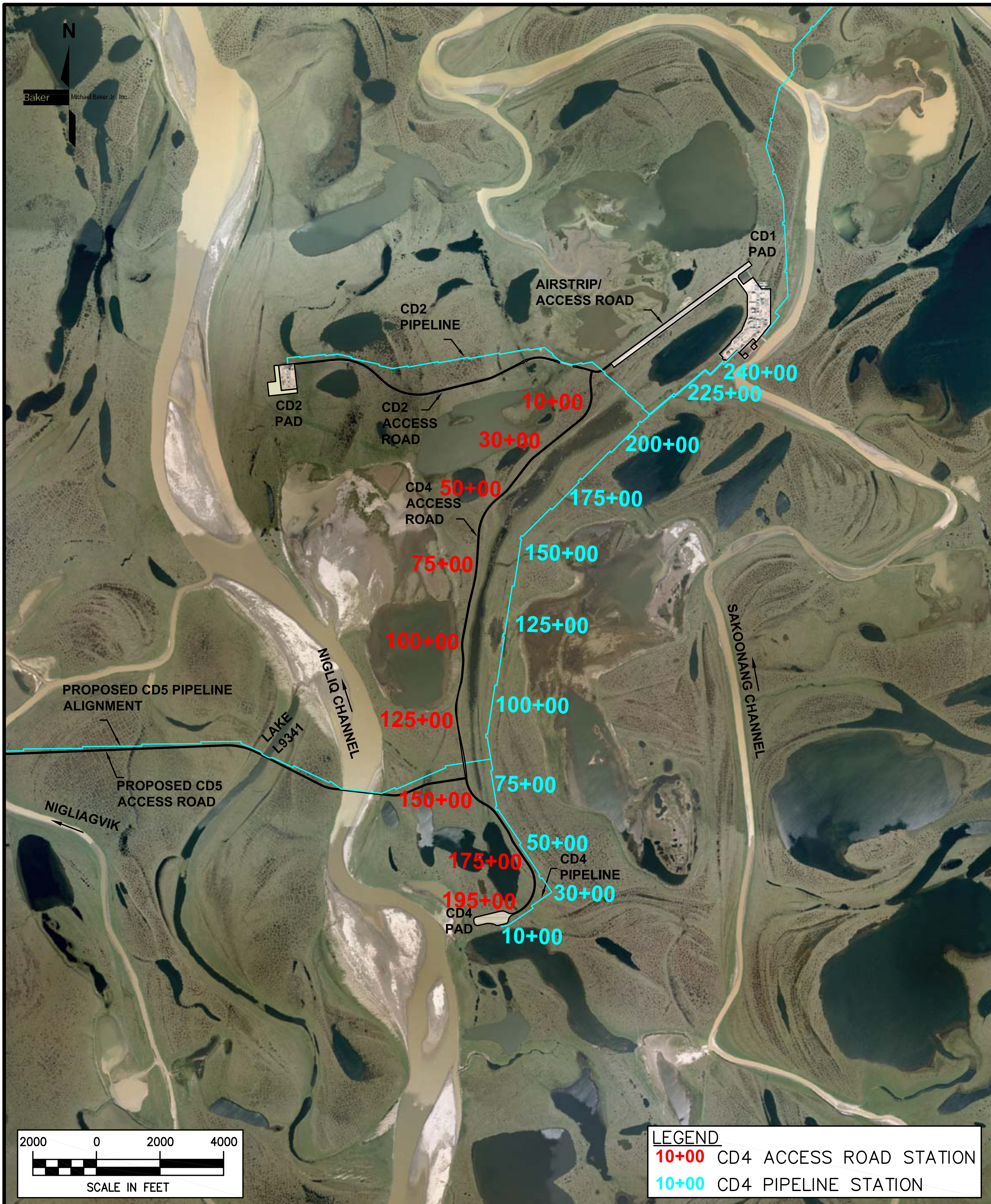
DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B13
CHECKED:	JAB	SCALE:	AS SHOWN

2009 2D MODEL
CD3 PAD & PIPELINE
STATIONING

FIGURE B13
(SHEET 1 OF 1)



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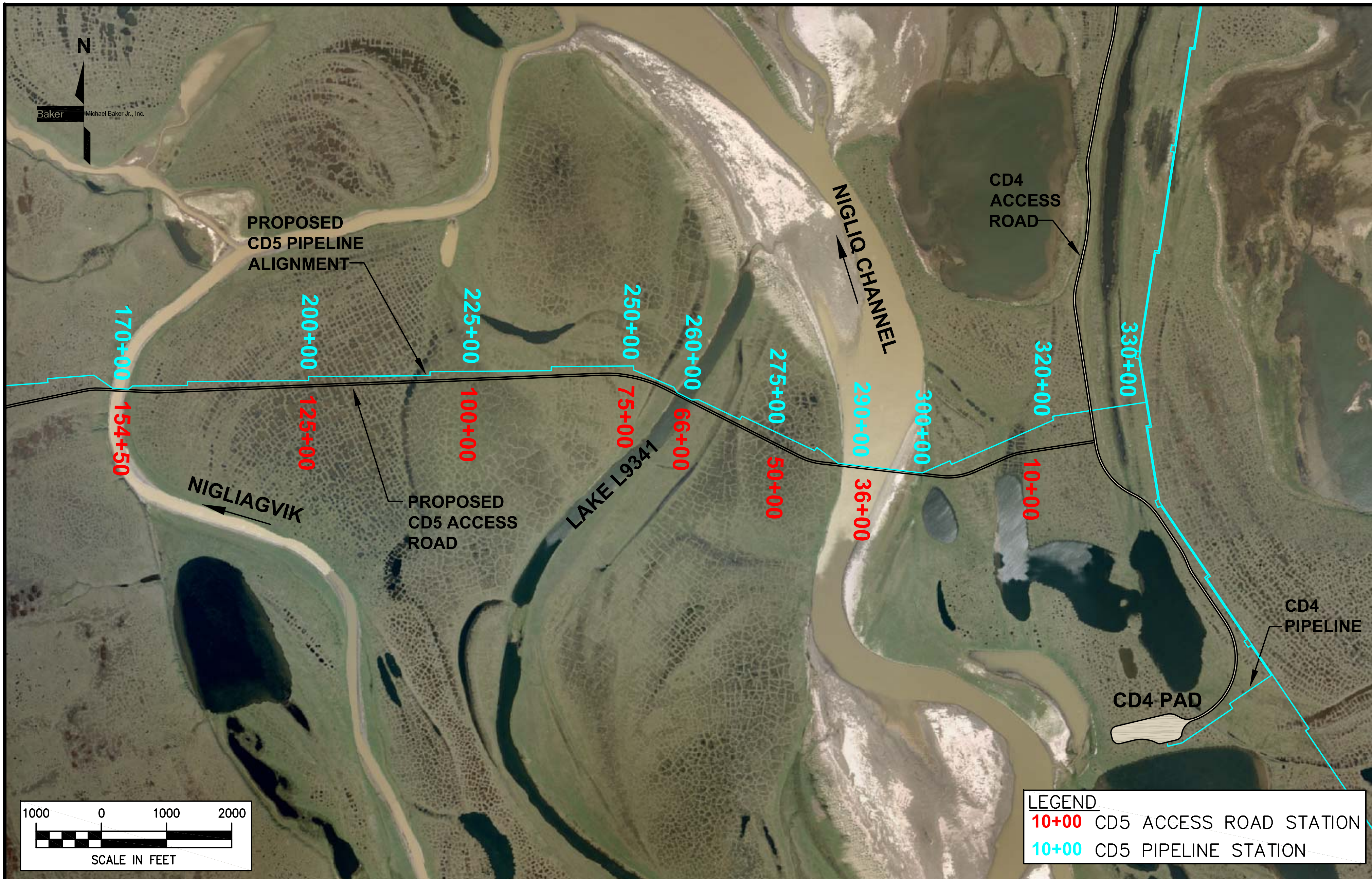
DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B14
CHECKED:	JAB	SCALE:	AS SHOWN

2009 2D MODEL
CD4 ACCESS ROAD &
PIPELINE STATIONING

FIGURE B14
(SHEET 1 OF 1)



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DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	FIGURE_B15
CHECKED:	JAB	SCALE:	AS SHOWN

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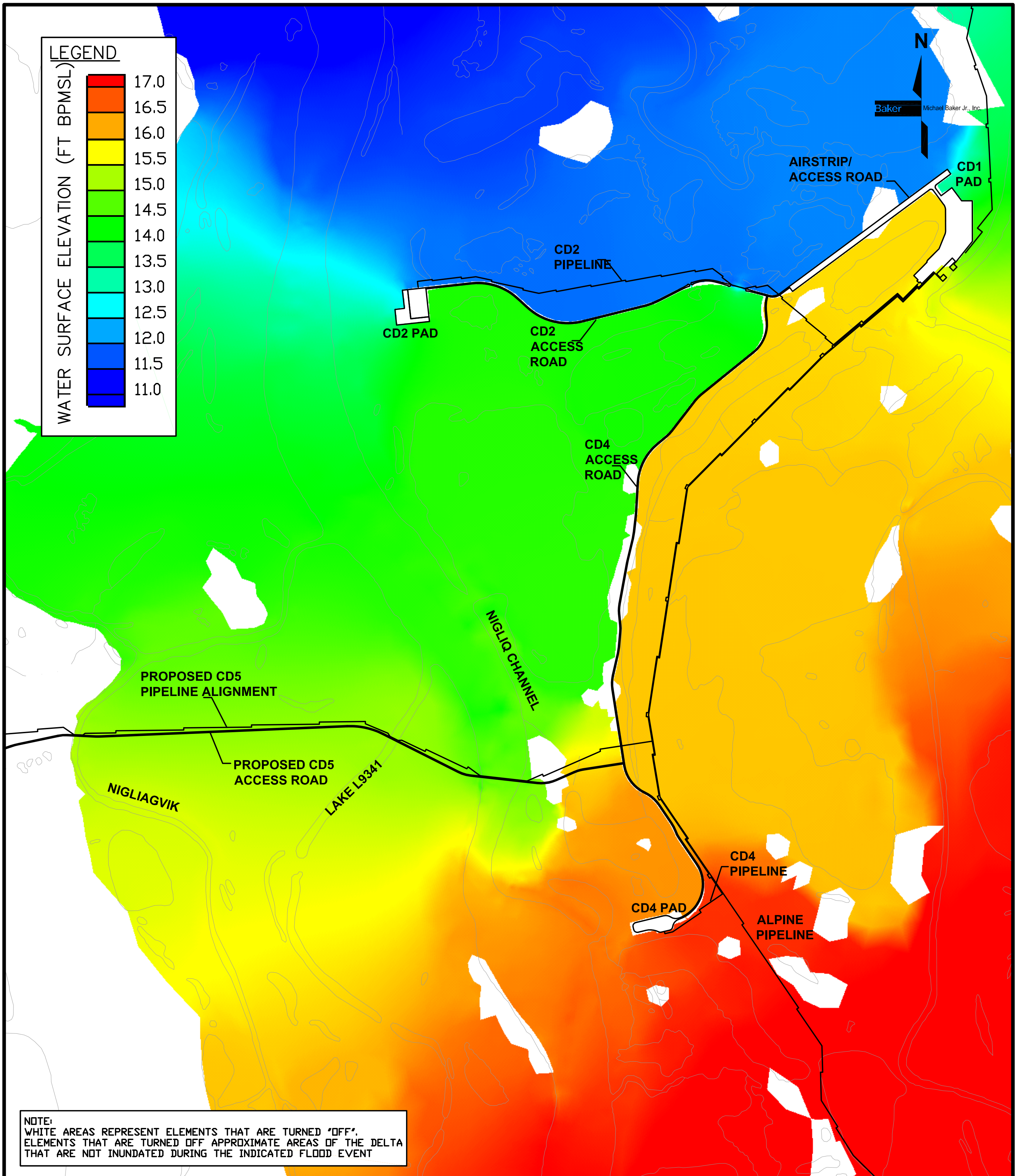
2009 2D MODEL
PROPOSED CD5 ACCESS ROAD & PIPELINE STATIONING

FIGURE B15
(SHEET 1 OF 1)



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2009 2D MODEL SOLUTION

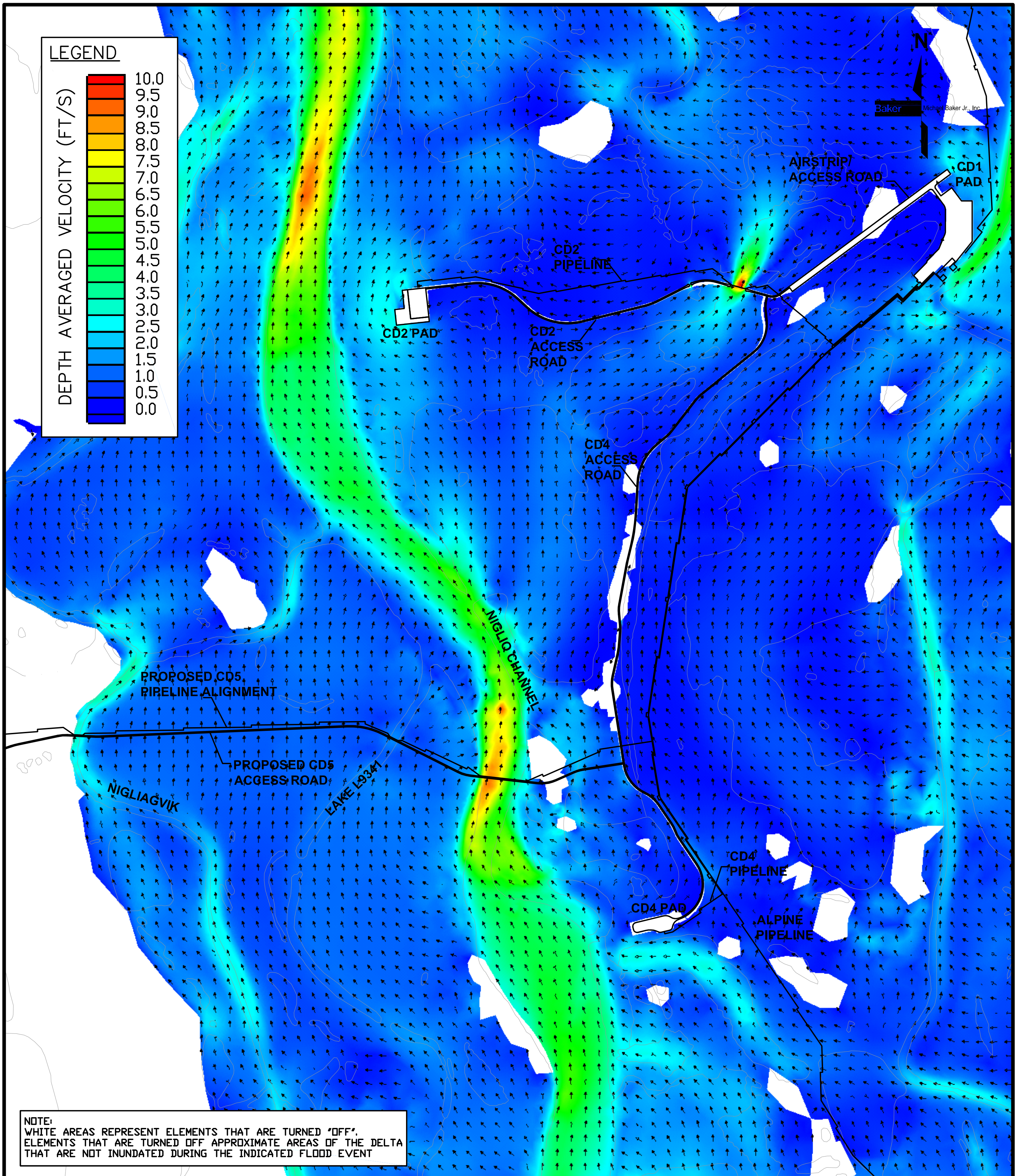
PRE- CD5: 200-YEAR FLOOD

WATER SURFACE ELEVATIONS

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A

FIGURE B16

(SHEET 1 OF 1)



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2009 2D MODEL SOLUTION

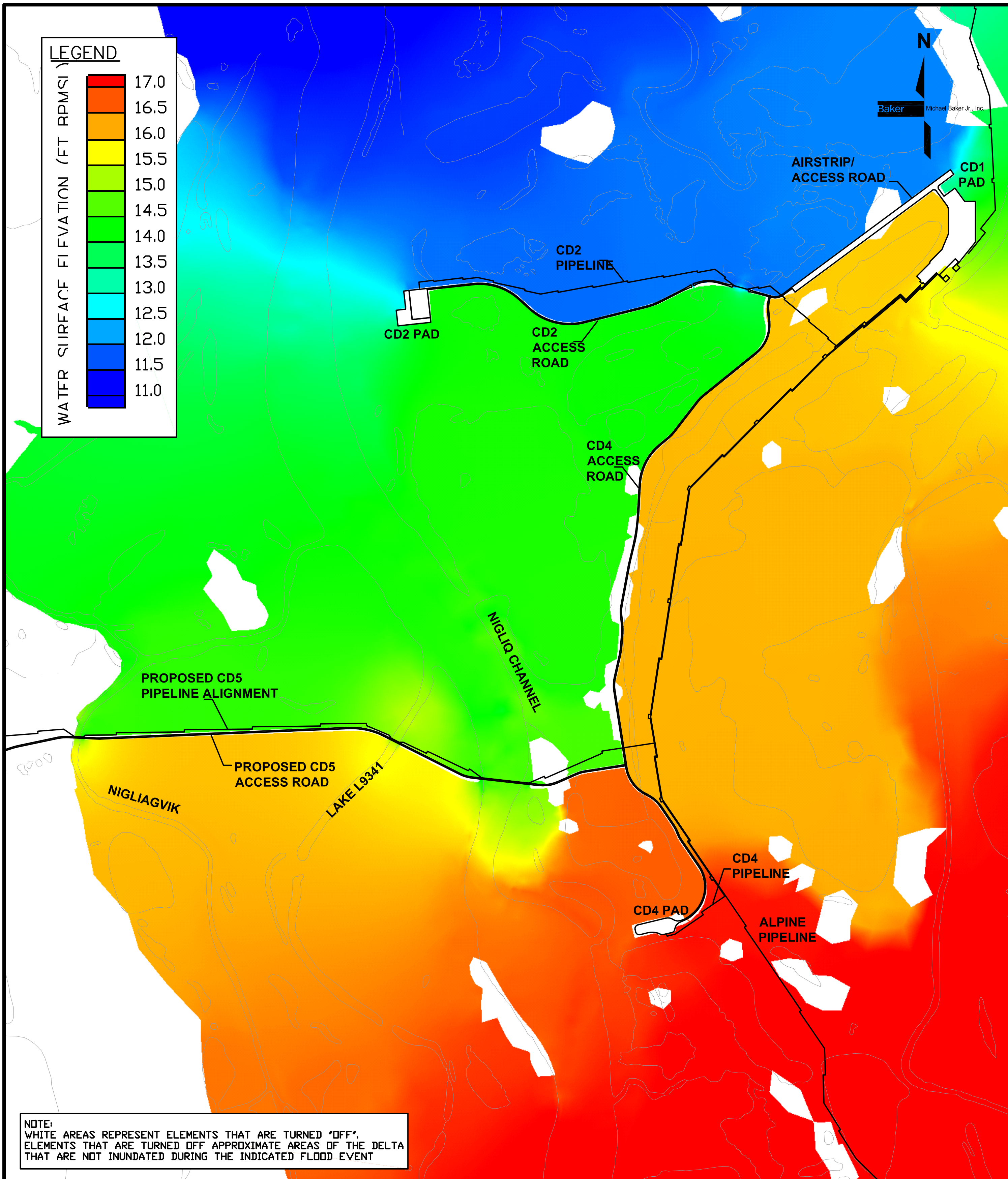
PRE- CD5: 200-YEAR FLOOD

DEPTH AVERAGED VELOCITIES

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A

FIGURE B17

(SHEET 1 OF 1)



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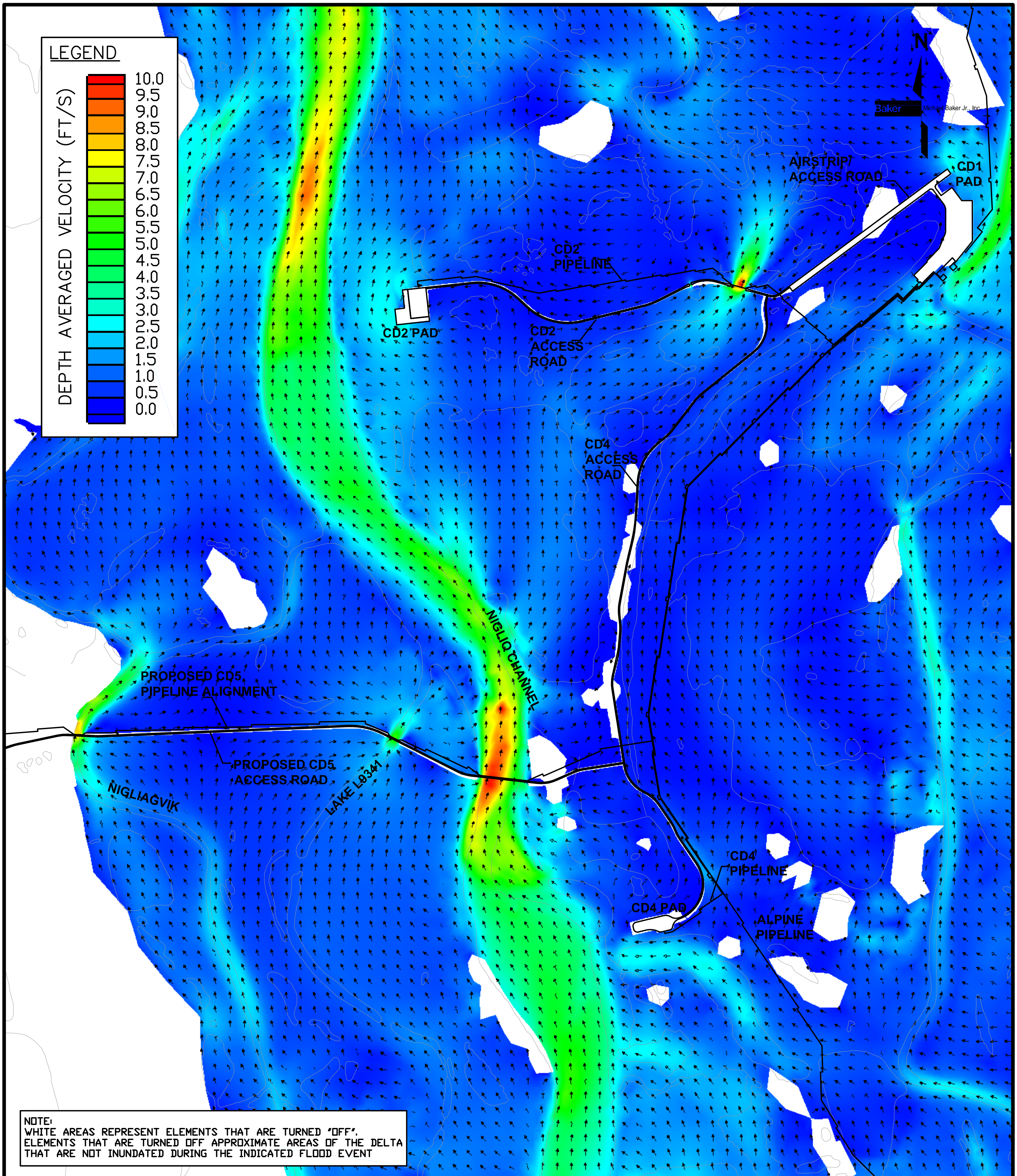
2009 2D MODEL SOLUTION
POST- CD5: 200-YEAR FLOOD
WATER SURFACE ELEVATIONS

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A

FIGURE B18
(SHEET 1 OF 1)



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2009 2D MODEL SOLUTION

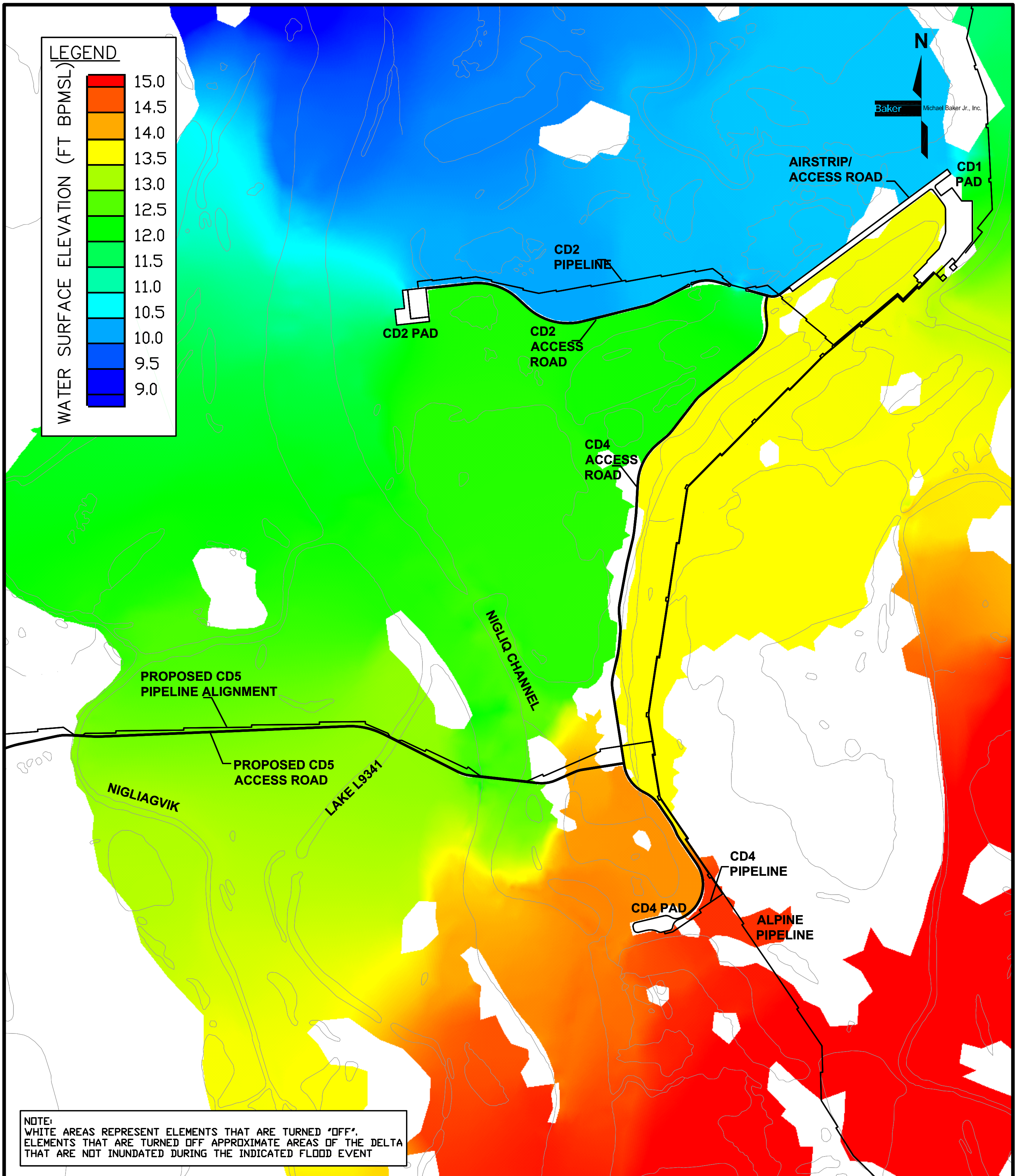
POST- CD5: 200-YEAR FLOOD

DEPTH AVERAGED VELOCITIES

FIGURE B19

(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A



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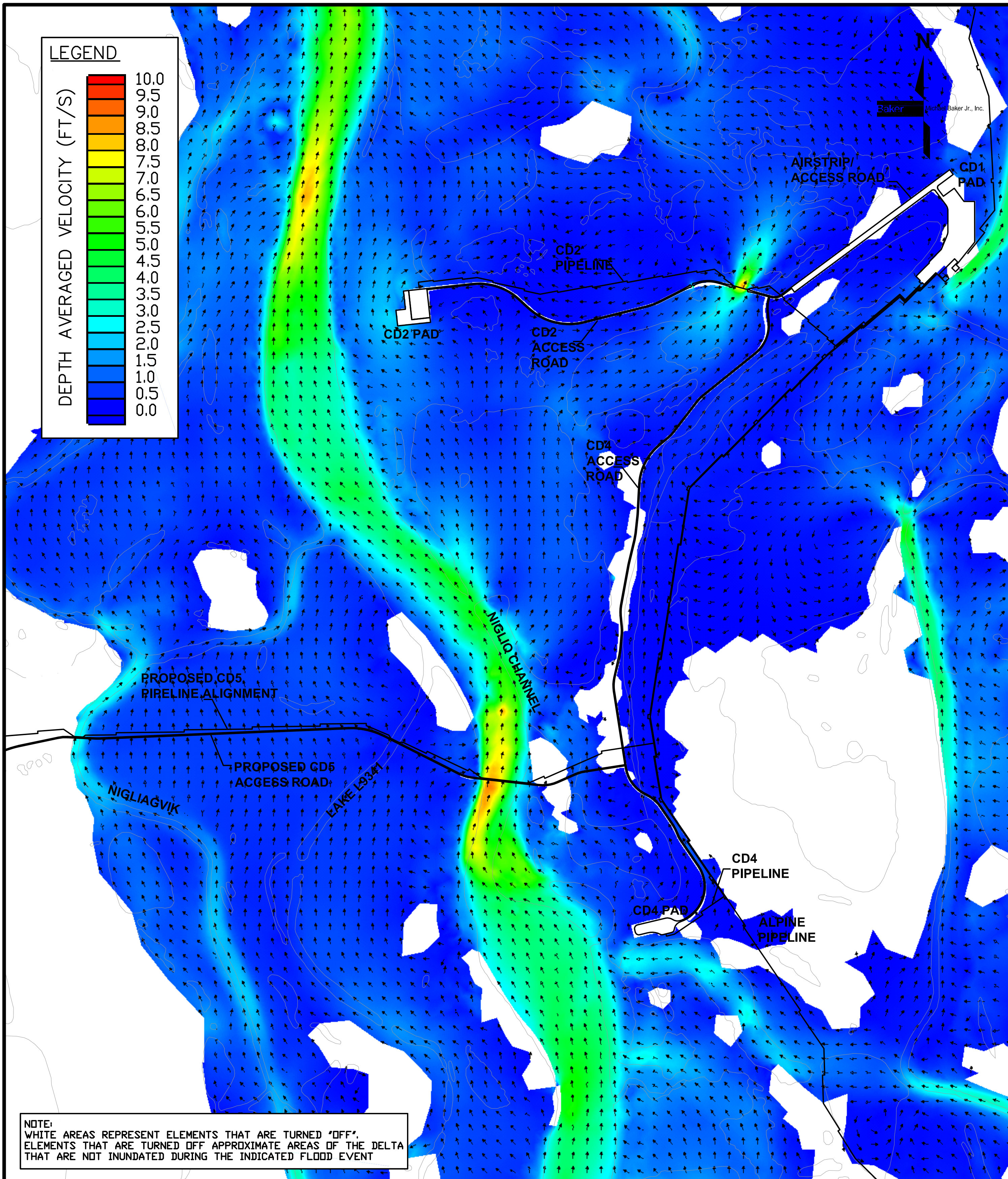
2009 2D MODEL SOLUTION
PRE- CD5: 50-YEAR FLOOD
WATER SURFACE ELEVATIONS

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A

FIGURE B20
(SHEET 1 OF 1)



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2009 2D MODEL SOLUTION

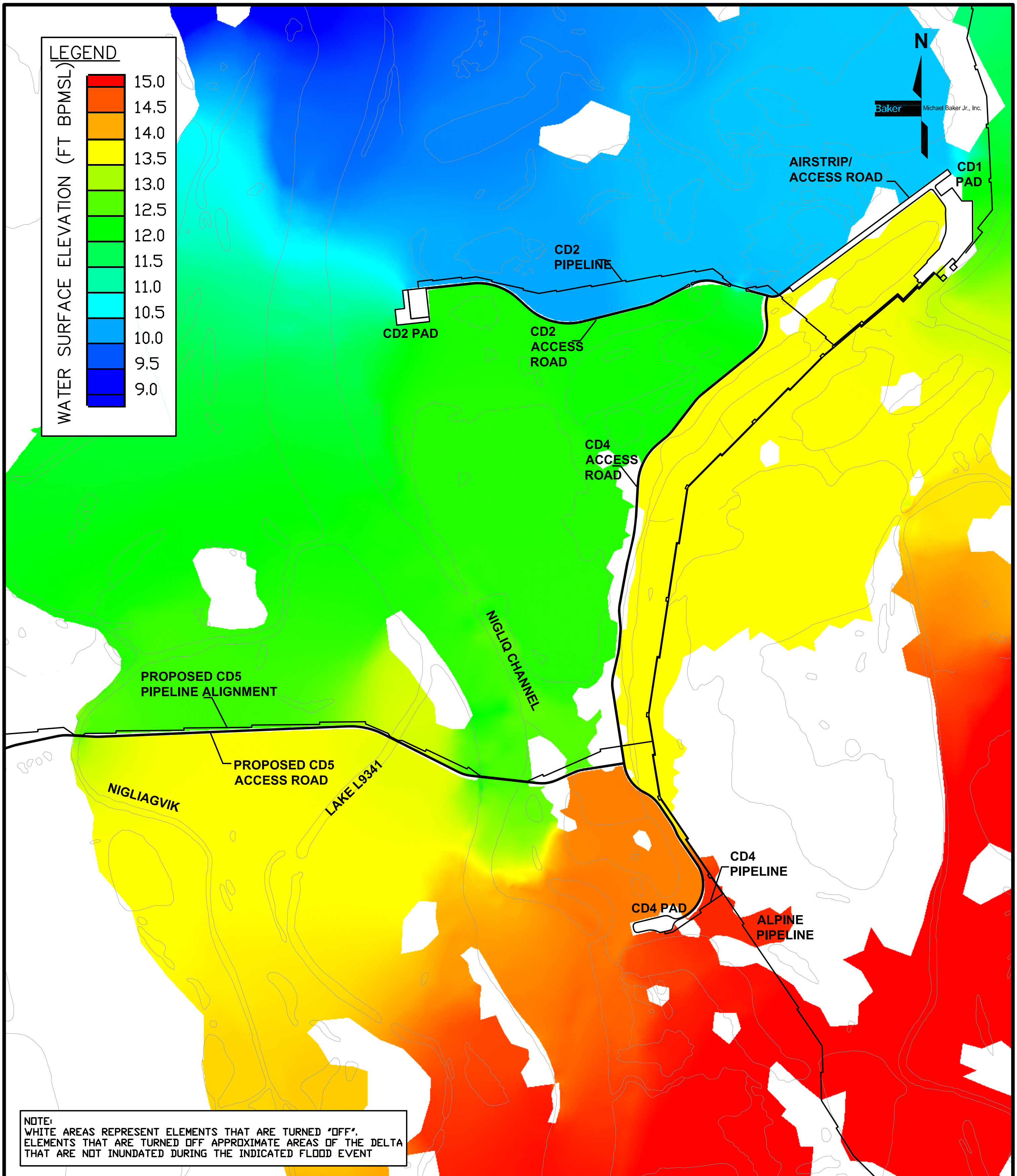
PRE- CD5: 50-YEAR FLOOD

DEPTH AVERAGED VELOCITIES

FIGURE B21

(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A



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2009 2D MODEL SOLUTION

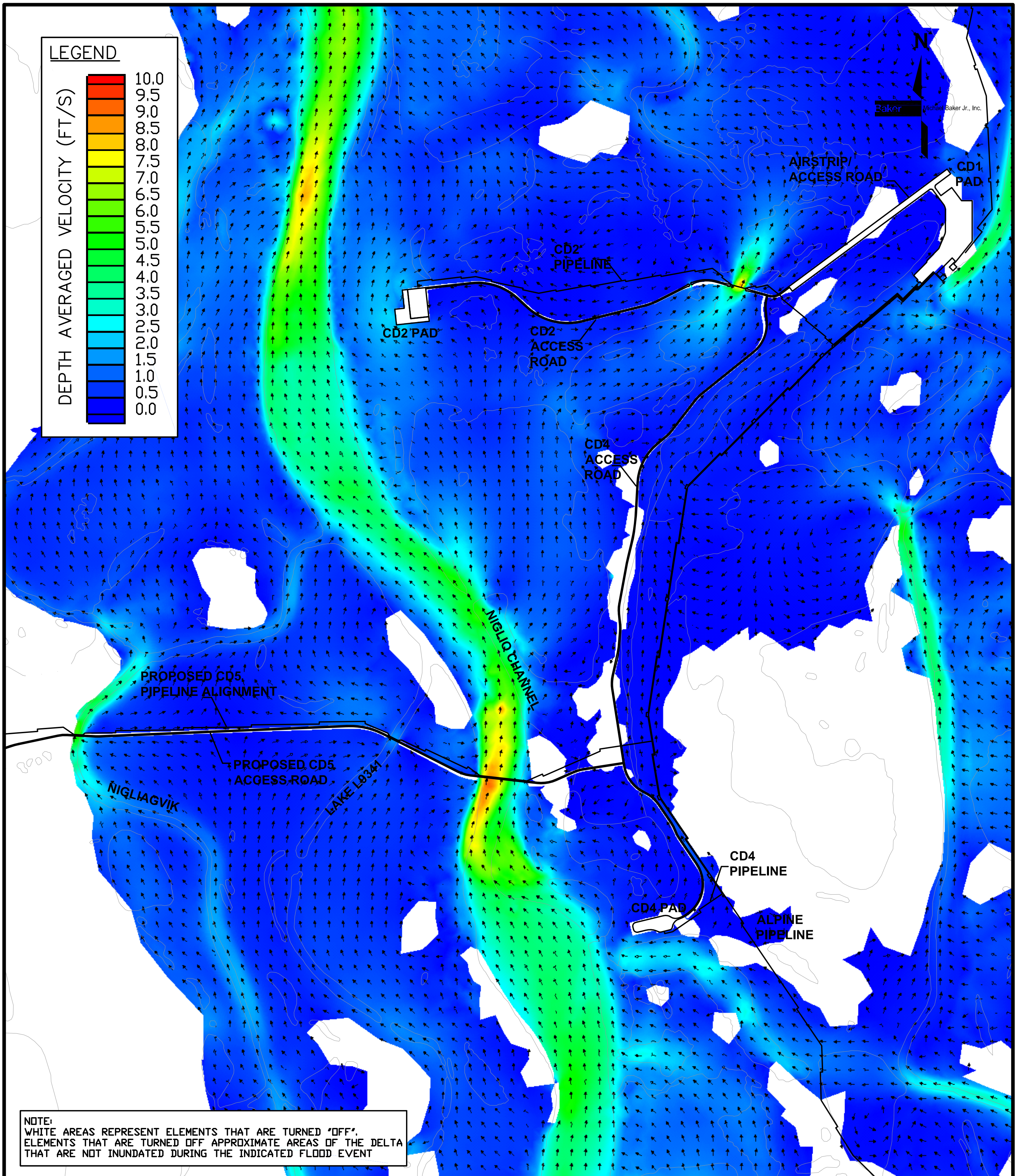
POST- CD5: 50-YEAR FLOOD

WATER SURFACE ELEVATIONS

FIGURE B22

(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A



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2009 2D MODEL SOLUTION

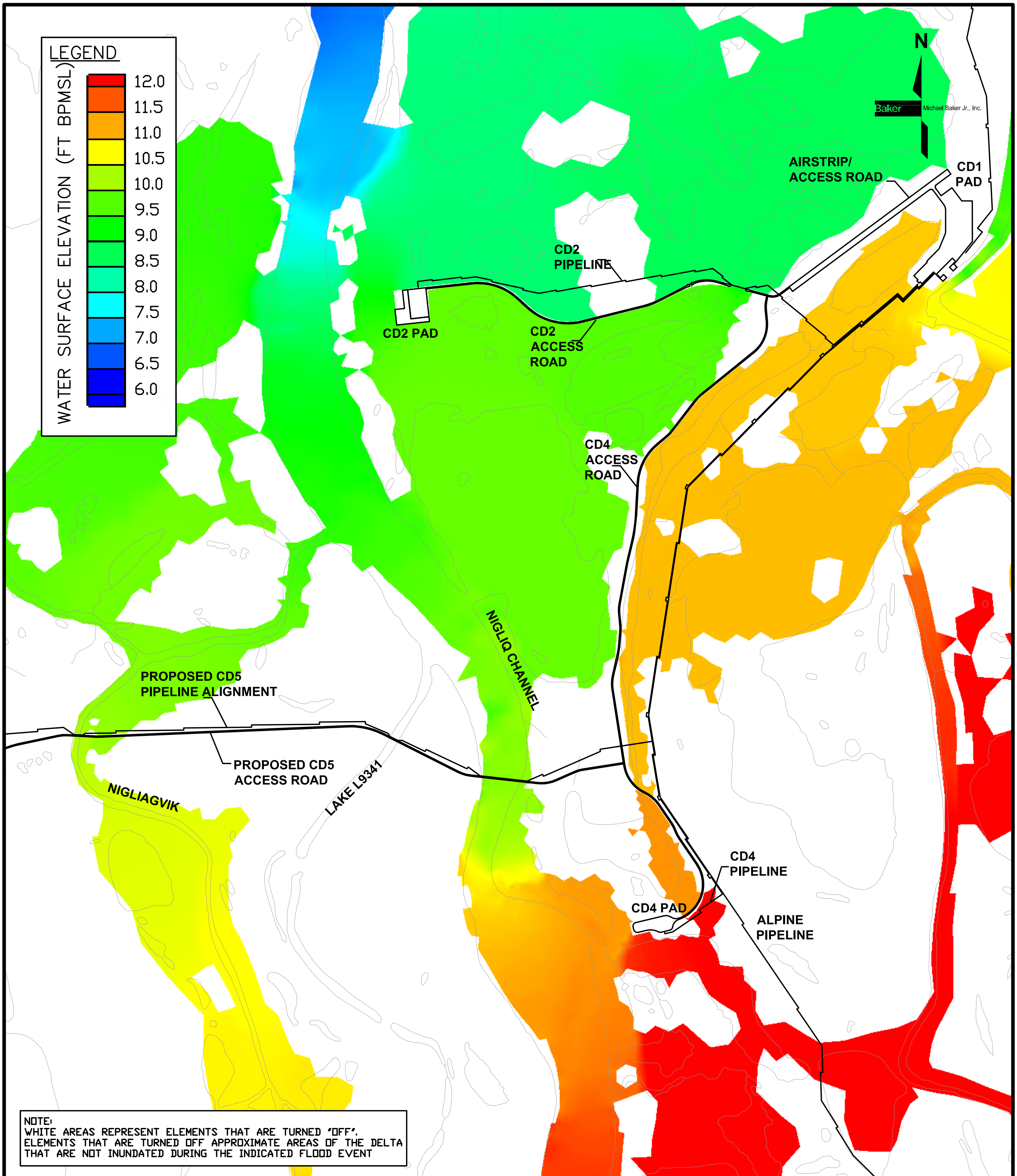
POST- CD5: 50-YEAR FLOOD

DEPTH AVERAGED VELOCITIES

FIGURE B23

(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A



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2009 2D MODEL SOLUTION

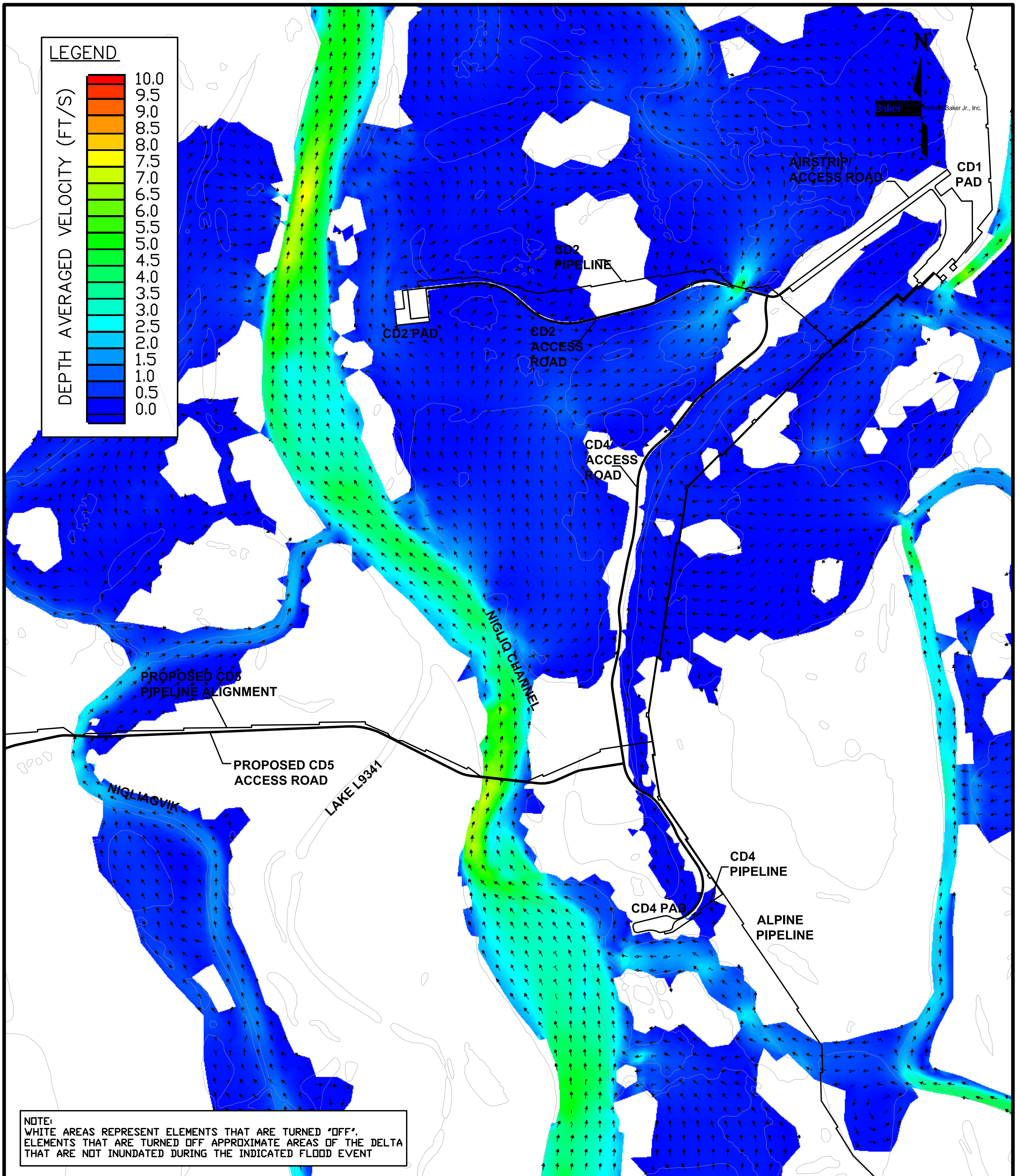
PRE- CD5: 10-YEAR FLOOD

WATER SURFACE ELEVATIONS

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A

FIGURE B24

(SHEET 1 OF 1)



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2009 2D MODEL SOLUTION

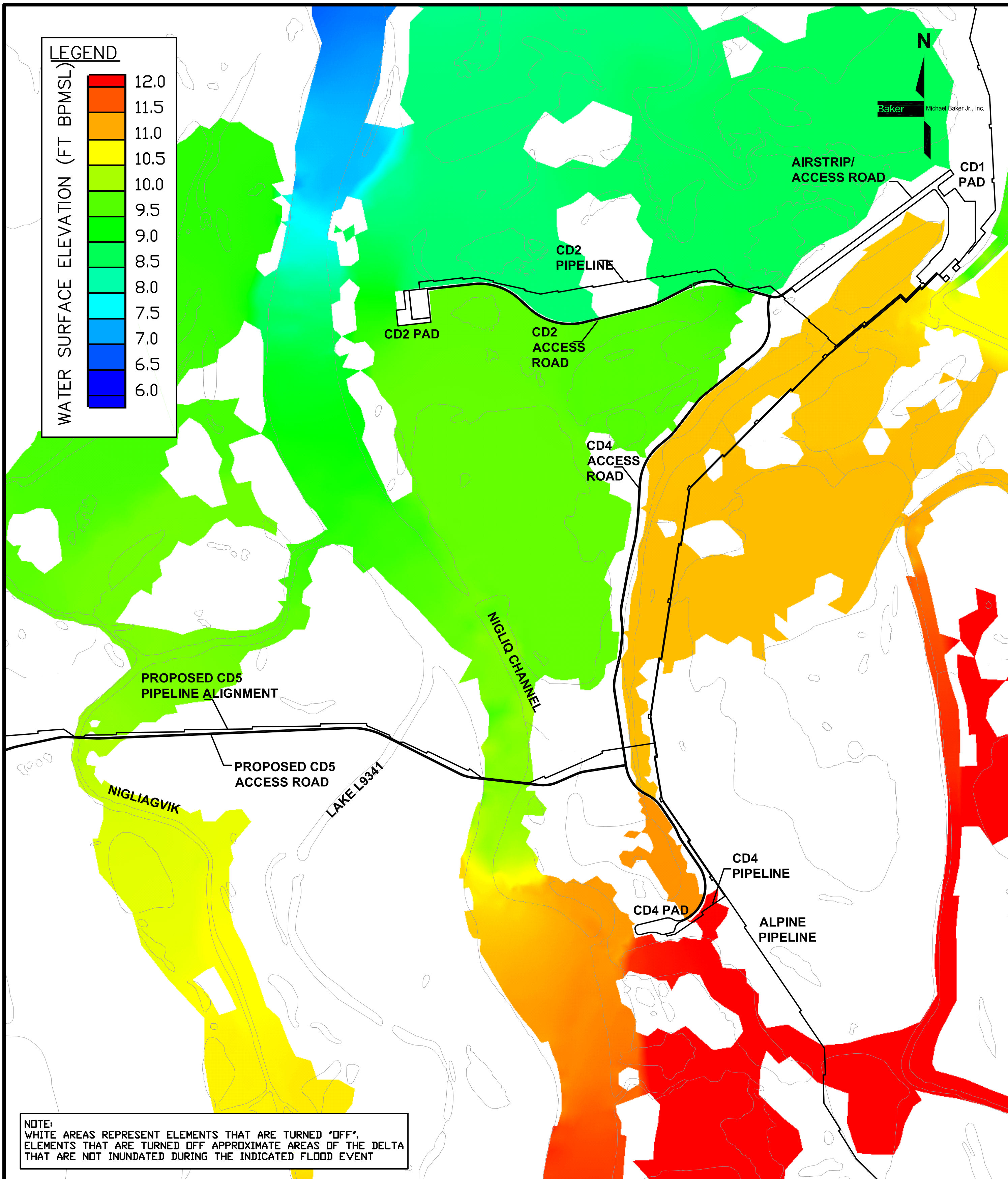
PRE- CD5: 10-YEAR FLOOD

DEPTH AVERAGED VELOCITIES

FIGURE B25

(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A



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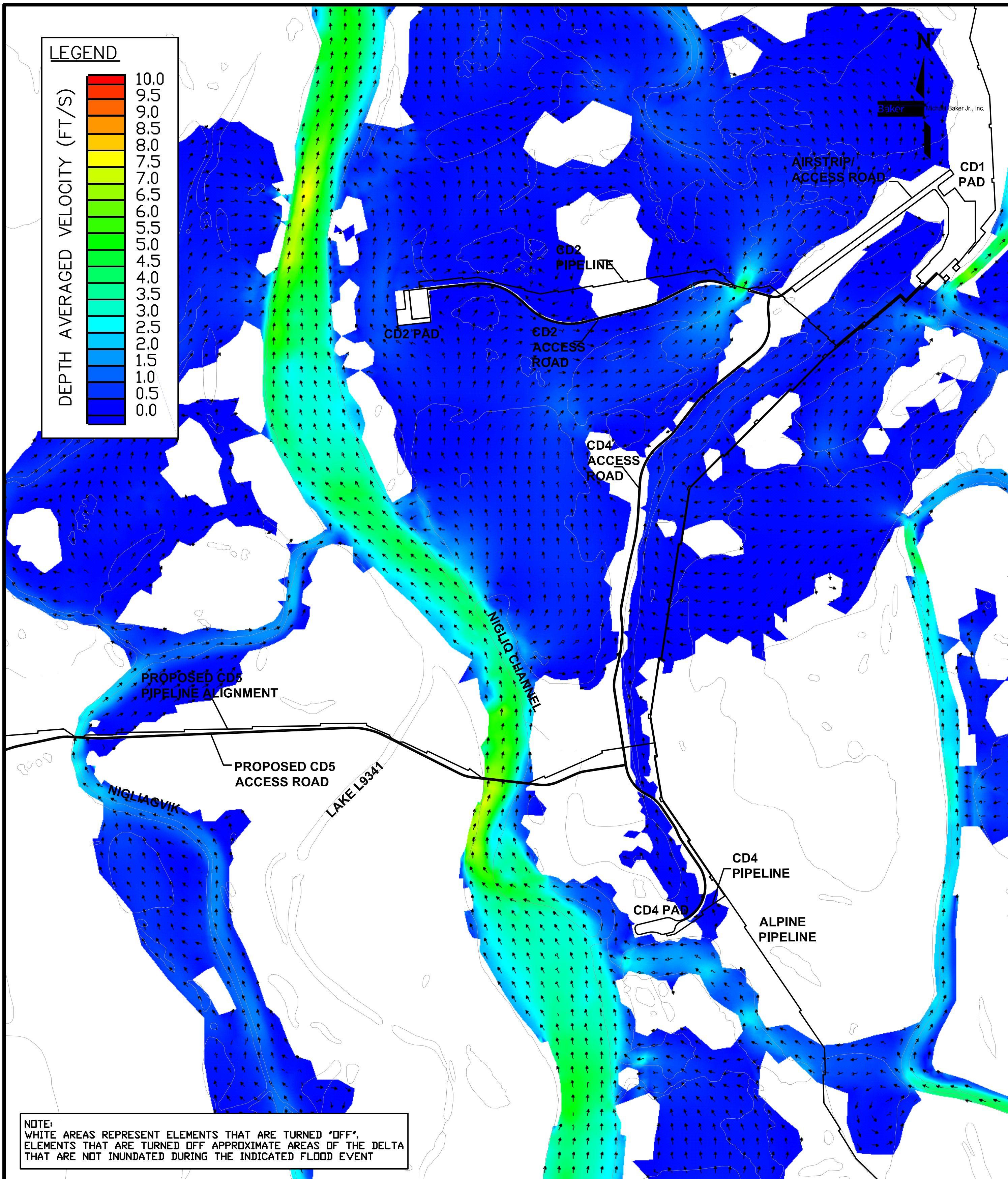
2009 2D MODEL SOLUTION
POST- CD5: 10-YEAR FLOOD
WATER SURFACE ELEVATIONS

FIGURE B26
(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A



NOTE:
WHITE AREAS REPRESENT ELEMENTS THAT ARE TURNED "OFF". ELEMENTS THAT ARE TURNED OFF APPROXIMATE AREAS OF THE DELTA THAT ARE NOT INUNDATED DURING THE INDICATED FLOOD EVENT

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2009 2D MODEL SOLUTION

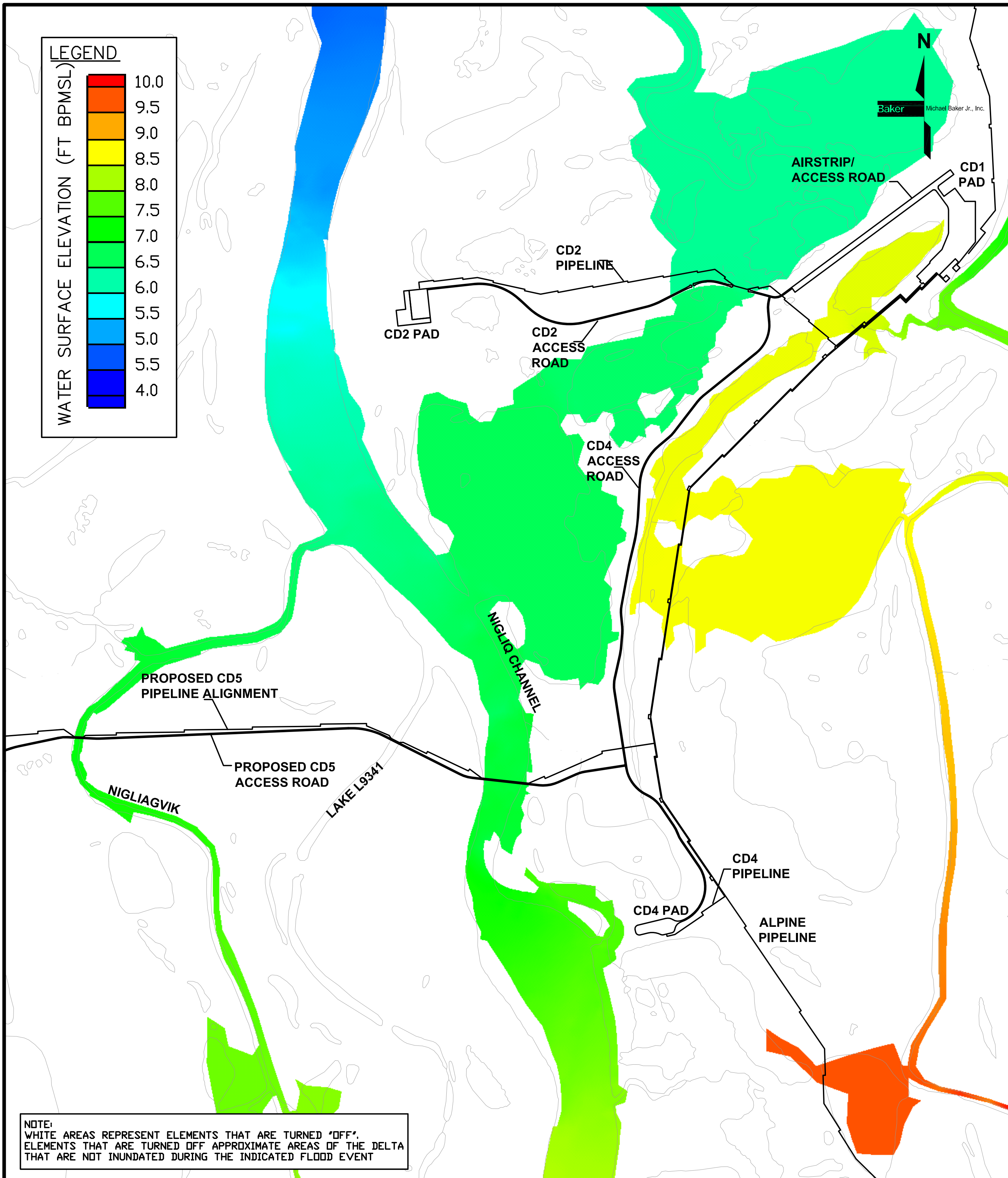
POST- CD5: 10-YEAR FLOOD

DEPTH AVERAGE VELOCITIES

FIGURE B27

(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A



NOTE:
WHITE AREAS REPRESENT ELEMENTS THAT ARE TURNED "OFF". ELEMENTS THAT ARE TURNED OFF APPROXIMATE AREAS OF THE DELTA THAT ARE NOT INUNDATED DURING THE INDICATED FLOOD EVENT

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2009 2D MODEL SOLUTION

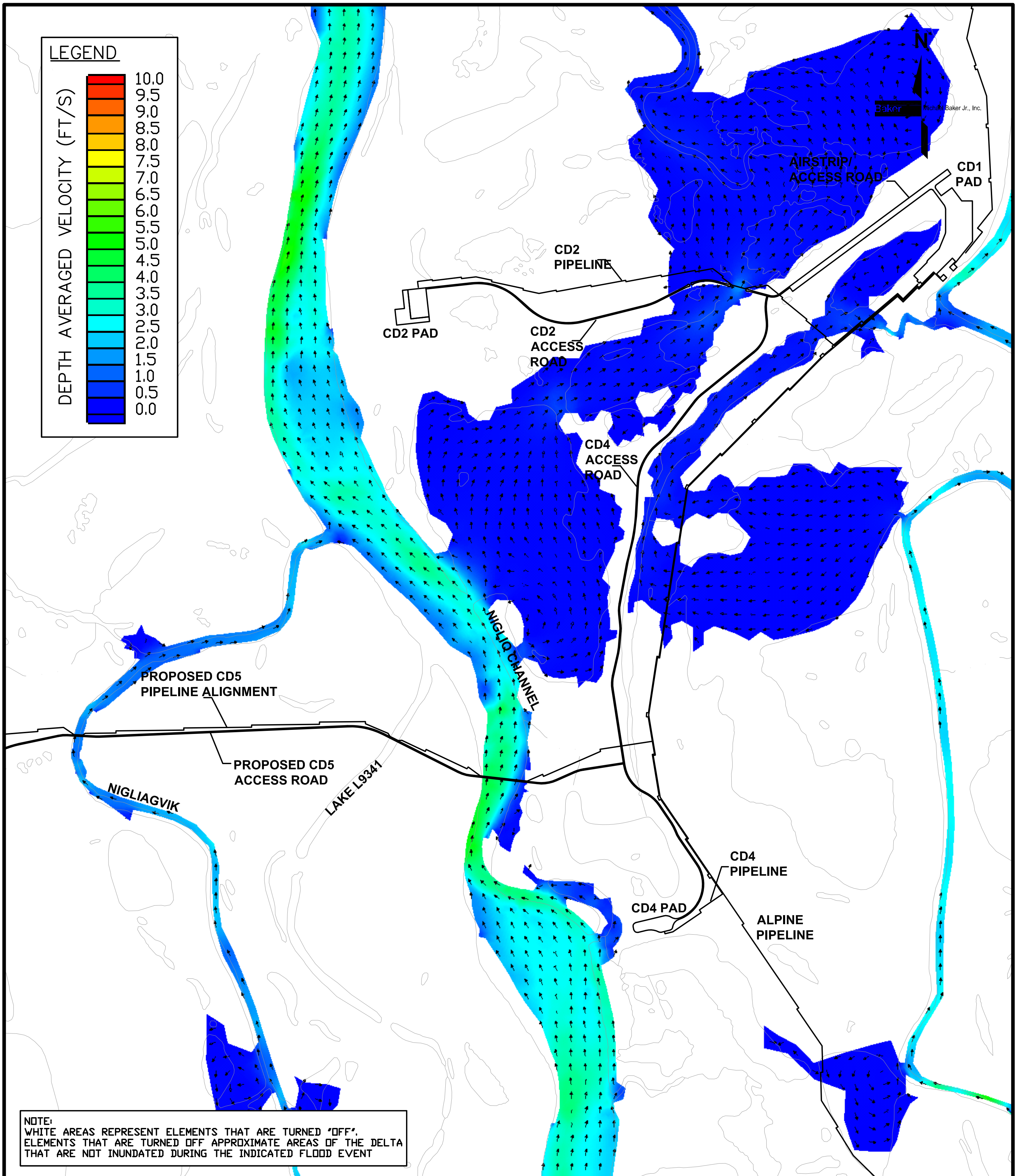
PRE- CD5: 2-YEAR FLOOD

WATER SURFACE ELEVATIONS

FIGURE B28

(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A



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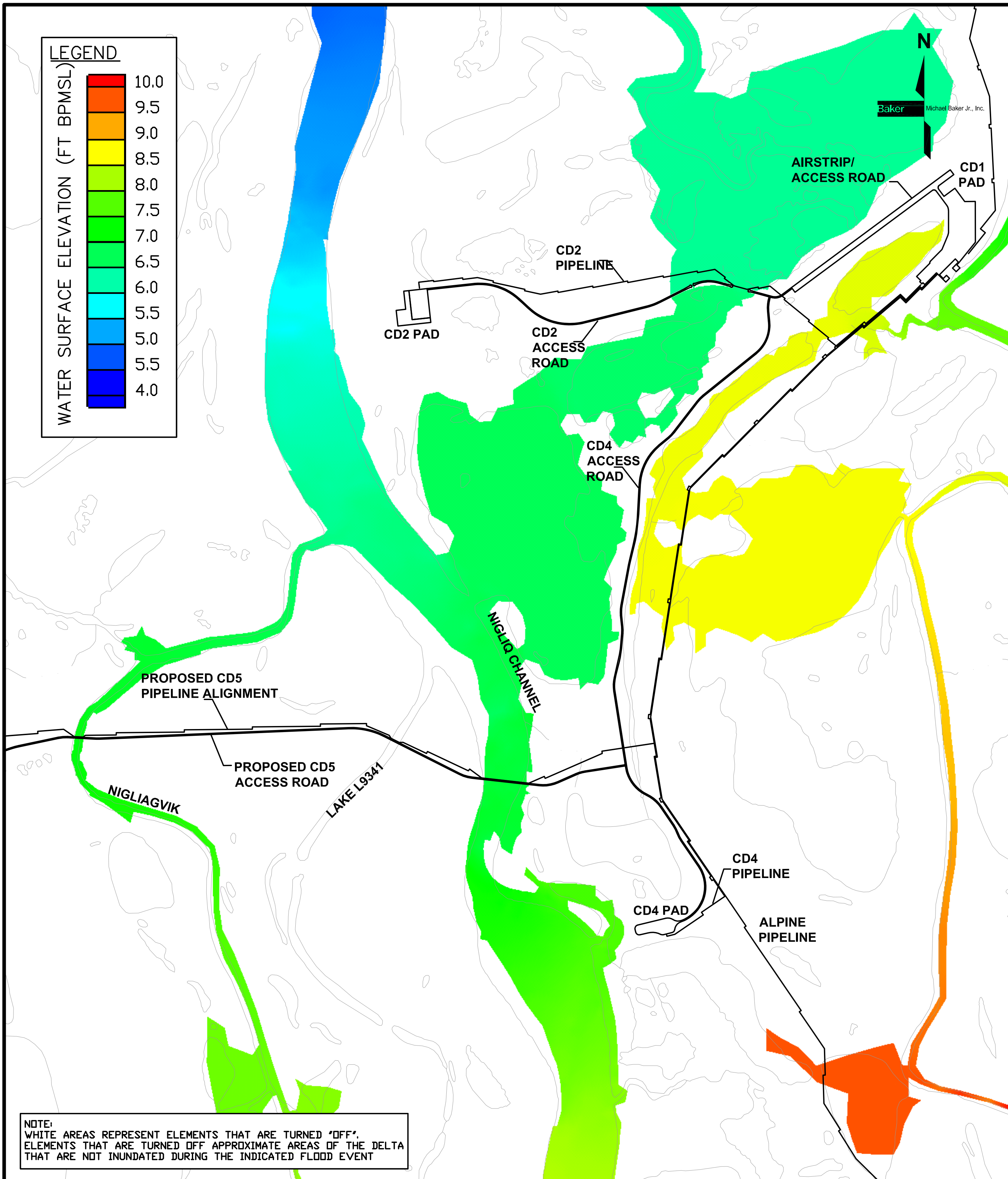
2009 2D MODEL SOLUTION

PRE- CD5: 2-YEAR FLOOD

DEPTH AVERAGED VELOCITIES

DATE: 4/1/09	PROJECT: 114536		FIGURE B29
DRAWN: MDM	FILE: MODEL_SOLUTIONS.DWG		(SHEET 1 OF 1)
CHECKED: JAB	SCALE: N/A		



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2009 2D MODEL SOLUTION

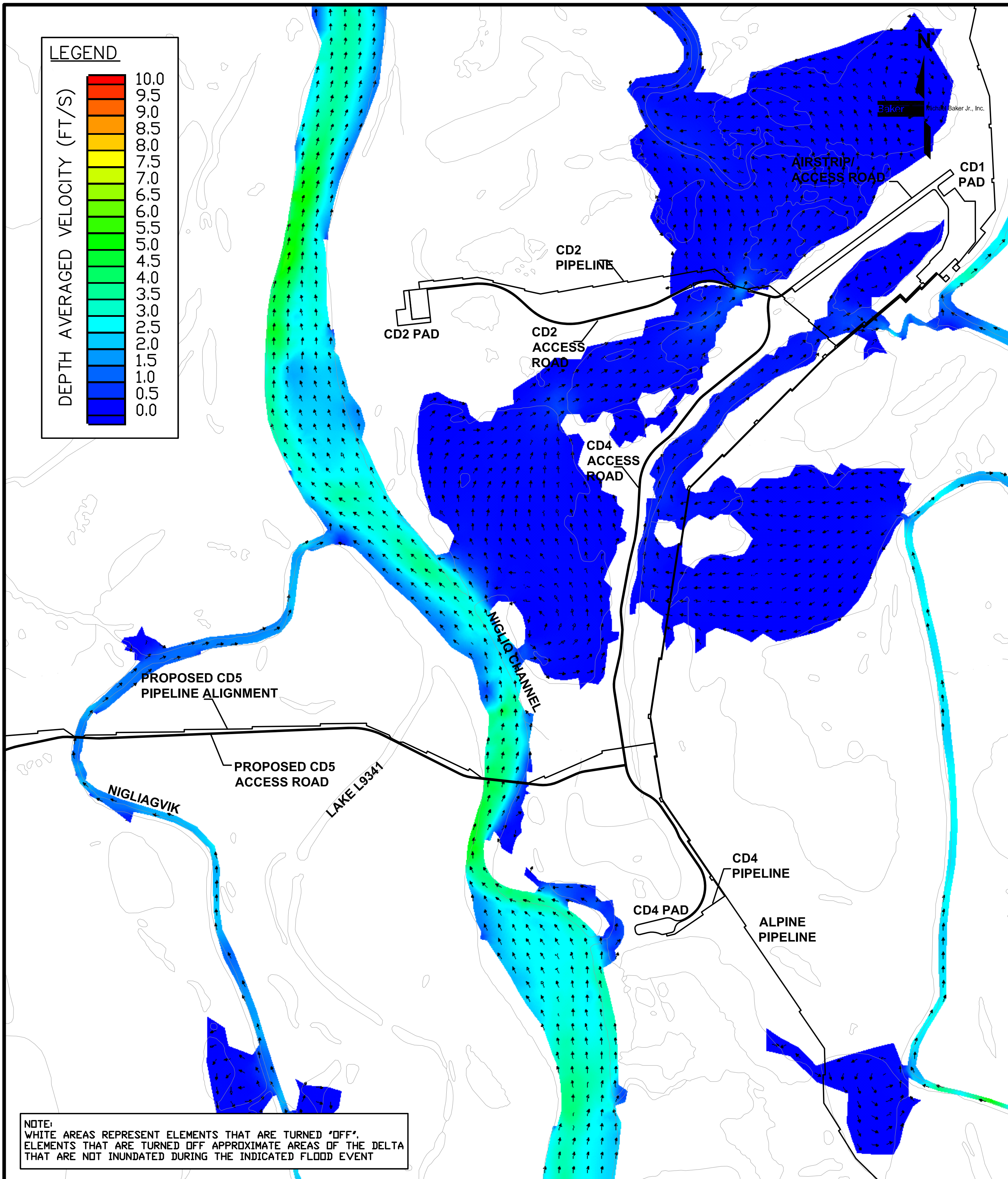
POST- CD5: 2-YEAR FLOOD

WATER SURFACE ELEVATIONS

FIGURE B30

(SHEET 1 OF 1)

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A



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2009 2D MODEL SOLUTION

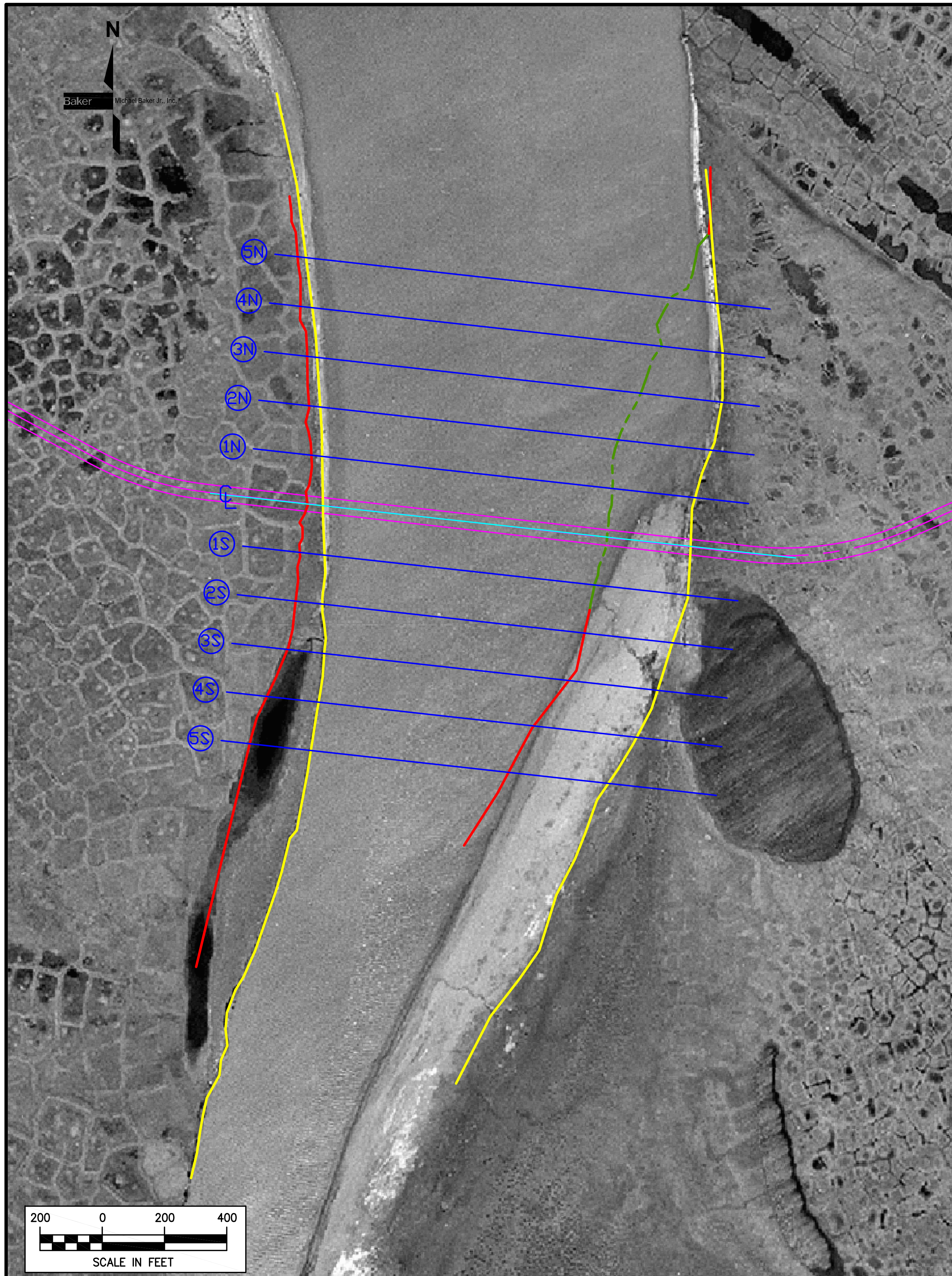
POST- CD5: 2-YEAR FLOOD

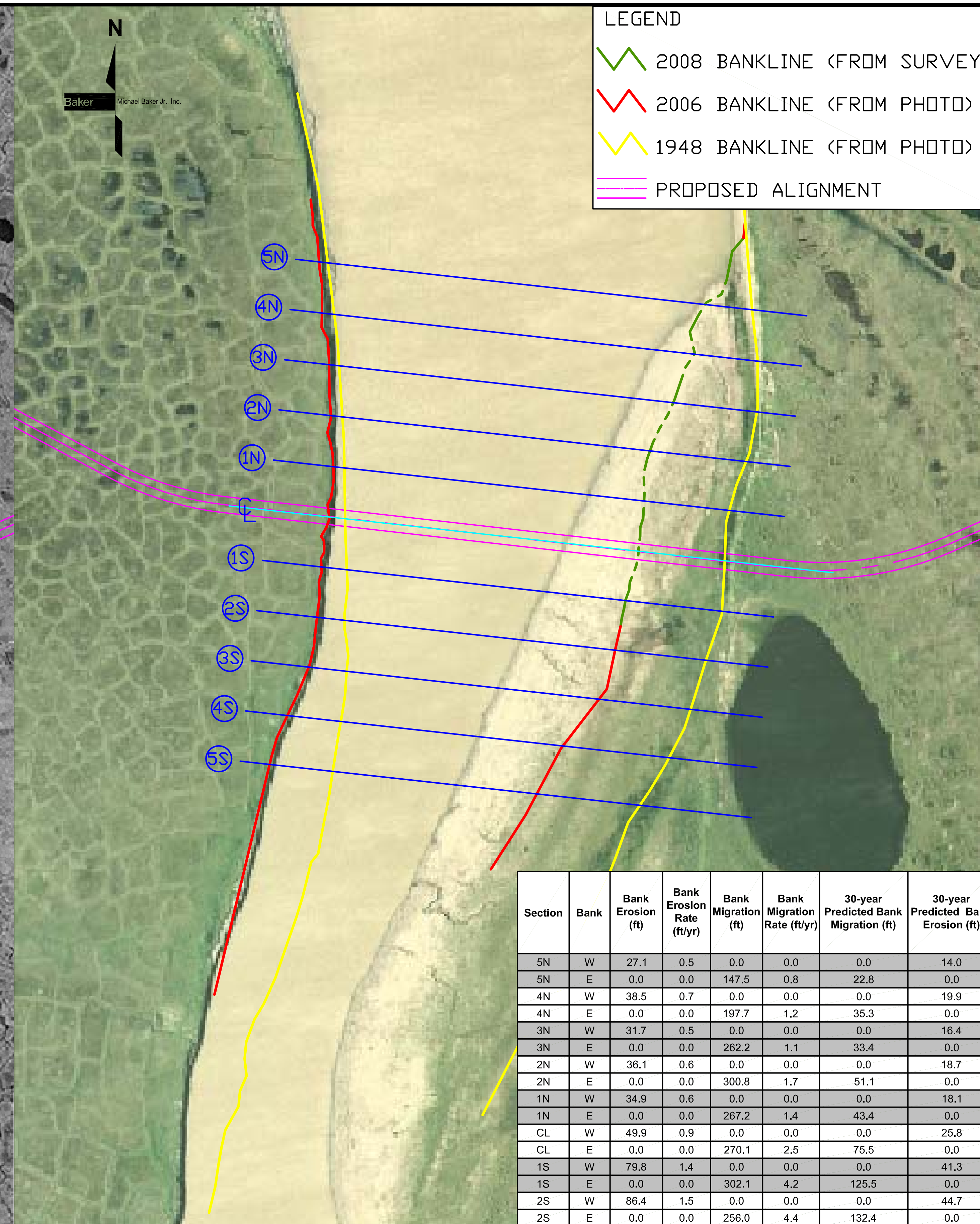
DEPTH AVERAGED VELOCITIES

DATE:	4/1/09	PROJECT:	114536
DRAWN:	MDM	FILE:	MODEL_SOLUTIONS.DWG
CHECKED:	JAB	SCALE:	N/A

FIGURE B31

(SHEET 1 OF 1)





Section	Bank	Bank Erosion (ft)	Bank Erosion Rate (ft/yr)	Bank Migration (ft)	Bank Migration Rate (ft/yr)	30-year Predicted Bank Migration (ft)	30-year Predicted Bank Erosion (ft)
5N	W	27.1	0.5	0.0	0.0	0.0	14.0
5N	E	0.0	0.0	147.5	0.8	22.8	0.0
4N	W	38.5	0.7	0.0	0.0	0.0	19.9
4N	E	0.0	0.0	197.7	1.2	35.3	0.0
3N	W	31.7	0.5	0.0	0.0	0.0	16.4
3N	E	0.0	0.0	262.2	1.1	33.4	0.0
2N	W	36.1	0.6	0.0	0.0	0.0	18.7
2N	E	0.0	0.0	300.8	1.7	51.1	0.0
1N	W	34.9	0.6	0.0	0.0	0.0	18.1
1N	E	0.0	0.0	267.2	1.4	43.4	0.0
CL	W	49.9	0.9	0.0	0.0	0.0	25.8
CL	E	0.0	0.0	270.1	2.5	75.5	0.0
1S	W	79.8	1.4	0.0	0.0	0.0	41.3
1S	E	0.0	0.0	302.1	4.2	125.5	0.0
2S	W	86.4	1.5	0.0	0.0	0.0	44.7
2S	E	0.0	0.0	256.0	4.4	132.4	0.0
3S	W	118.7	2.0	0.0	0.0	0.0	61.4
3S	E	0.0	0.0	287.2	5.0	148.6	0.0
4S	W	167.2	2.9	0.0	0.0	0.0	86.5
4S	E	0.0	0.0	332.7	5.7	172.1	0.0
5S	W	197.5	3.4	0.0	0.0	0.0	102.2
5S	E	0.0	0.0	322.6	5.6	166.9	0.0

Notes:
1. Bank erosion values denote loss of bank; the 2006/2008 bank line is located outboard of the 1948 bank line
2. Bank migration values denote accretion of bank; the 2006/2008 bank line is located inboard of the 1948 bank line

PROPOSED CD5 WESTERN ACCESS
NIGLIQ CHANNEL
BANK MIGRATION ANALYSIS
FIGURE B32
(SHEET 1 OF 1)

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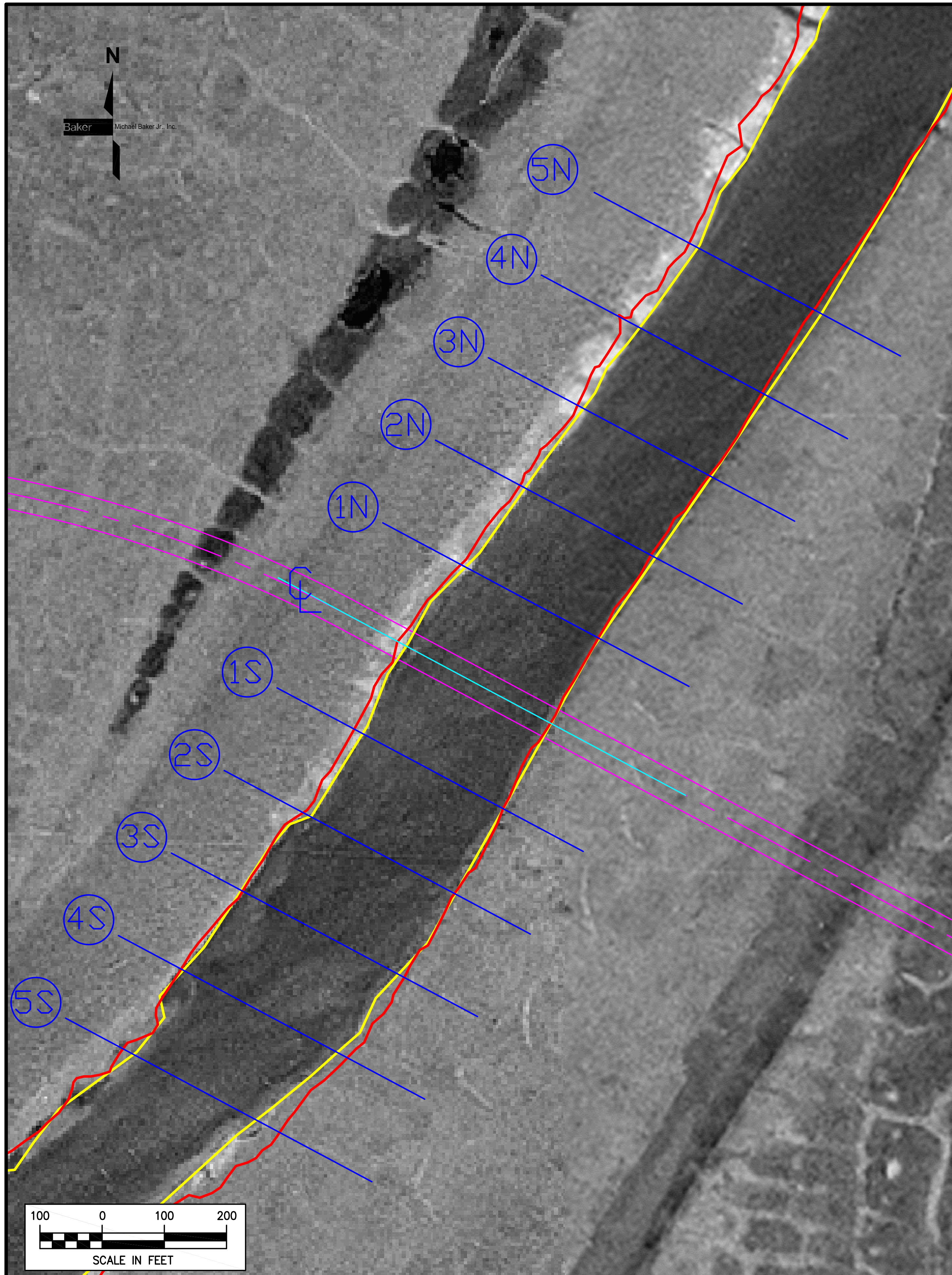
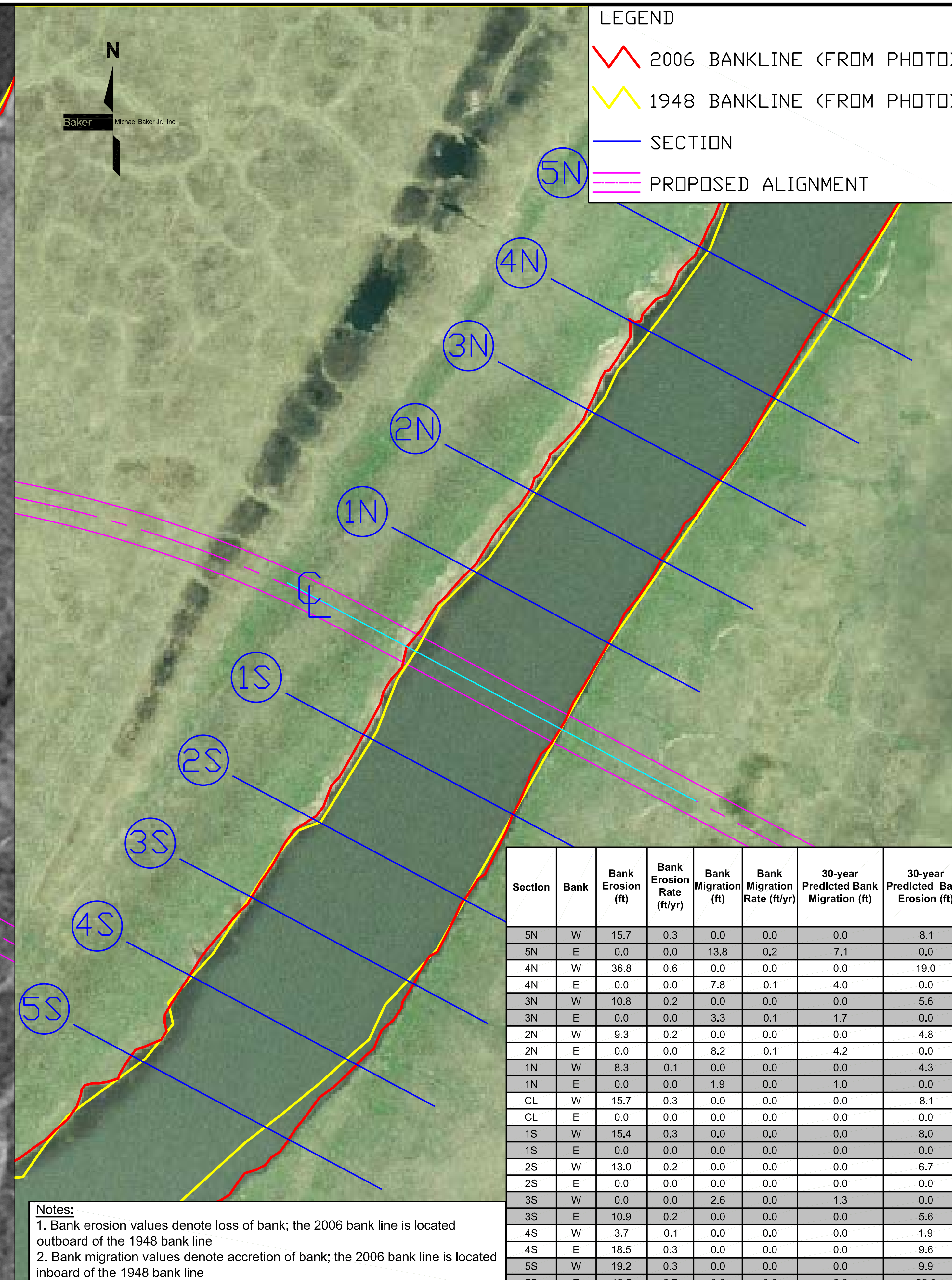
Alaska, Inc.

DATE:	5/15/09	PROJECT:	114536
DRAWN:	MDM	FILE:	CD5_BANK_MIGRATION.DWG
CHECKED:	JAB	SCALE:	AS SHOWN





LEGEND

2006 BANKLINE (FROM PHOTO)

1948 BANKLINE (FROM PHOTO)

SECTION

PROPOSED ALIGNMENT

Section	Bank	Bank Erosion (ft)	Bank Erosion Rate (ft/yr)	Bank Migration (ft)	Bank Migration Rate (ft/yr)	30-year Predicted Bank Migration (ft)	30-year Predicted Bank Erosion (ft)
5N	W	15.7	0.3	0.0	0.0	0.0	8.1
5N	E	0.0	0.0	13.8	0.2	7.1	0.0
4N	W	36.8	0.6	0.0	0.0	0.0	19.0
4N	E	0.0	0.0	7.8	0.1	4.0	0.0
3N	W	10.8	0.2	0.0	0.0	0.0	5.6
3N	E	0.0	0.0	3.3	0.1	1.7	0.0
2N	W	9.3	0.2	0.0	0.0	0.0	4.8
2N	E	0.0	0.0	8.2	0.1	4.2	0.0
1N	W	8.3	0.1	0.0	0.0	0.0	4.3
1N	E	0.0	0.0	1.9	0.0	1.0	0.0
CL	W	15.7	0.3	0.0	0.0	0.0	8.1
CL	E	0.0	0.0	0.0	0.0	0.0	0.0
1S	W	15.4	0.3	0.0	0.0	0.0	8.0
1S	E	0.0	0.0	0.0	0.0	0.0	0.0
2S	W	13.0	0.2	0.0	0.0	0.0	6.7
2S	E	0.0	0.0	0.0	0.0	0.0	0.0
3S	W	0.0	0.0	2.6	0.0	1.3	0.0
3S	E	10.9	0.2	0.0	0.0	0.0	5.6
4S	W	3.7	0.1	0.0	0.0	0.0	1.9
4S	E	18.5	0.3	0.0	0.0	0.0	9.6
5S	W	19.2	0.3	0.0	0.0	0.0	9.9
5S	E	42.5	0.7	0.0	0.0	0.0	22.0

Notes:
1. Bank erosion values denote loss of bank; the 2006 bank line is located outboard of the 1948 bank line
2. Bank migration values denote accretion of bank; the 2006 bank line is located inboard of the 1948 bank line

PROPOSED CD5 WESTERN ACCESS
LAKE L9341
BANK MIGRATION ANALYSIS
FIGURE B33
(SHEET 1 OF 1)

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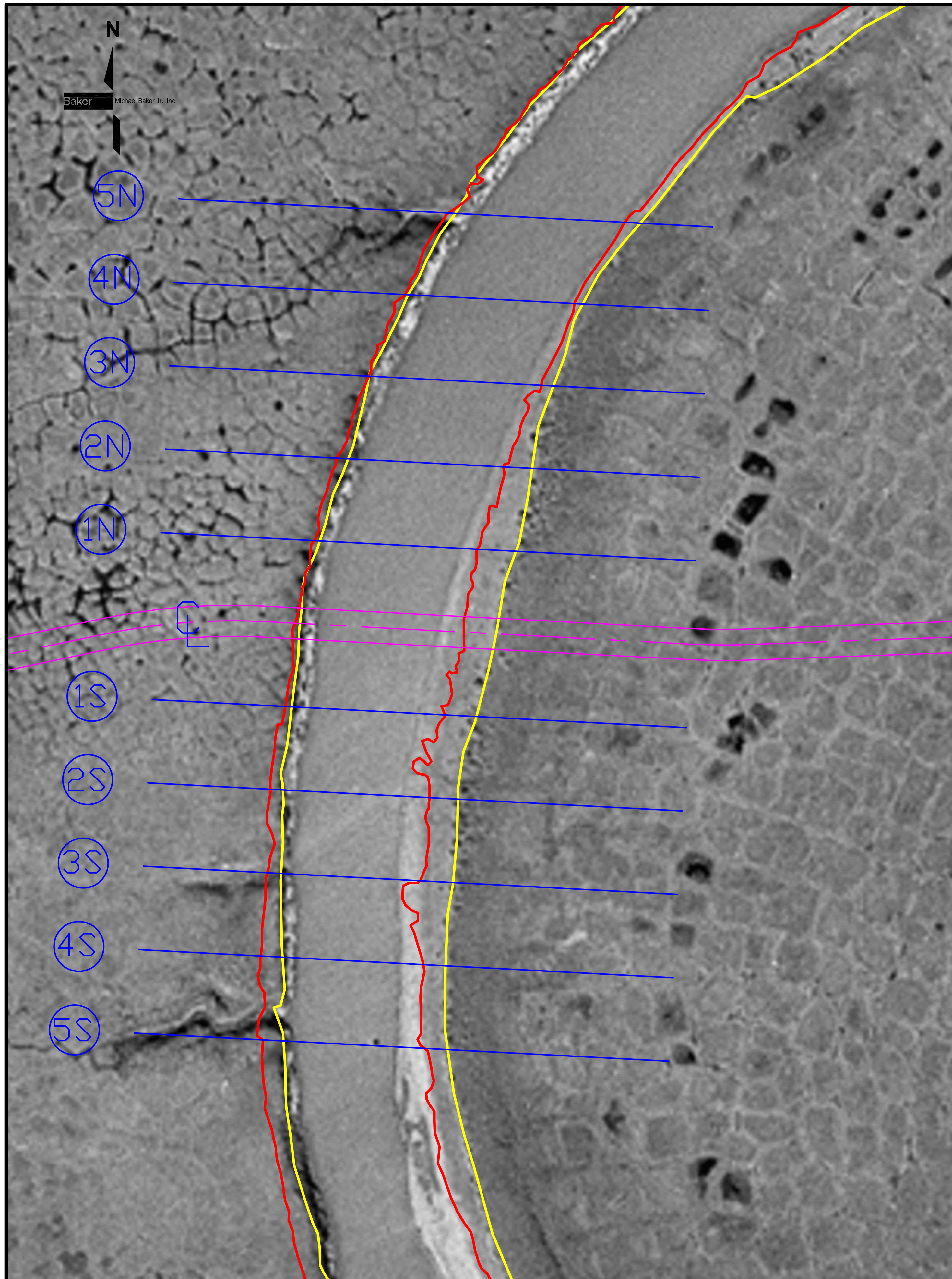
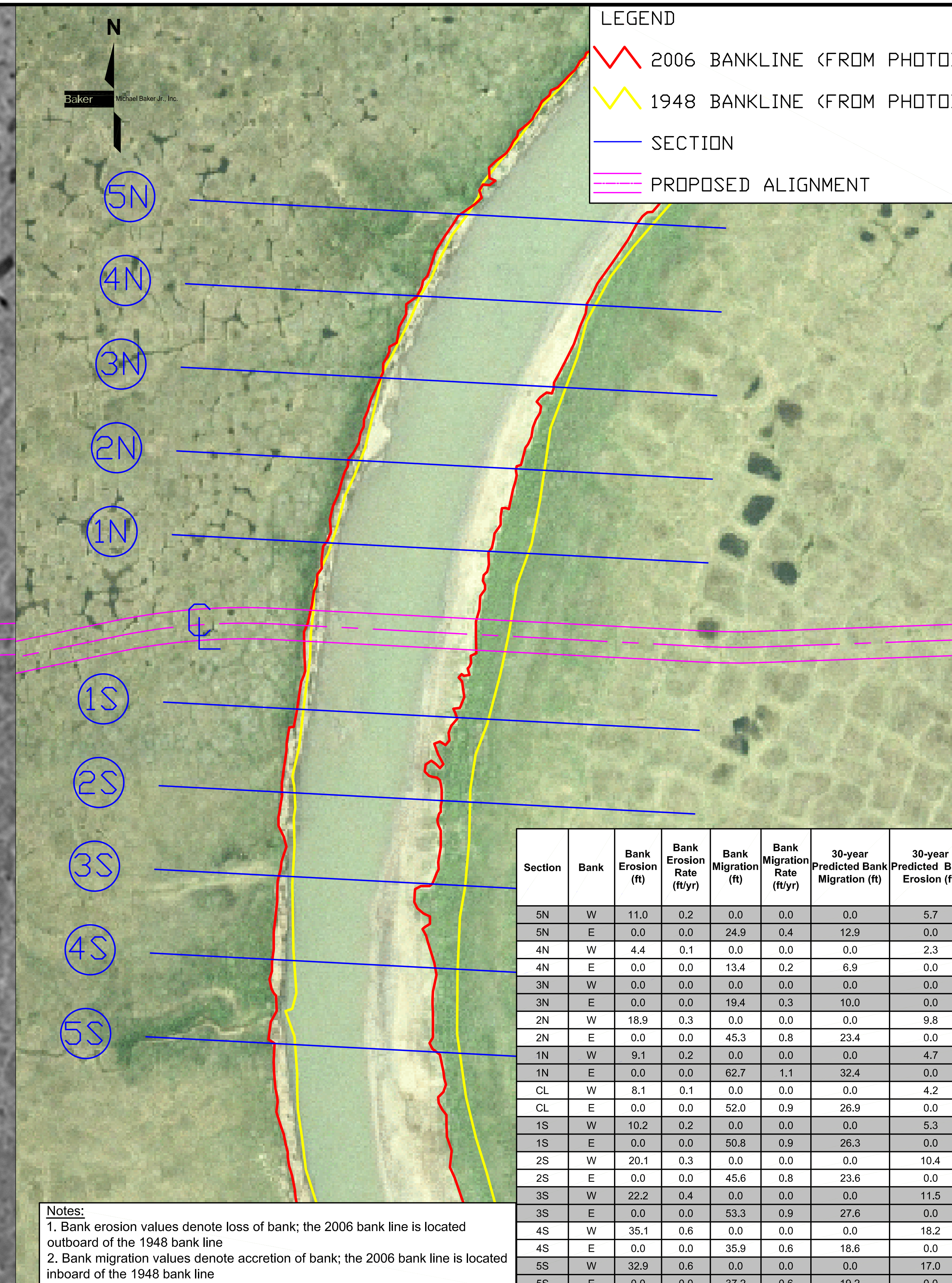
DATE: 5/15/09
DRAWN: MDM
CHECKED: JAB
PROJECT: 114536
FILE: CD5_BANK_MIGRATION.DWG
SCALE: AS SHOWN





Section	Bank	Bank Erosion (ft)	Bank Erosion Rate (ft/yr)	Bank Migration (ft)	Bank Migration Rate (ft/yr)	30-year Predicted Bank Migration (ft)	30-year Predicted Bank Erosion (ft)
5N	W	11.0	0.2	0.0	0.0	0.0	5.7
5N	E	0.0	0.0	24.9	0.4	12.9	0.0
4N	W	4.4	0.1	0.0	0.0	0.0	2.3
4N	E	0.0	0.0	13.4	0.2	6.9	0.0
3N	W	0.0	0.0	0.0	0.0	0.0	0.0
3N	E	0.0	0.0	19.4	0.3	10.0	0.0
2N	W	18.9	0.3	0.0	0.0	0.0	9.8
2N	E	0.0	0.0	45.3	0.8	23.4	0.0
1N	W	9.1	0.2	0.0	0.0	0.0	4.7
1N	E	0.0	0.0	62.7	1.1	32.4	0.0
CL	W	8.1	0.1	0.0	0.0	0.0	4.2
CL	E	0.0	0.0	52.0	0.9	26.9	0.0
1S	W	10.2	0.2	0.0	0.0	0.0	5.3
1S	E	0.0	0.0	50.8	0.9	26.3	0.0
2S	W	20.1	0.3	0.0	0.0	0.0	10.4
2S	E	0.0	0.0	45.6	0.8	23.6	0.0
3S	W	22.2	0.4	0.0	0.0	0.0	11.5
3S	E	0.0	0.0	53.3	0.9	27.6	0.0
4S	W	35.1	0.6	0.0	0.0	0.0	18.2
4S	E	0.0	0.0	35.9	0.6	18.6	0.0
5S	W	32.9	0.6	0.0	0.0	0.0	17.0
5S	E	0.0	0.0	37.2	0.6	19.2	0.0

Notes:
1. Bank erosion values denote loss of bank; the 2006 bank line is located outboard of the 1948 bank line
2. Bank migration values denote accretion of bank; the 2006 bank line is located inboard of the 1948 bank line

PROPOSED CD5 WESTERN ACCESS
SMALL BRIDGES - BANK MIGRATION ANALYSIS
NIGLIAGVIK
FIGURE B34
(SHEET 1 OF 1)

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DATE:	7/28/08	PROJECT:	111661
DRAWN:	MDM	FILE:	FIGURE_1-3.DWG
CHECKED:	JAB	SCALE:	1" = 200'