Highway 40 South of Kananaskis Lakes - Epicentre of the Storm

By:

Des Kernahan, P. Eng.
Senior Transportation Engineer
Associated Engineering

and

Erin Rooney, P. Biol.
Biologist/Regional Manager
Summit Environmental Consultants, Inc.

Paper prepared for presentation at the

Emergency Repair and Construction of Transportation Infrastructure Damaged by Catastrophic Environmental Events

session of the 2014 Conference of the
Transportation Association of Canada
Montreal, Quebec

Abstract

The 2013 floods brought enormous changes to the natural and man-made landscapes in many parts of southern Alberta. Associated Engineering was hired by Alberta Transportation to coordinate, prioritize and determine site specific strategies for repairing a 55 km stretch of Highway 40 south of Kananaskis Lakes, southwest of Calgary, Alberta. This section of highway traverses the Highwood Pass, the highest paved road in Canada, and is located adjacent to the headwaters of the Highwood River. This was the epicentre of the June 19 to 22, 2013 rainfall event, where over 325 mm fell, and was the origin for the flood damage and devastation that travelled downstream through numerous communities, including High River.

A total of 117 distinct sites with flood damage were identified, including debris flows across the highway, washouts, culvert blockages, erosional scours, and hydrological changes that carved new channels where they had never existed prior to June 2013. Each site was triaged into one of four categories, which were defined as follows: Stage 1 – required to provide access for construction operations; Stage 2 – required to open the highway to the public; Stage 3 – work off the road surface required to fully restore the highway cross-section; and Stage 4 – major works requiring substantial engineering design effort. The Stage 1 work was initiated immediately, using Alberta Transportation's local highway maintenance Contractor. A combined Tender was then issued, with an interim completion date in the fall of 2013 for the Stage 2 work and a final completion date in the summer of 2014 for the Stage 3 work. Some Stage 4 work continues to be worked on as separate Tenders or integrated into the existing contract in 2014.

One of the greatest challenges of the project was the environmental component, as over 50 of the sites required some form of regulatory approval under the Provincial and Federal legislation. Several sites required channel reconstruction, including over 250 metres of a watercourse classified as highly sensitive due to its important bull trout spawning habitat. In order to improve the local stream hydraulics, re-establish connectivity of the channel to maintain fish passage, and protect the highway from future flooding events, the watercourse was re-aligned with its historical channel. Fisheries mitigation measures, engineering plans, as well as hydrotechnical and fluvial geomorphologic assessments were required for these submissions.

This paper will review the effects of the flood, and discuss numerous challenges faced throughout the assessment, design and construction phases of the project.

Introduction

Highway 40 is a Provincial highway located in mountainous terrain in southwestern Alberta. The highway provides access to “Kananaskis Country”, an area south of the Trans-Canada Highway between the City of Calgary and Banff National Park. Attractions in this area include Peter Lougheed Provincial Park, Kananaskis Village, Nakiska Mountain Resort (location of the 1988 Winter Olympics) and many other tourist and recreational facilities. South of the major tourist sites, Highway 40 traverses the Highwood Pass, which at an elevation of approximately 7,200 feet above sea level is the highest paved roadway in Canada. Beyond the pass, Highway 40 continues southeast to Highwood House, where the intersection with Highway 541 and 940 provides an alternate access route (from the south and east) to the Kananaskis area. The section south of the major tourist sites is low volume with an average annual daily traffic volume of 350 vehicles per day, and is closed between December 1 and June 15 of each year due to major wildlife migration movements in the area. A location plan showing this section of Highway 40 is included in Figure 1. The weather in this area is typical of the Rocky Mountains with quickly changing conditions, and snowfall beginning in October and lasting through June annually.

Highway 40 was built as a two lane paved road to replace the original gravel forestry trunk road. Highway 40 was built 30 - 40 years ago to service the growing demand for mountain recreation, including skiing, horseback riding, hiking, white water sports, motor biking, road biking, hunting, and camping. Provincial parks set up complemented with a world class golf course, hotel, and convention centre using newfound Alberta wealth from oil and gas revenues. Highway 40 also serves forestry and hydro-electric industries in the area.

Between June 19 and June 22 of 2013, a combination of natural conditions (large snowpack and frozen ground) combined with a major extended rainfall event caused extensive flooding and damage to numerous locations in Southern Alberta. The extremely large volume of rain resulted when a low pressure system stalled over southern Alberta, pushing humid air from the northeast over Calgary towards the mountains. Over 75 millimetres of rain fell in Calgary, and over 100 mm fell in Canmore, which is located on the Trans-Canada Highway just east of the Banff Park Gates. The heaviest rainfall, however, occurred further south along the eastern ranges of the Rocky Mountains, with the “epicentre” of the storm lying just east of Highway 40 in the southern Kananaskis area. In this area, over 325 mm of rain fell, as illustrated on the rainfall contour map (Figure 2), resulting in severe erosion and damage to the natural environment and constructed infrastructure. Drainage courses were completely overwhelmed by the incredible volume of water, with a hydrometric station on the Highwood River measuring flow volumes in excess of 30 times the average flow rate prior to the gauge breaking as a result of the force of the event (Figure 3). From this area, the water travelled east through the watershed causing extensive damage in downstream communities including Calgary and High River.

This section of Highway 40 was significantly impacted as a result of being located through the valley of the epicentre of the storm. Most of the damage consisted of debris such as rocks and trees that washed over the highway and plugged ditches and culverts; erosion scours that washed out the roadway embankment, and morphological changes in watercourses that carved completely new drainage channels. In the immediate aftermath of the flood, efforts were focussed on re-opening the Trans-Canada Highway and other highways with a high economic impact, primarily completed on an emergency basis through Alberta Transportation’s Maintenance Contractor. Once these emergency repairs were complete, efforts re-focussed on opening the rest of the highway network, including Highway 40,and Engineering Consultants were retained to complete assessments of damage, design of repairs, environmental assessments and permitting, tendering, and supervision of construction.

Design Stage

An initial overview assessment to identify the number, location and severity of the various damage sites was completed for Alberta Transportation by Thurber Engineering along Highway 40 from the Trans-Canada Highway to Highwood House via helicopter. Associated Engineering and subsidiary company Summit Environmental Consultants Inc. (Summit) were subsequently retained by Alberta Transportation in mid-July to complete the engineering work for the southern section, a 55 kilometre long stretch from the Peter Lougheed Park entrance to Highwood House shown in Figure 4. There were 117 different sites along this stretch of highway that were washed out or damaged due to the heavy erosion, including 20 locations where the highway was completely impassable. At one site, approximately 60 m of highway was completely washed away, and the existing multi-plate structure was damaged beyond repair. As a low volume highway serving no settlements and primarily recreational users, this section of Highway 40 had been closed and gated on both ends to prevent public access since the flood.

Upon award of the assignment, the project team quickly organized a site investigation which was completed on July 23, 24 and 25 of 2013. As one of the primary driving forces behind the project methodology was accelerating the schedule, the investigation had multiple purposes that went beyond a typical preliminary survey. This included assessing the extent of damages, determining the proposed repair strategy, measurement of quantities, and understanding environmental sensitivities at each of the 117 sites. This required involvement of senior engineering and environmental staff as part of the investigation, as key design decisions would be made in the field. To maximize efficiency, GPS enabled cameras and voice recorders were used for data collection, which were subsequently georeferenced to create a data management system using mapping software. A LiDAR survey was also completed to ensure accuracy of quantities at the sites with larger volumes of material to be moved, and to generate a survey of the post-flood water course conditions both within and outside of the highway Right-of-Way for the required hydrotechnical assessments.

The general intent of the project was to re-establish the original highway design. For the most part, the highway is in the northeast side of the valley, with mountains to the northeast and the valley to the southwest. There were numerous sites on the mountain side of the cross section with rock debris flows crossing the highway and/or filling the ditches and culverts creating excess material. There were also numerous sites on the valley side of the cross section with major erosion scours that required fill material. Wherever feasible, material from sites with excess debris was used to repair erosion scours, eliminating the need to haul debris off site and significantly reducing borrow material requirements. The design and construction at simple debris flow and erosion scour sites was relatively straight forward, however a number of the sites were significantly more complex. Case studies describing several of these sites are included in subsequent sections of this paper.

Tendering Challenges

At the outset of the project, the manner in which the project would be awarded to a Contractor had not been established. The repair work on higher profile highways such as the Trans-Canada that was completed on an emergency basis immediately after the flooding was essentially directly awarded to the Department's Maintenance Contractor, through their existing Maintenance Contract. While it was evident that this would also be the quickest way to get the rest of the highway network open, including Highway 40, consideration had to be given to whether this project also qualified as an emergency. Through discussion with Alberta Transportation, it was concluded that on the basis of the low traffic volumes and recreational nature of the traffic, justification could not be made to directly award the construction work, and that a public tender would ensure the best value to the taxpayers.

The decision to proceed with a public tender created certain challenges. It required that the project team prepare the tender documents in as equitable a manner as possible for all potential bidders. Given the Maintenance Contractor's on-going role they would certainly have additional knowledge of the project in any Tendering scenario, however the fact that the highway was currently closed to traffic and completely impassable at 20 locations would result in a situation where it would be virtually impossible for any other proponent to develop a realistic bid, due to the inordinate amount of uncertainty and associated risk.

In order to both expedite the Tendering process and level the playing field to the greatest extent possible, each site was classified into one of four categories, which were defined as follows:

- Stage 1 – required to make the highway passable for Alberta Transportation, Alberta Environment, Provincial Parks staff, and emergency services including firefighters and search and rescue, as well as for future construction operations;
- Stage 2 – required to ensure adequate safety to enable opening the highway to the public;
- Stage 3 – work off the road surface required to fully restore the highway cross-section; and
- Stage 4 – major works requiring substantial engineering design effort.

The Stage 1 work was initiated immediately, using the Maintenance Contractor. A combined public Tender for Stage 2 and Stage 3 was then issued on August 28, which closed on September 10, 2013. The Tender included an interim completion date of November 8, 2013 for the Stage 2 work and a final completion date of July 15, 2014 for the Stage 3 work. Some Stage 4 work was added to the construction Contract as additional work, while other components of the Stage 4 work will be Tendered in the late summer of 2014 upon completion of the necessary design work.

While having the Stage 1 work completed by the Maintenance Contractor provided them with additional insight into the current site conditions, access for the personnel noted above was necessary within a very short timeframe and this was the only reasonable alternative to provide this. In addition, while the highway would remain closed to the public upon completion of the Stage 1 work as adequate safety measures were not reinstated, it provided the opportunity to hold a pre-Tender site tour with all potential bidders. This tour was attended by Senior Engineering and Environmental staff from the project team, Alberta Transportation representatives, and interested bidders. Discussions were held on the general intent of the scope of the project and repair design strategy, as well as specific field reviews at several of the key sites. The pre-Tender tour also provided an opportunity for Contractors to provide input on the proposed repair methodology and Special Provisions in the Contract documents. As this was a highly unusual project for all involved, the input based on the Contractor's experience and understanding on the limitations of their equipment was valuable. Key components of this input were incorporated into the Tender through an Addendum, and modifications had a significant benefit during the construction phase.

Environmental

The project site is located under the jurisdiction of several environmental laws and regulations. As the site spanned 55 kilometers, there were dozens of sites with different regulatory triggers. Understanding the environmental requirements was key to keeping the project on schedule. An overview of the regulatory landscape is provided below.

Federal:
Fisheries Act (pre November 25, 2013, as most work has been completed prior to this): Works were completed based on compliance with operational statements and notifying Fisheries and Oceans, or through submission of a request for project review. Applications were reviewed based on a priority for flood related projects. Authorizations were received when required.

Navigable Waters Protection Act (pre April 1 2014, as most work has been completed prior to this): If the works do not fall under the minor works, then submission for project review was required. Transport Canada did implement a priority review of flood related projects for the duration of activities completed in 2013.

Provincial:
Our project area was located in both the green and white zones of Alberta. Green zones are those managed primarily for forest production, watershed protection, fish and wildlife management, and recreation (Alberta Land-use Framework 2008), and are mostly publicly owned. White zones are lands designated for settlement, including agriculture, and are mostly privately owned. This added another layer of complexity to navigating the regulatory requirements for the work.

Water Act:

Code of Practice for Watercourse Crossings: The code applies to crossing structures conveying watercourses across the highway. There was an exemption under the Code for certain crossing structures in the Green zone. For other structures that were not exempt, if the terms of the Code could be followed, notifications could be submitted. Preparation of items to comply with the code included recommendations from a fisheries biologist, review of fisheries databases, plan drawings showing the work to be completed at the site, and photoplates. Monitoring during the construction activities was also often a recommendation of the fisheries biologist (in Alberta we use the term Qualified Aquatic Environmental Specialist, QAES).

In situations where the Code could not be followed (no crossing structure, or the site activities would require alteration of the bed and banks greater than 20m upstream or downstream of the crossing structure), an application under the Water Act was required. After the floods, the Provincial government implemented an expedited authorization process to assist those who were rebuilding. The one window application was designed for projects that would be requiring both Water Act (instream) and Public Lands Act (bed and shores of a water body, or other publicly owned land that is outside of an existing disposition) approval. This application and review process was designed to streamline the approvals by separating them into low or high risk projects, affecting the depth of review required before approval could be issued.

Public Lands Act: As stated above, in the Province of Alberta, administers work on the bed and shores of all water bodies. Activities that required temporary access to complete rehabilitation and repairs, or activities resulting in modification and installation of permanent features, required authorization under the Public Lands Act. Most sites required temporary field authorizations for access to complete work outside of the established highway road disposition. Some sites may require permanent occupation of the bed and shores of the water body, triggering a Department Licence of Occupation. These are longer term dispositions as compared to the temporary field authorizations.

Emergency Process:
Upon completion of the site reconnaissance in the spring, it was clear that a few sites were critical from a safety, or aquatic protection perspective. Under the Code of Practice there is the allowance to complete works without notification or approval if the site is deemed to have imminent risk to the aquatic environment, public health or safety, or an imminent risk of structural failure to a watercourse crossing. This clause was activated through the ministerial director levels at Alberta Transportation and Alberta Environment and Sustainable Resource Development. Two sites had work completed under this clause.

The project included spawning habitat for the provincially designated (sensitive) bull trout. The headwaters of the Highwood River (named Storm Creek for the most upstream portion) are listed with the highest classification of sensitivity for completing instream works (Class A). The Province designates Restricted Activity Periods (RAP), outlining the dates when sensitive life stages for fish present in those water bodies should be protected (and instream work should be minimized). Class A streams are so sensitive and the habitat they provide so valuable to the fish species in the system, that no RAPs are designated for these areas. The remainder of the project site worked in and around Class C streams which were for the majority subject to a RAP of September 1 – August 15 (works could be completed with minimal impact to sensitive life stages of fish between August 16 – August 31).

In order to work with the Contractor to complete the works in the time available, the Environmental staff required an understanding of the plans for each site. An assessment of what regulatory triggers was then completed, and notifications or applications were prepared and submitted. Some sites required a two phased approach in order to conform with the RAP as best as possible. For example, at Site 106 (described in further detail below) approval was obtained to install a diversion berm prior to the RAP, after which time crews were then able to come back and complete the rest of the site restoration in the dry.

Construction Overview

Construction commenced on September 30, 2013. Due to the varying site conditions and the schedule driven nature of the initial site investigation and in-field design, much of the work had to be refined by the engineering staff onsite. Resident engineering and environmental monitoring were led by key staff members who were involved during the initial assessment and design stage, which ensured their familiarity with the project and understanding of the intent of the design. The field staff were responsible for making decisions on site, working closely with the Contractor to keep progress moving. Timelines were tight, and the Contractor brought in four additional subcontractors to assist with completing the work. During the peak of the construction phase, activities were on going simultaneously at more than 20 sites.

The fall of 2013 construction period was very productive, with all of Stage 2 activities completed prior to the interim completion date of November 8, 2013, enabling the highway to be opened to the public. Work had been simultaneously on going at many of the Stage 3 sites, and continued through until winter shut down on November 22, 2013. Of the 117 sites, all but 22 were completed in 2013. The high production and spread out nature of the project over 55 km required very efficient survey layout and quantity measurement. The LiDAR survey was used as the preconstruction survey at a number of the sites, however additional field survey was completed to tie-in the LiDAR survey to real world elevations, to ensure accuracy of quantities.

At the majority of the debris flow and erosion scour damage sites, construction was relatively straight forward, however there were several sites with significant construction and environmental challenges. Case studies of three of the most complex sites are described in the following sections.

Case Study – Site 106

At site 106, there was an existing meander in Storm Creek to the west of the highway. During the flood the water level raised significantly, resulting in the outside of the meander pushing further to the east where it caused major erosion damage to the highway embankment. The resulting scour was approximately 70 metres long, and at the widest point only the east shoulder of the pavement surface remained in place as illustrated in Photoplate 1.

The first step at this site was construction of an isolation berm on the upstream end of the site to enable the reconstruction of the highway embankment to be completed in the dry. Storm Creek is a Class A stream, with highly sensitive bull trout fish spawning habitat. As such, the lowest impact instream work window was between August 16 and 31. As the Contract had not been awarded prior to this period in 2013, the isolation work at this site (and several other sites) was completed as part of the Stage 1 work carried out by Alberta Transportation's Maintenance Contractor. The isolation berm, shown in Photoplate 2, was constructed using lock blocks, locally sourced rock and geotextile.

Once the isolation measures were in place, the reconstruction of the roadway embankment was relatively straight forward and was included in the Stage 2 portion of the Contract. The embankment was reconstructed using locally sourced rock debris, with grades and contours to replace the pre-flood conditions. Heavy rock rip rap was used to armour the embankment to the high water level to protect the roadway from future high flow events. The reconstructed road embankment is shown in Photoplate 2.

Case Study – Site 129

Site 129 is located between the Lantern Creek and Lineham Creek Recreation Areas, approximately 14 km north of Highwood House (junction with 541 and 940). At this location, Highway 40 is approximately 17 metres higher in elevation than the Highwood River. Prior to the flood event, the main river channel was west of the toe of the highway slope. The entire floodway and valley bottom shows historical use of another channel further west, approximately 150 metres from the fill slope. During the flood, these channels became blocked with tree and rock debris, forcing the main flow of water to the east towards the highway. As a result, a major erosion scour was created at the toe of the embankment slope, resulting in subsequent upslope failure as shown in the aerial photo in Photoplate 3. The failure was approximately 130 metres long at the base and 11 metres high, with an additional major crack on the sideslope between the main failure and the roadway surface. During the initial site investigation, this location was designated as a Stage 4 site, on the basis that it was less urgent as it was not impacting the roadway surface itself, was protected by existing guardrail, and substantive hydrotechnical work was required to ensure acceptable performance of the repairs in the long term. Another contributing factor to the initial Stage 4 classification was that despite the obvious damage, the embankment above the main failure and crack appeared to be stable, and as the water levels were well lower than what they would have been during the flood when the damage was caused, it appeared unlikely that additional damage or failure of the slope would occur in the short term.

The plan for this site changed in late October 2013, when cracking on the roadway surface was noted above the failure. This created a major concern that the slope instability was larger than originally assumed, and if this site were left in its current state freshet flows in the spring of 2014 could further scour the toe of the embankment. This could result in additional upslope failure, and subsequent failure of the road surface itself. In addition to the potential disruption to the highway, complete failure would result in large inputs of sediment into the Highwood River, which would impact fish and fish habitat. Hydrotechnical work was initiated to determine an effective plan for diverting the main flow away from the toe of the slope to allow it to be reconstructed and armoured to prevent future damage. Due to the concern of major damage occurring during freshet flows, the initial goal was to complete the first stage of the repair prior to winter shut down. Winter conditions arrived before plans and regulatory approvals could be obtained. Changing site conditions in the spring of 2014 resulted in activities starting in late May, during high water. Diversion channels were constructed and established, and built to withstand freshet flows.

A plan showing the diversion and reconstruction plan is included as Figure 5. The approach is based on a temporary diversion of the river that minimizes the disturbance to the watercourse and fish habitat, and utilizes the historical capacity of the river that is currently being limited by a large log jam. The toe of the re-constructed slope has been established to an elevation above the high-water mark, and was not affected by 2014 freshet flows because of the diversion measures implemented. Completion of the reconstruction of the slope will be completed mid-summer 2014.

Access to the site has been constructed along the side slope just north of Site 129. In order to access the dry gravelled area to construct the diversion channel and berm, the equipment had to ford the river multiple times to avoid becoming stranded during the freshet flows. The existing log jam was removed and the main flows successfully directed through the historical channel (to the west of the trees at the bottom of the plan Figure 5, approximately 150 metres from the toe of the highway embankment slope). The excavator then worked in the dry to excavate the material to construct the diversion channel. Activities were isolated from the river by leaving a gravel plug in place on the upstream end. Upon completion of the diversion channel, the plug was removed to allow any flows not in the historical channel to start flowing into the diversion channel. Environmental monitoring occurred throughout the construction activities to monitor in-stream turbidity and implemented mitigation measures to minimize impact. The diversion was completed by the placement of a temporary concrete lock block berm on the upstream end. Due to high flows, approximately 20 lock blocks were used in the construction of the diversion channel. In addition to these activities, the site continued to experience water flowing through the site from various side channels and drainage culverts upstream of the project site. To isolate the work area and minimize continued sediment inputs into the river, a third channel was established outside the footprint of the established workspace area required for the re-construction of the failed slope.

Once isolation was complete, the repairs of the embankment slope commenced with the addition of fill material, rebuilding of the slope to match the adjacent embankment slope (approximately 2.5 Horizontal to 1 Vertical). The fill consisted of native rock/washout material excavated from other washout sites along Highway 40 and borrow material. The toe of the embankment slope (Stage 1 berm) was armoured with heavy rock rip rap (approximately 4 metres high, 600 cubic metres). Approximately 30,000 cubic metres of fill material was required to entirely repair the embankment slope.

The construction schedule is summarized below:

May 2014

- Construct temporary access road to the bottom of the embankment;

- Remove the existing log jam and direct the main flow to the historical channel location (to the west of the trees at the bottom of the plan);
- Construct the temporary diversion channel to capture any flows that do not end up in the historical channel;
- Construct the temporary diversion berm;

June/July 2014

- Repair the toe of the failing slope by adding fill material and rip rap armouring to an elevation above the high water mark;
- Repair the remainder of the embankment slope in the dry (no in stream work required);
- Restore embankment slopes along temporary access road; and
- Complete site reclamation (hydroseeding and/or erosion blanket).

Case Study – Site 92

Site 92 was the most complex site on the project from a hydrological, environmental and repair strategy perspective. At this location, major debris flows plugged two large diameter culverts and existing drainage courses, resulting in a complete change in the location of Storm Creek and a tributary from the east as illustrated in Figure 6. BF 78361 is a culvert on the north end of the site and conveys flows from the east tributary. A second, larger culvert (BF 78968) south of BF 78361 services Storm Creek itself. The infilling of BF 78361 diverted the east tributary along the east side of Highway 40 for about 160 metres to where it rejoins the original channel of Storm Creek. The infilling of BF 78968 resulted in Storm Creek being diverted away from its original course to the west side of the highway, creating a new highly unstable channel carved out along the west ditch line of the highway for about 2.5 kilometers.

It was apparent during the initial assessment that at some point during the flood the east tributary flowed over top of the highway, then re-establishing a new channel east of the highway resulting in major erosion damage to the east sideslope, the northbound lane road structure and half of the southbound lane road structure for approximately 160 metres between the two culverts. This left only one lane drivable, and deteriorating due to erosional forces and instability of the embankment. In addition, there were numerous locations along the new Storm Creek channel on the west side of the highway where major scours impacted the sideslope and west side of the road structure. In order to re-establish pre-flood conditions, encourage stability of the channel, maintain adequate flow for fish passage and water quality along this section of Storm Creek, a seven stage construction plan was developed and executed as described below. This work was completed in the fall of 2013.

Stage 1

Stage 1 involved constructing a temporary ditch on the east side of the highway between BF 78361 and BF 78968 to act as a temporary diversion channel for the east tributary. The reconstructed east ditch was 2 metres wide, approximately 100 metres long and had a grade of 6 to 7%. Approximately 500 cubic metres of material was moved during this stage.

Stage 2

Stage 2 consisted of diverting flow from the east tributary into the temporary diversion channel east of the highway. This also provided an opportunity to confirm that water was travelling down the re-established Storm Creek channel to the downstream location before proceeding to the next stages of construction and redirection of Storm Creek itself. Water flows from this east tributary dissipated into the gravelly substrate partially upstream of BF 78968 and the remainder downstream.

Stage 3

Stage 3 involved cleaning out and repairing BF 78968. The outlet of the culvert was exposed and material was removed from the pipe from the outlet end working towards the inlet. The removed material was stockpiled temporarily south of the site on the east side of the highway. This work was completed in the dry as the Storm Creek flows on the west side of the highway were below the inlet of the pipe and silt fencing was installed across the culvert inlet to prevent sediment from entering the creek from the work being done inside of the culvert. The minimal water flow from the east tributary was dissipating into the gravelly substrate partially upstream and the remainder downstream of the culvert outlet, such that there was no deposition of sediment from this work are into Storm Creek. Approximately 1000 cubic metres of debris was moved during this stage of construction.

Stage 4

Along the original Storm Creek channel south of BF 78968 (and east of the highway), a 5 metre wide channel with 3:1 side slopes and a 2% grade was re-graded into which the temporary diversion channel from the east tributary was connected to. This original channel re-establishment of Storm Creek continued approximately 250 metres downstream in order to establish adequate slopes to convey flows from Storm Creek. Sediment traps (1 metre deep and up to 5 metres wide by 5 metres long) were constructed approximately 100 metres apart along the 250 metre stretch to trap any sediment that had accumulated during construction activities. Given the 2.5 km distance as well as the amount and type of debris (i.e. gravel and cobble) between BF 78968 and the tie-in location to Storm Creek (downstream at Site 102), sediment generated from construction activities were filtered out prior to entering Storm Creek. This was confirmed with turbidity readings taken in storm Creek, upstream of the culvert at Site 102. The estimated volume of debris moved during this stage was 7,000 cubic metres, while the total volume to be moved at the site was 18,800 cubic metres. All of the surplus material temporarily stockpiled south of the site, east of the highway was later used to fill in the west ditch erosion after Storm Creek was diverted back through BF 78968, as noted in Stage 5.

Stage 5

During Stage 5, pre-flood flow conditions were re-established by redirecting Storm Creek through BF 78968. The goal was to maintain connectivity of the channel along this section of Storm Creek. In order to achieve this, lock blocks and clean heavy rock rip rap and native material was placed immediately south of the inlet to BF 78968 to create a ditch block. Once the majority of the flow was diverted through BF 78968, geotextile was used as filter fabric and native fill placed behind the lock blocks in order to construct the remainder of the ditch block. The ditch block was raised to an elevation of approximately 700mm below the top of BF 78968 in order to ensure 'normal' high flows continue through BF 78968, while allowing for emergency overflow above the ditch block in the event that another large flood occurs. Clean, large rocks were placed within Storm Creek and along the banks just upstream of the inlet culvert at BF 78968 over approximately 30 metres in order to repair the erosion scour and to raise the elevation of the stream bed so flow will be directed into the inlet culvert. This was completed in the wet, so it was important to ensure only clean rock was used.

Stage 6

Stage 6 consisted of cleaning out and repairing BF 78361. The channel upstream and downstream of BF 78361 were re-established for the east tributary. The banks of Storm Creek just downstream of the outlet culvert were armoured using heavy rock rip rap to protect against future erosion. Once repairs were complete, the isolation structure just upstream of the inlet culvert to BF 78361 was removed and the east tributary flow diverted to its pre-flood location through BF 78361. Approximately 300 cubic metres of material was removed during Stage 6.

Stage 7

Stage 7 involved widening out the east ditch to the highway side slope embankment between BF 78361 and BF 78968 to maximize the channel cross-section and provide emergency over flow should BF 78361 be plugged in a future flood event. The roadway embankment was re-established using approximately 1,000 cubic metres of native rock and fill. Heavy rock rip-rap was placed along the side slope to prevent future erosion and protect the embankment from another major flood.

A sequence of pictures looking downstream from BF 78968 are included in Photoplate 4, showing the pre-flood, post-flood and post-repair conditions.

From an environmental perspective, this site had numerous complexities not found to the same degree at other locations. As mentioned earlier, Storm Creek is a Class A watercourse because of its fish spawning habitat for bull trout. The fisheries biologist involved with preparing the documents for submission to obtain Water Act approval had found data to support that fish were not able to access this reach of Storm Creek due to an impediment to passage downstream. Recommendations were carried out that included setting minnow (gee) traps and electrofishing the channel of Storm Creek prior to diverting it back into its original channel for verification. Not a single fish was found during the search. To protect downstream populations, numerous mitigation measures were implemented to minimize sediment transport, which included construction of temporary sediment traps, staging of work to minimize disturbed ground, turbidity monitoring throughout construction, and control of water flows outside of active work zones.

While Fisheries and Oceans approval was obtained for this site, the severity and potential for danger to the safety of vehicles over the road was so high that the work was completed under the Emergency Clause of the Water Act

Conclusion

The 2013 floods resulted in significant damage to several locations in Southern Alberta. The epicentre of the July 19 to July 22, 2013 rainfall event was located in the eastern section of the Rocky Mountains, in the south Kananaskis area. Major damage occurred at 117 sites on a 55 km stretch of Highway 40 from Highwood House to the Peter Lougheed Park Boundary, the closest Provincial Highway to the area, and the highest paved roadway in Canada.

Classification and prioritization of required repairs enabled an efficient project delivery. One of the greatest challenges of the project was the environmental component, as over 50 of the sites required some form of regulatory approval under the Provincial and Federal legislation. The majority of the sites were repaired in the fall of 2013, enabling the highway to reopen to the public. Quantities of work completed in 2013 included 72,700 cubic metres of Common Excavation, 18,100 cubic metres of Borrow Excavation, 3,400 cubic metres of Heavy Rock Rip Rap and 940 tonnes of Granular Base.

At the beginning of the 2014 construction season, discussions with Alberta Environment and Sustainable Resource Development allowed for limited duration and locations at which to commence work in May and early June, prior to the standard road opening mid-June. Work completed in 2014 was primarily related to Stage 4 sites that required additional planning and design that could not be accommodated in the schedule for the works completed in 2013. This included Site 129, Site 112, and another complex site, Site 133. Site 133 (Lineham creek crossing) resulted in complete failure of a 4.5 metre diameter multiplate culvert and washout of approximately 30 metres of the highway, as illustrated in Photoplate 5. A detour for this site with a temporary bridge was constructed in Stage 1, with the permanent repair scheduled to open in the fall of 2014.

In addition to sites that were not addressed in 2013, reclamation including temporary and long term erosion and sediment control and vegetation establishment is to be completed, along with post-construction environmental monitoring to ensure effective recovery of affected ecosystems.

Figures

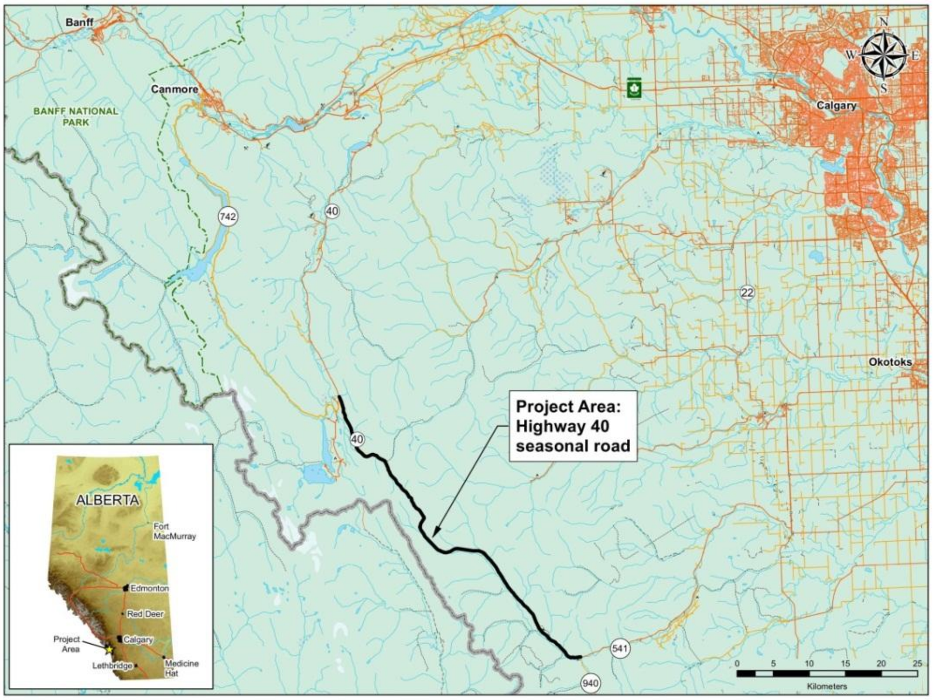


Figure 1 - Location map

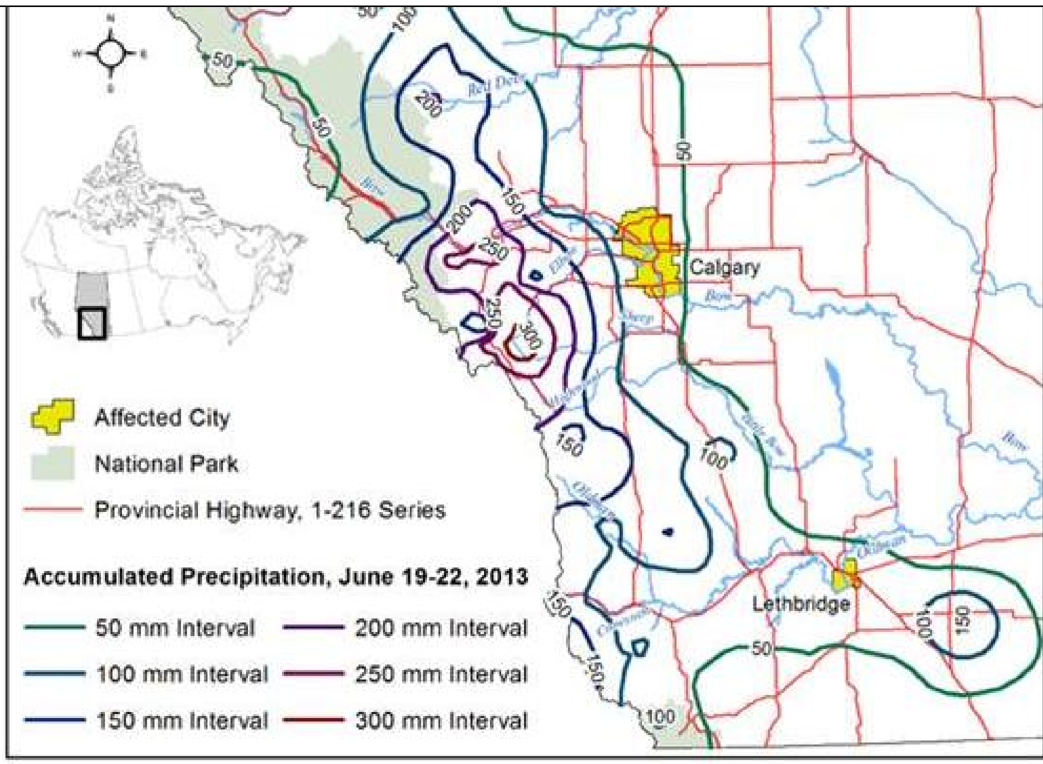


Figure 2 – Isopleth map of accumulated rainfall June 19-22, 2013.

Figures

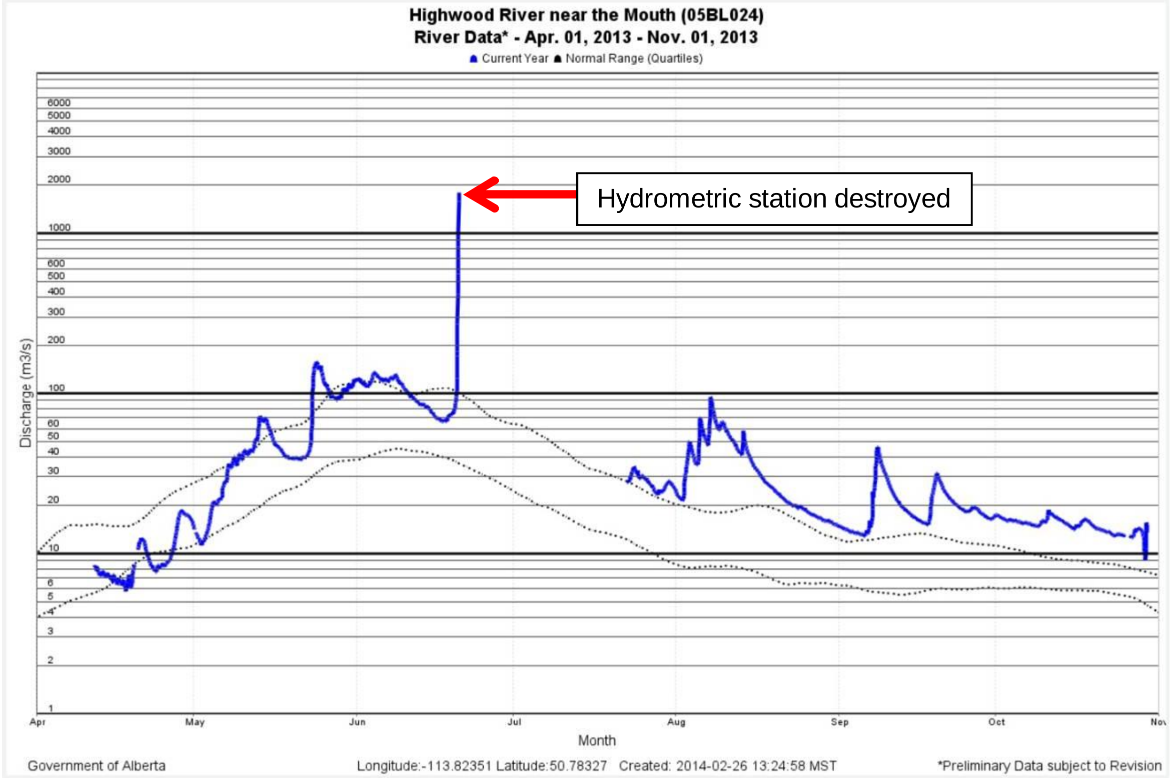


Figure 3 - Highwood river hydrometric station data

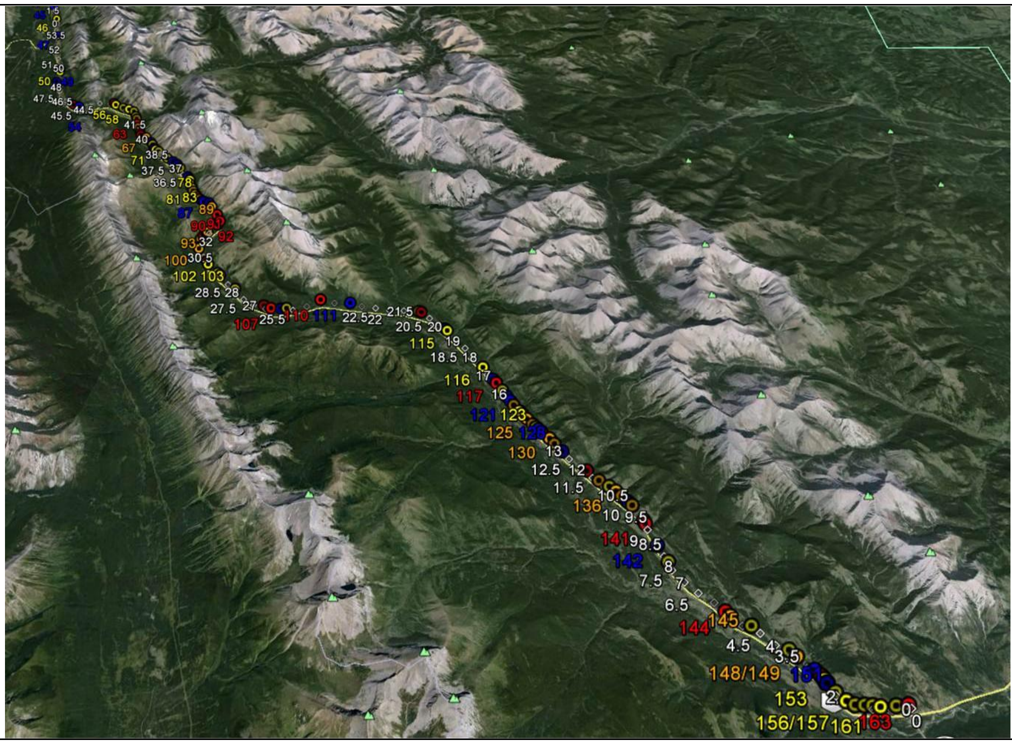


Figure 4 – Site Assessment Map

Figures

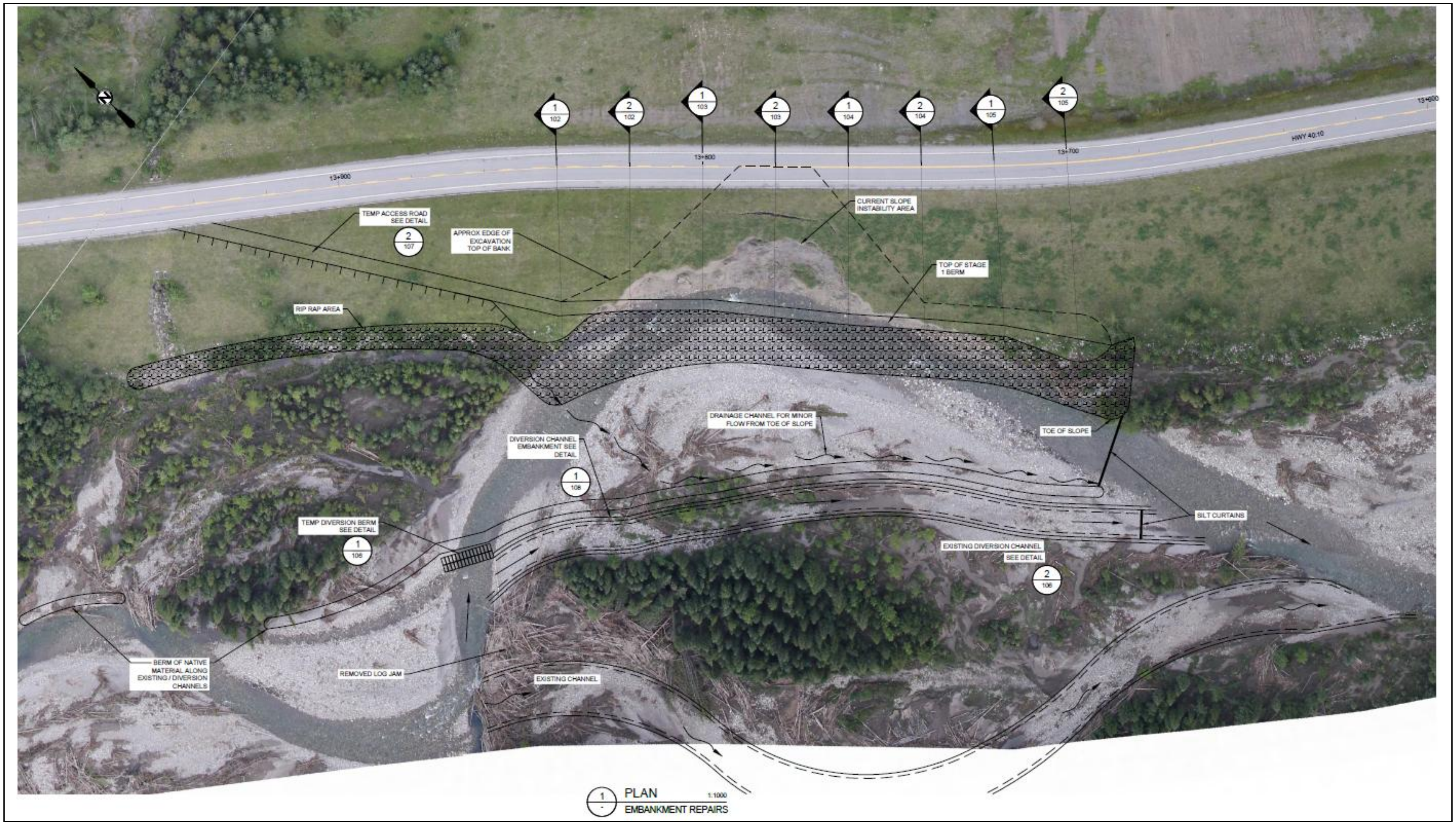


Figure 5 - Site 129 Rehabilitation plan drawing

Figures

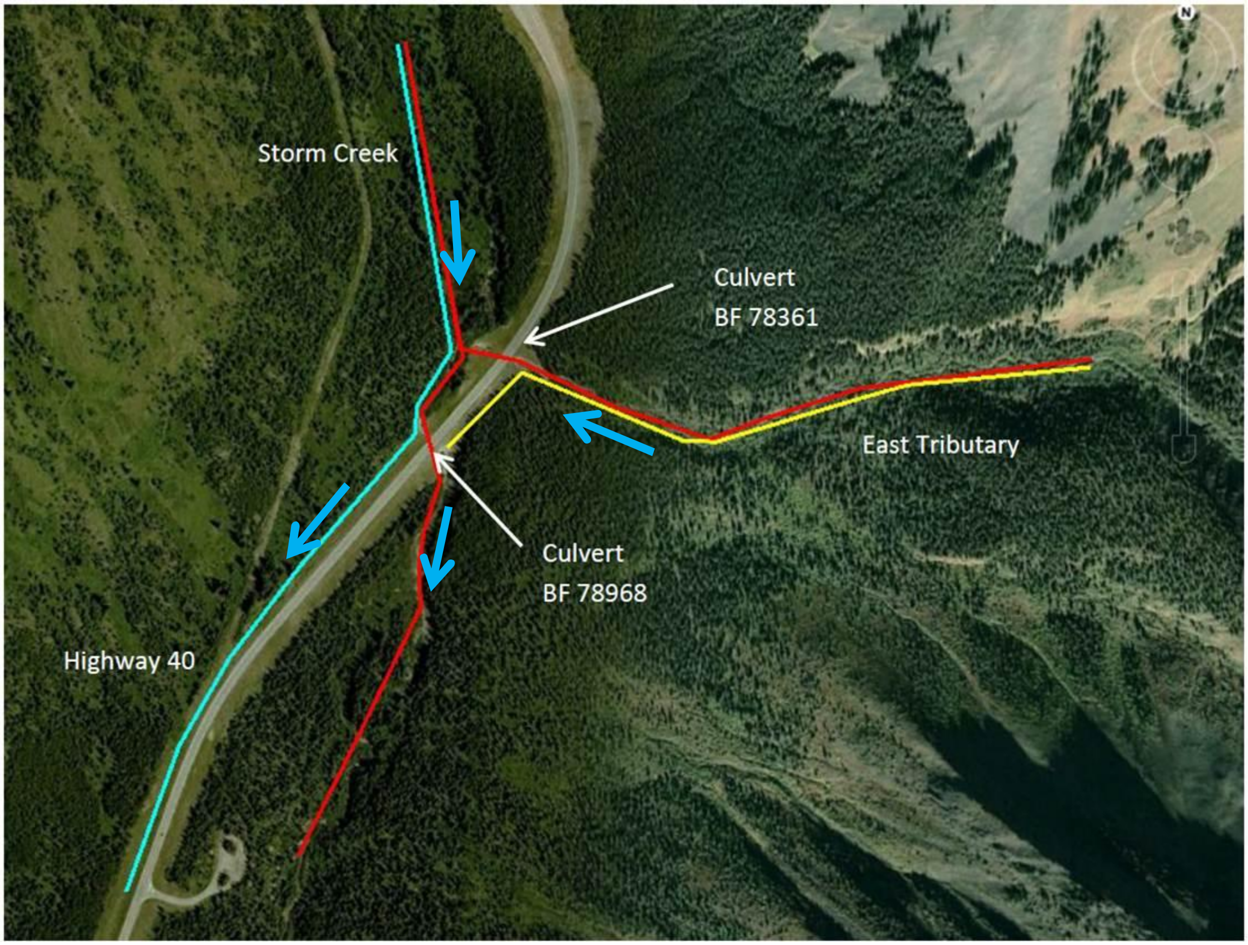
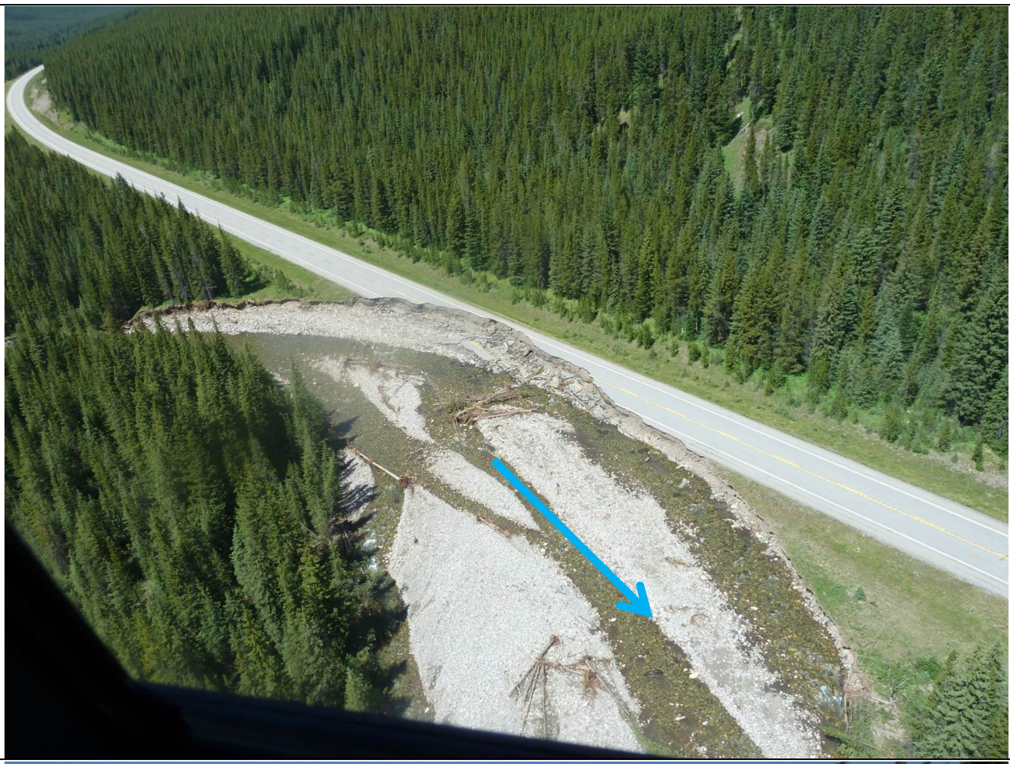


Figure 6 - Site 92 Flow Interaction (red indicates pre flood flow pathways and turquoise and yellow indicate post flood pathways)

Photoplates

Photoplate 1 - Site 106 Storm Creek a) aerial photo post 2013 flood; b) Site photo facing upstream

a)



b)

Photoplate 1 (cont'd) - Site 106 Storm Creek c) Isolation berm installed outside of Restricted Activity Period; d) Post rehabilitation activities

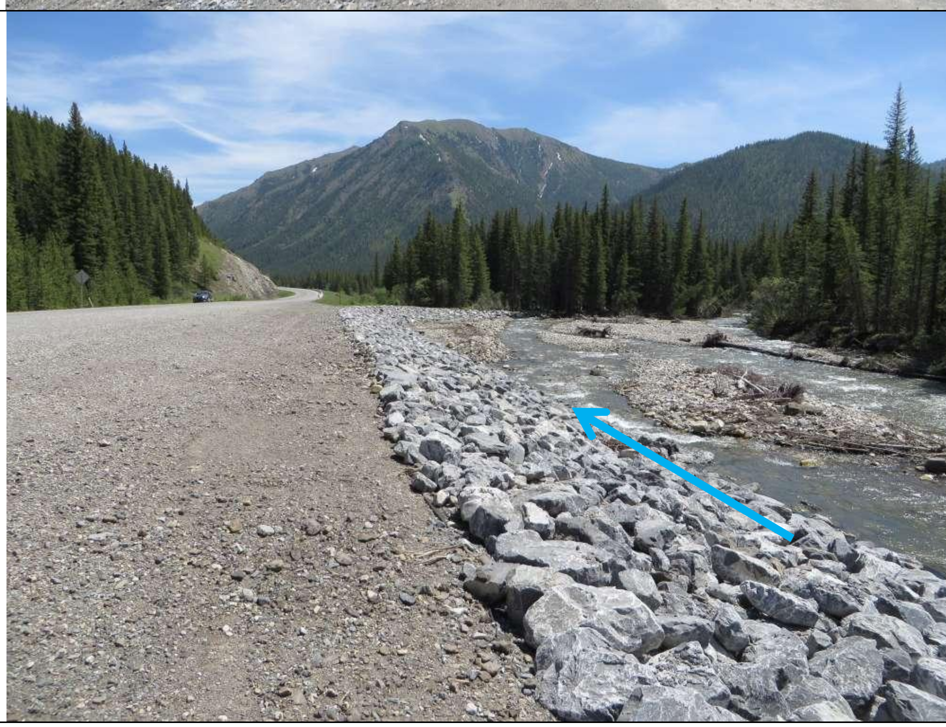
c)

d)

Photoplate 1 (cont'd) - Site 106 Storm Creek e) Post rehabilitation activities in summer 2014; f) Post rehabilitation activities in summer 2014

e)

f)



Photoplate 3 Site 129 Highwood River – a) Post 2013 floods facing downstream; b) During reclamation, diversion channel and slope re-building

a)

b)

Photoplate 3 (cont'd) Site 129 Highwood River – c) During reclamation, slope re-building; d) during reclamation, slope re-building – note temporary diversion lock-block berm

c)

d)

Photoplate 4 - Site 92 Storm Creek a) Pre- 2013 flood; b) Post 2013 Flood. Point of reference indicated with red line.

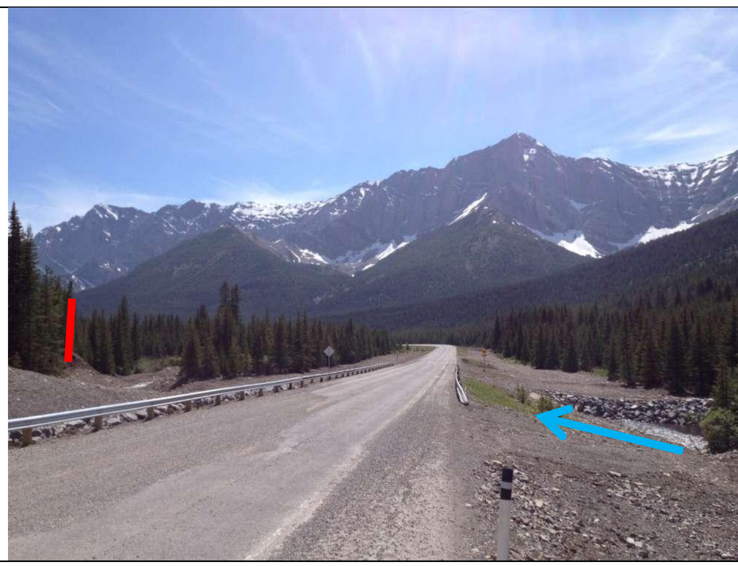
a)

b)

Photoplate 4 cont'd- Site 92 Storm Creek c) Post-Reclamation d) Summer 2014 Post Reclamation

c)

d)



Photoplate 5 - Site 133 Lineham Creek site facing north; Facing downstream