Winnipeg

APPENDIX A

AUTHORIZATION FROM THE CITY OF WINNIPEG TO OBTAIN ENVIRONMENTAL APPROVALS

Winnipeg

Corporate Finance Department • Services des finances générales

January 19, 2010

To Whom It May Concern:

RE: DISRAELI BRIDGES PROJECT
ENVIRONMENTAL PERMITS APPLICATIONS

This letter provides confirmation that The City of Winnipeg has authorized the following group to be its delegated agents for the purposes of obtaining the Environmental Approvals for the Disraeli Bridges Project:

- Plenary Roads Winnipeg,
- PCL Constructors Canada Inc.,
- Wardrop Engineering.

If you have any questions, please contact me at (204) 986-2538.

Yours truly,

Henry S. Hunter, P. Eng.
Manager, Capital Projects

cc: D. McMenemy Papst, Solicitor, Legal Services, Corporate Support Services
B. Ebenspanger, Bridge Design and Projects Engineer, Public Works

3rd floor – 510 Main Street • 510, rue Main, 3e étage • Winnipeg • Manitoba • R3B 1B9
tel/tél. (204) 986-6162 • fax/ téléc: (204) 986-3350 • www.winnipeg.ca

APPENDIX B

ENVIRONMENT ACT LICENCE PROPOSAL FORM

Environment Act Proposal Form

Manitoba Conservation

Name of the development: The Disraeli Bridges Project

Type of development per Classes of Development Regulation (Manitoba Regulation 164/88):
Class 2: 8. Water Development and Control - Alterations to stream channels which affect fish mobility and habitat

Legal name of the proponent of the development:
City of Winnipeg

Location (street address, city, town, municipality, legal description) of the development:
Disraeli Freeway at the Red River

Name of proponent contact person for purposes of the environmental assessment:
Bill Ebenspanger, P.Eng.

Phone: (204) 986-3712

Fax: (204) ~~942-4811~~ 986-5302

Mailing address: Public Works Department - Engineering Services Division
City of Winnipeg
106-1155 Pacific Ave.
Winnipeg, Manitoba R3E 3P1

Email address: BEbenspanger@winnipeg.ca

Webpage address: www.winnipeg.ca/publicworks/MajorProjects/DisraeliBridges

Date: 26 February, 2010

Signature of proponent, or corporate principal of corporate proponent: [signature]

Printed name: Bill Ebenspanger.

A complete **Environment Act Proposal (EAP)** consists of the following components:

- **Cover letter**
- **Environment Act Proposal Form**
- **Reports/plans supporting the EAP** (see "Information Bulletin - Environment Act Proposal Report Guidelines" for required information and number of copies)
- **Application fee** (Cheque, payable to Minister of Finance, for the appropriate fee)

Per Environment Act Fees Regulation (Manitoba Regulation 168/96):

Class 1 Developments $500
Class 2 Developments $5,000
Class 3 Developments:
Transportation and Transmission Lines.....$5,000
Water Developments $50,000
Energy and Mining....................................$100,000

Submit the complete EAP to:

Director
Environmental Assessment and Licensing Branch
Manitoba Conservation
Suite 160, 123 Main Street
Winnipeg, Manitoba R3C 1A5

For more information:
Phone: (204) 945-7100
Fax: (204) 945-5229
Toll Free: 1-800-282-8069, ext. 7100
http://www.gov.mb.ca/conservation/eal

APPENDIX C

PUBLIC CONSULTATION REPORT

DISRAELI BRIDGES PUBLIC CONSULTATION PROCESS -- FINAL REPORT

INTRODUCTION

Public consultation is a collaborative effort that brings together all of those who have an interest in or affected by a project to work together, share information and provide feedback that helps to shape the project planning and decision making process. The Disraeli Bridges public consultation process was planned and implemented to provide opportunity for the public to have input on City of Winnipeg plans to rehabilitate the Disraeli Freeway Bridge and Overpass.

This report begins by identifying the goals and objectives of the public consultation process. The key activities of the public consultation are explained in the methodology section showing how they contributed to the overall process. Next, the Disraeli Bridges rehabilitation options that were presented to the public are described. Following, the results of the public input are presented. Lastly, the evaluative and decision making process is presented including the Stakeholder Advisory Committee's recommendation to City Council.

GOALS AND OBJECTIVES

The Disraeli Freeway Public Consultation Program was designed to incorporate pubic input into the conceptual planning and preliminary design of the project. The goal of the public consultation was for the public to contribute meaningfully to ensure a project that is:

Technically sound; reflects the needs of the community, and city in general; cost-effective; environmentally responsible and safe; and, generally understood and accepted by most of those affected.

Fundamental to public consultation and integral to former Public Works capital project public consultations, this process was to be based on:

- Maintaining an open, honest and flexible forum for public input
- Identifying public concerns/values/aspiration /priorities;
- Conveying information to and collecting information from the public; and
- Receiving public input for consideration in final recommendations.

METHODOLOGY

The public consultation process unfolded in three distinct stages: 1) Research phase resulting in a Community Profile and Impact Study (April 2006); 2) Stakeholder Advisory Committee (SAC) to work closely with the project consultants and City of Winnipeg project representatives; and, 3) Public communication to provide information about the project and obtain public input. The components of the public consultation methodology are described as follows:

1. Community Profile and Impact Study

A research phase was undertaken to learn about the communities surrounding the Disraeli Bridges project. The scope of the Community Profile and Impact Study[1] includes the neighbourhoods of Elmwood and East Kildonan on the north side of the Freeway and North Point Douglas and South Point Douglas on the south end of the Freeway. North of the Disraeli Freeway the study area is bounded by Chief Peguis Trail to the north, the CPR to the east and the Red River. South of the Disraeli Freeway the study area is bounded by Redwood to the north, Main Street to the west, Galt Ave. to the South and the Red River.

The Community Profile is the first step before initiating a planning and public consultation process for a large capital project located within an established community(ies). It provides an overview of the key physical, social, and economic characteristics of the communities. The Profile presents an understanding of the historical roots and the current areas of focus and development within these communities. Key organizations and community leaders are identified, many of whom were interviewed as part of the study (approximately 25). Finally, six key issues having direct implications for the Disraeli Bridges project are identified as follows:

- The generally agreed upon need for public consultation as part of the planning and design of the project;
- The perception of the Disraeli Bridge s as utilitarian and not connected or providing any enhancement to the surrounding community;
- Lack of knowledge about project options and what the rehabilitation project can offer different bridge users and the surrounding community;
- General acceptance of the need for renewing municipal infrastructure in spite of the disruption during construction;
- The importance of effective, targeted public communication that reaches the different publics that make up the surrounding communities as learned through the socio-economic and qualitative information in the Profile.

2. STAKEHOLDER ADVISORY COMMITTEE

A Stakeholder Advisory Committee (SAC) was established to work together with the City of Winnipeg project representatives to provide input, identify issues and discuss reasonable options to enhance the project and help mitigate impacts during construction. The project consultants including Dillon Consulting, Earth Tech and Hilderman Thomas Frank Cram Architects were actively involved in the process presenting information and responding to questions. Unlike the Provencher Bridge project where the City of Winnipeg had started with a blank slate and worked collaboratively with stakeholders to develop project options, the scope of this project was constrained by a pre-established and limited capital budget. As such, the committee was to be asked to focus on a preliminary conceptual plan that had been recommended by the consultants

1. [1] Disraeli Freeway Rehabilitation Project: A Community Profile and Impact Study – April 2006

as best fitting the City's available budget, while meeting rehabilitation upgrade standards and including some additional upgrades to improve safety and accessibility.

The Stakeholder Advisory Committee included representatives from organizations and businesses best representing the sectors in the communities surrounding the Disraeli Freeway and citywide most affected by and interested in the project.

Elmwood/East Kildonan	
Seniors	Good Neighbours Seniors Centre
Community network/development	River East Neighbourhood Network
Business	Petal Purr-Fect
Schools	Mennonite Brethren Collegiate Institute
Point Douglas	
Residents	North Point Douglas Residents Association
Business	Exchange District BIZ
Schools	Argyle School
Citywide	
Civic Centre arts organization	Manitoba Centennial Centre
Cycling	Manitoba Cycling Association/Bike to the Future
Commerce/Business	Winnipeg Chamber of Commerce

A process was designed that led the SAC through a series of meetings that included the presentation of project information – with the opportunity for questions and discussion. At each meeting SAC members worked in small groups and as a full group to provide feedback or to identify areas where further information was required before they could provide that input. Additionally, SAC members were asked to share information and bring forward feedback from their constituency groups they were representing on the committee. There was a new focus at each meeting as follows:

- Meeting #1 –Introductions; description of need for project; orientation to public consultation process; and presentation of Community Profile Impact Study

- Meeting #2 – Presentation of engineering team's conceptual design study and most highly rated alternative for information, discussion and community reaction; presentation of landscape architectural concept plan for discussion and feedback

- Meeting #3 – Presentation of traffic analysis data and traffic management options during construction to facilitate discussion, other suggestions and feedback; ask stakeholders to consult with their constituents and share their feedback at next meeting

- Meeting #4 – Presentation of SAC members' feedback from their constituents; discussion of consultants further study of SAC feedback/suggestions and traffic management recommendations

- Meeting #5 – Responses to questions and SAC discussion/exploration of various factors influencing the Disraeli Bridges project including: recent cycling developments in Winnipeg, pedestrian and cyclists' needs and opportunities, managing construction impacts, connection to other upcoming transportation projects, impact on business; Development of three project options to be presented to broad public for input

- Meeting #6 – Update SAC about developments in launching broad public consultation process; identify potential questions arising from public and develop/discuss the response

- Meeting#7 – Presentation of public input research and analysis; SAC consideration of which concept best meets public's input

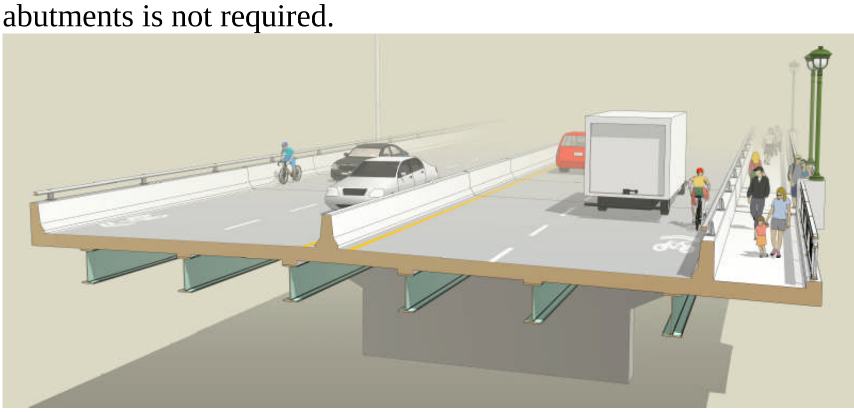
- Site walk-a-bout – SAC tour of bridges, on/off ramps, pedestrian access under the bridge, existing active transportation route in Point Douglas

- Meeting#8 – Evaluation and final decision making process leading to recommendation of preferred concept

3. REHABILITATION OPTIONS PRESENTED TO BROAD PUBLIC

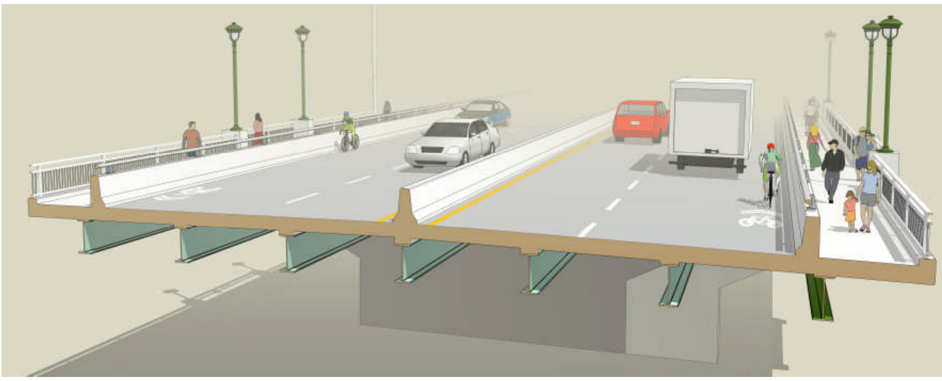
After considering the needs of all users of the Disraeli Bridges, the SAC developed three project options to present to the broad public and they are described, with illustrations, as follows:

<u>Concept A - $125 Million:</u>
This option provides basic rehabilitation for the structures with a proposed deck width of 20 metres. There are two 4.4 metre shared vehicle and cyclist curb lanes and one 1.8 metre sidewalk on the east side. In this concept, pedestrians use under-bridge crossings, the crossing at Dearborn Avenue and the overpass at Argyle School to cross to the other side. Modification of piers or abutments is not required.

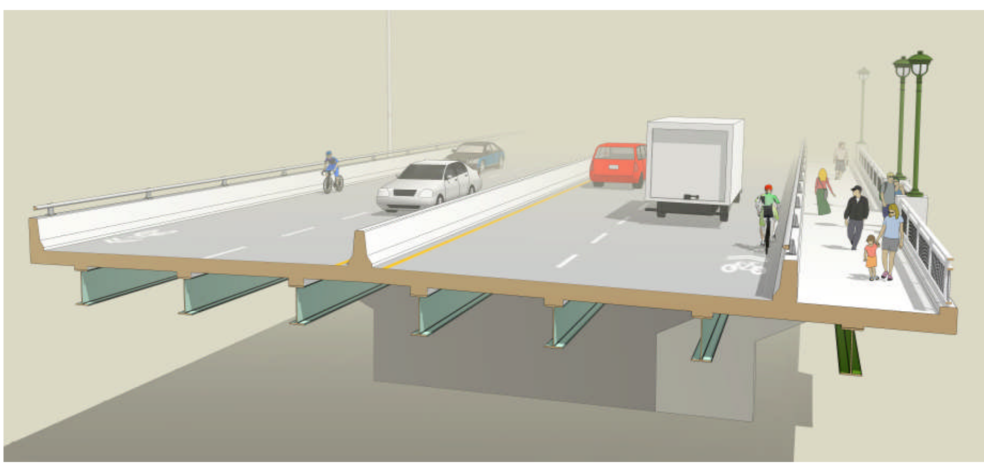

[2]

[2] Dillon Engineering and Hilderman Thomas Frank Cram

Concept B- $160 M:
Similar to Concept A, with 4.4 metre shared vehicle and cyclist curb lanes, the deck would be widened to 22.1 metres to accommodate a second 1.8 metre wide sidewalk on the west side. With two sidewalks, pedestrians would not have to cross the roadway or go under the bridge to reach the other end, enhancing accessibility and security. This option requires piling as well as modifications and widening of the land-based piers and abutments and additional girder lines supporting the wider deck.



Concept C - $160 M:
This option is requires the deck to be widened to 21.4 metres, includes only one sidewalk widened from 1.8 to 2.5 metres, and would increase vehicle and cyclist shared curb lanes from 4.4 to 4.75 metres. With this concept, the widened sidewalk provides more accommodation for pedestrians and recreational users. As with Concept A, the sidewalk would be located along the east edge. This option also requires piling and modifications and widening of the land-based piers and abutments, and additional girder lines supporting the wider deck.



4. BROAD PUBLIC INPUT

Representatives from the various sectors on both sides of the Disraeli Bridges most directly affected by and interested in the project such as local businesses, residents and schools were directly involved in the project on the Stakeholder Advisory Committee. However, opportunities for broad public involvement were designed and carried out as part of the public consultation process as well. The Disraeli Freeway is an important transportation route in the north-east quadrant of Winnipeg, and closure of that route for construction would affect traffic even beyond that. Further, it is a route that serves commuters driving to and from Winnipeg's downtown from outlying Winnipeg neighbourhoods and bedroom communities. Lastly, the cost for a capital project of this size is a cost borne by all tax payers city-wide.

The Community Profile and Impact Study described many kinds of different neighbourhoods with respect to socio-economic indicators, public involvement in other community initiatives and issues and the degree to which citizens are affected by the project. A public communication plan was designed to capitalize on different means of communication to reach the different publics.

An informative publication, in the form of a colour, 6-page fold out newsletter with text and illustrations and maps, was produced for door to door distribution to each address in the neighbourhoods closest to the Freeway. Close to 11,000 newsletters were distributed in Point Douglas, Chalmers, Glenelm, Munroe West, Kildonan Drive and a portion of Rossmere from April 21 – 23, 2008.

A similar publication in the form of a display advertisement was also published in the Winnipeg Free Press and a community newspaper, The Herald on April 24th and The Winnipeg Sun on April 25th.

A media release prior to the Open Houses resulted in wide-spread and accurate media coverage about the project.

Open Houses were held in three different locations within the project area, including the Norquay Community Centre in Point Douglas, the MTS Centre in Downtown and the Good Neighbours Seniors Centre in East Kildonan.

Graphic display panels including bridge illustrations and maps, text storyboards and other display materials provided information about the three bridge concepts and traffic management planning. A computerized traffic modeling presentation helped visitors gain a realistic view of how traffic currently flows through key intersections and how it is anticipated to flow during construction. Project resource people with expertise in bridge engineering, landscape architecture, transportation planning, community planning, and public consultation, and SAC members, were available for discussions with visitors. The Open Houses were fairly well attended with best attendance at the Point Douglas and East Kildonan locations. Interaction at the open houses was very constructive. Generally, those in attendance were the "informed public" – they had read the material and wanted more information, clarification, or discussion.

In total, approximately 700 individuals registered their views about the project either through response coupons, open house comment sheets, general emails, and the phone or mail-back surveys.

5. SURVEY RESEARCH RESULTS[3]

As part of the public consultation process, different information gathering methodologies were utilized to reach different publics. A random sample telephone survey was conducted with 400 residents living in Point Douglas, Elmwood and East Kildonan. A survey was attempted of all the 91 businesses along Henderson Highway from the Disraeli Bridges to Leighton. Of those businesses where the survey was dropped off, 53 returned the survey. Additionally, all Winnipeggers had the opportunity to learn about the project and provide "informed input" either by returning a response coupon from the newsletter that had been distributed through the study; by returning a response coupon from one of the full page ads that appeared in three local newspapers; filling out a comment sheet at one of the three open houses that were held in different locations through the study area; or, by writing or e-mailing the City of Winnipeg Public Works Department directly.

With respect to the residents' survey, respondents were asked to consider the three options for the project and provide their feedback. The three options were described by interviewers in this manner:

Option A: In widening the bridge, the Disraeli will lose the sidewalk on its west side in order to provide more space for traffic on the roadway. The curb lanes in either direction will be expanded from 11 to 15 feet to accommodate a shared vehicle and cyclist lane. The sidewalk on the east side will be widened from 5 to 6 feet to accommodate pedestrians. This concept is estimated to cost $125 million.

Option B: Similar to Option A, except it would include a second sidewalk on the west side of the bridge. Both sidewalks would be widened from 5 to 6 feet. This concept is estimated to cost approximately $160 million.

Option C: Similar to Option A, however, the expanded curb lanes in either direction would be widened to 16 feet instead of 15 feet in order to provide more distance between vehicles and cyclists. As with Concept A, there would only be one sidewalk on the east side, but it would be widened to 8 feet instead of 6 feet to accommodate both pedestrians and recreational cyclists. This concept is estimated to cost $160 million.

Although there are some differences to be noted between the different groups – residential survey, business survey and informed public – there are some general conclusions that were drawn:

- There is no one option that is favoured by a clear majority of respondents. However, there are preferences that emerge within each surveyed group based on where the respondent lives and how they use the bridge. To elaborate:
    - On the residents' survey, amongst those living closest to the Bridges a majority preferred Option B (Point Douglas – 39% and Elmwood – 42%) as it

2. [3] Summary of Disraeli Bridges Rehabilitation Research – June 3, 2008

best serves the needs of those who walk over the bridges, followed by 33% in each area for Option C.

- With the informed public, there is a preference for Option B (49%) followed by Option C (37%).
- Amongst the business respondents a majority preferred Option C (42%) followed by Option B (26%).
- On the residents' survey, those that 1) cross the bridge on foot prefer Option B (50%) because it provides easy access for pedestrians on both sides and limits the need to have to cross under the bridge, 2) those that report biking across the bridge prefer Option C (48%) as it provides additional amenities for cyclists, and 3) among drivers, there is an almost even split among the three options because essentially drivers needs are equally met with all three options.

- A clear majority support the investment of funds for features that they value. As a result, Option A, which is the least expensive of all three is not a strong contender for most respondents.

- Neither of the two options that are most preferred includes all of the features that a majority can support. Options B and C, which are the most popular options, include features that are unique to each particular option. As such, it becomes a trade-off where to have the feature they desire, makes the other options unacceptable.

- While each option addresses the interests of a particular group, none combines those interests into a single options that is acceptable to the majority

Public issue – 6 lane bridge option and bridge closure during construction

Mr. Jim Maloway, the Elmwood MLA, attended the Open Houses for the project. While he sought information from City of Winnipeg representatives and project consultants, rather than registering his views and proposals with them, he contacted media for an interview at the Elmwood/East Kildonan Open House where he expressed his interest in a 6-lane option and concern about the bridge closure during construction.

The project's public consultation process reported 3% of respondents who registered a preference for a 6-lane option for the project. However, as this was not included as one of the potential options for the project, it doesn't reflect what the public response might have been.

Following Mr. Maloway's media coverage, he ran ads in The Herald asking residents to register their 'vote' for a 6-lane option which he forwarded to City Council. Full and accurate information was not provided to residents about the features and implications of the 6-lane option, nor was it compared to the other options for the project. As such these 'votes' don't represent the informed public. As the debate played out in the media, the focus turned towards the issue of bridge closure during construction. This continues to be a concern expressed by residents and business owners in the Elmwood/East Kildonan community

6. FINAL PROJECT OPTIONS

Once the results of the public input had been analyzed and presented, the SAC further assessed these three options in light of the input. Their efforts were two-fold: 1) Reviewing new ideas and modifications to the options that were brought forward for consideration by members of the pubic; and, 2) Considering modifications to the existing options that would best incorporate the amenities identified as important to the greatest number of respondents.

As a result, two new options were identified, referred to as Modified Concept A and Modified Concept B. The first was submitted by Bike to the Future, a community organization "working to make cycling in Winnipeg a safe, enjoyable, accessible and convenient transportation choice year-round". The second is a modification of Option B, which was developed by the SAC in an effort to combine all of the features that the majority support, namely cyclists and pedestrians. Both are described as follows:

Concept Modified A:
In addition to a basic rehabilitation of the bridge structures as described with Concept A, an additional multi-use bridge would be built over the river for cyclists and pedestrians that would link to the existing Active Transportation Route along Annabella in Point Douglas. The total estimated cost is $140 million.

Through discussion it became apparent that this option would need further study to address different questions such as: Where the multi-use bridge would be situated over the river; impact of this bridge on future plans for rehabilitating or replacing the Louise Bridge; potential differences in pedestrians' experience compared to cyclists' when utilizing the bridge and how that might be mitigated; whether there would be value in placing the bridge to the west as the one sidewalk on the existing structures will be on the east side.

Concept Modified B:

The SAC developed this option by expanding the amount of deck in order to provide the best features of both Concepts B and C. This option would include two widened sidewalks that could be used as multi-purpose, recreational pathways. This option requires an additional girder line and the estimated cost is $185 million.

7. EVALUATIVE DECISION MAKING PROCESS

After full discussion, the SAC underwent an evaluative decision making process in order to rate each option according to the project goal and evaluative criteria emerging from this goal.

- Technically Sound (function and least design risk)
- Needs of the Community
- Needs of the City
- Cost Effectiveness (best value for money spent)

- Environmentally Responsible (increases cycling, using existing facilities, construction impacts)
- Personal Safety (actual and perception)
- Access (connection to neighbouring communities)
- Generally understood and accepted by most of those affected

SAC members were asked to keep their *Statement of Guiding Values* in mind:

- Bridges have to be attractive for everyone's use including drivers, cyclists and pedestrians
- Long term planning is needed for the next 50 years with respect to population and demographics
- Plan with an "eye to the future" when it comes to cycling and meeting cyclists' needs
- Connectivity with the surrounding community on and off the bridges (particularly Point Douglas) including bike paths, neighbourhood streets and sidewalks
- A safer environment for pedestrians and cyclists both in actuality and a friendlier feeling (includes speed of traffic, not crossing underneath the bridges to get to the other side)
- Concern for economic impact on business community and neighbourhood quality of life during construction
- Opportunity afforded by a large capital project to include public art and to add an attractive urban design esthetic to the surrounding community (note the proximity to Waterfront Drive)
- Good connectivity during closure to ease access (allowing left turn from Lily onto Logan)

8. RECOMMENDATION

The Stakeholder Advisory Committee members were faced with a difficult challenge in concluding their process. Two options rated highly in meeting the evaluative criteria that the SAC established for the project – Concept B and Modified Concept A. However, each option did so in different ways.

Concept B, which includes two 1.8 metre sidewalks, one on each side, is viewed as addressing the needs of pedestrians very well while still providing the shared curb lanes to accommodate cyclists. Modified Concept A, which includes one sidewalk on the east side of the bridges but adds to the project a new multi-use bridge for cyclists and pedestrians to the east of the existing bridges and connects to the existing active transportation route along Annabella in Point Douglas. This option is viewed as accommodating cyclists particularly well, and maximizing connections with the surrounding communities but not addressing the overall needs of pedestrians very well. However, further study is needed to determine more of the project dimensions.

The SAC resolved their challenge by recommending the concept that rated most highly of the two – Concept B. The SAC went another step and asked that the Public Works Department provide Council with information about Modified Concept A, as an option that came forward through the public consultation process that did rate highly, just not as highly as Concept B. It is an option that would need study to further examine and develop the concept in all of its dimensions.

9. CONCLUSION AND NEXT STEPS

The SAC were pleased to complete their responsibility to the project by developing a recommendation to City Council. Further, positive reaction to the public consultation was received from members of the public who liked the information that was provided and were pleased to be consulted about the project. These are some next steps for the project with the public consultation process:

1. During the public consultation, project representatives were asked many times to report back about what was heard from the community. It will be important to do that as soon as possible. It should start with an informative publication to communicate to residents in the community and city wide the results of the public consultation.

2. While there wasn't a formalized response through the project's public consultation program about the interest in a 6-lane option for the project, it would be advisable to provide full, accurate information about the option, something that the community was never provided when the Elmwood MLA's votes were being gathered. We are told that there is much misinformation in the community about this option.

3. A communication program during construction should be initiated with a consortium of business sector representatives on both sides of the bridges to work together to develop a plan that will include various components such as: traffic re-routing signage and locations, marketing and promotional materials, maps and others.

4. Once a concept is chosen for the project, a public consultation process will be needed through the design phase with stakeholder involvement to ensure that their input is incorporated appropriately in consultation with project consultants and leaders.

All those who were involved with the process will eagerly await City Council's decision.

Respectfully submitted by,

Susan Freig MCP
Susan Freig and Associates
Community Planning and Public Consultation

August 11, 2008

APPENDIX D

RED RIVER HYDROLOGY REPORT

Bruce Harding Consulting Ltd

To	Rick Haldane-Wilsone, P.Eng. Manager Structural Engineering	**Date**	April 7, 2010
From	Bruce Harding, P.Eng.	**File**	WDP_8
Subject	Disraeli Bridge Rehabilitation Project Red River Hydrology	**cc**	

The following summarizes the hydrology for the Red River at the Disraeli Bridge providing average monthly flows, flood hydrology and hydrology during construction. The hydrology for the Red River is complicated by the operation of the Floodway, which diverts flow around the City of Winnipeg during times of a flood within the Red River Valley. Additionally, the Saint Andrews Lock and Dam, located downstream of Winnipeg, controls river levels through the City of Winnipeg during the open water period. On this basis, the hydrology and selection of data for analysis has to be reviewed to ensure that the information presented is representative of conditions

Average Monthly Flows

The monthly average flows for the Red River have been developed from historical streamflow records for the Red River near Lockport gauge (WSC 05OJ010). The Lockport gauge would be representative of 'normal" conditions without the operation of the Floodway. The diversion of flows to the Floodway typically occurs for Red River flows in excess of approximately 1100 m^3/s. The Lockport gauge includes contributions from the Assiniboine River, which enters the Red River a short distance upstream of the Disraeli Bridge. Note that there are other tributary streams including Grassmere Drain and Parks Creek; however these tributaries contribute relatively small inflow to the Red River when averages are taken into consideration. Refer to Table 1 for the monthly averages.

As indicated, the Saint Andrews Lock and Dam controls water levels through the City of Winnipeg during the open water period typically between May and October. The target control level is approximately 223.7 m and the water levels are maintained at this level independent of flows in the Red River except under flood conditions.

Table 1
Red River at Disraeli Bridge
Monthly Average Discharge

Month	Discharge * (m^3/s)
January	57
February	54
March	148
April	789
May	677
June	348
July	281
August	154
September	109
October	107
November	103
December	70
Annual	241

* - Based on analyses of the Red River near Lockport (WSC 05OJ010) streamflow gauge

Flood Hydrology

Flood hydrology for the Red River as previously indicated is complicated by the operations of the Floodway which diverts a proportion of flow around the City of Winnipeg in order to reduce water levels within the City during a flood event. Manitoba Water Stewardship has recently updated the flood hydrology for the Red River within the City of Winnipeg taking into account recent upgrades to the Floodway. The hydrology derived by Manitoba Water Stewardship is based on a detailed and comprehensive assessment of recorded flows in addition to the incorporation of estimates of extreme historical events.

The table from Manitoba Water Stewardship summarizing their assessment is appended for reference. The assessment from Manitoba Water Stewardship has flood hydrology derived for the Red River at James Avenue which would be indicative of flood conditions at the Disraeli Bridge site. Table 2 summarizes the flood hydrology for the Red River at the Disraeli Bridge taking into account the flows diverted to the Floodway.

The backwater analyses of the Red River for the project require a discharge for the downstream boundary condition. The discharge required reflects conditions downstream of the Saint Andrews Lock and Dam at the Floodway outlet. The discharge would be approximately equal to the discharge at the Disraeli Bridge when the Floodway is not operating, however this cannot be assumed under flood conditions when total flows are greater than approximately 1100 m^3/s. The discharge has been estimated from the Manitoba Water Stewardship updated hydrology table by summing the Red River at James Avenue discharge and the Floodway discharge. Table 2 summarizes the estimated discharge downstream of the Saint Andrews Lock and Dam.

Table 2
Red River
Flood Hydrology

Flood Event	Red River at Disraeli Bridge * (m^3/s)	Red River downstream of St. Andrews Lock and Dam ** (m^3/s)
50% Flood	1005	1005
20% Flood	1361	1597
10% Flood	1401	2033
5% Flood	1453	2597
2% Flood	1810	3452
1% Flood	2292	4225
0.625% (160 Year) Flood	2331	4775

* - Red River at James Ave, Manitoba Water Stewardship, Updated Red River Hydrology -February 2010
** - Sum of Red River at James Ave discharge and Floodway discharge, Manitoba Water Stewardship, Updated Red River Hydrology -February 2010

Hydrology During Construction

The phasing and scheduling of the various construction activities including work platform installation, pier construction and girder erection are all dependent on flow conditions in the Red River. Construction of these key components of the project must be scheduled outside of the high flow period in order to reduce the risk of project delays and complications due to the restriction of the river by the work platform.

Hydrology throughout the construction period has been derived to enable the assessment of proposed works on river levels and channel velocities and to assign a probability of occurrence in order to quantify risk.

The streamflow records for the Red River near Lockport gauge (WSC 05OJ010) were analyzed for various periods through the year which correspond to the various phases of bridge construction. As previously indicated, the Lockport gauge would be representative of the Disraeli Bridge site for flows within the Red River which are less than approximately 1100 m^3/s. The discharge in the Red River through the City of Winnipeg would be reduced once flows start to be diverted to the Floodway. Note that no construction is proposed in the period from April 1 to June 30, which typically coincides with the highest flows in the Red River.

Table 3 summarizes the hydrology for various periods throughout the construction period. Additionally, the observed daily maximum discharge in that period is presented for comparison to illustrate the potential for high flows in that period.

Table 3
Red River at Disraeli Bridge
Hydrology During Construction

Construction Period	**Discharge (m^3/s) ***					**Observed Peak Discharge (m^3/s) ***
	50%	**20%**	**10%**	**2%**	**1%**	
July to October incl.	357	647	878	1490 **	1790 **	1300 – Aug 16, 1993
October 1 to 15	97	170	231	404	493	318 – Oct 9, 1994
October 16 to 31	115	203	275	474	577	427 – Oct 22, 1994
November 1 to 15	105	197	276	509	634	1010 – Nov 15, 2000
November 16 to 30	82	156	225	455	593	1010 – Nov 16, 2000
December 1 to 15	74	121	154	229	260	275 – Dec 5, 2000
December 16 to 31	63	101	126	178	198	193 – Dec 16, 2000
January	57	88	108	149	166	143 – Jan 1, 2001
February	54	81	99	139	156	151 – Feb 28,1998
March 1 to 15	63	137	228	680	1070	937 - Mar 15, 1998
March 16 to 31	204	525	873	2190**	3060**	1770 – March 30, 1995

* - Based on frequency analyses of the Red River near Lockport (WSC 05OJ010) streamflow gauge

** - discharge at the Disraeli Bridge would be reduced due to diversion of flows to the Floodway

It is clearly evident that higher flows can persist well into December in any given year. A late season heavy rainfall event occurred in November 2000, which resulted in extremely high, albeit rare, flows in the Red River through November and into December 2000. This event by coincidence coincided with the construction of the replacement Provencher Bridge with the work platforms advanced well into the river. On that basis, it is advised that the advancement of the work platforms to their complete extent be delayed until December 1.

The flows in the Red River in March increase considerably as the month progresses. Typically flows remain low for the first half of March, however with an early spring and runoff, flows have the potential to increase quickly and affect construction. It is recommended that removal of the work platforms begin prior to the middle of March, with complete removal by the end of March to ensure that no restriction exists in the river which could potentially aggravate flooding concerns.

Bruce Harding, P.Eng.
Senior Hydraulic Engineer

TABLE 1. RESULTANT FLOWS IN THE CITY OF WINNIPEG FOR DIFFERENT RETURN PERIODS OF ANNUAL EVENTS WITH SHELLMOUTH DAM, PORTAGE DIVERSION AND THE EXPANDED FLOODWAY IN OPERATION

			FLOWS WITHIN THE CITY (CFS)							
RETURN PERIOD OF NATURAL FLOOD CONDITION AT REDWOOD BRIDGE	FLOODWAY INLET (UPSTREAM)	FLOODWAY	D/S of FLOODWAY INLET	LASALLE RIVER	STURGEON CREEK	CONTRIBUTION FROM LOCAL AREA	SEINE RIVER	ASSINIBOINE AT HEADINGLEY	RED RIVER AT JAMES AVE	JAMES AVENUE ELEVATION (CITY OF WPG DATUM)
160 yr	161,000	86,291	74,709	2,800	1,500	450	450	2,400	82,309	24.77
100 yr	142,300	68,254	74,046	2,500	1,400	400	400	2,200	80,946	24.50
50 yr	115,400	58,005	57,395	2,200	1,250	350	350	2,350	63,895	20.64
33 yr	102,300	51,082	51,218	1,900	1,100	300	300	1,900	56,718	18.91
20 yr	85,900	40,397	45,503	1,600	950	250	250	2,750	51,303	17.60
10 yr	66,300	22,313	43,987	1,300	800	200	200	3,000	49,487	17.11
5 yr	48,900	8,353	40,547	1,100	650	150	150	5,450	48,047	16.75
2 yr	28,100	0	28,100	1,000	400	100	100	5,800	35,500	13.47

NOTES:

1. Original flow arrays taken from Kozera 2002 study, which he updated in 2005, and from Warkentin 2007. These have since been modified based on frequency analyses by Kelln and Luo in 2009 and flow arrays provided by Warkentin in 2010.
2. Return periods and natural flows for operation of flood control works taken from frequency curve of natural (unregulated) peak flows for the Red River at Redwood Bridge dated September 2010. Also used was a systematic frequency analysis encompassing recorded and historic flows at Grand Forks, Emerson and Upstream of the Forks described in an e-mail from Kelln to Bowering dated Sept 22, 2004 and filed in 5.5.1 and 11.1. Parts of this analysis were updated by Luo and Kelln in 2009.
3. The Red River Floodway with an expanded capacity of 130,000 cfs at an inlet elevation of 778 feet was used in simulations. The conveyance for the smaller floods was based on the performance of the floodway in the spring 2006. The curve was feathered into the curve provided by KGS in March 2009 at the upper end for higher flows under the expanded floodway. The floodway inlet natural rating curve as developed by Acres (2004) was used in the simulation of Floodway operation.
4. Normal operation of the Portage Diversion was assumed whereby Lake Manitoba is low enough to accommodate Portage Diversion flows as required.
5. Interpolation of values in the table is suggested if values for a return period which is not shown are desired.

6.For the 100-yr and 160-yr conditions, Rule 2 for Red River Floodway operation is in effect. For the 160-yr condition, the inlet level is two feet above the natural level. Therefore, the results shown for this condition should be considered tentative, pending further discussion and analysis.

APPENDIX E

REMEDIAL ACTION PLAN FOR UPLAND WORKS

WARDROP
A TETRA TECH COMPANY

May 6, 2010

1000070300-LTR-V0003-02

Mr. Randy Webber
Regional Supervisor
Winnipeg District
Manitoba Conservation
160 – 123 Main Street
Winnipeg, MB R3C 1A5

Dear Mr. Webber

Subject **Remedial Action Plan**
Adjacent to the Disraeli Bridge – Winnipeg, Manitoba

Wardrop Engineering Inc. (Wardrop) is planning to proceed with the offsite disposal of potentially impacted soil excavated as part of the land-based construction activities for the new Disraeli Bridge over the Red River in Winnipeg, Manitoba. The potentially impacted soil will be excavated to facilitate pile installation and footing construction for the abutment and piers on the south side of the river adjacent to Disraeli Street and Rover Avenue. The area of the land-based construction activities is shown on Figure 1, attached. Our proposed remedial action plan (RAP) is detailed in the following sections.

PROJECT DESCRIPTION – DISRAELI BRIDGE PROJECT

The Disraeli Bridge project will comprise the construction of a new bridge structure spanning the Red River. The existing roadway will be realigned to the new bridge and exits and entrances will be redesigned. The new four lane bridge structure will be located to the west of the current structure. The current bridge structure will be converted to a pedestrian bridge.

SITE BACKGROUND

Site Setting

The site is located between Disraeli Street and Disraeli Freeway, and north of Gladstone Street. A site plan is presented on Figure 1, attached. The area encompasses a grassed area as well as a portion of the riverbank. Surrounding land uses include the Red River to the north; Disraeli Street to the west, across which is a playground; the extension of Gladstone Street to the south; and Disraeli Freeway to east, across which is commercial property. The commercial property is occupied by Manitoba Hydro and is the location of a former manufactured gas plant (MGP).

Site Investigations

The report prepared for Manitoba Hydro by UMA Engineering Ltd. (UMA) and dated December 2003 provided a summary of the numerous investigations that have been conducted at the site of the former MGP as well as along the river bank adjacent to Rover Avenue. The following summarizes the investigations in the area of the Disraeli Bridge project site located to the west of the existing Disraeli Bridge.

Disraeli Street was assessed by the City of Winnipeg during a sewer upgrade program. The date of the assessment is unknown. Test drilling was conducted along Disraeli Street prior to the sewer upgrading, and with exception of impacted soils near the gate chamber and outfall structure at the intersection of Disraeli Street and Rover Avenue, no evidence of impact was reported to have been detected within the remaining test holes.

In 2000, an investigation was conducted west of the Disraeli Bridge along the bank of the river. Eight boreholes (TH2K-11 to TH2K-16, TH2K-19 and TH2K-20) and one test pit (TP99-2) were advanced within the immediate area of existing bridge pier 5. Visual impacts of liquid coal tar, staining, and odours were noted in all boreholes at depths between 1.1 m and 4.6 m below grade. Staining at a depth of 0.3 m below grade was noted in borehole TP99-2.

In 2001, an investigation was conducted on the south bank of the Red River, west of the Disraeli Bridge. The assessment included the advancement of a test pit (TP01-01) at the base of the excavation for the construction of the outfall structure and two boreholes (BH01-47 and BH01-48) drilled to the west of the outfall structure. Coal tar related hydrocarbon impacts were detected in soil samples recovered from test pit TP01-01, and from borehole BH01-47. Liquid coal tar was also observed within the excavated test pit.

In 2002, an investigation included the advancement of a borehole MW-29 to the southwest of the outfall structure and completion of the borehole as a nested piezometer. Naphthalene and BTEX impacts were detected in soil samples recovered from the borehole at depths greater than 5 m.

In February 2010, Wardrop completed a limited subsurface investigation at five of the planned substructure units for the new Disraeli Bridge. The investigation was conducted to the west of the existing bridge on the south bank of the Red River. The purpose of the investigation was to characterize the impacts (if any) within the soils that will be excavated during the installation of the piles and substructure footings SU1 to SU5. The investigation included the manual advancement of one borehole to a depth of 2 m below grade in the location of SU5; the mechanical advancement of three boreholes to a depth of 3 m below grade in the location of SU2, SU3, and SU4; and the mechanical advancement of one borehole to a depth of 6 m below grade in the location of SU1.

In February and March 2010, AECOM conducted a sediment sampling program as part of Manitoba Hydro's 2009/2010 Sutherland Environmental Management Plan. The sampling program included the mechanical advancement of a borehole to a depth of 7.3 m below grade at substructure footing SU5.

Site Geology

The native subsurface soils in the general area of the site are highly variable and consist of interbedded layers of low to high plastic clay, low plastic silt, and fine grained sand. Glacial till underlies the lacustrine materials at depths ranging from 8.2 m to 15.6 m below grade, and consists primarily of silt, although some gravel and sand are also present. According to the *Geological Engineering Maps and Report* produced by the former University of Manitoba Department of Geological Engineering in 1983, the carbonate bedrock in the area of the site is of the Selkirk Member and consists of mottled, fossiliferous dolomitic limestone, with abundant chert nodules in the upper limestone layer. Based on previous investigations in the vicinity of the site, bedrock is encountered at approximately 33 m below grade.

Based on the Wardrop investigation in February 2010, the site stratigraphy comprised clay fill from grade to a depth ranging from 0.8 m to 1.8 m below grade, underlain by silt, with varying percentages of clay to the maximum depth of the boreholes (3 m to 6 m below grade) for boreholes advanced in planned substructure locations SU1 to SU4. The remaining borehole was advanced in the planned pier location SU5 at the interface of the river bank and shoreline, which comprised silt with varying amounts of clay from grade to the depth of the borehole at 2 m below grade. An apparent odour and/or petroleum hydrocarbon sheen was noted at 0.8 m and 1.6 m below grade.

Site Hydrogeology

Primarily low permeability tills and glaciolacustrine silt and clay deposits dominate the area with the exception of locations along the floodplains of the river where permeabilities may be greater. Fractures in the glaciolacustrine silts and clays, as well as in the till deposit, can be a source of greater permeabilities.

The major underlying aquifer in the Winnipeg area is the upper 15 m to 30 m fractured zone of the Upper Carbonate Aquifer. The aquifer is somewhat confined by the overburden and underlying lower permeability carbonate bedrock.

Prior to the development of the aqueduct system which supplies the City of Winnipeg with potable water, the Upper Carbonate Aquifer was an important source of water for both municipal and industrial use. The Upper Carbonate Aquifer remains a potable water source in areas bordering the City (east of the Red River) and for some industrial use within Winnipeg. It is known that the Red River supplied process water to the former MGP.

The Lower Carbonate Aquifer occurs in the bottom 7.5 m to 15 m of the Red River formation, along the interface of the upper shale unit of the Winnipeg formation. This aquifer is of limited use for potable water supply. The Winnipeg Formation contains an upper sandstone aquifer which ranges in thickness form 6 m to 12 m and a lower sandstone aquifer approximately 3 m thick. Both sandstone aquifers contain non-potable saline waters.

NATURE AND EXTENT OF IMPACT

Overview of Site Impact

Based on information presented 2003 and 2006 UMA reports, the potential impact in the area of the land-based construction activities can be summarized as follows:

- Maximum historical naphthalene concentration of 8890 mg/kg in test pit TP01-01 at 0.6 m below the base of the excavation for the outfall structure, and a concentration of 1300 mg/kg at 1.2 m below grade in borehole TH2K-14.
- Maximum historical benzo(a)pyrene concentration of 346 mg/kg in test pit TP01-01 at 0.6 m below the base of the excavation for the outfall structure, and a concentration of 628 mg/kg in test pit TP01-01 at 2.0 m below the base of the excavation for the outfall structure.
- Maximum historical ethylbenzene and xylene concentrations of 2.95 mg/kg and 1.55 mg/kg, respectively, in borehole BH01-47 at 1.4 m below grade.
- Maximum historical concentrations of polycyclic aromatic hydrocarbons (PAHs), phenanthrene; pyrene, benzo(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; indeno(1,2,3-cd)pyrene; and dibenzo(a,h)anthracene of 2250 mg/kg, 1230 mg/kg, 311 mg/kg, 225 mg/kg, 134 mg/kg, 133 mg/kg, and 25.1 mg/kg in borehole TH2K-14 at 1.22 m to 1.52 m below grade, respectively.

The results of the limited site investigation conducted by Wardrop in February 2010 in the area of the land-based construction activities can be summarized as follows:

- The soil sample collected from borehole W3 at 1.5 m below grade exhibited a naphthalene concentration of 0.270 mg/kg and a phenanthrene concentration of 0.278 mg/kg.
- The soil sample collected from borehole W4 at 1.5 m below grade exhibited an indeno(1,2,3-cd)pyrene concentration of 2.61 mg/kg, a benzo(a)pyrene concentration of 2.74 mg/kg, a naphthalene concentration of 0.051 mg/kg, and a phenanthrene concentration of 0.382 mg/kg.
- The soil sample collected from borehole W5 at 0.8 m below grade revealed a benzene concentration of 2.1 mg/kg, a toluene concentration of 1.6 mg/kg, a naphthalene concentration of 4.95 mg/kg, and a phenanthrene concentration of 0.218 mg/kg.
- The soil sample collected from borehole W5 at 1.6 m below grade exhibited a benzene concentration of 6.2 mg/kg, a toluene concentration of 3.6 mg/kg, and PHC fractions F2 and F3 concentrations of 549 mg/kg and 463 mg/kg, respectively. Acenaphthene, benzo(a)pyrene, fluorene, naphthalene and phenanthrene were detected at concentrations of 2.30 mg/kg, 1.23 mg/kg, 1.50 mg/kg, 22.7 mg/kg, and 3.55 mg/kg, respectively, within the soil sample.
- The analytical results are presented on Table 1, attached.

The results of the investigation conducted by AECOM in February 2010 in the area of the substructure pier location SU5 can be summarized as follows:

- The soil sample collected from borehole TH10-01 at 0.10 m to 0.30 m below grade exhibited PAHs including a naphthalene concentration of 1260 mg/kg and a benzo(a)pyrene concentration of 134 mg/kg.
- The sample collected from borehole TH10-01 at 1.8 m to 2.0 m below grade exhibited PAHs including a naphthalene concentration of 4600 mg/kg and a benzo(a)pyrene concentration of 702 mg/kg. This sample was reportedly recovered from a coal tar seam.
- Applicable excerpts from the AECOM analytical tables are presented as Table 2, attached.

REMEDIAL ACTION PLAN

Exposure Pathways

The UMA report prepared for Manitoba Hydro in 2006 and entitled: *Comprehensive Environmental Management Plan for Residuals from Historical Operations at the Sutherland Avenue Former Gas Plant* identified three major human health exposure pathways:

- Direct exposure to PAH-impacted soil (i.e. dermal contact, soil ingestion, and particle inhalation);
- Exposure to volatile components of subsurface coal tar impact in the outdoor environment; and,
- Exposure to volatile components of subsurface coal tar impact via soil vapour intrusion into the indoor environment.

The land-based construction activities for the new Disraeli Bridge will not change the identified exposure pathways. Since the new bridge construction activities will not involve an indoor environment, only the first two exposure pathways are considered applicable for this RAP. Land-based activities related to the new bridge will involve soil excavation at five locations for pile placement and footing construction. Access to the construction area will be restricted to authorized personnel. Authorized personnel will be aware of encountering potentially impacted soil in the excavations. Unnecessary exposure to authorized personnel will be avoided through the use of protective clothing and respirators; and decontamination after working in the excavations exposing potentially impacted soil.

Description of Remedial Action Plan

The purpose of the RAP is to address the potentially impacted soil that may be excavated during the land-based construction activities on the south side of the river adjacent to Disraeli Street and Rover Avenue. The remedial action will consist of the following:

- Excavation of potentially impact soil at five locations to facilitate pile installation and footing construction for the abutment and piers on the south side of the river adjacent to Disraeli Street and Rover Avenue.
- Off-site disposal of potentially impacted soil containing chemicals of concern at concentrations exceeding the applicable Canadian Council of Ministers of the Environment (CCME) guidelines.
- Backfilling around the new substructures with compacted "clean" excavated material, pending confirmatory analytical results indicating that concentrations of chemicals of concern do not exceed the applicable CCME guidelines, and/or imported clean backfill.

Applicable Guidelines/Standards

The UMA (2006) report referenced the CCME (2002) Residential/Parkland soil quality guidelines as applicable for the locations surrounding the MGP site and the riverbank. For the purposes of this RAP, the current CCME *Canadian Environmental Quality Guidelines* (2007), *Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil* (2008), and the *Carcinogenic and Other Polycyclic Aromatic Hydrocarbons* (2008) soil quality guidelines have been used for comparison purposes.

Applicable Guidelines/Standards (cont'd)

It is not the intent to remediate, beyond the limits of excavation, any impacted soil that may be encountered during the land-based construction activities. The purpose is only to address impacted soil that may be excavated during the land-based construction activities.

Excavation of Potentially Impacted Soil

Land-based activities related to the new Disraeli Bridge will involve soil excavation at five substructure locations for pile placement and footing construction on the south side of the river adjacent to Disraeli Street and Rover Avenue. Footing excavations will extend to approximately 2 m below grade. Pre-drilling for installation of the 406-mm diameter precast concrete piles at the south abutment SU1 will extend to approximately 4.5 m (vertical pile) or 6 m (battered pile) below the base of the footing excavation. An estimated total of 650 m^3 of soil will be excavated from the five substructure locations. Based on readily available information and the recent analytical results, the 650 m^3 of excavated soil include an estimated 70 m^3 of "clean" soil from substructures SU1 and SU2, and an estimated 580 m^3 of potentially impacted soil from substructures SU3, SU4 and SU5.

During excavation at each of the five locations, soil will be assessed in the field based on visual observations, headspace vapour concentrations measured with GasTECH™ combustible gas indicator, noticeable odours, and available analytical results from previous investigations. Soil assessed in the field to be "clean" (i.e., no visual evidence of impact and no noticeable odour) will be stockpiled on the site for later use as backfill material, pending confirmatory analytical results. The "clean" soil will be stockpiled on polyethylene sheeting adjacent to the excavation from which the soil was removed.

Excavated soil assessed in the field to be impacted (i.e., visual evidence of impact and/or noticeable odours) will be loaded directly onto trucks or into roll-off bins for offsite disposal. In the event that trucks or bins are not immediately available, the soil will be temporarily stockpiled on polyethylene sheeting adjacent to the excavation from which it was removed. The stockpile will also be covered with polyethylene sheeting until it is removed for offsite disposal. Any stockpile will be located within a fenced area accessible only to authorized personnel.

Excavated material assessed in the field to be coal tar or coal tar-saturated (i.e. visual evidence of coal tar) will be loaded directly onto roll-off bins for temporary storage on the site. The bins will be located within a fenced area accessible only to authorized personnel. The bins will remain on the site until a sufficient quantity of the coal tar or coal tar-saturated soil has been collected for offsite disposal.

Site Restoration

The excavated areas will be backfilled with clean compacted fill material to either existing grade or to the design grade set out by the new bridge construction. Any subsequent finish grading and landscaping will be in accordance with the new bridge construction.

Off-Site Disposal

Based on the results of the Wardrop and AECOM 2010 investigations, the excavated potentially impacted soil will be suitable for disposal at MidCanada Environmental Services treatment facility in Ill des Chenes, Manitoba. Disposal of the impacted soil at MidCanada will require approval from the Director of Manitoba Conservation. The approval will be requested by MidCanada.

Coal tar and coal tar-saturated soil will be transported to Clean Harbor's hazardous landfill in Lambton, Ontario.

Confirmatory Sampling

Since it is not the intent to remediate, beyond the limits of excavation, any impacted soil that may encountered during the land-based construction activities, no confirmatory sampling at the limits of the excavations is proposed.

Equipment Decontamination

Excavating and pile drilling equipment that comes in contact with impacted soil will be decontaminated prior to that equipment leaving the site. Loose or visible soil will be scraped or brushed off the equipment. The equipment will then be pressured washed. The wash water will be collected on the site for subsequent disposal pending analytical results. Soil and solids from the decontamination process will be disposed at the MidCanada facility.

Closure Report

Following the completion of the site activities, Wardrop will prepare a closure report summarizing the site activities and including any soil analytical data.

Please contact Andrew Eason at (204) 988-0536 if you have any questions or comments.

Sincerely

WARDROP ENGINEERING INC.

Shauna Zahariuk, B.Env.Sc., CEPIT
Environmental Scientist

Reviewed by

WARDROP ENGINEERING INC.

Andrew Eason, P.Eng.
Senior Environmental Engineer

AE/pp

Attachments
Figure 1
Table 1
Table 2

A. EASON

APEGM
Certificate of Authorization
Wardrop Engineering Inc.
No. 195 Date: April 30, 2011

References

AECOM, 2010. Analytical results from 2009/2010 Sutherland Environmental Management Plan, Sediment Sampling Work Plan.

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UMA Engineering Ltd., 2003. *Manitoba Hydro Former Manufactured Gas Plant, 35 Sutherland Avenue, Winnipeg, Manitoba, Supplemental Environmental Site Investigation.*

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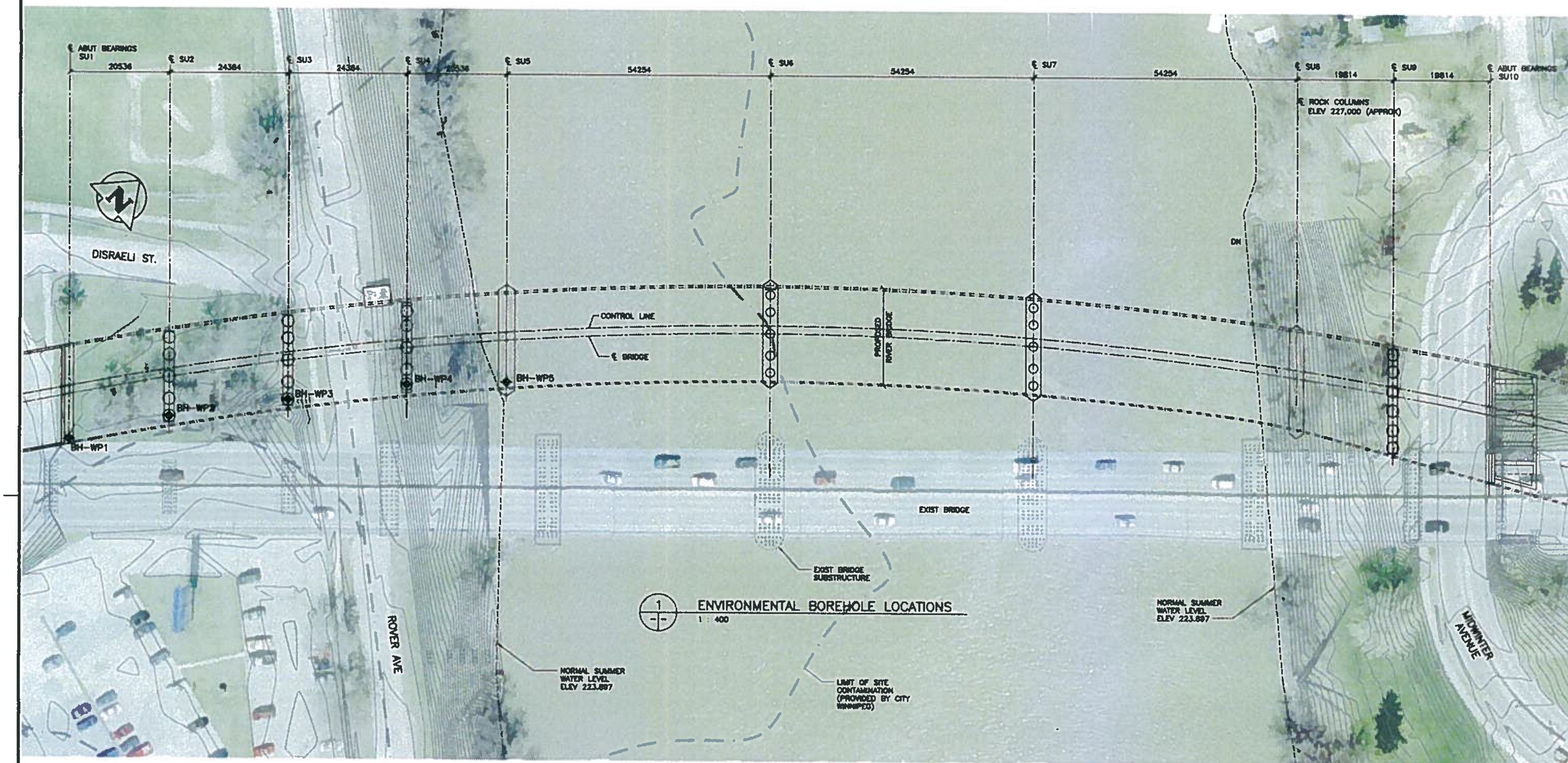
Wardrop Engineering Inc., 2010. *Environmental Investigation, Soil Characterization, South Substructure Units, Disraeli Bridge, Winnipeg, Manitoba.*

LIMITATIONS

The scope of this report is limited to the matters expressly covered and is intended solely for the client to whom it is addressed. Wardrop makes no warranties, expressed or implied, including without limitation, as to the marketability of the site, or fitness for a particular use. The assessment was conducted using standard engineering and scientific judgement, principles and practices, within a practical scope and budget. It is partially based on the observations of the assessor during the site visit, in conjunction with archival information obtained from a number of sources, which is assumed to be correct. Except as provided, Wardrop has made no independent investigations to verify the accuracy or completeness of the information obtained from secondary sources or personal interviews. Generally, the findings, conclusions, and recommendations are based on a limited amount of data (e.g., the number of boreholes drilled, and the number of water samples submitted for laboratory analyses) interpolated between sampling points, and the actual conditions (e.g., the type, level, and extent of impacted media) on the property may vary from that described above. Any findings regarding site conditions different from those described above upon which this report is based, will consequently change Wardrop's conclusions and recommendations.

DISCLAIMER

This Wardrop Engineering report has been prepared in response to specific requests for services from the client to whom it is addressed. The content of this document is not intended for the use, nor is it intended to be relied upon, by any person, firm, or corporation other than the client of Wardrop Engineering to whom it is addressed. Wardrop denies any liability whatsoever to other parties who may obtain access to this Document by them, without express prior written authority of Wardrop Engineering and its client who has commissioned this Document.



LEGEND:
◆ BOREHOLE LOCATION

DESIGN TEAM

WARDROP
A TETRA TECH COMPANY

SCATLIFF+MILLER+MURRAY Inc.

Stantec

McGOWAN·RUSSELL

B.M. ELEV | T.B.

NO.	REVISIONS	DATE	BY
A	ISSUED FOR INTERIM REPORT	10.02.11	S.Z.

CONSULTANT

WARDROP
A TETRA TECH COMPANY

DESIGNED BY S.Z.	CHECKED BY
DRAWN BY C.I.	APPROVED BY / DATE
HOR. SCALE / VERTICAL: AS NOTED	AUTHORIZED BY / DATE
DATE 10.02.10	ACCEPTED BY / DATE

PRELIMINARY DRAWING

NOT TO BE USED FOR CONSTRUCTION

CONSULTANT DRAWING NO.
1000070300-SKT-V0001

Plenary Roads

PCL
CONSTRUCTION LEADERS

DISRAELI BRIDGES PROJECT
RED RIVER BRIDGE

ENVIRONMENTAL BOREHOLE LOCATIONS

CITY DRAWING NUMBER

SHEET OF

FIGURE 1

TABLE 1

Soil Sample Laboratory Analytical Results - February 2010
Disraeli Bridge - South River Bank / West of Bridge

Laboratory Analyses	Laboratory Analytical Results (mg/kg)						Environmental Quality Guidelines [1, 2, 3] (mg/kg)
	W1	W2	W3	W4	W5		
	3.8 m	1.5 m	1.5 m	1.5 m	0.8 m	1.6 m	
BTEX							
Benzene	<0.0050	<0.0050	0.010	0.007	***2.1***	***6.2***	60 / 1.0
Toluene	<0.010	<0.010	0.01	<0.010	***1.6***	***3.6***	110 / 0.10
Ethylbenzene	<0.050	<0.050	<0.050	<0.050	<0.050	0.2	120 / 50
Xylenes	<0.10	<0.10	<0.10	<0.10	0.2	1.7	65 / 37
CCME Fractions							
F1 - BTEX (>nC_6-nC_{10})	<10	<10	<10	<10	<10	<10	210 / 970
F2 (>nC_{10}-nC_{16})	<10	<10	<10	<10	106	***549***	150 / 150
F3 (>nC_{16}-nC_{34})	56	<50	57	250	118	***463***	1300 / 300
F4 (>nC_{34})	<50	<50	<50	122	<50	109	5600 / 2800
Polycyclic Aromatic Hydrocarbons (PAHs)							
Acenaphthene	<0.010	<0.010	<0.010	<0.010	0.051	***2.30***	0.28
Acenaphthylene	<0.010	<0.010	0.118	0.687	0.036	0.135	320
Acridine	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	NG
Anthracene	<0.010	<0.010	0.100	0.136	0.114	1.22	2.5
Benzo(a)anthracene	<0.010	0.017	0.539	0.757	0.357	1.37	6.2
Benzo(a)pyrene	<0.010	<0.010	0.595	***2.74***	0.331	***1.23***	0.6
Benzo(b)fluoranthene	<0.010	<0.010	0.678	2.18	0.281	1.14	6.2
Benzo(ghi)perylene	<0.010	<0.010	0.344	4.06	0.111	0.661	NG
Benzo(k)fluoranthene	<0.010	<0.010	0.235	0.941	0.141	0.740	6.2
Chrysene	<0.010	<0.010	0.236	0.701	0.194	1.40	6.2
Dibenzo(ah)anthracene	<0.010	<0.010	0.055	0.356	0.020	0.115	1.0
Fluoranthene	<0.010	0.013	0.474	0.762	0.411	3.09	15.4
Fluorene	<0.010	<0.010	<0.010	<0.010	0.052	***1.50***	0.3
Indeno(1,2,3 cd)pyrene	<0.010	<0.010	0.375	***2.61***	0.152	0.940	1.0
1-Methyl Naphthalene	<0.010	<0.010	0.064	<0.010	0.047	2.61	NG
2-Methyl Naphthalene	<0.010	<0.010	0.053	<0.010	0.042	2.47	NG
Naphthalene	<0.010	<0.010	***0.270***	***0.051***	***4.95***	***22.7***	0.013
Phenanthrene	<0.010	<0.010	***0.278***	***0.382***	***0.218***	***3.55***	0.046
Pyrene	<0.010	0.014	0.527	1.08	0.373	2.35	7.7
Quinoline	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	NG
Grain Size							
<75 um	40.0	98.0	84.0	76.0	84.0	84.0	NG
>75 um	60.0	2.0	6.0	24.0	6.0	6.0	NG
Moisture Content (%)	24.2	24.1	17.6	25.4	33.3	39.4	NG

Notes:

[1] CCME, *Canadian Environmental Quality Guidelines* (2007), Residential / Parkland, fine-grained / coarse-grained, eco soil contact and groundwater check (aquatic life).

[2] CCME, *Canada-Wide Standard for Petroleum Hydrocarbons in Soil* (2008), Residential, fine-grained / coarse-grained, eco soil contact and protection of aquatic life.

[3] CCME, *Carcinogenic and Other Polycyclic Aromatic Hydrocabrons (PAHs)* (2008), Residential / Parkland, soil contact and protection of freshwater life.

NG = No Guideline

Bold Text = Laboratory analytical results in excess of the referenced guidelines

TABLE 2

AECOM Sediment and Soil Sample Laboratory Analytical Results - February 2010
Disraeli Bridge - SU5 / South River Bank / West of Bridge

Parameter	Sample Name @ Depth/Date	
	TH10-01 @ 0 - 10 CM	TH10-01 @ 10 - 30 CM [1]
	02/03/2010	02/03/2010
% Sand Content	5	13
% Silt Content	26	25
% Clay Content	69	62
Naphthalene	<0.010	***1260***
2-Methyl Naphthalene	<0.010	***180***
1-Methyl Naphthalene	<0.010	119
Acenaphthylene	<0.010	***46.4***
Acenaphthene	0.011	***195***
Fluorene	<0.010	***141***
Phenanthrene	<0.010	***589***
Anthracene	<0.010	***169***
Fluoranthene	<0.010	***385***
Pyrene	<0.010	***335***
Benzo(a)anthracene	<0.010	***145***
Chrysene	<0.010	***129***
Benzo(b&j)fluoranthene	<0.010	149
Benzo(k)fluoranthene	<0.010	43
Benzo(a)pyrene	<0.010	***134***
Indeno(1,2,3-cd)pyrene	<0.010	97.2
Dibenzo(a,h)anthracene	<0.010	***12.9***
Benzo(g,h,i)perylene	<0.010	55.6
Quinoline	<0.050	<0.25
Acridine	<0.050	<20
Total PAH_{16}	0.161	***3886.1***

Notes:
CCME, Interim Sediment Quality Guidelines (PEL) for Freshwater, Update 2007.
-- indicates no criteria
All concentrations in mg/kg
N/A - not applicable
BOLD indicates exceeded guideline value presented by AECOM
[1] - MDL adjusted for required dilution or sample matrix effects

All analytical results provided to Wardrop by AECOM

Parameter	Sample Name @ Depth (m) / Date					
	TH10-01 @ 1.8 - 2.0 [1]	TH10-01 @ 3.4	TH10-01 @ 4.0 - 4.1	TH10-01 @ 4.9 - 5.0	TH10-01 @ 6.4 - 6.7	TH10-01 @ 7.0 - 7.3
	2/24/2010	2/24/2010	2/24/2010	2/24/2010	2/24/2010	2/24/2010
% Sand Content	62	79	44	59	2	44
% Silt Content	20	8	34	22	25	40
% Clay Content	18	13	23	19	73	16
FOC	0.181	0.0047	0.0071	0.0034	0.0125	0.0025
Total Organic Carbon	18.1	0.47	0.71	0.34	1.25	0.25
Benzene	***4.35***	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Toluene	***0.576***	<0.010	<0.010	<0.010	<0.010	<0.010
Ethylbenzene	14.8	0.013	<0.010	<0.010	<0.010	<0.010
Xylenes	9.19	<0.030	<0.030	<0.030	<0.030	<0.030
Naphthalene	***4600***	0.086	0.109	0.079	<0.010	<0.010
2-Methyl Naphthalene	***1160***	0.012	<0.010	0.011	<0.010	<0.010
1-Methyl Naphthalene	1170	0.015	<0.010	0.011	<0.010	<0.010
Acenaphthylene	***155***	<0.010	<0.010	<0.010	<0.010	<0.010
Acenaphthene	***3360***	0.088	0.012	0.022	<0.010	<0.010
Fluorene	***1250***	0.017	<0.010	<0.010	<0.010	<0.010
Phenanthrene	***4080***	0.173	0.017	0.046	0.018	<0.010
Anthracene	***1390***	0.084	<0.010	0.031	<0.010	<0.010
Fluoranthene	***1790***	0.061	<0.010	0.023	<0.010	<0.010
Pyrene	***2590***	0.089	<0.010	0.033	0.011	<0.010
Benzo(a)anthracene	***673***	0.026	<0.010	0.017	0.012	<0.010
Chrysene	***732***	0.025	<0.010	0.014	<0.010	<0.010
Benzo(b&j)fluoranthene	477	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(k)fluoranthene	160	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(a)pyrene	***702***	0.019	<0.010	<0.010	<0.010	<0.010
Indeno(1,2,3-cd)pyrene	378	<0.010	<0.010	<0.010	<0.010	<0.010
Dibenzo(a,h)anthracene	***38.7***	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo(g,h,i)perylene	255	<0.010	<0.010	<0.010	<0.010	<0.010
Quinoline	<25	<0.050	<0.050	<0.050	<0.050	<0.050
Acridine	<20	<0.050	<0.050	<0.050	<0.050	<0.050
Total PAH_{16}	***22630.7***	0.728	0.278	0.345	0.171	0.16

Notes:
CCME, Interim Sediment Quality Guidelines (PEL) for Freshwater, Update 2007.
All concentrations in mg/kg
-- indicates no criteria
N/A - not applicable
BOLD indicates exceeded guideline value presented by AECOM
[1] - MDL adjusted for required dilution, Dibenzo(a,h)anthracene, Quinoline and Acridine MDL adjusted for sample matrix effects

All analytical results provided to Wardrop by AECOM

Winnipeg

APPENDIX F

INVENTORY OF VEGETATION IN THE STUDY AREA

Inventory of Vegetation in the Local Study Area (from Dillon 2009)

Species Name	Common Name	Date added to list	Native/Introduced
Acer negundo	Manitoba maple	6-Aug-02	N
Acer saccharinum	Silver maple	20-Aug-02	
Agropyron cristatum	Crested wheatgrass	20-Aug-02	I
Agropyron repens	Quack- grass, Couch-grass	6-Aug-02	I
Ambrosia spp.	Ragweed	6-Aug-02	
Ambrosia trifida	Great ragweed	20-Aug-02	N
Anemone nemorosa var. bifolia	Wood anemone	6-Aug-02	
Arctium spp.	Burdock	6-Aug-02	I
Arnica cordifolia	Heart-leaf arnica	20-Aug-02	N
Artemisia absinthium	Absinthe	20-Aug-02	I
Artemisia spp.	Sage	6-Aug-02	
Aster spp.	Aster	6-Aug-02	
Bidens frondosa	Common beggarticks	20-Aug-02	N
Brassica spp.	Mustard	6-Aug-02	
Bromus inermis	Smooth brome	6-Aug-02	I
Campanula rapunculoides	Creeping bluebell	6-Aug-02	I
Capsella bursa-pastoris	Shepherd's-purse	6-Aug-02	I
Carex spp.	Sedge	8-Aug-96	N
Chenopodium album	Lambs-quarters	20-Aug-02	I
Cirsium arvense	Canada thistle	6-Aug-02	I
Cornus stolonifera	Red osier dogwood	18-Oct-04	N
Cotoneaster acutifolia	Cotoneaster	20-Aug-02	I
Fraxinus pennsylvanica	Green ash	6-Aug-02	N
Glechoma hederacea	Gill-over-the-ground	6-Aug-02	I
Laportea canadensis	Wood nettle	6-Aug-02	N
Leonurus spp.	Motherwort	6-Aug-02	
Linum lewisii	Lewis wild flax	20-Aug-02	N
Lonicera tatarica	Tartarian honesuckle	18-Oct-04	I
Lythrum salicaria	Purple loosestrife	6-Aug-02	I
Matricaria matricarioides	Pineappleweed	8-Aug-96	I
Melilotus alba	White sweet-clover	6-Aug-02	I
Parthenocissus quinquefolia	Virginia creeper	6-Aug-02	N
Phalaris arundinacea	Reed canary grass	20-Aug-02	N
Poa pratensis	Kentucky blue grass	8-Aug-96	N/I
Polygonum spp.	Smartweed	6-Aug-02	
Populus deltoides	Cottonwood	6-Aug-02	N
Potentilla anserina	Silverweed	6-Aug-02	N
Prunus virginiana	Red-fruited choke cherry	6-Aug-02	N
Rumex crispus	Curled dock	6-Aug-02	I
Rumex spp.	Wild rhubarb	6-Aug-02	
Salix amygdaloides	Peach-leaved willow	6-Aug-02	N
Salix exigua	Sandbar willow	20-Aug-02	N
Salix spp.	Willow	8-Aug-96	
Sambucus racemosa	Red elderberry	20-Aug-02	N
Sonchus arvensis	Perennial sow-thistle	8-Aug-96	I
Sonchus spp.	Sow thistle	6-Aug-02	I
Spartina pectinata	Prairie cord grass	20-Aug-02	N
Taraxacum officinale	Dandelion	18-Oct-04	I
Taraxacum spp.	Dandelion	6-Aug-02	
Tragopogon pratensis	Goats-beard	20-Aug-02	I
Ulmus americana	American elm	8-Aug-96	N
Ulmus pumila	Siberian elm	20-Aug-02	I
Urtica dioica	Stinging nettle	6-Aug-02	N
Xanthium strumarium	Cocklebur	6-Aug-02	N

APPENDIX G

RED RIVER DISRAELI BRIDGE SEDIMENT STABILITY ANALYSIS

Tetra Tech, Inc.
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Fairfax, VA 20176
703.385.6000

Memorandum

Date: June 22, 2010

From: John Hamrick, Tetra Tech

To: Michel Gregoire, Rick Haldane-Wilsone, Dave Tyson, Wardrop

Subject: Red River Disraeli Bridge Sediment Stability Analysis

Summary

A modeling analysis was conducted to estimate the stability of bed sediment in the Red River in the vicinity of a proposed new Disraeli Freeway bridge in Winnipeg, Manitoba. The analysis considered a number of ice free flow conditions before and after bridge construction and work bridge constricted winter flow conditions during construction. The Environmental Fluid Dynamic Code (EFDC) was used for the modeling analysis which involved determination of bed stresses under the various conditions simulated. Table 1 summarizes the flow conditions and corresponding bed stresses which for all cases occur in the vicinity of the bridges. For the three ice free flow conditions having discharges of 200, 1005, and 2240 cms (cubic meters per second), the maximum bed stresses for future conditions increased by less than 6 percent over those for the corresponding flows under existing conditions. For the highest flow rate the existing and future maximum stresses are 16.3 and 17 N/m^2, respectively. For winter construction conditions, when the river is constrained between work bridges, the maximum bed stress reaches 16.5 N/m^2 for a winter high flow of 154 cms. To determine the bed surface material size which would be stable under these stress conditions, the modified Shield's diagram, Figure 1, was utilized. The diagram indicates that 30 mm and larger gravel will be stable for bed stresses less than 20 N/m^2. After the construction work bridges are removed, 150 mm cobble will be left in the foot print of the west bridge to assure that existing sediment bed contamination is not disturbed. Material of the same size will also be placed on the west and east river banks. The 150 mm material will be stable under

flow conditions on the order of 10,000 cms, well beyond range of extreme flows for the Red River. The highest stresses are predicted to occur between the two central piers after construction and between the work bridges during winter construction. However, since these stresses exceed the highest historical stresses by less than 6 per cent and there is no historical evidence of excessive scour between the existing central bridge piers, it is anticipated that this area will remain stable. In the event that flows in excess of 154 cms are forecast during winter construction, emergency placement of gravel in excess of 30 mm in the constriction between the work bridges is advisable. The material could be later removed at the time the work bridges are removed.

Background

A new Disraeli Freeway bridge will be constructed over the Red River in Winnipeg, Manitoba, just down stream of the existing bridge. Figure 2 shows the river shoreline in this area including the existing bridge piers, new bridge piers and the footprint of a pair of temporary work bridges that will be present during the construction of the new bridge. The west side of the river bed downstream of the existing bridge piers is contaminated with residual form historical production of manufactured gas at a facility just upstream form the existing bridge. There is some consensus that the river bed in the contaminated area is stable with respect to erosion due to high levels of hydrocarbon residual binding the inorganic sediments. To prevent disturbance of the area during construction, a geo-textile fabric over laid with coarse gravel will be put in place before construction of the work bridges. The fabric and coarse gravel will remain to armor the contaminated area after the work bridges are constructed.

To assess the potential for erosion in the gap between the work bridges during construction and erosion associated with the new bridge in place, a hydrodynamic modeling analysis was conducted to determine maximum bed stresses and requirements for sediment stability. The analysis is based on the use of a multi-dimensional hydrodynamic and the widely accepted Shield's criteria for stability of noncohesive sediment beds.

The Environmental Fluid Dynamic Code (EFDC) was selected for use in the modeling analysis. The EFDC model is widely used to simulation flow, water quality, sediment transport and contaminant transport in surface water systems. The EFDC model has been used to simulate hydrodynamics, sediment transport and contaminant transport and fate at a number of contaminated sediment superfund sites in the United States, including the Housatonic, Willamette, Tittabawassee, and Fox Rivers. The EFDC model has been applied to simulate hydrodynamics in the North Saskatchewan and Athabasca Rivers in Canada.

Modeling Analysis Approach

The EFDC model was configured to simulation two-dimensional, depth average flow in the study region which extends approximately 600 and 800 meters upstream and downstream, respectively form the bridges area. Bathymetric and topographic data for configuration for the model include a recent bathymetric survey, cross sections, adjacent GIS topography and preliminary design data for the work bridges, all shown in Figure 3. Figures 4 and 5 show the entire model grid and river bathymetry interpolated to the grid for existing conditions. Figure 6 shows the grid and bathymetry in the vicinity of the bridges. The horizontal grid resolution is approximately 5 meters with 36 grid cells across the channel and 280 along the channel. The modified grids and bathymetry in the vicinity of the bridges for winter construction and future conditions are shown in Figures 7 and 8, respectively.

Eight model simulations were conducted. Existing and future conditions were simulated for flows of 200, 1005, and 2240 cms (cubic meters per second) and winter construction conditions were simulated for flows of 75 and 154 cms. These flows and corresponding downstream boundary water surface elevations were provide by Mr. Bruce Harding and based on analysis of historical flows and HEC-RAS simulations, respectively. The 200 cms flow represents normal summer conditions, while the 1005 cms flow represents the 50 percent flood. The high 2040 cms flow corresponds to the historical flow on May 4, 1997 which is approximately the 1 percent flood event. The 75 and 154 cms flows represent the 50 and 10 percentile flows expected between the beginning of December and end of February. These inflows were introduced uniformly across the cross section of the upstream boundary, the southeast grid face in Figure 3. A constant elevation was maintained at the down stream boundary for flow conditions. For the 200, 1005, and 2240 cms flows the downstream boundary water surface elevation was set to 223.8, 225.7, and 228.9 meters, respectively. For the 75 and 154 cms winter flows, the elevations were set to 222.3 and 223.1 meters, respectively. The model simulations were cold started with the water surface elevation everywhere set to the downstream elevation and allowed to run until steady conditions were achieved. For the two highest flows, the inflow was gradually increased from a lower flow rate to the high flow values.

Analysis Results

Results form the eight simulations are presented graphically in Figures 9 through 24. Odd number figures show depth average velocity vectors overlaid on bed bottom elevation contours. Even number figures show bed stress vectors overlaid on contours of the bed stress magnitude. Table 1 summarizes the flow conditions and corresponding bed stresses which for all cases occur in the vicinity of the bridges. For both existing and future conditions at the 200 cms discharge rate, maximum bed stresses are less than 1 N/m^2 (Newton per square meter). The Shield's stability diagram, Figure 1, indicates that noncohesive sediment greater than 2 mm are stable under this stress. Finer noncohesive material having clay fractions in excess of 10 percent and consolidated cohesive material can be stable under this level of stress. Also observations that significant erosion has not occurred in the vicinity of the existing bridge piers support the conclusion of stability at this flow rate and maximum bed stress. For the 1005 cms flow under existing and future conditions maximum bed stresses of 8.8 and 9.3 N/m^2, respectively, occur between the bridge piers. At this stress level noncohesive sediment greater than 10 mm in diameter are stable as shown in Figure 1. At the highest flow rate of 2240 cms, maximum bed stress reach 16.2 and 17 N/m^2 under existing and future conditions, respectively. For the higher, 154 cms, flow under construction conditions a maximum stress of 16.5 N/m^2 occurs between the work bridges. These results indicate that construction and future high flow conditions will only slightly exceed the highest flow under the existing condition. The Shield's diagram, Figure 1, indicates that 30 mm and larger gravel will be stable for bed stresses less than 20 N/m^2. After the construction work bridges are removed, 150 mm cobble will be left in the foot print of the west bridge to assure that existing sediment bed contamination is not disturbed. Material of the same size will also be placed on the west and east river banks. The 150 mm material will be stable under flow conditions on the order of 10,000 cms, well beyond range of extreme flows for the Red River. The highest stresses are predicted to occur between the two central piers after construction and between the work bridges during winter construction. However, since these stresses exceed the highest historical stresses by less than 6 per cent and there is no historical evidence of excessive scour between the existing central bridge piers, it is anticipated that this area will remain stable. In the event that flows in excess of 154 cms are forecast during winter construction, emergency placement of gravel in excess of 30 mm in the constriction between the work bridges is advisable. The material could be later removed at the time the work bridges are removed.

Table1. Flow Conditions and Maximum Bed Stresses

Flow Rate cms	Current Conditions Maximum Stress N/m^2	Winter Construction Maximum Stress	Future Conditions Maximum Stress
75		5.74	
154		16.5	
200	0.82		0.89
1005	8.80		9.30
2240	16.2		17.0

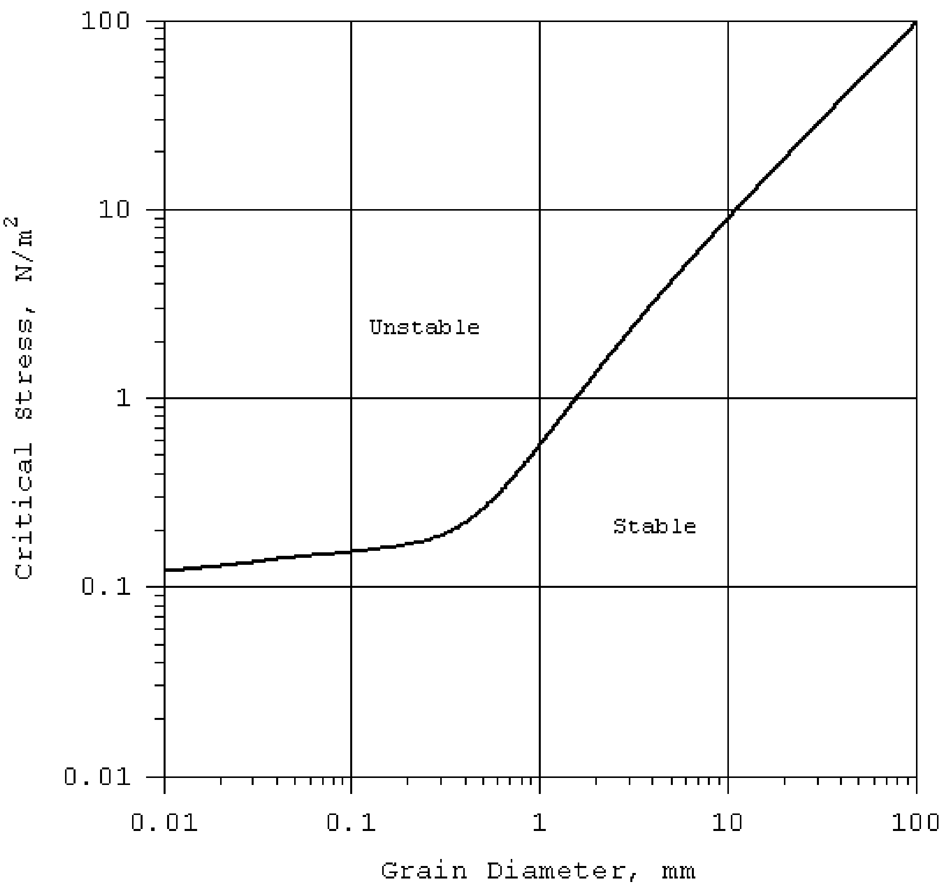

Figure 1. Modified Shield's diagram showing critical stress for erosion of noncohesive sediment as a function of grain diameter.

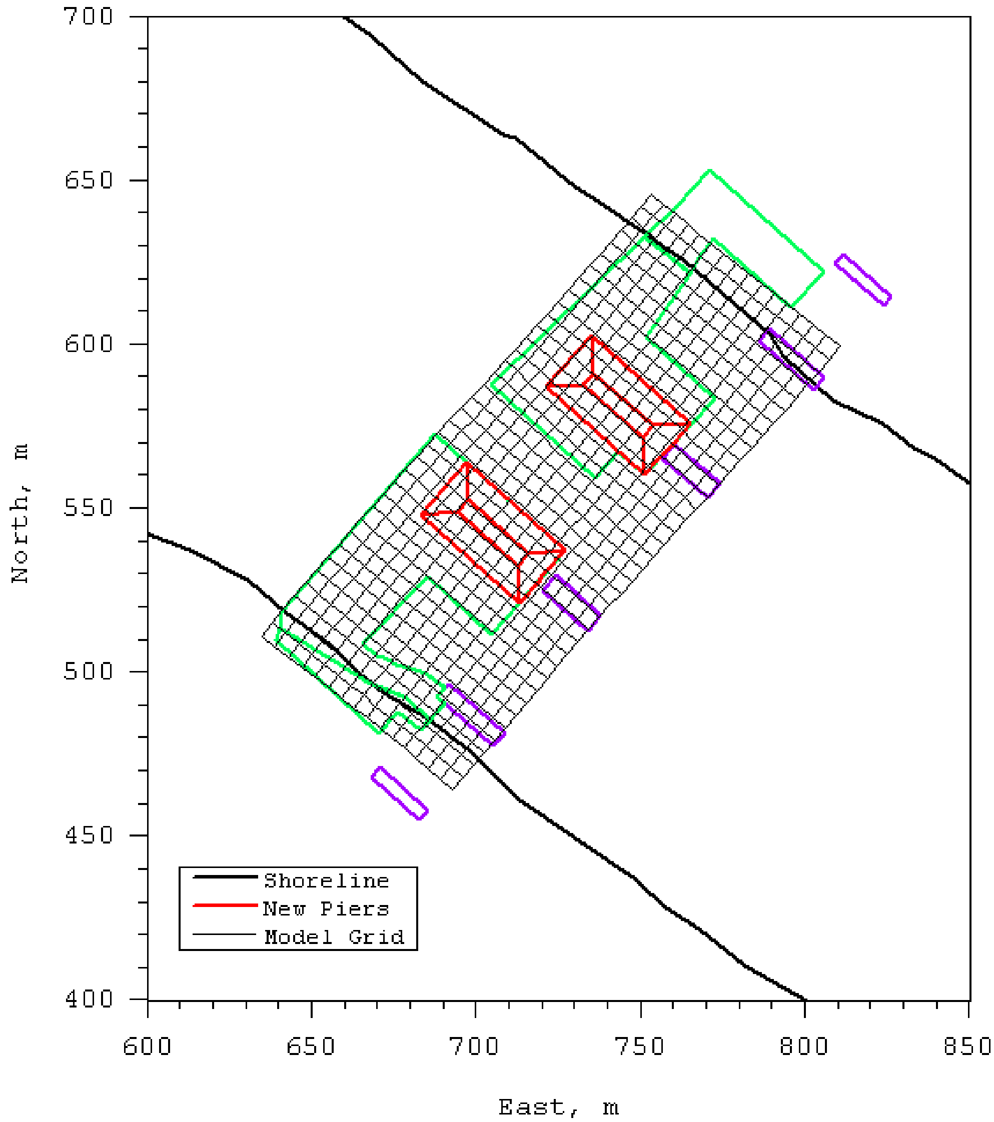

Figure 2. River shoreline and features associated with the existing bridge, construction activities, and new bridge. Existing bridge piers, blue, will remain in place. New piers and their riprap footprint are show in red. Temporary work bridge shown in green.

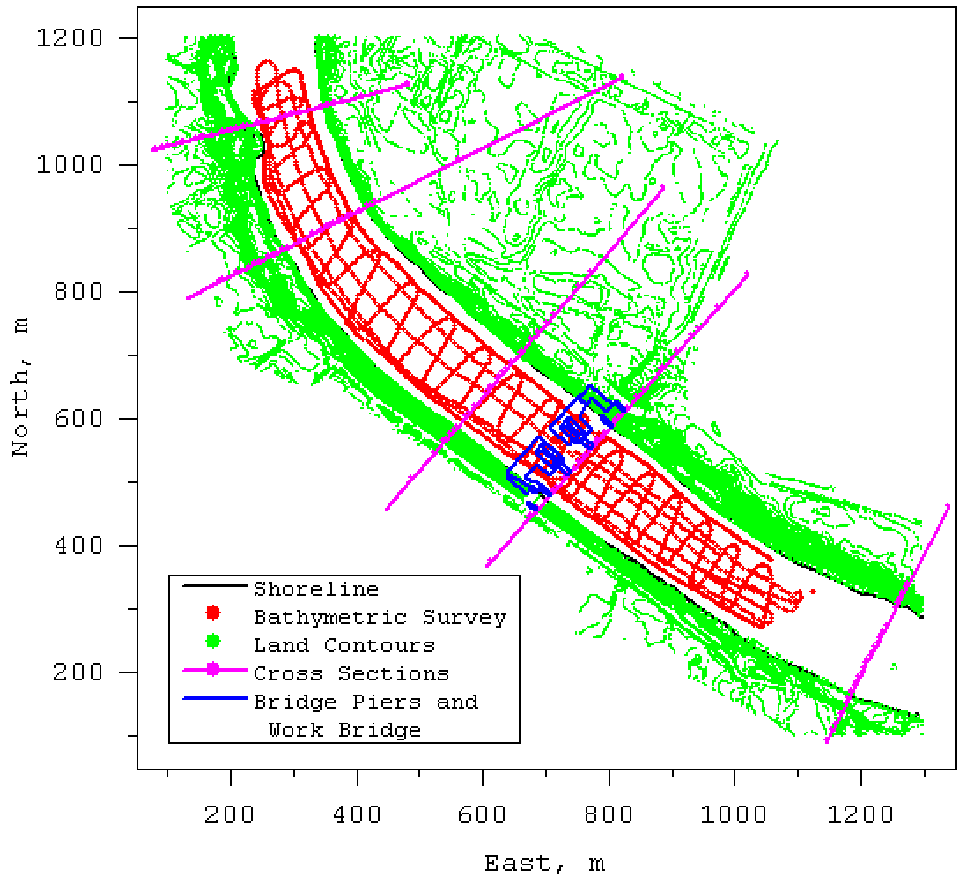

Figure 3. River shoreline and source of bathymetric and topographic information used for model configuration.

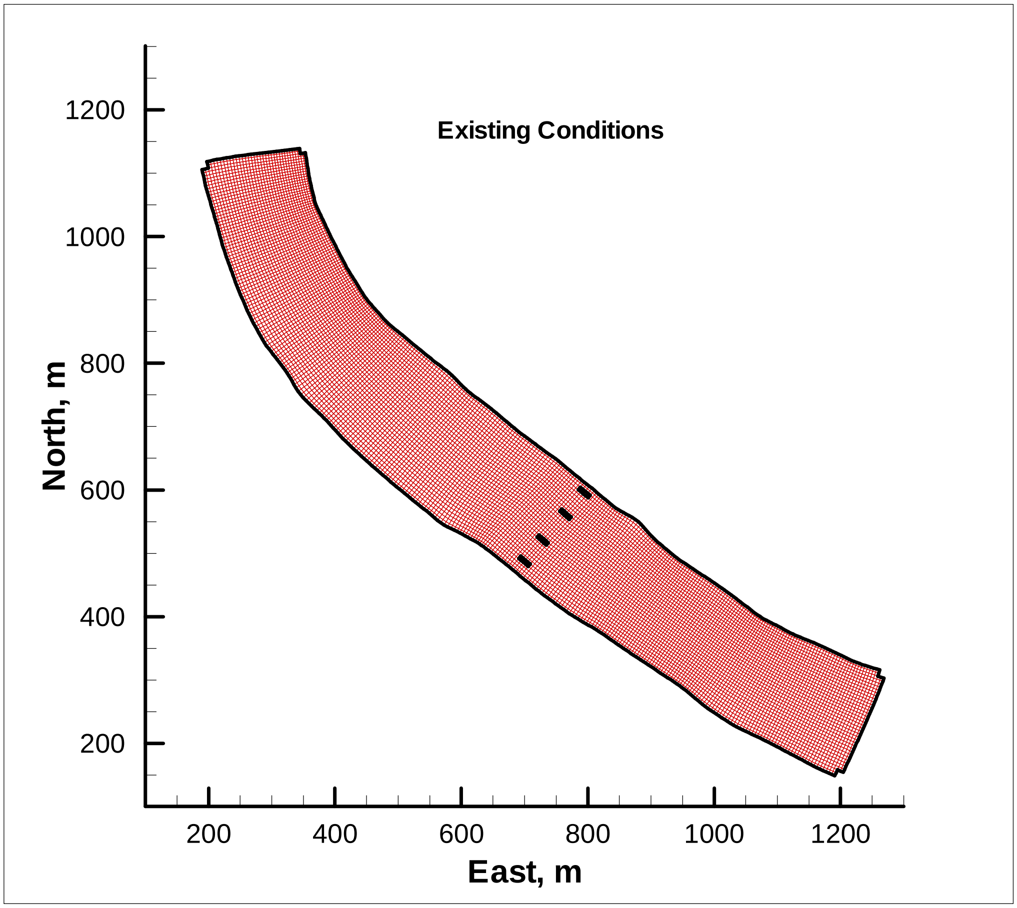

Figure 4. Model grid for existing conditions

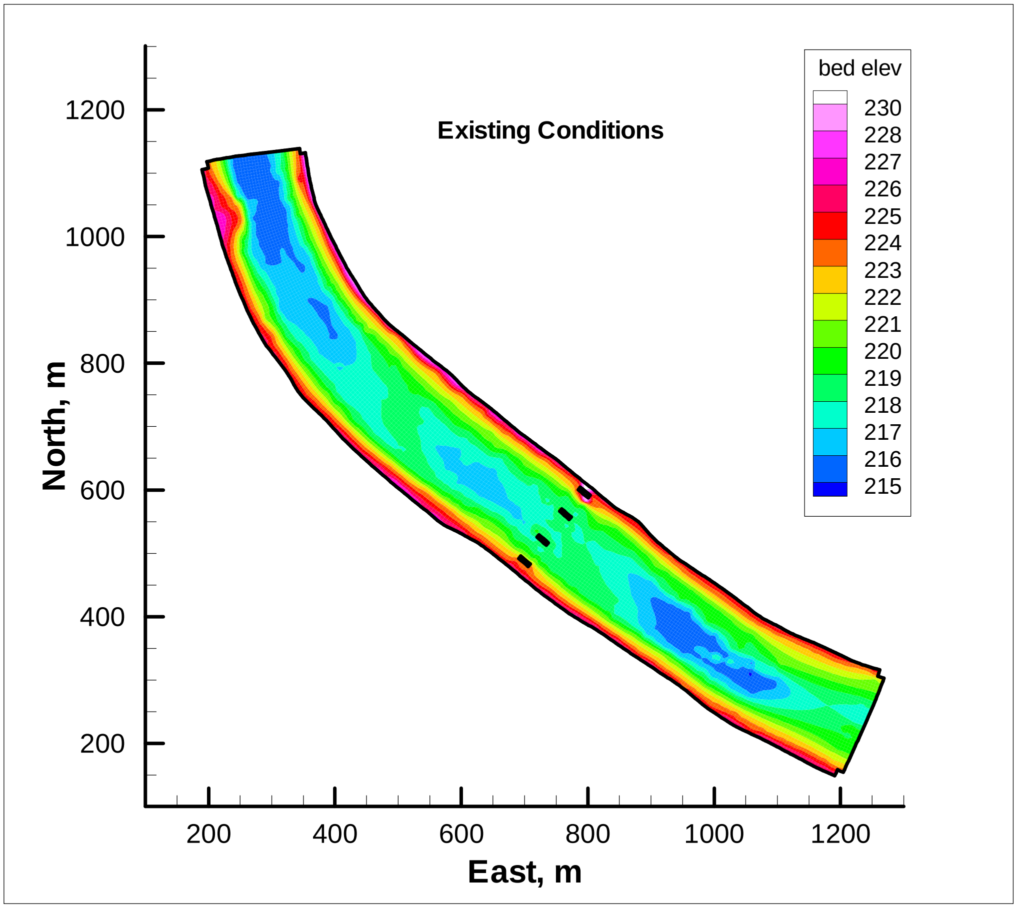

Figure 5. Model bathymetry for existing conditions.

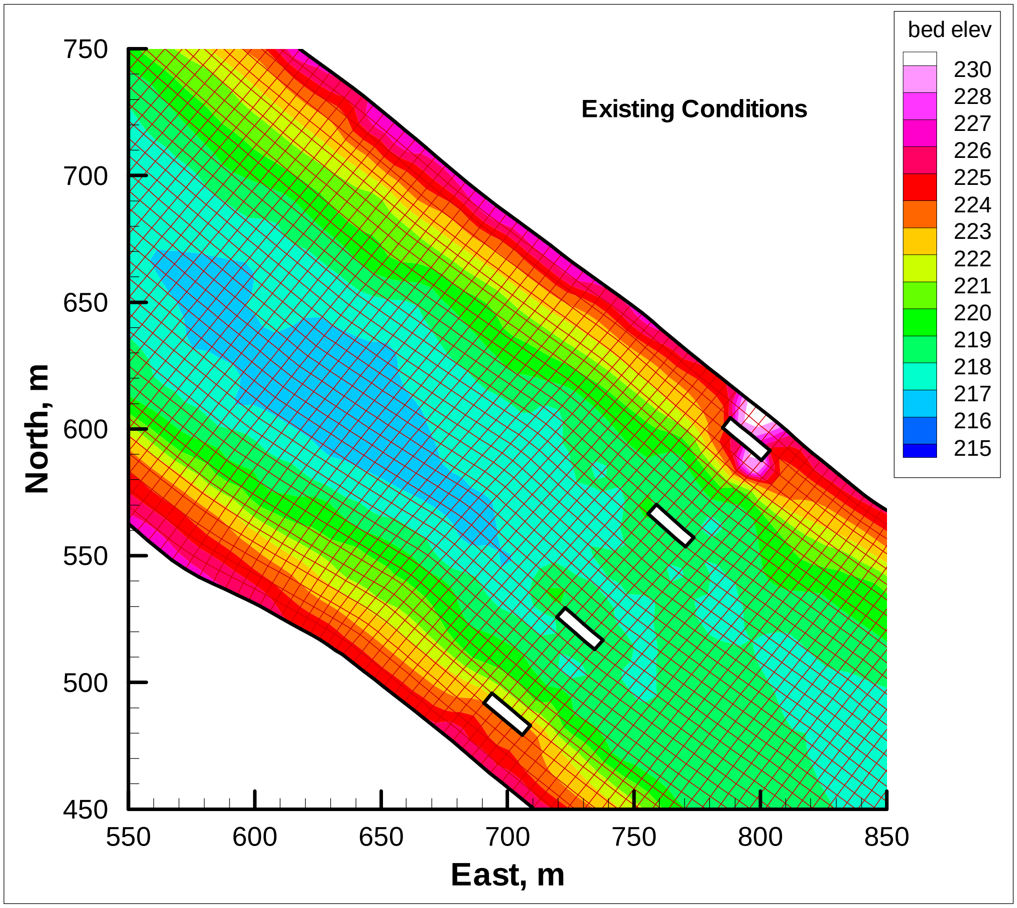

Figure 6. Model grid and bathymetry in the vicinity of the bridge site for existing conditions.

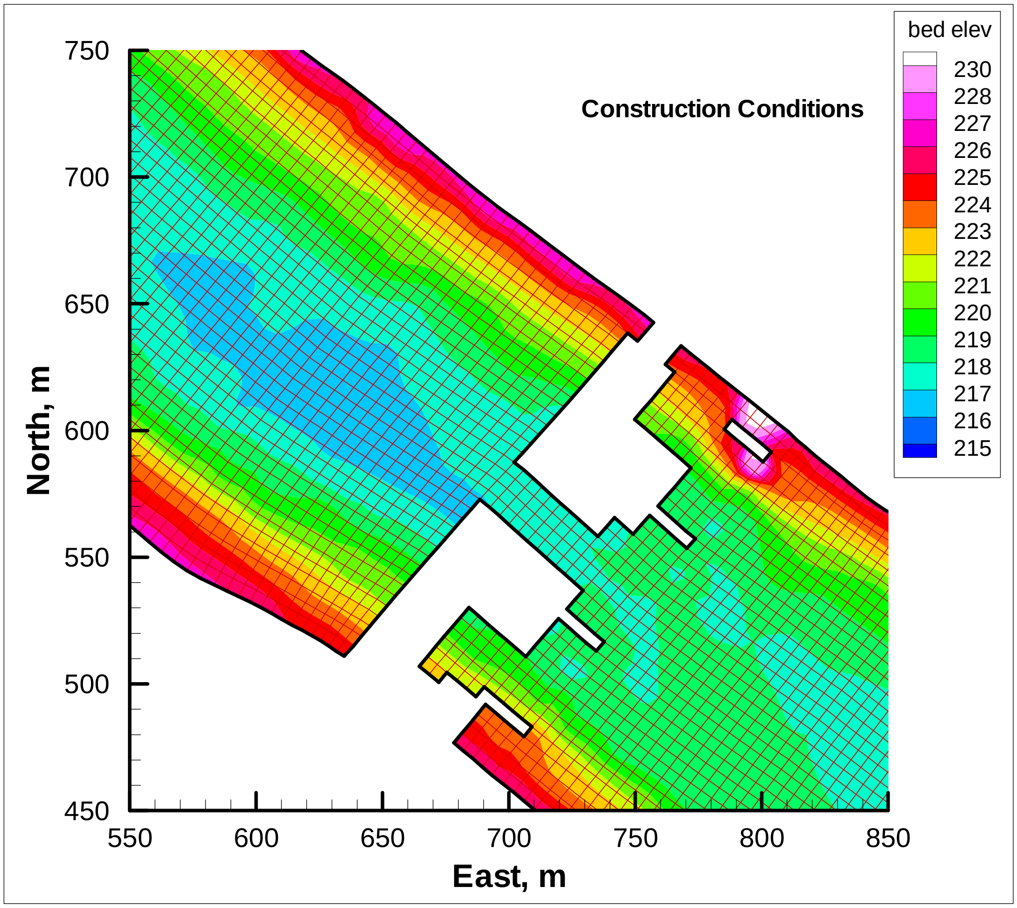

Figure 7. Model grid and bathymetry in the vicinity of the bridge site for construction conditions.

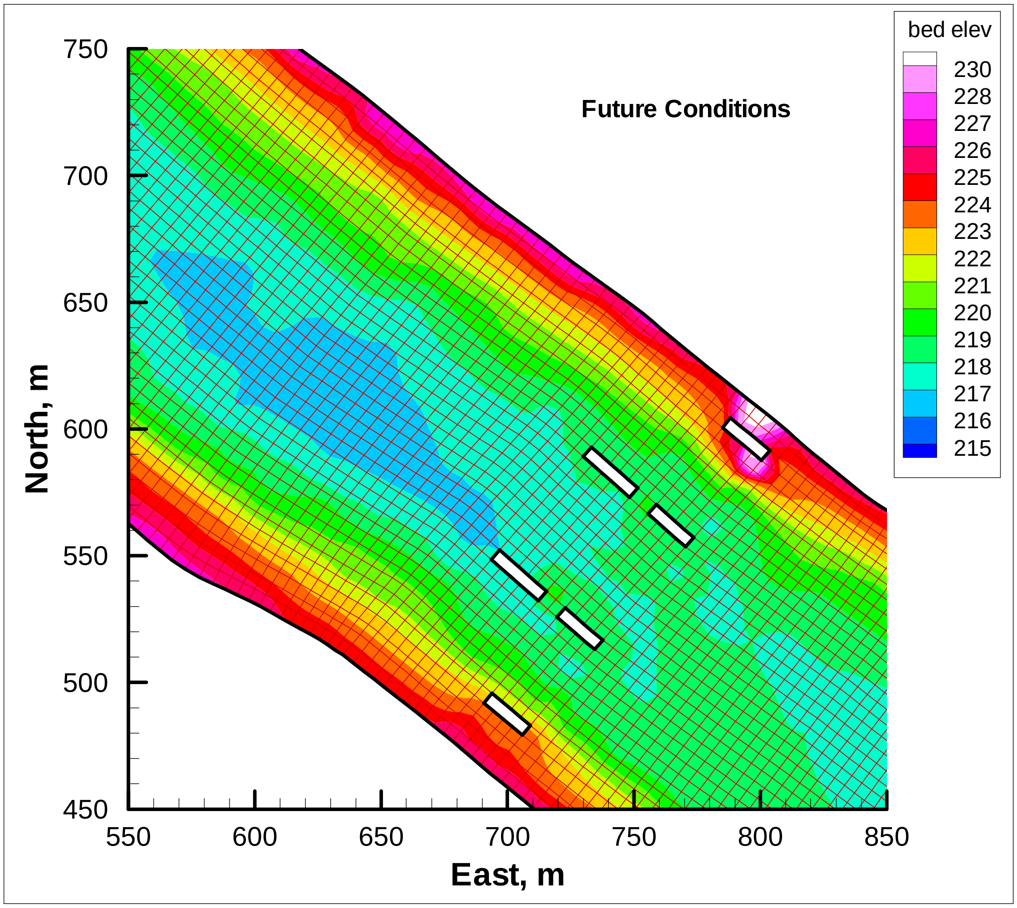

Figure 8. Model grid and bathymetry in the vicinity of the bridge site for future conditions.

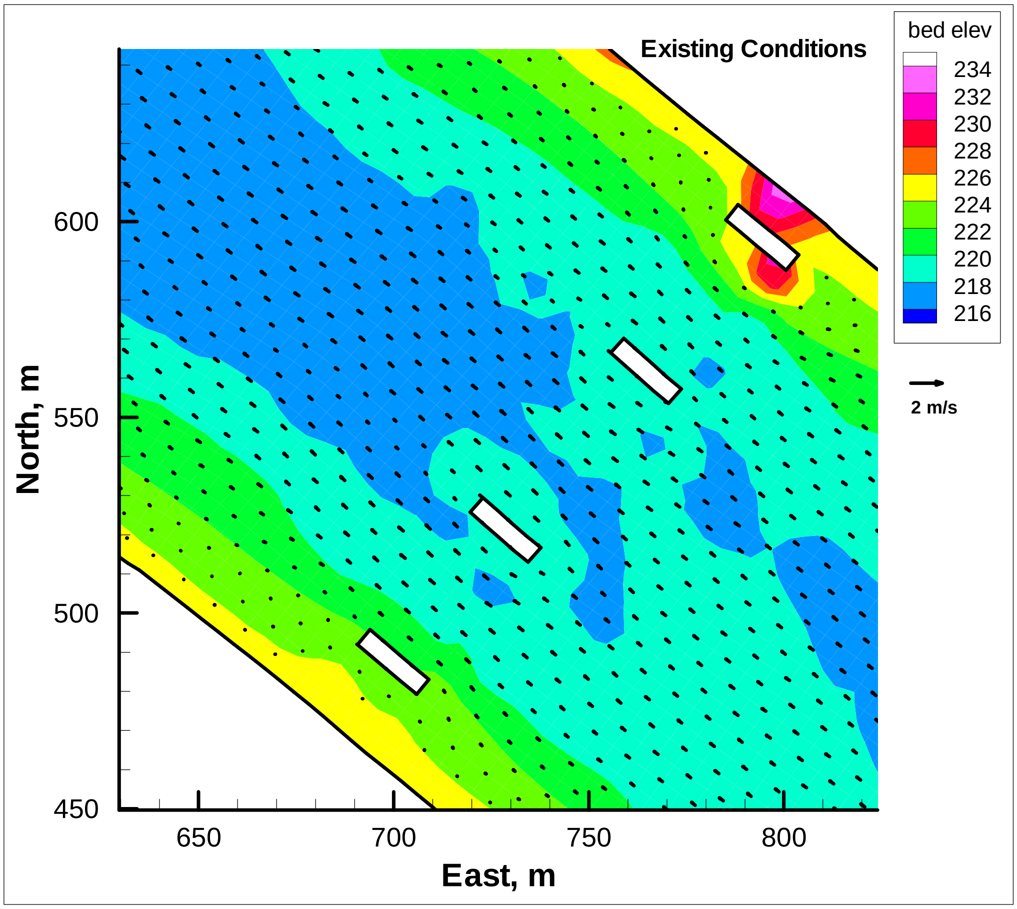

Figure 9. Velocity and bed elevation for existing conditions with a 200 cms flow.

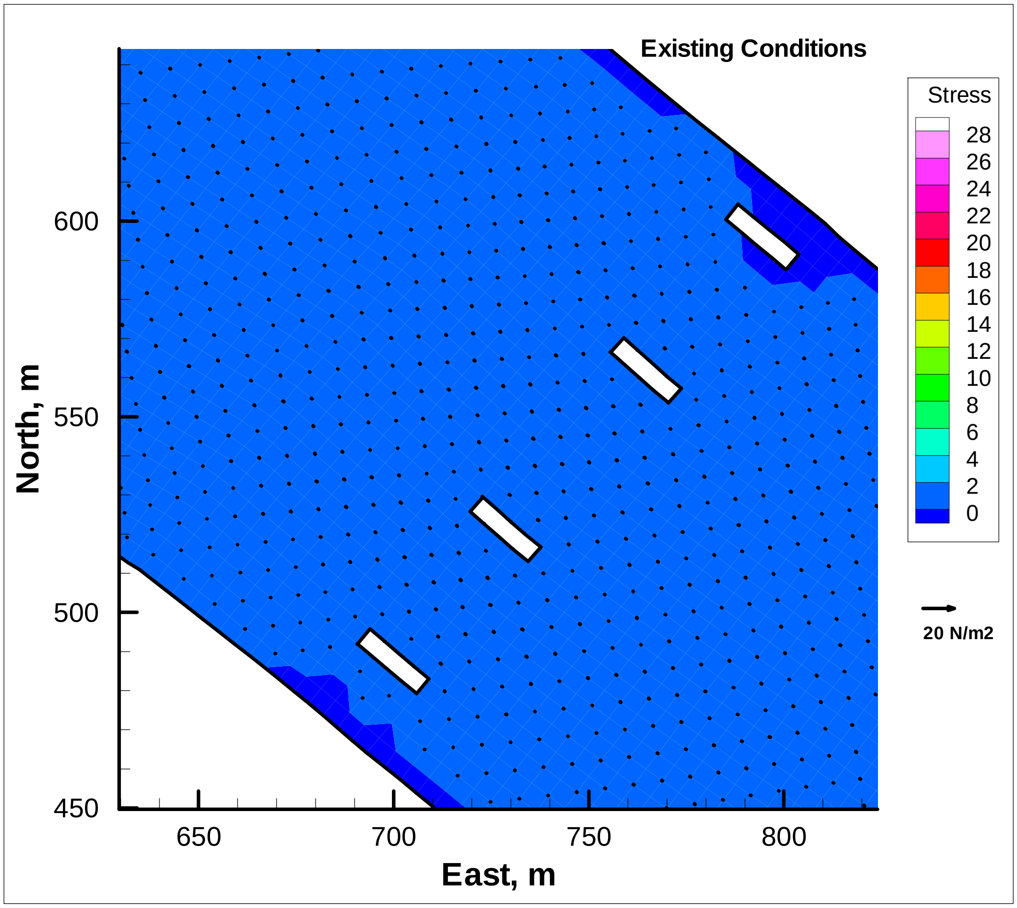

Figure 10. Bed stress vectors and magnitude for existing conditions with a 200 cms flow.

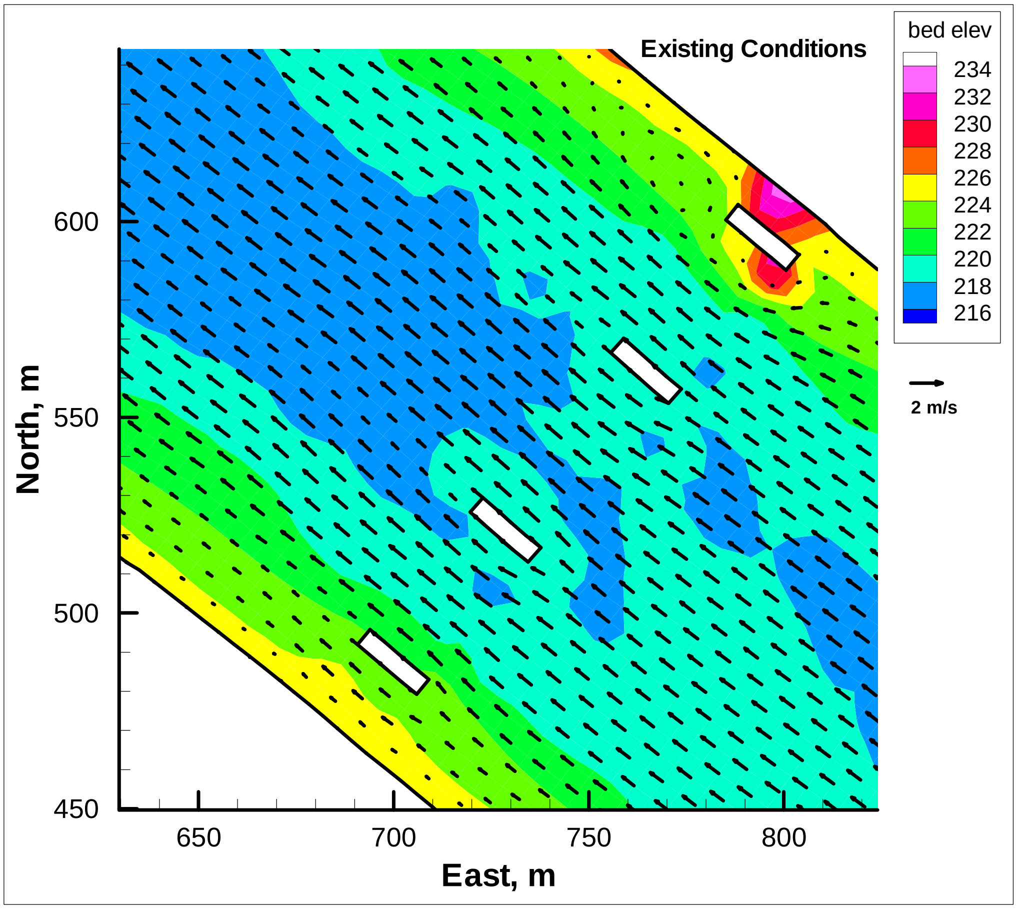

Figure 11. Velocity and bed elevation for existing conditions with a 1005 cms flow.

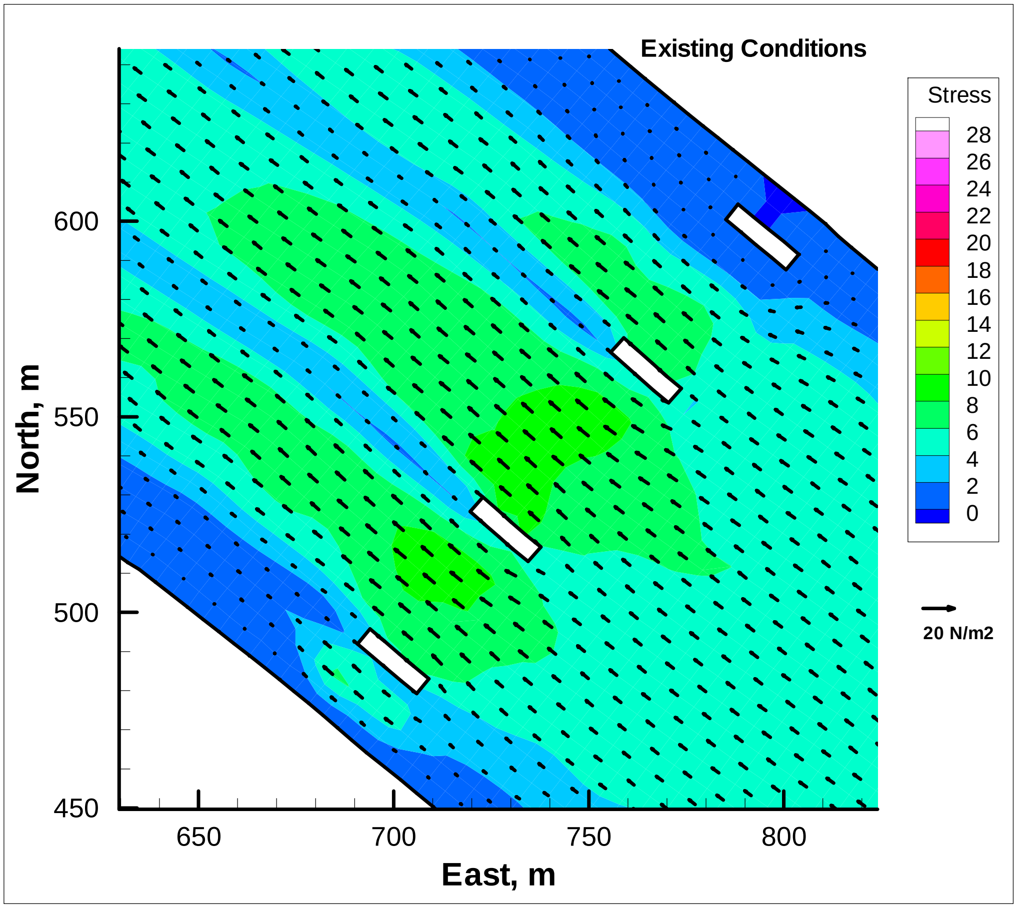

Figure 12. Bed stress vectors and magnitude for existing conditions with a 1005 cms flow.

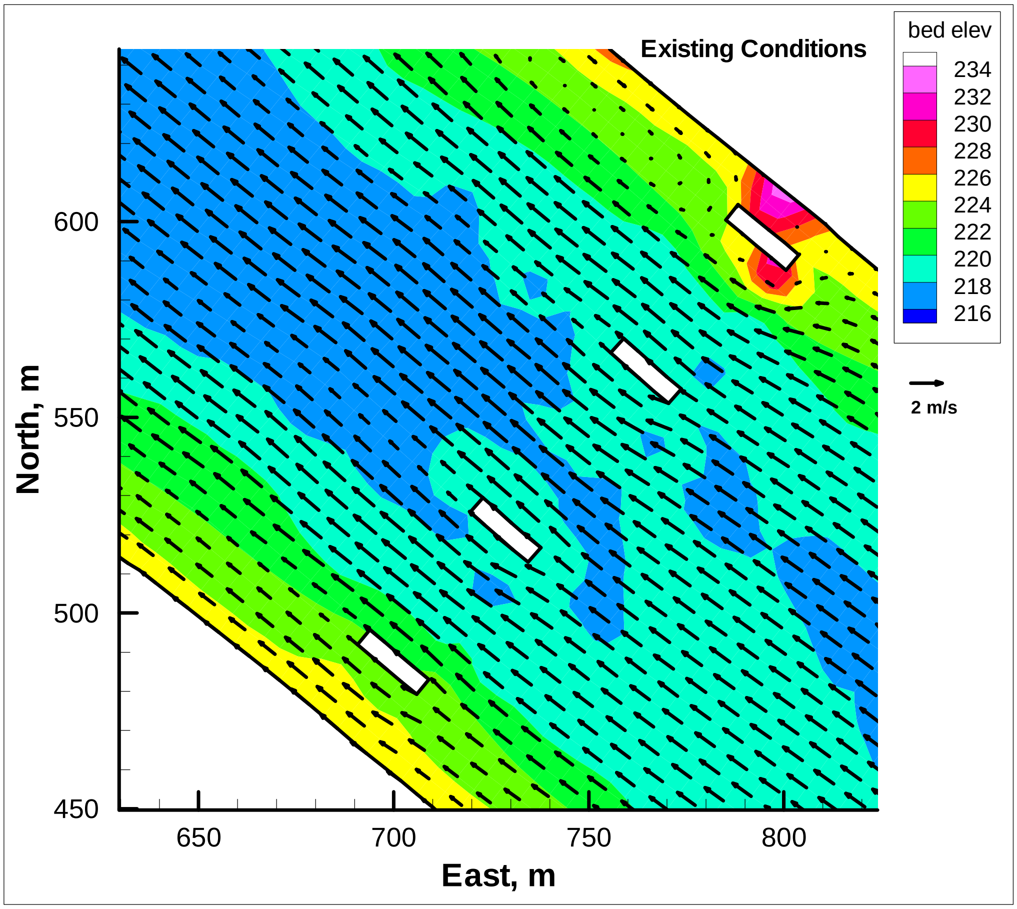

Figure 13. Velocity and bed elevation for existing conditions with a 2240 cms flow.

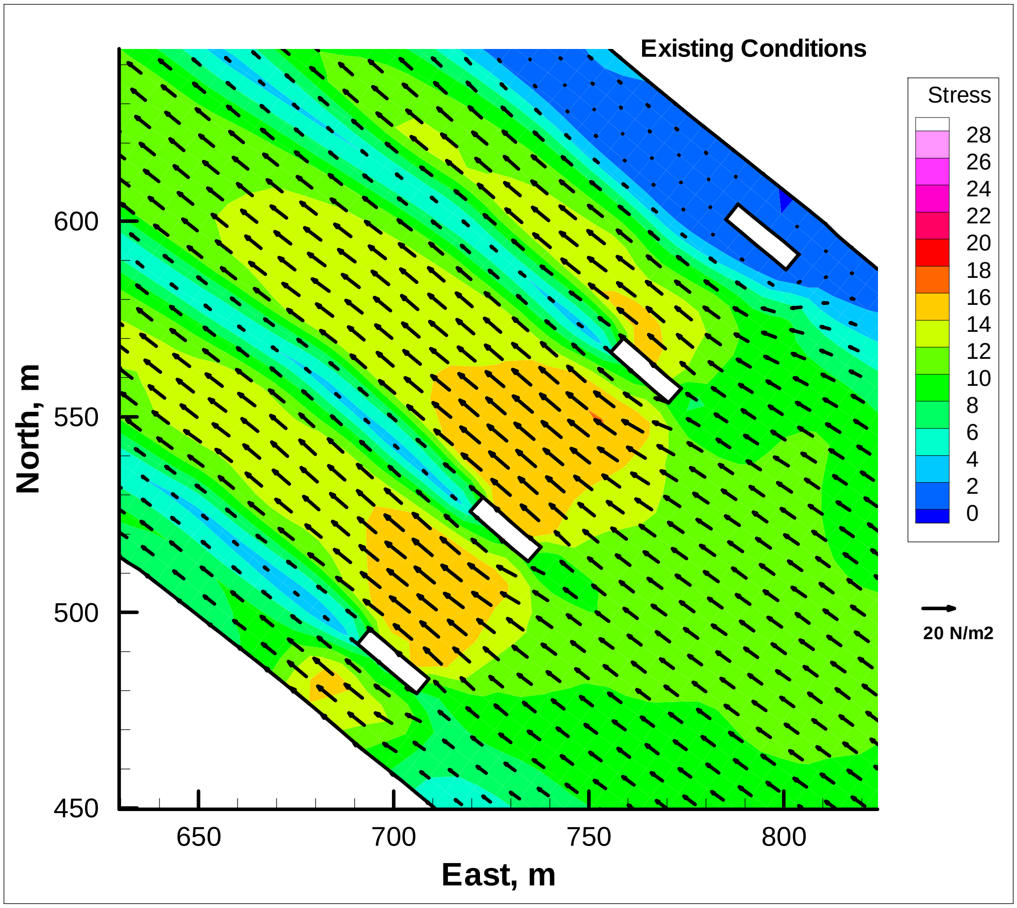

Figure 14. Bed stress vectors and magnitude for existing conditions with a 2240 cms flow.

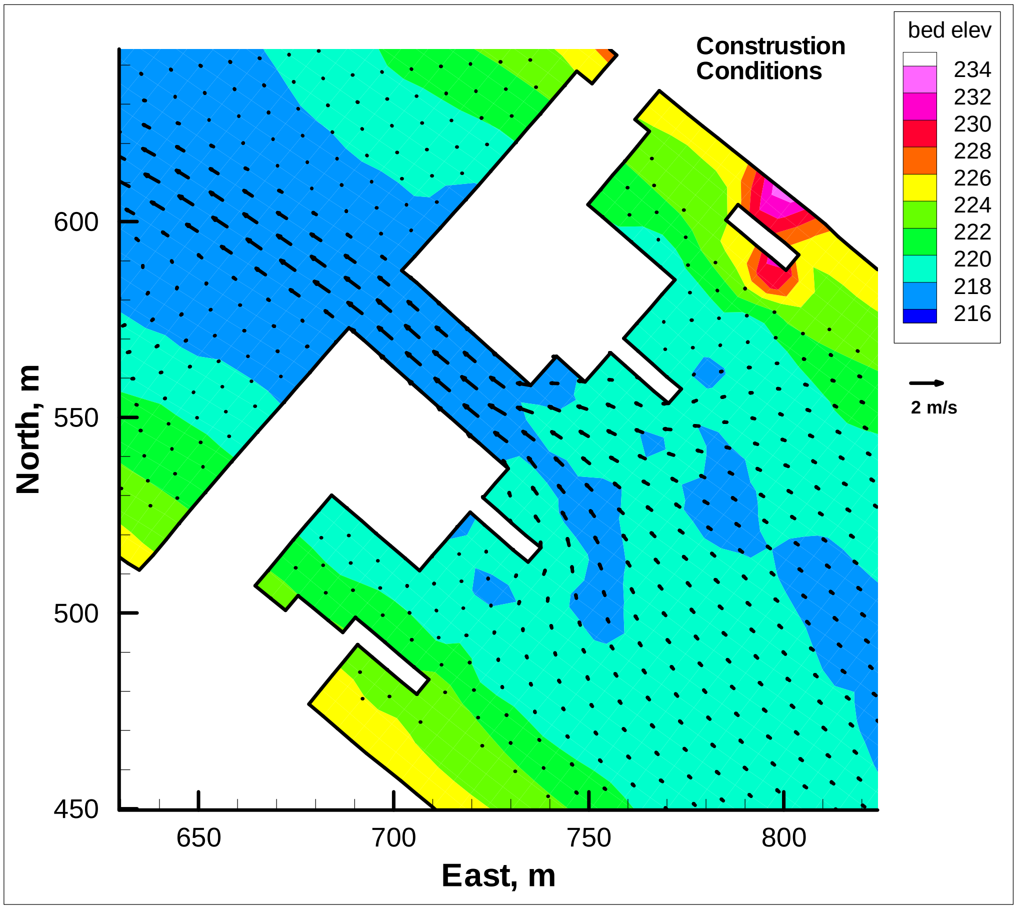

Figure 15. Velocity and bed elevation for construction conditions with a 75 cms flow.

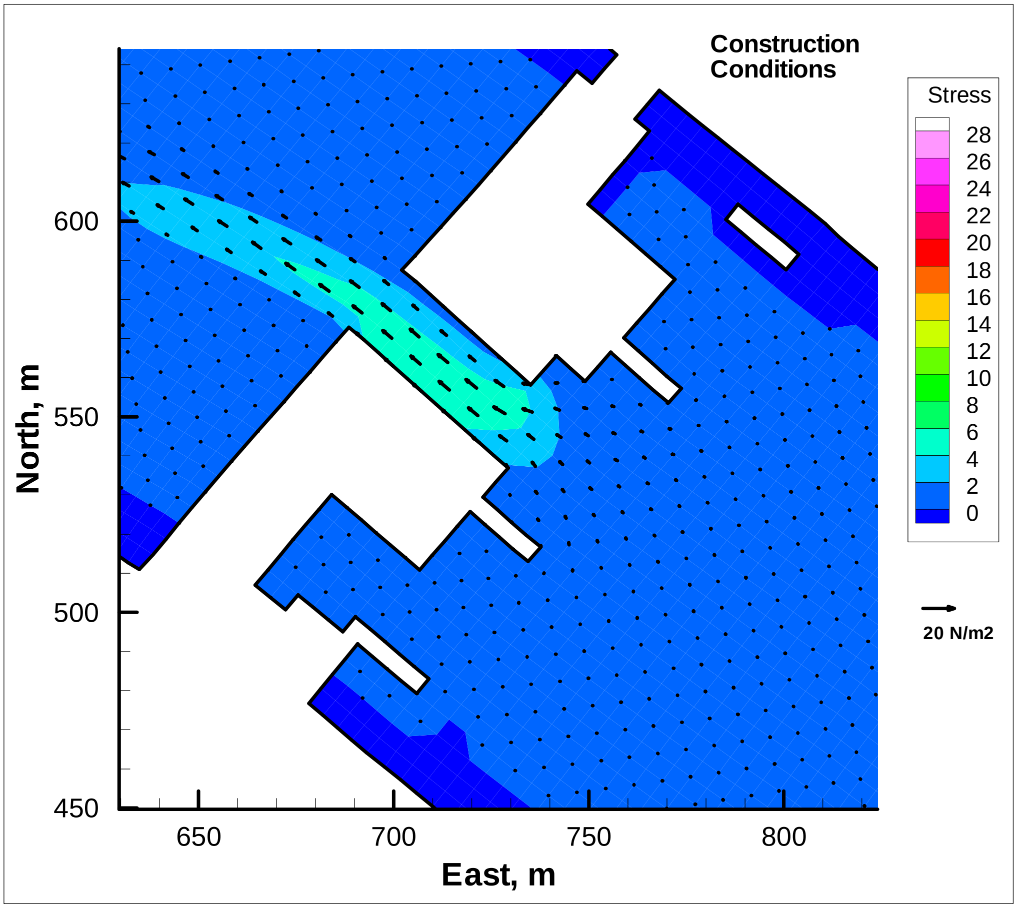

Figure 16. Bed stress vectors and magnitude construction conditions with a 75 cms flow.

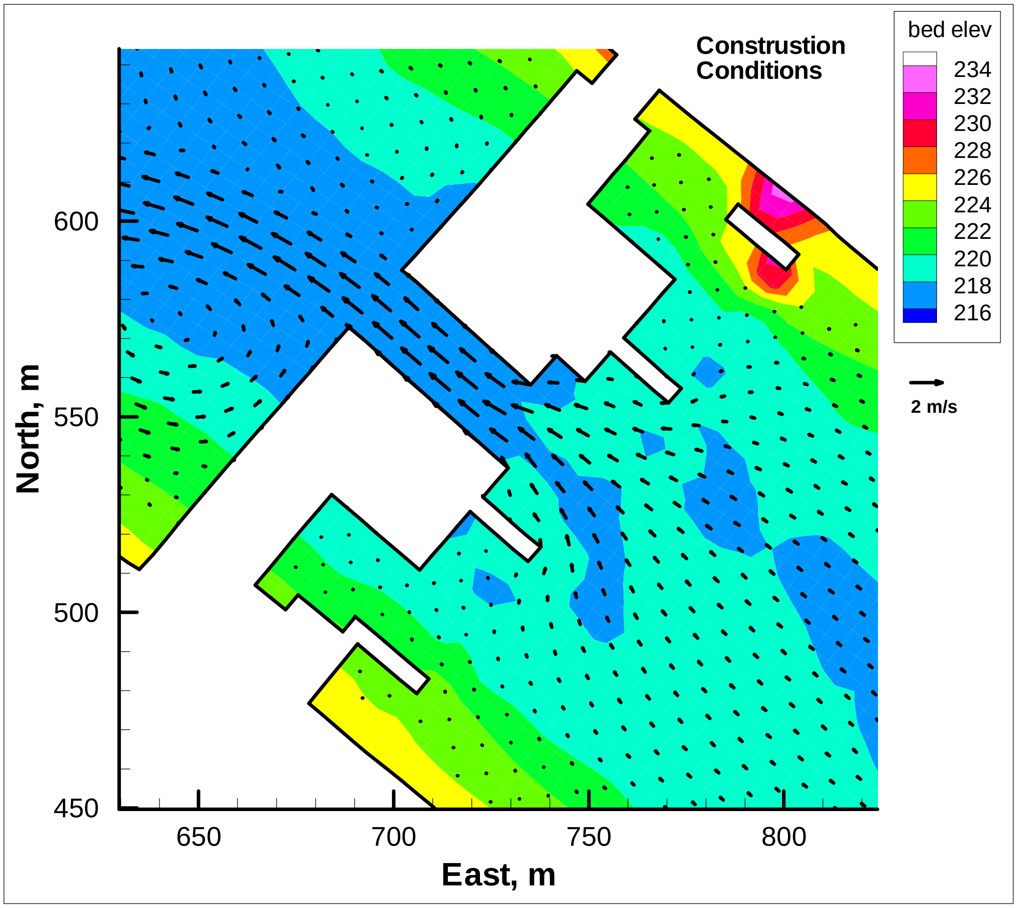

Figure 17. Velocity and bed elevation for construction conditions with a 154 cms flow.

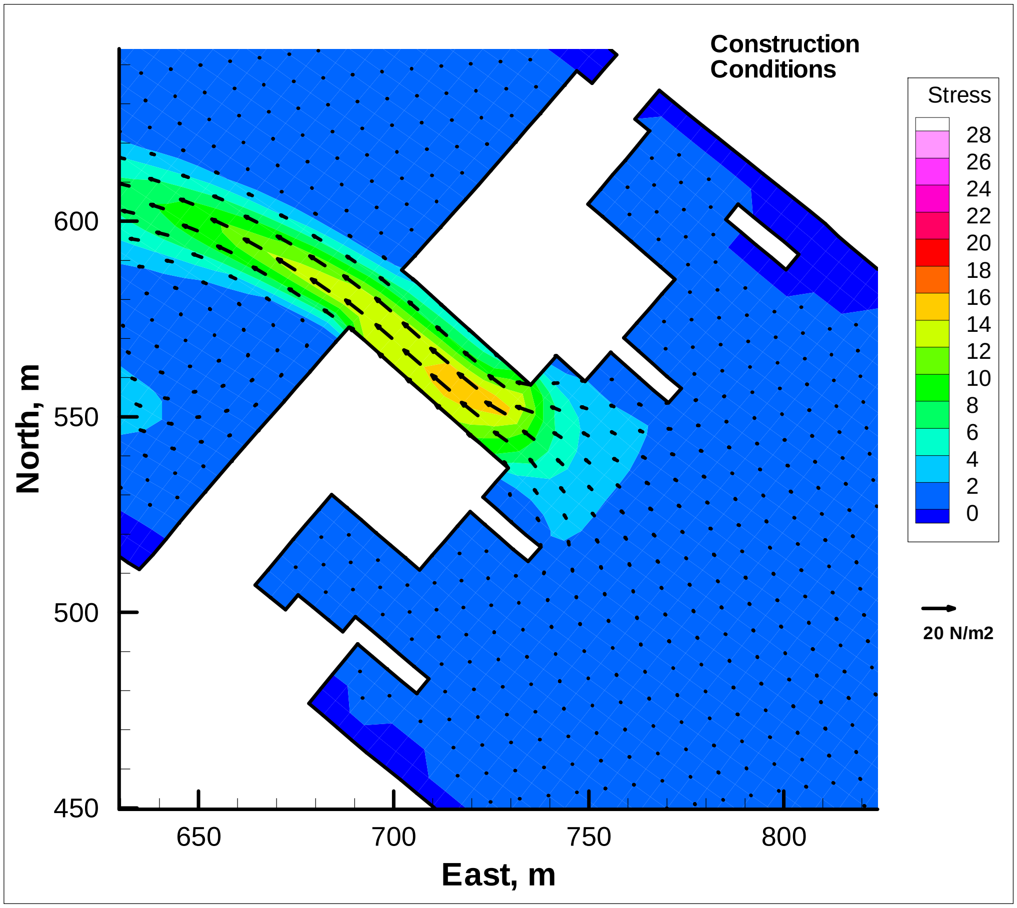

Figure 18. Bed stress vectors and magnitude construction conditions with a 154 cms flow.

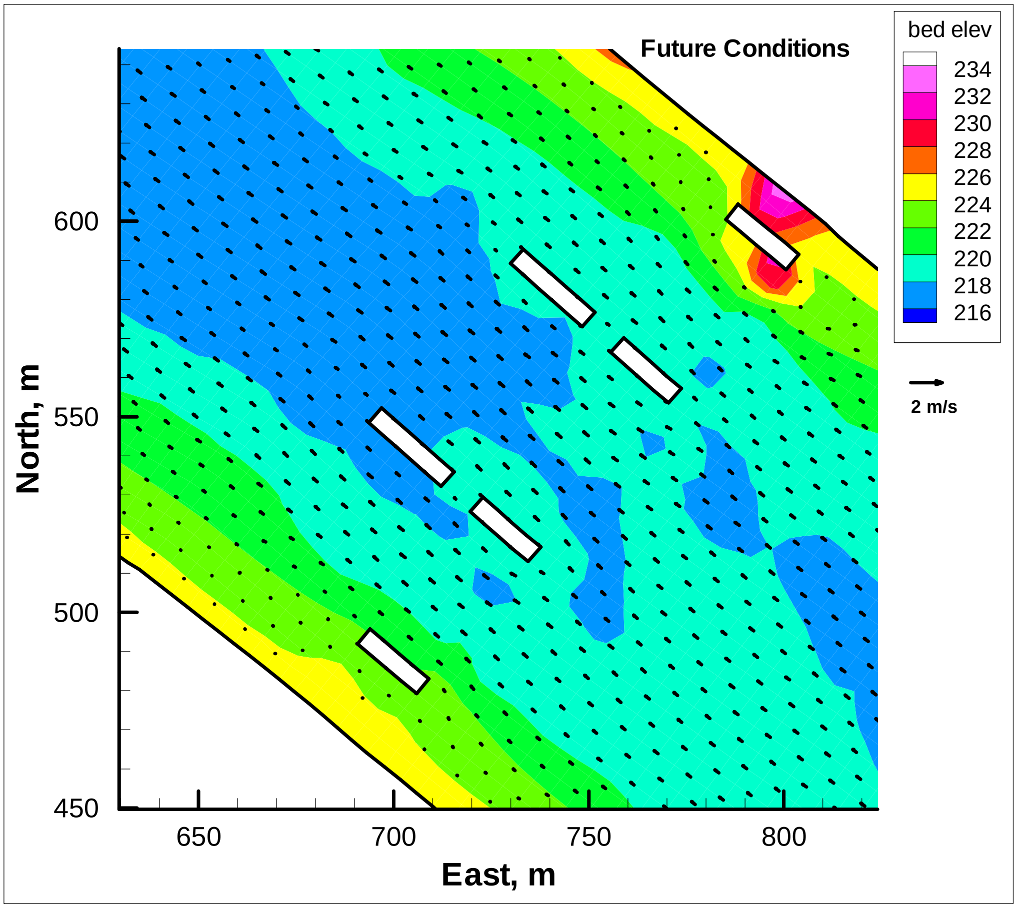

Figure 19. Velocity and bed elevation for future conditions with a 200 cms flow.

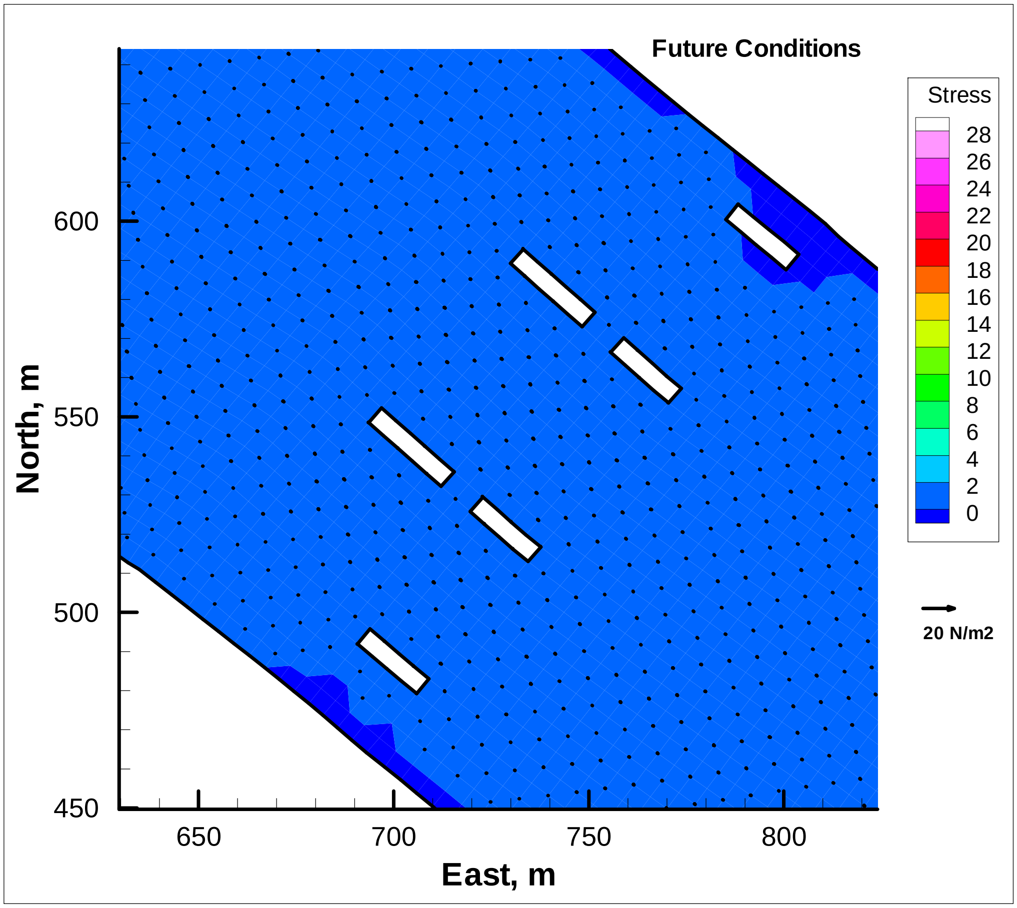

Figure 20. Bed stress vectors and magnitude for future conditions with a 200 cms flow.

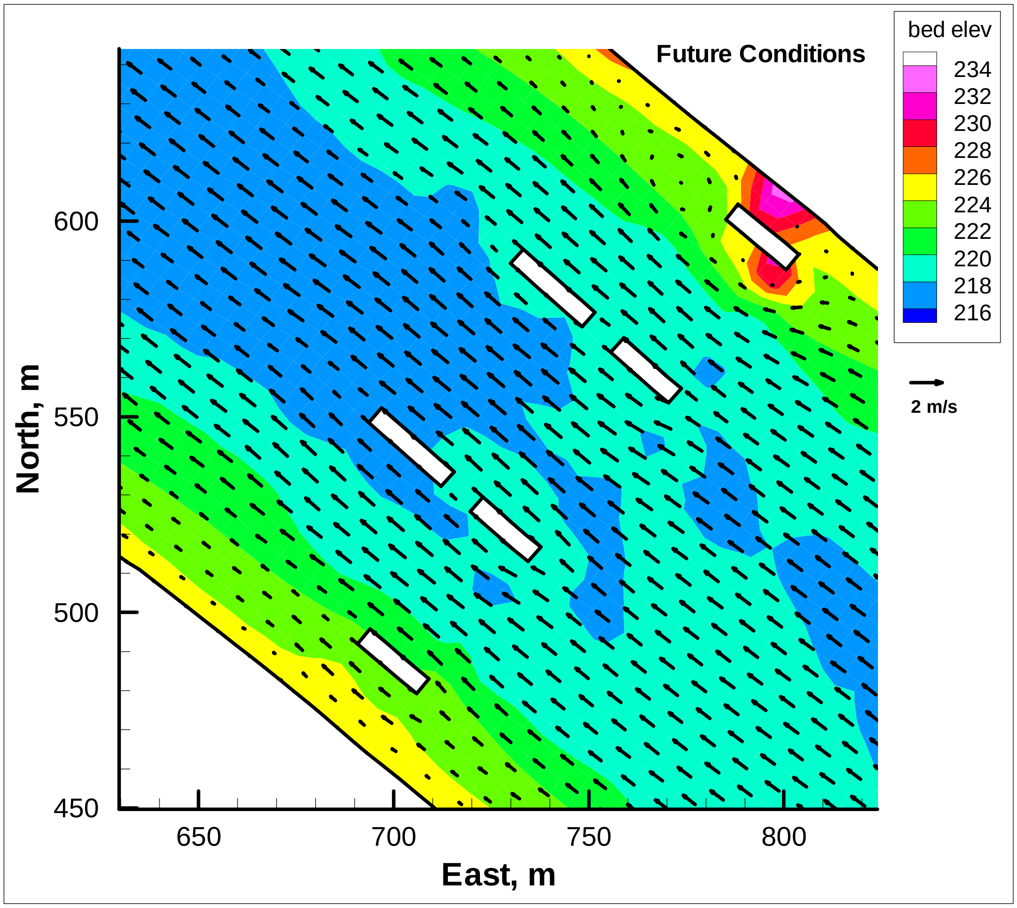

Figure 21. Velocity and bed elevation for future conditions with a 1005 cms flow.

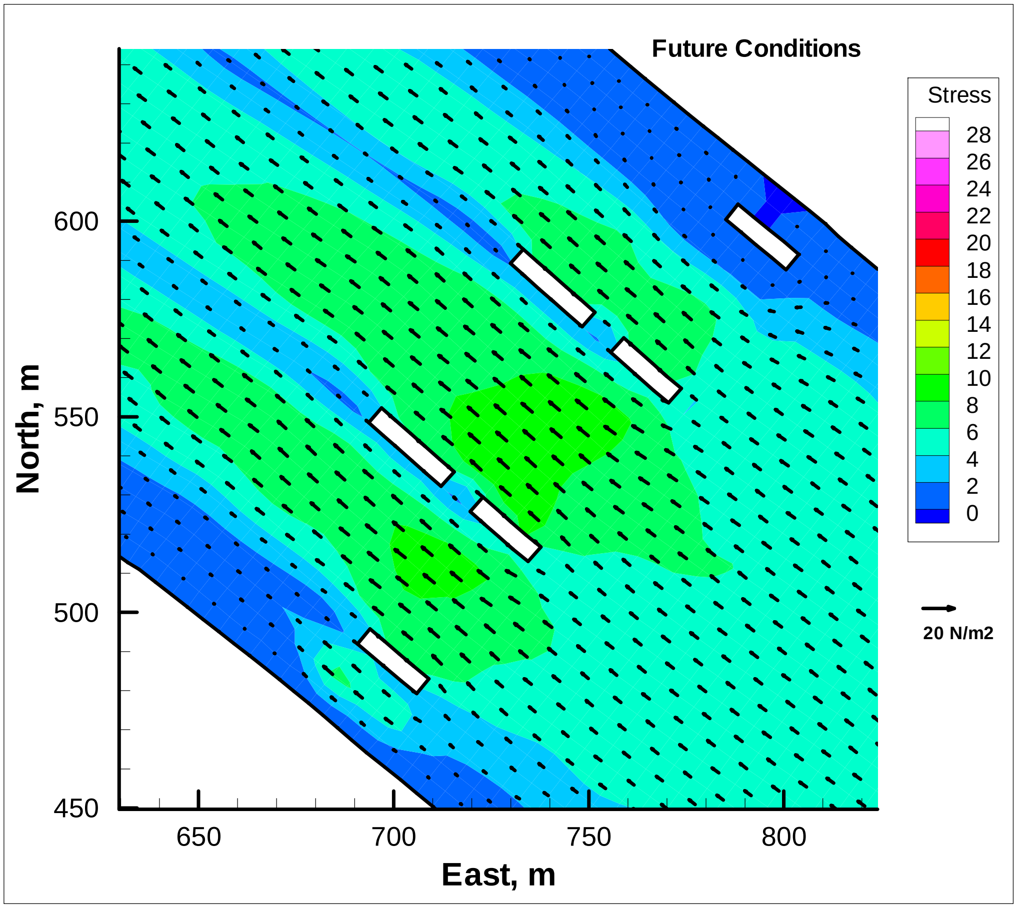

Figure 22. Bed stress vectors and magnitude for future conditions with a 1005 cms flow.

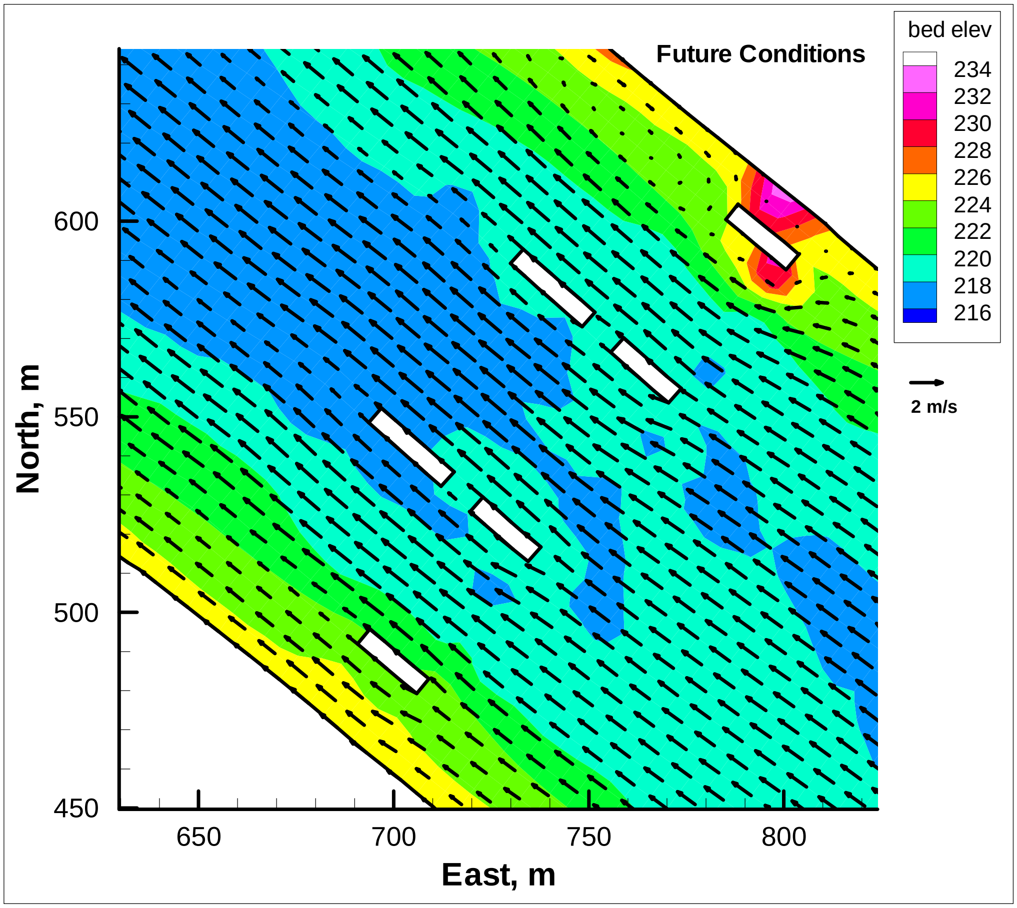

Figure 23. Velocity and bed elevation for future conditions with a 2240 cms flow.

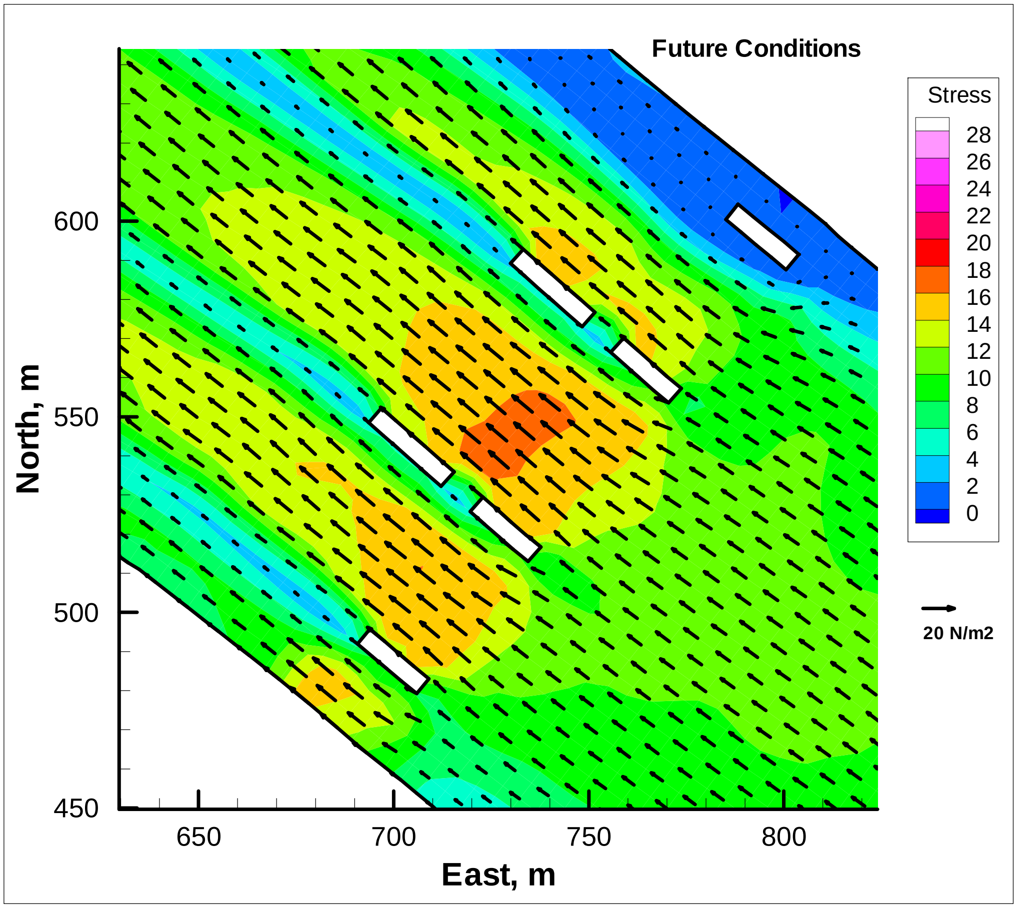

Figure 24. Bed stress vectors and magnitude for future conditions with a 2240 cms flow.