9.0 CHAPTER 9 – PIER SCOUR SURVEY

9.1 INTRODUCTION

Many rivers in Alberta are dynamic in nature, with bank erosion and scour resulting in changes to river geometry over time. Scour, or lowering of the streambed, can occur due to natural processes, such as bedform movement and increased bed load transport under high flow conditions. Additional scour can occur at stream crossings due to constriction of the flow and forces associated with flow interference at structural elements, such as piers and abutments. Some factors that can affect the rate and extent of scour at a pier include:

- Pier geometry – pier width and shape, elevation and extent of footing or pile cap
- Flow alignment – can change due to lateral channel erosion, partial blockage due to drift and/or ice, migration of bedforms etc.
- Subsurface geology – location and depth of bedrock, competency of bedrock, variability across the channel
- Runoff history – magnitude and frequency of large runoff events
- Stream characteristics – flow velocity and depth, bedforms, planform, lateral migration

Due to the wide range of factors and the complex nature of the scour process, the ability to accurately model and predict future changes is limited. It is therefore important to monitor changes at sites that are considered to be vulnerable to scour, such as piers with spread footings or short piles. Monitoring these changes often requires hydrographic surveying, as the stream beds near the piers at many sites are not accessible for visual inspection and/or traditional land-based surveying techniques. Knowledge of changes in streambed in the vicinity of these piers is required to assess the safety of the bridge system and identify required rehabilitation activities. This document describes the current approach to pier scour inspection and survey for Alberta Transportation bridges.

9.2 HISTORY

Alberta Transportation has been undertaking pier scour surveys at many sites across the province since the late 1950's. Much of this work was undertaken by in-house staff until 1996, using various techniques including depth sounders, boats, booms, and sounding rods. Since 1996, this work has mostly been carried out by consultants. The typical set-up for recent surveys has been a low draft boat with a digital depth sounder integrated with a robotic total station to collect xyz data.

Prior to the early 1990's, surveys were obtained on a reactionary basis, such as in response to recent flooding, upcoming construction activities, or sites with known issues. In the early 1990's, a systematic approach was developed. The entire inventory of major bridges was assessed for scour vulnerability, based on theoretical prediction equations. All major river crossings were assigned a pier scour priority rating of 1 to 4, with 1 being assigned to the most critical sites (e.g. shallow spread footings) and 4 assigned to bridges that were deemed to not be of interest to the pier scour program (e.g. piers out of water).

By 1999, baseline surveys had been obtained for most sites in the pier scour inspection program (priority 1 – 3). These surveys consisted of either detailed streamed contour surveys for larger, higher priority sites to profile surveys (cross sections taken just u/s and d/s of the bridge) at the remaining sites. Results from these surveys were used to plan future survey work and to identify rehabilitation needs at problematic sites (e.g. BF00315 - St. Mary River, BF78104 McLeod River). Following the baseline surveys, it was decided to identify further survey needs in the short term based on flood events and infrastructure assessment needs. This resulted in a reduction in the number of surveys between 2000 and 2008. Surveys obtained in this time frame included 9 surveys at high priority sites following the June 2005 flood, and 5 surveys in 2008 to assist with bridge rehabilitation assessments.

For the 2008 surveys, it was observed that the cost of a contour survey had increased significantly. As a result, alternative approaches to data collection were evaluated. In addition, the type of information required was re-assessed, with consideration given to site specific requirements. It was also observed that the pier scour priority system needed to be updated due to bridge rehabilitation, replacement, and new construction activities.

The potential benefits of a more formal inspection schedule were also identified, including economic efficiency of data collection, improved ability to respond quickly to upcoming information needs, and having a more current evaluation of the state of the most scour vulnerable bridges in the system. Based on these factors, the pier scour database was updated in January 2009, with a re-assessment of priorities, the addition of categories of inspection, and the introduction of a formal schedule for survey of larger crossings.

9.3 PIER SCOUR PRIORITY AND SURVEY CATEGORY

As of January 2009, there are 1047 major bridges over rivers in the Alberta Transportation inventory system that are classified as “in service” and not under the jurisdiction of a city. The following number of bridges are considered to not be of interest to the pier scour survey program:

Category	Number of Structures
Causeway (crossing a lake or reservoir)	10
Non – AT (not owned by Alberta Transportation)	21
No Piers (single span bridges)	312
Piers not In-stream (piers not within the active waterway at low flow)	292

The 412 remaining structures have been classified as “Criteria” bridges in the screening field of the pier inspection database. Of these, 200 bridges were determined to have foundations deeper than 10m below streambed, and have been assigned a priority of 4, meaning that they also are not of interest to the pier scour survey program.

The remaining 212 bridges have been assigned priorities of 1 to 3 based on the type of foundation and the relative dimension of depth of penetration (P - stream bed to bottom of foundation element) to the pier width (W - measured square to the flow at streambed level). This ratio is used as local scour at piers tends to scale on the width of the obstruction to flow. The required data can be found on the general layout drawings for most sites. In a few cases, sufficient inventory data was not available, and conservative assumptions were made in the calculation of priorities. Priority calculations are based on the most critical pier at a structure. The following criteria have been used:

	Priority = 1	**Priority = 2**	**Priority = 3**
Spread Footing	P/W < 1.5	1.5 <= P/W < 3	P/W > = 3
Short Pile (< 6m)	P/W < 3	P/W >= 3	
Long Pile (6 – 10m)		P/W < 3	P/W > = 3

These bridges were also categorized by type of inspection anticipated due to the nature of the stream and the limits of equipment available to collect data. The three categories assigned are as follows :

B – Big stream crossing (T > 50m at low water), likely requiring a manned boat and sounder to collect streambed elevations in the vicinity of the piers
S – Small stream crossing (T <=50m), likely requiring depth sounding, but too difficult to mobilize a manned boat – remote sounding/wading may be appropriate
V – Visual inspection (ground at pier base readily visible from shore, typically T < 20m)

The number of structures in each category (Jan. 2009) are as follows :

	Priority = 1	**Priority = 2**	**Priority = 3**	**Total**
B	28	34	26	88
S	14	27	25	66
V	9	22	27	58
Total	**51**	**83**	**78**	**212**

Of the 88 "B" sites, approximately 10 sites are in the planning/design/construction process and will not require pier scour inspection unless replacement is deferred for an extended period. The pier scour inspection categories, priorities, and supporting inventory data are stored in the "Pier Scour Inspection Management" table in the HIS database ("S:\Bridge Planning\Engg Software\HIS\HIS.mdb"). This database should be updated once per year to account for changes in infrastructure (link to BIS data) and to update survey categories and priorities based on the most recent inspections.

9.4 SURVEY REQUIREMENTS

For sites classified as "V", site confirmation should be made that the streambed in the vicinity of the pier is visible. If so, photographs covering the streambed topography in the vicinity of the pier should be obtained. In addition, if any scour holes are visible or if recent changes in bed topography are apparent, a measurement of the lowest point on the streambed in the vicinity of the pier (within 5m) should be made relative to the bridge deck above the pier. This will facilitate comparison with previous inspections. If the bed topography in the vicinity of the pier can not be readily assessed, the site should be treated as an "S" site and survey information obtained as described below, unless this is due to highwater conditions.

For sites classified as "B" or "S", depth soundings should be obtained in the vicinity of each in-stream pier and along profiles parallel to the bridge. The profiles should be taken close to both the upstream and downstream faces of the bridge. Soundings in the vicinity of the pier should include measurements as close to the pier as possible and cover the streambed for 15m ("B" sites) or 10m ("S" sites) from the pier shaft in all directions, if possible. Data density should be such that there are no gaps in the data that exceed 3m ("B" sites) or 2m ("S" sites). The position of each sounding should be recorded, to enable production of an xyz surface of the streambed. The outline of the pier should be readily visible in the data-set. Profile soundings should extend as close to water's edge as can readily be sounded, with a maximum spacing of 5m ("B" sites) or 3m ("S" sites) between points.

The resulting xyz data-set should be delivered as a CSV text file. The horizontal positioning of the points should be produced in TM grid (parameters provided) or geographic coordinates for use in GIS systems, and with a desirable accuracy of 1m. The streambed elevations will preferably be provided as geodetic, but elevations relative to the reference system used on the most recent general layout drawing are also acceptable, with a desirable accuracy of 0.3m. Where geodetic elevations are provided, deck elevations over the piers must be available to enable comparison with previous data-sets.

The methods and equipment used to collect and prepare this data are not specified. It is anticipated that structures classified as "B" will require the use of manned boats and electronic depth sounders. Positioning can be done by any means as long as it meets the desirable accuracy requirement and can result in conversion to a GIS compatible coordinate system. Structures that are classified as "S" may require more portable techniques, such as wading, sounding from the bridge deck, or using a remote control boat equipped with a sounding system. Consumer grade GPS units may not be sufficient to meet the accuracy expectations, especially due to blockage from satellites due to bridge decks and steep valley walls. Measured offsets from infrastructure elements may be acceptable, if they can be converted to GIS coordinates (e.g. georeferenced photography, accurate GPS measurements) and meet the accuracy requirements.

Surveys are typically done during low flow conditions for safety, accuracy, and scheduling reasons. It is possible that some infilling of scour holes may occur at some sites. Where feasible, visible changes in bed surface material should be noted, and probing of the bed with a bar should be considered. In addition to the xyz data covering the streambed near the piers and along the profiles, the elevation of the water surface and photos of the bridge at the time of survey should be provided.

Drift accumulations at piers can significantly impede the ability to undertake scour surveys. For all "B" sites, contact should be made with regional personnel prior to the annual survey activities to determine if drift accumulations are present at the proposed sites. If possible, arrangements should be made to remove large drift accumulations prior to the survey. A crane with a clamshell bucket has proven to be successful at removing drift from the nose of piers.

Other issues that can impact pier scour surveys include :

- Availability of consultant(s) and/or equipment
- Point of access to river for larger equipment
- Channel and point bars that can impact navigation of larger boats
- Strong currents that can impact navigation of smaller boats
- Weather conditions, such as high winds

9.5 SCHEDULE

For public safety and accountability reasons, it is desirable to inspect all of the pier scour susceptible sites within a somewhat regular cycle, with that cycle being reduced for higher risk sites. The recommended cycle is in the range of every 5 years for priority 1 sites to every 10 years for priority 3 sites. Additional factors to include in determining the pier scour inspection survey schedule include geographic grouping for economy, combining trips with RPW inspection sites, the occurrence of large runoff events, and the availability of survey resources.

This schedule is most important for “B” sites due to the mobilization effort, expense, and limited availability of resources. There are approximately 70 “B” sites that currently require pier scour inspection, not counting structures soon to be removed and some marginal sites that are very remote and can probably be inspected by other means. Based on inspection priorities, inspection cycle criteria, geographic grouping, and recent inspection history, a 10 year program for inspection has been developed. This program results in 10 “B” sites being inspected each year. An annual review of this schedule should be undertaken to account for factors such as recent observations, flooding impacts, and bridge rehabilitation assessment requirements.

To meet the proposed inspection cycle for “S” and “V” sites, approximately 9 “S” inspections and 7 “V” visual inspections will be required annually. A similar methodology can be applied to developing an annual program for these sites. However, as these sites do not require the same amount of equipment and effort as the “B” sites, there is likely to be significant overlap with site inspections for other bridge planning and RPW inspection purposes, so there is less need to develop a formal long range program. Annual review should be undertaken to ensure all sites are meeting the inspection cycle goal and are classified correctly.

These surveys will require ice-free conditions and for safety reasons should generally be done at low flow conditions. As spring runoff generally occurs around April, and most large storm runoff events occur in June and July, May, August and September are the preferable months for surveys. However, monitoring Alberta Environment rainfall and runoff gauges in the vicinity of planned trips can facilitate identification of periods of low flow at any time in the summer.

Tracking of historic surveys and proposed upcoming survey and inspection schedules are maintained in the “Pier Scour Inspection Management” and “Pier Scour Inspection History” tables in the HIS database. The “Management” table has fields for year of last survey and year of next survey, which should be updated after each survey for a given site. The “History” table has fields for survey type, survey by, and survey year, and “Penetration Depth” (minimum height between ground and bottom of foundation). Each new survey will result in appending a record to this table.

9.6 EVALUATION

Collected xyz data for “B” and “S” sites can be processed and developed into contour plots and profiles. Contours can be compared to previous surveys using GIS tools to determine the difference between surfaces. Profiles can be superimposed onto previous profile plots for rapid visual assessment. Bank tracking plots using historic airphotos should also be referenced, where available. Survey actions and updated assessments of pier scour priorities are tracked in the HIS tool. In addition to prepared plots, brief reports should be prepared, summarizing field conditions and observations along with scour assessment and recommendations. Tracking the “Penetration

Depth" field in the "History" table will enable rapid identification of sites with significant changes in bed topography.

The major factors to consider when evaluating scour survey data include :

- Elevation of deepest scour hole relative to base of structural support
- Location and extent of scour hole
- Change in geometry since last survey
- Nature of channel bed
- Changes in flow alignment in the vicinity of the bridge opening

For sites where little change has been observed and there appears to be little risk to the infrastructure, the processed report can be filed and the database updated. However, at sites where significant scour holes are observed and/or there have been significant changes since the last survey, the survey results may trigger action such as rehabilitation or increased rate of inspection. In some cases, the results may identify the need for a bridge replacement assessment. Potential rehabilitation actions include addition of a protection layer near the base of the scour hole, underpinning of the foundation, or realignment of flow using river protection works upstream. Adding a protective layer can lead to additional scour if not done properly.