ABSTRACT

Over the last 25 years Fording Coal Limited has completed a number of environmental projects at their Fording River Operations located in the southeast coal block approximately 30 km north of Elkford, BC. These projects involved major river diversions, and water quality control settling ponds, stream enhancement projects for cutthroat trout including the development of an entire side channel for fisheries mitigation, fish passage structures and wildlife habitat restoration. Some of these projects date back to the late 1970’s and have been in operation for over 20 years. Many of these projects have been presented at previous Mine Reclamation Symposia, starting with the first symposium in 1976.

Some of the questions that are often asked are: what will that river diversion or stream enhancement project look like 20 years from now? will the river and/or side channel still be natural and productive? Will the vegetation disturbed by construction return to its former abundance? And how did these projects survive the major June 1995 flood that did considerable damage in the Elk River Valley and tributary watersheds?

This paper and pictorial overview will compare the projects that exist now to those that were constructed and presented at the Mine Reclamation Symposium over 20 years ago. Projects and design concepts that have worked well will be discussed, and where improvements could be made, these will be highlighted. Many of the above questions will be answered.

INTRODUCTION

Fording Coal Limited's Fording River Operations is located in southeastern British Columbia approximately 30 km north of Elkford, British Columbia. The open pit mining operations and coal processing facilities are located in the Fording River Valley with the coal processing plant and office complex situated at elevation 1,680 metres. The open pit mining operations historically have been located on the valley slopes at elevations ranging between 1,680 and 2,100 metres. In addition, the Fording River and its Upper Tributary, Henretta Creek, have been diverted for short sections to accommodate valley floor mining and construction of mining infrastructure such as tailing ponds, haul roads, and other mining infrastructure.
Fording River Operations commenced production in 1971 and clean coal production has increased from approximately 3 to 8 million tons per year. Over the 28-year history of the mine the Fording River has been diverted twice and Henretta Creek has been diverted through large pipes and now has been returned to a reconstructed channel. Over the same period the Fording River system has experienced two major floods, one in 1974 and the record event that occurred on June 5, 1995.

This paper covers the major river diversions, water quality control settling ponds, stream enhancement work for cutthroat trout, fish passage structures and wildlife habitat restoration projects. Some of these projects were constructed over 23 years ago and have been presented at previous Mine Reclamation Symposia. This paper and pictorial overview will compare the projects that exist now to those that were constructed over 20 years ago.

The projects that will be discussed briefly in this paper are:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Year of Construction</th>
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<tbody>
<tr>
<td>1</td>
<td>Fording River Diversion (Required to construct South Tailing Pond)</td>
<td>1976</td>
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<tr>
<td>2</td>
<td>Henretta Dragline Project (Piped diversion and restoration of Creek Channel)</td>
<td>1990</td>
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<td>3</td>
<td>Fish Pond Creek (Mitigation for the Henretta Dragline Project)</td>
<td>1990</td>
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<td>4</td>
<td>Upper Fording River Habitat Complexing (Mitigation for Henretta Dragline Project)</td>
<td>1990</td>
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<tr>
<td>5</td>
<td>Fishway at entrance to Haul Road Culverts (Provides access to Henretta Mining Projects)</td>
<td>1990</td>
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<tr>
<td>6</td>
<td>Kilmarnock Settling Ponds</td>
<td>1989</td>
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<tr>
<td>7</td>
<td>Clode Settling Ponds</td>
<td>Unknown (before 1975)</td>
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<tr>
<td>8</td>
<td>Riparian Re-vegetation for Fisheries and Wildlife</td>
<td>1970 to Present</td>
</tr>
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FISHERIES

Westslope cutthroat trout (Oncorhynchus clarki lewisi) is the only fish species occurring in the upper Fording River. The upper Fording River includes that portion of the watershed upstream of a series of impassable falls located about 30 km downstream of the Fording Coal Ltd. Operation. Cutthroat trout fry were transplanted into this part of the watershed by residents of the area between 1928 and 1941 and have since colonized accessible areas. The fisheries resources in the upper Fording River have been the subject of several studies since 1975, most of which have been related to coal mining operations.

The total potential area available for trout distribution in the upper Fording River watershed (gradient <=3%) is 116 ha, with approximately 4.5 ha in Henretta Creek. The 4.5 ha of Henretta Creek represents 4% of the available upper Fording River watershed and 17.5% of the available tributary area (25.6 ha). The section of Henretta Creek which was impacted by the Henretta Dragline Project between 1990 and 1998 is approximately 1.1 ha (1,850 m) of lower Henretta Creek (culvert and impoundment area). This represents about 1% of the available upper Fording River watershed and 4% of the total available tributary area.

Mean trout sizes (aged 2+ to 5+) in the proposed mine area of Henretta Creek were relatively similar year round during the 1990 fisheries studies (mean lengths - 148 mm; range 110-208). Mean trout densities determined in April, September and December, 1990 were estimated at 2.0 trout/100 m², 1.3 trout/100m², and 1.6 trout/100m², respectively. Limited sampling in the upper Henretta watershed indicated that trout densities were significantly less than the lower Henretta Creek.

By comparison, the Fording River appears to be much more productive. Mean September/October fish densities of 4.3 trout/100 m², 22.9 trout/100 m², and 10.7 trout/100 m² in the mainstream river upstream, within, and downstream of the Fording Coal mine area, respectively have been documented. In addition, densities in an exfiltration stream from Fording Coal's Clode settling pond system and a nearby groundwater-fed stream ("Fish Pond Creek") had trout densities of 15.6 trout/100 m² and 31.3 trout/100 m², respectively. These data suggest that the mainstream Fording River and tributaries in the existing mine area are potentially much more productive than Henretta Creek.
The fishery resource in the upper Fording River provides an extremely limited contribution to angling in the region. Angling in Henretta Creek and the upper Fording River around the proposed mine site is not a common recreational activity. The vast majority of the cutthroat trout in the Fording mine area are below the legal size of 30 cm in length and few trout of this size have been documented in Henretta Creek.

FORDING RIVER DIVERSION

A major diversion of the Fording River was required in 1976 to provide sufficient flat area in the valley bottom to construct a new south tailing pond. The tailing pond covered an area of 6.5 ha and required a 25-metre high dam to be constructed across the valley bottom. The river diversion was excavated in silts and glacial tills and the channel bottom was primarily based in shales;, silts and mud stone. Most of the latter material was rippable and did not require blasting.

As a result of the river diversion (1,200 metres in length) being shorter than the section of the Fording River that was abandoned for the construction of the tailings pond (1,700 metres in length), several drop structures were required to reduce the channel gradient. The drop structures were formed from large interlocking rocks and included pools below each drop structure, which were also formed from interlocking rocks. The total drop across each drop structure was 0.8 metres and the maximum drop to the first pool was 0.5 metres. In addition to the drop structures, rock islands and rock clusters were installed to provide rearing habitat, cover and resting areas for cutthroat trout.

As can be seen from the photographs, which are presented with this paper, immediately after construction the channel was very uniform completely devoid of vegetation as well as natural cover that would be created by such features as large organic debris (LOD). A few days after water was diverted into the channel, a thalweg started to develop as well as glides and riffles. Erosion of the softer silt and mud stones also was initiated.

Approximately two years after construction, a biological survey was carried out to assess fish utilization of the diversion channel. Pools below the drop structures and scour holes around the rock clusters and islands were utilized by rearing cutthroat trout. Fish densities were 55 trout/100 m² in the pools below the drop structure and 10 trout/100 m² in the sections of the river between the drop structure (Ref. 3).
In 1985, after several years of spring freshets, some of the rock islands and rock clusters were relocated to suit the secondary meander sequence that had developed in the channel bottom.

On June 6, 1995 the Fording River valley experienced a major flood event that likely exceeded the 100-year return period. The flood in the Fording River, as well as other major tributaries to the Elk River System, resulted in extensive damage to property and transportation infrastructure. Roads, railways and bridges were washed out and private and public property was flooded.

The flood damage to the Fording River diversion consisted of the loss of several drop structures and erosion of the soft silt and mud stone bedrock in the vicinity of the destroyed drop structures.

After the flood, the diversion channel was inspected and the following was observed:

- Deeper pools had formed and most of the drop in channel invert, that was formerly created by the destroyed drop structures, now occurred over a shorter section that resulted in a series of pools, chutes and drops.
- Based on biological surveys carried out in 1997 and 1998, the larger deeper pools were heavily utilized by cutthroat trout. The natural drop that was created was also considered not to be a barrier to migrating fish (Ref. 1).

For the balance of the diversion channel, the remaining drop structures were not damaged and several pools and chutes, as well as rock habitat features, were enhanced by exposure to the high flows.

No remedial work was recommended, but additional placements of LOD in the channel and plantings along the top edge of undercut banks was recommended (Réf. 1) to provide greater diversity in fish habitat.

HENRETTA DRAGLINE PROJECT (1990)

In order to complete the mining in the valley bottom, Henretta Creek was temporarily diverted around the South Pit mining area using two parallel culverts approximately 1,000 metres in length. A seven-metre high diversion dyke was constructed to intercept all surface and subsurface flows and divert the water into the twin culverts. The entire; diversion facility was designed for a floodflow with a 200-year return period (Q200). Flows exceeding Q20 would spill over the diversion dyke.
spillway into the South Pit, from where the water is subsequently pumped back into the culvert system. Some of the features associated with the diversion are summarized below:

- The twin culverts are 2,200 and 1,800 mm diameter corrugated metal pipe which allowed "nesting" during shipment to the site. All joints have hugger band couplings with neoprene "O" rings to minimize seepage loss to the pits.
- As the mining area developed the culverts were relocated to allow for mining of the west and north pits.
- Upon completion of mining operations the Henretta Creek channel was restored and the twin culverts will be removed in the year 2000.

Restoration of the Henretta Creek channel involved a lined channel reconstructed with a meander sequence, pool and riffle areas, habitat features and a large overwintering lake and hydric meadow near the downstream end of the diversion. The present and proposed features are described in Table 2.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Present and Proposed Features Of the Reconstructed Henretta Creek Channel</th>
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<tbody>
<tr>
<td>1</td>
<td>Develop Primary and Secondary Meander Sequence</td>
</tr>
<tr>
<td>2</td>
<td>Impervious liner located approximately 1.5 metres below channel invert within a 16-metre wide erosion zone</td>
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<tr>
<td>3</td>
<td>Secondary meander sequence with defined thalweg would be allowed to develop naturally with scour pools and deposition areas (within defined channel erosion width)</td>
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<tr>
<td>4</td>
<td>Once the channel has stabilized habitat features would be installed consisting of large organic debris (LOD) and large rock with selected areas supplemented with spawning gravel.</td>
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<tr>
<td>5</td>
<td>The relocated channel discharges into a lake with a surface area of approximately 3.2 ha and depths varying between 5 and 15 metres.</td>
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<tr>
<td>6</td>
<td>A shallow hydric meadow is included within the lake for ungulate habitat.</td>
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<tr>
<td>7</td>
<td>The channel invert and lake outlet are stabilized with invert controls constructed of selected rock grouted with concrete.</td>
</tr>
<tr>
<td>8</td>
<td>The new floodplain and channel banks will be planted with riparian species such as willow, cottonwood, pine and spruce.</td>
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</table>
One of the major haul road crossings of Henretta Creek included twin culverts approximately 120 metres long with approximately 20 metres of rock mine waste as cover. Since this road will remain in service to complete reclamation operations and possibly access other mining areas, the facility was designed for fish passage complete with holding pools, fishway weirs, and partial backwatering of the culvert invert.

The slide presentation shown today includes a comparison of the project as it was constructed in 1990, during mining operations 1991 to 1998 and as it looks today after Phase I of the Henretta Creek channel was restored in 1999. During the next few years, habitat features will be installed in the new channel to suit the initial thalweg and erosion patterns that developed after the first years high water. In addition, vegetation will be planted along the channel, as well as around the newly created lake and hydric meadow.

The major haul road crossing of Henretta Creek: will remain in operation for several more years until all mining opportunities are completed in the valley. The custom fishway at the entrance to the haul road culverts has worked well and as can be seen from the photographs taken today in comparison to those taken immediately after construction in 1991, there are virtually no changes. After the major flood in 1995, there was no damage to the fishway and/or the large holding pool at the entrance to the culverts. The haul road culverts should remain in operation for many years to come with guaranteed fish passage to the upper watershed.

FISH POND CREEK AND UPPER FORDING RIVER HABITAT REPLACEMENT
(OFFSITE MITIGATION FOR HENRETTA CREEK DRAGLINE PROJECT)

The basic approach to mitigation is that reclamation of the minesite and spoil as well as the restoration of Henretta Creek represents the long-term mitigation of impacts.

The short-term impacts, during the period of mining and subsequent reclamation, are the subject of the off-site mitigation strategy.

CUTTHROAT TROUT HABITAT ENHANCEMENT

As mitigation for removing approximately 1,500 metres of Henretta Creek from natural fish production for a 6 to 7 year period, two nearby areas of the Fording River were targeted for enhancement. One of these areas was a natural groundwater fed stream with a history of utilization
by cutthroat trout as a prime overwintering area. The second area was on the Fording River immediately upstream of its confluence with Henretta Creek.

Fish Pond Creek is located approximately 2 km downstream of the Henretta Dragline project. The creek originates in a groundwater fed pond and extends downstream approximately 800 metres before discharging into the Fording River. The head pond has historically been used by cutthroat trout for overwintering and was deepened about ten years ago and enhanced with natural cover (i.e. root wads and rock groupings).

The remainder of Fish Creek was enhanced in the fall of 1991 and basically consisted of the development of four (4) reaches (see Figure 1). The upper reach included the construction of two major overwintering pools, five pocket pools, addition of spawning gravel above and below selected pools and the addition of cover. The cover included the following types:

- Large organic debris (LOD), such as clean root wads, timber debris and extensive planting of riparian vegetation such as willow clusters and evergreens along the perimeter of the channel and pools.
- Submerged rock groupings in the deep pools to provide avoidance areas from Merganser predation.
- Manmade floating cover for the large pool areas which was installed in conjunction with LOD and riparian vegetation.

The second reach, with a length of approximately 120 metres, had a relatively steep gradient and was developed utilizing a combination of pocket pools, stabilized spawning gravel areas, rock wing spurs and transplanting of riparian vegetation. LOD was installed in all pocket pools to provide cover for rearing and spawning trout.

The third reach was developed as a natural lake area complete with islands and peninsulas to maximize the perimeter margins that could be planted with riparian vegetation. The lake or pool areas are approximately 2 metres deep and include floating cover over selected areas of the pond. It is anticipated that these areas will be used for overwintering and possible summer rearing as well. Depending on food supply, the area may produce larger fish, similar to the fish rearing in other isolated pond areas within the mine property.
The Technical and Research Committee on Reclamation

Plan:

- Head Pond
- Pocket Pools (typical)
- In Channel Holding Ponds (typical)
- Invert Control (typical)
- Floating Cover (typical)
- Overwintering Ponds

**Figure 1**

- Head Pond Enlarged and Deepened to Intercept Groundwater Flows
- Pocket Pools Installed and Channel Deepened to Intercept Sub-Surface Flows
- Large Overwintering Ponds Constructed to Intercept Sub-Surface Flows

**Fish Pond**

Creek Channel Development For Cutthroat Trout
The lower reach in Fish Pond Creek is relatively steep, has excellent natural cover and was enhanced with rock spurs and the addition of spawning gravel by natural distribution.

The slides presented with this paper show the construction details of the habitat complexing and improvements to Fish Pond Creek that were carried out in 1990/1991. In comparison, photographs taken in 1999 show how the channel has matured, both planted and riparian vegetation has grown and provided improved cover for cutthroat. Biological assessments have also been carried out in 1998 (Réf. 1) and a brief summary of the findings has been showed on Figure 2.

In addition to Fish Pond Creek, a 450-metre length of the Upper Fording River was also targeted for enhancement. This section of the Fording River was steep (in excess of 5 percent slope) with natural substrate consisting of cobbles and boulders with some finer gravel in isolated areas. There were very few pools and no instream LOD cover. The riparian vegetation was generally good but the utilization by cutthroat was low, possibly as a result of limited holding areas and virtually no instream cover.

This area was developed as mitigation for the loss of riffle-glide habitat in Henretta Creek. As a result of the steep gradient in this area of the river, pool and holding areas were constructed using large rock clusters and islands, root wads cabled to selected trees and rock spurs located on the river bends. It was anticipated this treatment would provide greater stability during flood flows. If habitat complexes moved or were broken up by high velocities, it is likely the resultant formation would still provide useful habitat.

The habitat features, as installed in 1991, are shown on a number of slides which supplement this paper. Generally the work carried out in 1991 looked promising, but the stability of the features were still a major concern because of the steep gradient. After the major flood event in June of 1995 the existing creek channel was drastically altered and most of the habitat features were broken up and deposited outside the normal wetted area of the river channel. As shown in the current photographs, attempts have been made to relocate some of the rock structures. However, further work is required to position the habitat features to suit the low flow thalweg of the stream. Stability will always be a concern in this steep section of the upper Fording River. In this regard, any additional habitat improvements are likely to be of short-term benefit.
<table>
<thead>
<tr>
<th>Fish Pond Creek</th>
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<tbody>
<tr>
<td>HABITAT</td>
<td>FISH DENSITY</td>
</tr>
<tr>
<td>Single and multiple pieces of LWD</td>
<td>Glide and pool</td>
</tr>
<tr>
<td>LWD combined with boulders</td>
<td>Glide and pool</td>
</tr>
<tr>
<td>Single boulder</td>
<td>Riffle and glide</td>
</tr>
<tr>
<td>Multiple boulders</td>
<td>Riffle and glide</td>
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<tr>
<th>Upper Fording River</th>
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<tbody>
<tr>
<td>HABITAT</td>
<td>FISH DENSITY</td>
</tr>
<tr>
<td>Single pieces of LWD or single boulders</td>
<td>Glide and pool</td>
</tr>
<tr>
<td>LWD combined with boulders</td>
<td>Glide and riffle</td>
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<thead>
<tr>
<th>Fording River Diversion (Note 2)</th>
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<tbody>
<tr>
<td>HABITAT</td>
<td>FISH DENSITY</td>
</tr>
<tr>
<td>Rock clusters and islands</td>
<td>Pool and glide</td>
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</tbody>
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<th>Lower Henretta</th>
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<tbody>
<tr>
<td>HABITAT</td>
<td>FISH DENSITY</td>
</tr>
<tr>
<td>Pool below waterfall</td>
<td>Pool and glide</td>
</tr>
</tbody>
</table>

**Note 1** Fish Utilization data from Reference No. 1
**Note 2** 1978 Aquatic Study, Reference No. 3 – 55 fish/100 m² (pools at drop structures) 10 fish/100 m² glides and pools between drop structures.

Fish Utilization for Fish Pond Creek
Upper Fording River, Henretta Creek
And Fording River Diversion (Note 1)

table 2

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STORMWATER SETTLING PONDS

There are a number of stormwater settling ponds at the Fording River mine site. The primary purpose of these ponds is to remove total suspended solids from streams and drainages affected by mine runoff, before being discharged into the Fording River and/or other fish-bearing streams.

The Kilmarnock Creek settling pond is designed to treat all turbid flows in Kilmarnock Creek before being discharged into the Fording River. The settling pond is designed to treat all flood flows with a return period often (10) years or less. Under some circumstances flocculants are added at the head of the pond to promote settling and to meet regulatory discharge requirements of 50 mg/litre. This is a conventional settling pond, where a portion of the total flow infiltrates to ground and the pond is empty for most of the year.

In contrast, the Clode settling pond is totally impounded with only a controlled high level outlet. Since the pond was constructed in the early 1970's, the pond has always retained water and vegetation has grown over a large portion of the bottom sediments. The pond is an ideal rearing area for cutthroat trout and fish have been observed and caught by angling with recorded weights exceeding 2 kg. In contrast to the Fording River where a large +5-year cutthroat trout would be 300 to 350 mm in length (approx. 300 to 400 grams), this pond has developed into a unique environment for larger fish. In this regard, both Fish Pond Creek and the Henretta Relocation Channel have been developed with a pond or lake component to have the potential to rear the larger cutthroat trout.

RIPARIAN VEGETATION

Since commencement of mining in 1970, Fording has carried out a program of re-vegetation research which has focused on the species, methods and timing of reclaiming areas disturbed by mining activities.

Over 30 years of field trials and operational experience in disturbance re-vegetation has resulted in successful re-establishment of 507 ha of land disturbed by mining. The key objective of the reclamation program is to establish self-maintaining plant species that return the land to equal to or better than the pre-mining land uses on a property average basis.
Reclamation of riparian areas has been a relatively minor but important component of total reclamation, as total disturbance near streams or wetlands has been small, but use by wildlife is high.

Excellent results in riparian re-vegetation have been achieved using such native species as Engelman spruce, cottonwood, willow, bog birch and sedges.

Native and agronomic grasses and legumes are also used where appropriate to the specific site. Wildlife and fish habitat has been returned to historic levels of use through detailed planning, research and implementation of programs designed for riparian areas.

REFERENCES


