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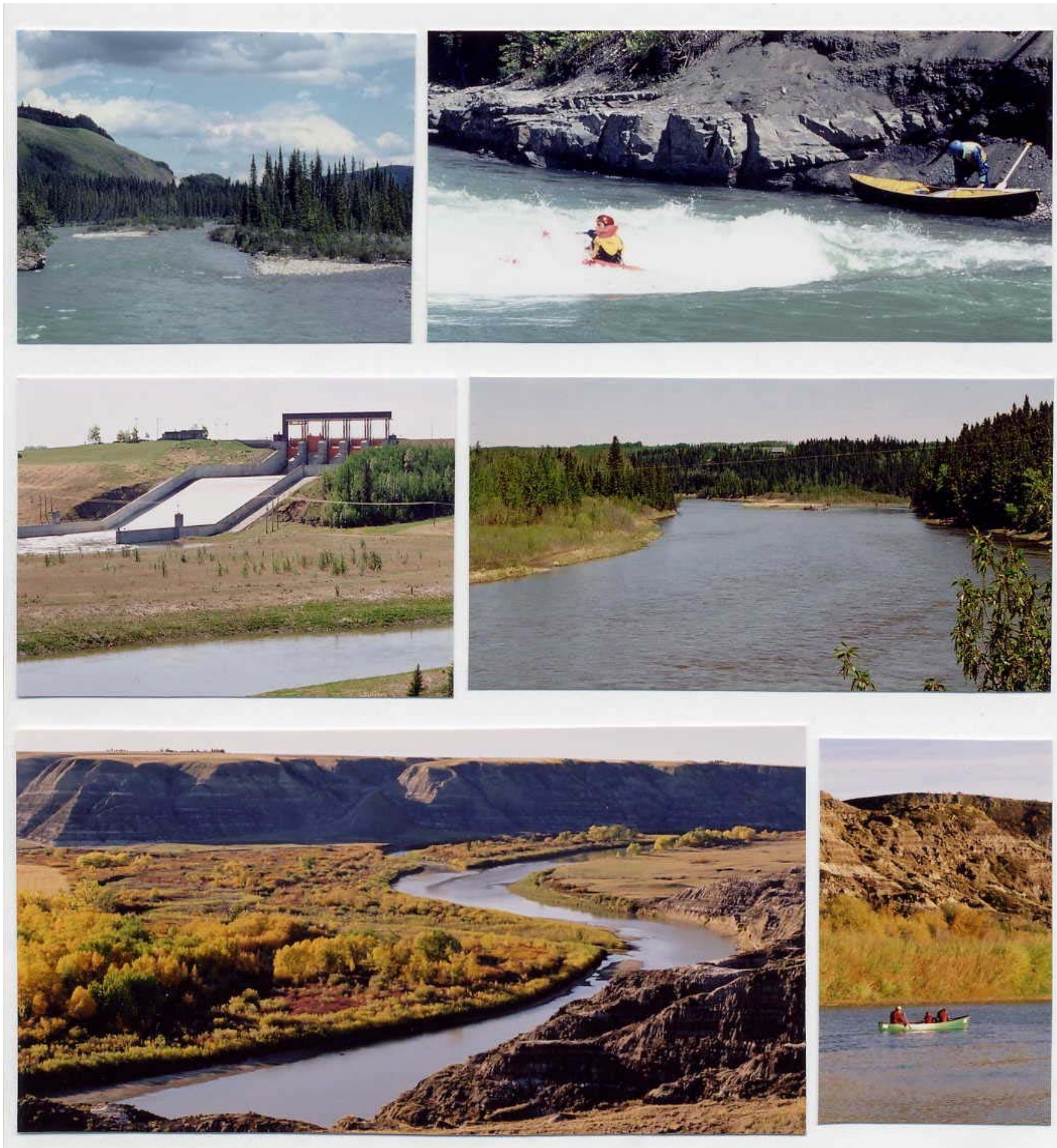

Recreational instream flow needs (R-IFN) for the Red Deer River, Alberta

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(Cover Photographs) - Figure 1. Upper reach (top row of photos, July 16, 2000, view downstream from Highway #40 Bridge (left), kayak surfing bottom hole at 'S-Bend' rapids (right)), Dickson Dam spillway and transitional reach (middle row, May 29, 1995, looking downstream from dam area (right)) and lower reach (bottom row, September 30, 2000, just upstream of Drumheller (left and right)) of the Red Deer River with canoes and kayaks shown.

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SUMMARY

The Red Deer River provides one of Alberta's and Canada's most popular streams for recreational paddling. The upper Red Deer River extends from near the Banff boundary downstream to the Gleniffer reservoir behind Dickson Dam and offers intermediate whitewater (grade II-III) that provides a provincial focus for whitewater kayaking, canoeing and rafting. A transitional reach (grade I+) occurs downstream from the Dickson Dam and provides a popular recreational resource through the City of Red Deer; boating is often combined with angling along the tailwater trout fishery. The lower Red Deer River consists of about 500 km of moving flatwater (grade I) largely through distinctive badlands such as near Drumheller and Dinosaur Provincial Park. This reach is particularly used by canoeists with opportunities for single and multiple-day trips.

The present study determined recreational instream flow needs (R-IFN) for paddling along the upper and lower reaches of the Red Deer River and also considered its paddleable tributaries. The study analyzed input from the River Trip Report Card (RTRC) program with 366 cards representing 3501 paddler days submitted from 1983 to 1997. Regression analyses were conducted to determine 'minimal' flows, the low flows that still provide reasonable quality paddling experiences, and 'preferred' flows that represent the low end of the favored flow range.

The results from the analyses of the RTRC were generally consistent with recommendations from regional guidebooks and maps and a previous technical report. The RTRC values were very consistent with results from the depth discharge method, a hydraulic modeling approach that determines the typical flow required for river depths of 0.6 m (for minimal flow) or 0.75 m (preferred flow). From these comparative analyses, the following R-IFN values were determined:

River Reach	Gauge	Minimal Flow m^3/s^*	Minimal Flow cfs	Preferred Flow m^3/s	Preferred Flow cfs
upper Red Deer River	Below Burnt Timber Cr.	20	700	30	1000
lower Red Deer River	Red Deer, Drumheller or Bindloss	25	900	45	1600

* m^3/s = cms = cubic meters per second; cfs = cubic feet per second

INTRODUCTION

The Red Deer River provides the northern tributary of the South Saskatchewan River Basin that also includes the Bow and Oldman rivers. Of these three major tributaries, the Red Deer is somewhat smaller than the others, typically providing about 21% of the natural flow into the South Saskatchewan River (Alberta Environment, 1984). The Bow and Oldman are about double the Red Deer, contributing about 43% and 36%, respectively.

Of the three tributaries, the Red Deer is the least dammed. A single major dam, the Dickson Dam, is situated about midway between Sundre and Red Deer and forms Gleniffer reservoir. A few smaller dams, particularly low head weirs, exist along tributaries.

The Red Deer River is also the least diverted of the three tributaries. As with the Bow and Oldman rivers, the greatest consumptive use for diverted water is for irrigation but this is far lower than for the Bow or Oldman rivers. Municipal and industrial demands are consequently proportionally higher for the Red Deer River, consuming 19% and 13%, respectively, of the water removed in 1977, a low flow year (Alberta Environment, 1984). In that year 68% of water consumption from the Red Deer went to irrigation, in contrast to 95% and 99% for the Bow and Oldman rivers, respectively (Alberta Environment, 1984).

Agricultural, municipal and industrial demands are likely to progressively increase along the Red Deer River. Situated about midway between Calgary and Edmonton, the City of Red Deer will probably experience considerable population increase. The Red Deer River Basin has a greater proportion of rural residents than either the Bow or Oldman basins (Alberta Environment, 1984) and smaller towns in the basin will probably also continue to grow in population along with an increase in other rural residents. The increasing population base will provide increasing demand of water for domestic and other uses, as well as increasing local demand of the river for its environmental, aesthetic and recreational values.

As well as providing a regional recreational resource the Red Deer River is also noteworthy as a provincially and even nationally recognized stream for sport and recreational paddling. Relative to this analysis, ‘paddling’ indicates human-powered boating; the Red Deer River is not used extensively for motor boats. Recreational boating provides a valued component of Alberta’s tourism and particularly ecotourism. In 1998, there were 12.2 million overnight person visits to Alberta and tourists from Canada, USA and overseas participated in outdoor activities 58, 41 and 38% of the time, respectively (Research Resolutions 1998). The Red Deer River provides a relatively natural landscape that offers a rich resource for outdoor activities and recreational paddling will probably continue to increase in popularity and socioeconomic importance.

The upper Red Deer River

With respect to recreational paddling and to environmental and management considerations, the Red Deer River may be considered to consist of three reaches (Figure 2). The upper Red Deer River extends from its headwaters in the Rocky Mountains of Banff National Park downstream through the foothills ecoregion past Sundre and to the Gleniffer reservoir behind Dickson Dam. The upper reach flows through forested foothills with a moderately steep longitudinal gradient (Table 1). The river generally consists of an alluvial channel although bedrock ledges commonly interrupt the gravel and cobble-dominated bed. The reach provides grade II to III whitewater and the Double Ledge reaches grade IV at higher flows. This level of difficulty appeals to a broad range of paddlers and is suitable for many private and commercial paddling activities. The upper reach is situated within the cold-water fish habitat zone and thus supports trout and mountain whitefish that provide angling opportunities that complement recreational paddling.

As described by Mark Lund (1997), the Red Deer River '… is Alberta's pre-eminent white water stream. No other river in the province attracts the usage that the Red Deer receives. It is near our population centers, it has excellent access, reliable water all season, great camping, and challenges for everyone.' (p. 44).

It is probable that over the past decade following the in-channel modifications at 'Canoe Meadows', the Kananaskis River has replaced the upper Red Deer River as Alberta's most densely-used whitewater stream. However, the Red Deer River contains about 70 km of prime whitewater paddling whereas the lower Kananaskis reach is much shorter and it is particularly the 7 km reach between 'Widow-maker' and its outflow into the Bow River that is heavily used along the Kananaskis. We are not aware of comparative user inventories but consider that both the upper Red Deer River and the lower Kananaskis River represent outstanding recreational whitewater resources. As well as being very popular with private paddlers, these two reaches also provide the two provincial centers of commercial paddling activities.

Consistent with the favorable interpretation by Mark Lund, Stuart Smith (1996), one of Canada's premier paddlers also highly rates the upper Red Deer River. His river guide lists the grade II run above Highway #940 as a 'favorite scenic float in the mountains' and two runs between Highway #940 and Sundre in his list of 'favorite fun stuff for playing.' (Highway #940 as referred to by Smith, is also known as Forestry Trunk Road, Highway #734 and Highway #40 in our report.). One particular rapid, the S-Bend, is especially popular for 'playboat' kayaking and canoeing and serves as a 'park and play' destination for paddlers from across Alberta and adjacent regions (Figure 1, top right). That rapid has hosted Alberta provincial 'freestyle' events, a sport competition that evolved into whitewater 'rodeo' that represents the current focus of paddle sport development. The upper Red Deer has also frequently served as the site for whitewater slalom and wildwater competitions, with frequent Foothills Cup events through the 1980's and 1990's, Alberta Provincial Championships and the 1972 Canadian National Whitewater Championships. In addition to these formal competitions, the river hosts many other activities and club events and is a popular site for canoe and kayak instruction. The upper Red Deer River also provides a focus for commercial whitewater rafting. Commercial rafting companies such as Chinook, Otter, Mirage, Hunter Valley, Mukwah and Whitewater Adventures provide numerous commercial raft trips along the upper Red Deer River.

As indicated in the assessment by Lund (1997), the appeal of the upper Red Deer River is partly due its proximity to Alberta's urban centers and also to its accessibility. The popular whitewater reaches are situated upstream from Sundre and are suitable for day-trips from Calgary or Red Deer and weekend trips from Edmonton, Lethbridge or Medicine Hat, as well as from most other areas in southern and central Alberta. The upper Red Deer River also has national significance as a whitewater resource and it is not uncommon to encounter paddlers from neighboring provinces and the United States during the summer months.

A secondary road parallels the whitewater reach of the upper Red Deer River and this facilitates access and egress, scouting and rescue. Much of the reach is within the Rocky Mountains Forest Reserve with a number of developed and undeveloped campsites and access parking points.

Transitional reach

A transitional reach occurs downstream from the Dickson Dam as the Red Deer River flows principally northward to the City of Red Deer and then through the 'Canyon' to the Highway #11 Bridge. The gradient through this transitional reach is shallower than the upstream reach and fewer obstructions occur, easing the navigational difficulty to about grade I+.

This reach would historically have been within the transition fish habitat zone and downstream of Red Deer, river water warming would have lead to further changes to the cool water fish habitat zone (Alberta Environment, 1984). The imposition of the Dickson Dam in 1983 has altered downstream river flows and conditions and this has been favorable for an artificial tail-water fishery that has become productive for the exotic brown trout. The developing trout fishery provides options for combining paddling and angling on river trips downstream from Dickson Dam.

The lower Red Deer River

Downstream of Highway #11, the Red Deer River further downgrades in longitudinal gradient and riffles are rare producing grade I paddling conditions. The river thus provides moving flatwater with minimal need for maneuvering and minimal obstructions or hydraulics (ferry crossings provide a notable exception). The river follows a relatively straight channel southwesterly through Drumheller in a distinctive valley 80 to 150 m deep. The river turns eastward and continues to flow through badlands along Dinosaur Provincial Park. The valley opens up near the Saskatchewan border and islands increase providing a more braided channel configuration. Slightly downstream from the Alberta/Saskatchewan border (fourth meridian), the Red Deer River joins the larger South Saskatchewan River. Various access points occur along the lower Red Deer River that is principally popular for canoeing with opportunities for single or multiple-day trips.

Complementing the favorable water features, the Red Deer River is unique in Alberta and in Canada in that it flows through all five of Alberta's major ecoregions (Figure 3). The headwaters are in the mountain ecoregion and near the border of Banff National Park the river enters the foothills ecoregion. The river subsequently flows through Alberta's southern-most zone of the boreal forest and near the City of Red Deer the (aspen) parkland ecoregion occurs. Prior to Drumheller, the river passes through the final ecoregion transition and its final segment flows through the prairie ecoregion.

Accompanying the ecoregion transitions, the upland vegetation changes from coniferous forests, to mixed woodlands with spruce, balsam poplar and aspen and then the parkland region that is dominated by aspen. The upland zones of the prairie ecoregion are treeless and the extensive cottonwood groves along the lower Red Deer River provide a marked contrast to the treeless hillsides and upland areas. The riparian (floodplain) zone along the river is dominated by cottonwoods, poplars that are well adapted to the dynamic streamside zones. The balsam poplar, *Populus balsamifera*, occurs upstream of Red Deer and between Red Deer and Drumheller, the prairie cottonwood, *Populus deltoides*, joins the balsam poplar in riparian woodlands and the two hybridize to produce distinctive balsam poplar x prairie cottonwood hybrids. Downstream of Drumheller the prairie cottonwood is the dominant riparian tree.

Thus, the upper Red Deer River and the lower Red Deer River provide very different experiences and opportunities with respect to paddling, fishing and landscape appreciation. The upper reach provides swift-flowing whitewater with numerous ledges, boulders and hydraulics, through a region of foothills forests. The lower river provides flatwater paddling through the relatively unique badlands landscape that interrupts the prairies. The two reaches are separated by the Gleniffer reservoir and by the transitional reach through the City of Red Deer. Recreational paddlers heavily use all three of the Red Deer River reaches and this usage of all three reaches is almost certain to grow in the future as the regional and provincial populations increase and as out-of-province visitors also increase.

To assist in river resource management and particularly, instream flow regulation the present study was undertaken to determine instream flow needs for paddling of the two Red Deer River reaches upstream and downstream of the Dickson Dam. Consistent with a similar prior study of the Oldman River and its tributaries (Rood and Tymensen 2001, Rood et al. 2002), the study of recreational instream flow needs (R-IFN) for the Red Deer River applied a number of different subjective and objective approaches in order to achieve confident R-IFN determinations.

METHODS

The study investigated different reaches of Alberta's Red Deer River and also considered its major tributaries (Figure 2, Table 1). The study particularly compared three methods for R-IFN determination:

(1) paddler survey,
(2) expert opinion, and
(3) hydraulic modeling.

Paddler Survey

River Trip Report Cards (RTRC) provided the basis for a voluntary, mail-in survey. Postcard style surveys were developed in 1983 (Figure 4) and distributed to paddling clubs in Alberta along with letters inviting participation. The cards were self-addressed with pre-paid mailing to encourage paddler response.

The ratings from the RTRC were converted to numerical scores from 1 (impossibly low) to 7 (dangerously high) with the two ratings for 'river' and 'rapids' being averaged. A suitability score was thus provided with '4' representing 'optimal' flow.

These raw data plots generally produced rather scattered distributions that did not indicate clear thresholds relative to flow suitability. The focus of the current analyses was to determine low flow criteria and consequent analyses considered the lower portion of the response data. A regression method commenced by recognizing the range of flows that were considered by some respondents as lower than ideal. Flows that were consistently judged as 'just right' or higher were above this threshold and these were omitted from subsequent curve-fitting regressions.

The remaining data were evaluated through quadratic regression (2^{nd} degree polynomial) since this function produced near-maximal coefficients of determination (r^2) for the previous rivers of the Oldman River Basin (Rood and Tymensen 2001, Rood et al. 2002). A curved response function was expected since it was anticipated that low flows would provide little improvement over the no-flow point up to the discharge at which the stream was approaching the depth that would consistently float a boat over riffles and permit full paddle blade immersion in most areas. Thereafter, it was expected that the suitability function would increase and then flatten out as the ideal flow range was approached.

Following the regression determination, the intercepts of the line of best fit with suitability ratings of 3 and 3.5 were identified and the associated discharges were interpolated to reflect the minimal and preferred flows, respectively (Figures 5 to 9).

Expert Opinion

To consider expert opinion, paddling guidebooks, maps and past technical reports for the regional streams were considered.

Hydraulic Modeling - Depth Discharge Method (DDM)

An objective, hydraulic modeling approach was developed and is referred to as the depth criteria, stage-discharge method or more concisely as the depth discharge method (DDM) (Rood and Tymensen 2001, Rood et al. 2002). Depths of 60 cm (2 ft) and 75 cm (2.5 ft) were applied to estimate minimal and preferred flows, respectively. The minimal flow (60 cm) provides a depth that is sufficient to immerse a typical paddle blade. The preferred flow (75 cm) typically provides a general enhancement of many hydraulic features while permitting the Eskimo roll.

Stage-discharge ratings tables were obtained from Alberta Environment for Water Survey of Canada gauging stations (Table 1). Subsequently, stage-discharge ratings curves were plotted and discharges that would provide the depth criteria were interpolated.

Historical Hydrologic Data

Historical discharges (Q) were obtained for the river reaches from HYDAT (2001 version, data to 1999), the hydrologic data base established for Water Survey of Canada gauging stations. Discharge (or ‘flow’) data involved daily mean flows.

RESULTS AND DISCUSSION

Paddler Survey - River Trip Report Card (RTRC)

A total of 366 RTRC were submitted for the Red Deer River Basin with 340 for the different reaches of the Red Deer River and 3, 4 and 19 for the Little Red Deer River, Burnt Timber

Creek and Panther River, respectively (Table 1). These response rates were considered sufficient for R-IFN evaluation for the Red Deer River reaches, minimal for the Panther River and insufficient for the Little Red Deer River and Burnt Timber Creek.

The RTRC represented an average of 8 boater days per card. Numbers of boaters were quite consistent across the different river reaches. Large groups along the upper Red Deer River included whitewater raft groups while large groups along the lower Red Deer River included canoe groups on multiple day trips.

There was some variation in the extent of contribution by the RTRC for the Red Deer River. The upper reach of the river was well represented but the transitional reach from Dickson Dam through Red Deer had only 7 RTRC submissions. The lower reach of the river was well represented by the RTRC.

Across all RTRC, approximately one-half indicated that the flows were 'just right'. This probably partially reflected the paddlers' enjoyment of the overall experience. The assessment provided on the RTRC partly reflected the broader recreational experience as well as the particular flow suitability.

For analyses of the RTRC, the upper Red Deer River reach was further broken down into two segments, #1 and #2, upstream and downstream of the Highway #40 Bridge (Figure 2, Table 1). Although segment #1 was fairly well represented, with 40 trip cards, few of these represented trips during low flow conditions. Consequently, the regression analysis was not confident at the lower end of the discharge range and the minimal and preferred flow values are less certain (Figure 5). Segment #2 was well represented through the flow range and this provided a more confident regression analysis (Figure 6). Based on the regressions, the minimal and preferred flows for segment #1 were estimated as 14 and 20 m^3/s while the more confident values for segment #2 were 18 and 26 m^3/s, respectively (Tables 3 and 5). It was expected that similar values would be determined for the adjacent reaches since a single hydrometric gauge was used and the free-flowing reach would have a natural channel geometry. We thus consider that the estimates for segment #2 provide good estimates of the R-IFN values for the upper Red Deer River.

With only 7 RTRC submissions, data were insufficient for the regression analysis for the transitional reach, segment #3. The lower Red Deer River was well represented with 81 and 39 submissions for segments #4 and #5 that were upstream and downstream of Highway #27. While different hydrometric gauges represented these segments, the inflowing tributaries were minor and similar R-IFN values were consequently anticipated. This was observed to be the case as the suitability plots were fairly similar for the two reaches and minimal and preferred flow values were correspondingly similar (Figures 7 and 8). Based on these analyses, minimal and preferred flows were estimated as 25 and 52 m^3/s for segment #4 and 27 and 62 m^3/s for segment #5, respectively. A progressive increase downstream along the river was anticipated as the river gradually increases in size (discharge, Table 1).

Expert Opinion

For the R-IFN approach involving expert opinion, the present study considered the various guidebooks, guide maps and previous studies for rivers in central Alberta (Table 2). Two guidebooks and a set of river guide maps were chosen that included recommendations regarding paddleable flows. However, the categorization of the flow recommendations varied across rivers and was sometimes incorporated into ambiguous text. There was some overlap regarding recommendations since Smith (1996) addressed the upper reach, Roth (2000) addressed the lower reach and Lund (1997) provided information about both the upper and lower reaches.

Despite these ambiguities, the R-IFN values provided by the different guide book and map authors were quite consistent. Lund (1997) provides values based on typical flow patterns and by implication these might be considered as minimal and preferred flows. For the upper Red Deer River, these values were 25 and 30 m^3/s and thus similar to the single value of 30 m^3/s provided by Smith (1996). For the lower Red Deer River, both Lund (1997) and Roth (1999, 2001) provide values of 20 m^3/s as the minimal flow and Lund (1997) further implies a value of 30 m^3/s as a preferred value.

The upper and lower reaches of the Red Deer River are quite different in geographic and recreational context and there are also differences in the relevant flow-dependent characteristics. For the upper reach, flow must be sufficient to provide sufficient depth to adequately cover boulders and other natural hazards. In contrast, the preferred flow along the lower Red Deer River is related to sufficient river velocity to provide a moderate rate of passage, or 'travel time'. Thus, depth is sufficient even below the minimal value but the slow current speed diminishes travel rate and provides paddling conditions vulnerable to upstream winds.

Hydraulic Analysis - the Depth, Discharge Method (DDM)

A number of previous researchers have applied various hydraulic methods for R-IFN analysis. Whittaker et al. (1993) categorized these approaches as 'prediction-based modeling methods'. We determined that the depth discharge method (DDM) was reasonably easy to apply and provided results for streams in the Oldman River Basin that were very consistent with values from various subjective approaches (Rood et al. 2002).

The DDM was applied to the Red Deer for the Below Burnt Timber Creek gauge for the upper reach and for the Red Deer and Drumheller gauges for the lower reach. Interestingly, the values for the upper reach were very similar to those determined for the Drumheller gauge with estimates of about 20 and slightly more than 30 m^3/s for the minimal and preferred flows, respectively. Although the Red Deer gauge is in between the other two hydrometric sites, it provided the most different values with estimates of about 35 and 50 m^3/s for minimal and preferred flows, respectively.

Comparisons across R-IFN Methods

The different subjective appraisals provided relatively consistent recommendations regarding minimal and preferred instream flows for recreational paddling (Table 3). Smith's (1996) and Lund's (1997) estimate for the upper Red Deer River were slightly higher than the value determined by the RTRC analysis. For the lower Red Deer River, the values of Roth (2000) and Lund (1997) were slightly lower than that provided by the RTRC data. Since the RTRC values reflect estimates from hundreds of paddlers, these may reflect a broader range of assessment views than those of the single guide book or map author. We thus consider that the RTRC estimates may be slightly more valid than the values provided by single guide sources. However, the differences were slight and the estimates across the subjective methods were typically within a range of about 25%.

A strength of the depth discharge method (DDM) is that it is based on physical characteristics and avoids subjective valuation. However, this modeling approach would only be useful if the output is consistent with subjective assessment that is the ultimate aim of the R-IFN analysis. This was the case in the present study as the DDM estimates for both minimal and preferred flows were consistently very close to estimates based on the subjective methods. In the prior development of the DDM with the streams of the Oldman River Basin, this hydraulic modeling approach was determined to be inappropriate for large rivers such as the lower Oldman River through Lethbridge (Rood and Tymensen, 2001). It was consequently anticipated that this approach would be unsuitable for the lower Red Deer River. In contrast to this expectation, the DDM values as determined for the Red Deer and Drumheller hydrometric gauges were actually very close to the values determined through the subjective approaches. The DDM values for the Bindloss gauge near the Saskatchewan border were however, inconsistent with determinations from the other gauges or from the subjective methods and this may reflect an atypical site-specific stage-discharge pattern due to the particular channel geometry.

As indicated, the recreational instream flow needs values of the present study were also compared to the recommendations from two prior technical studies. The values of the current analyses were quite consistent with those determined by Bloomfield et al. (1984) as part of the South Saskatchewan River Basin Planning Program. Those values were based on assessments of 'the minimum desirable depth for paddling a canoe', a value of 60 cm. Meetings with canoeists and previous literature further combined to refine the suggested minimal flow requirements. The accuracy of the analyses by Bloomfield et al. (1984) for the Red Deer River is consistent with their accuracy for streams in the Oldman River Basin (Rood and Tymensen 2001, Rood et al. 2002).

The values of the present study are not fully consistent with the values determined by the Wood Bay Consulting Group Ltd. (1994). That study assessed flow suitabilities using a number of cross sections and applied hydraulic depth and width criteria. Surprisingly, the Wood Bay (1994) values varied by more than 6-fold for the lower reach of the Red Deer. Since there are no major tributaries and the longitudinal gradient and channel characteristics are very consistent along the lower reach it would be strongly predicted that the suitable flows for paddling would be quite constant along that reach.

Earlier researchers had investigated the application of simple ratios between paddleable flows and broader hydrologic characteristics, particularly the mean annual discharge (Corbett 1990, Tennant 1976). Rood and Tymensen (2001) also investigated the relationships among rivers in southern Alberta and found there was a very close correlation between mean annual discharge (Q) and the aggregate estimate of minimal flow for recreational paddling along small to mid-sized rivers. This consistency was also observed in the present study for the upper Red Deer River where the aggregate estimate of the minimal flow was about 22 m^3/s, very close to the mean annual discharge of 21.3 m^3/s for the Red Deer River below Burnt Timber Creek (Table 4). With a rounding off to about 10%, either determination would provide the value of 20 m^3/s as the minimal flow for the upper Red Deer River.

For the lower Red Deer River, the mean annual discharge was substantially higher than the minimal flow as determined by either the subjective determinations or the depth discharge method (Table 4). Conversely, the mean annual discharge for this reach was very close to the preferred flow (Table 5). We previously determined that the mean annual discharge provided a close estimate of minimal flow for recreational paddling for small and medium-sized rivers but this relationship was less applicable to larger rivers. This same pattern applies for the Red Deer River with close agreement for the upper reach but reduced agreement for the lower reach.

This relationships between paddleable flows and mean discharge probably result from fundamental proportionality between stream flow and channel geometry. The size of an alluvial stream channel is a particular physical consequence of stream flow and associated with this size, typical depth characteristics will result. It is thus reasonable that basic relationships would exist between typical depth and flow.

TRIBUTARIES

Unlike the Oldman and Bow rivers, there are no large tributaries of the Red Deer River. With respect to paddling use, the Panther River was reported in 19 River Trip Report Cards (RTRC) and is described by Smith (1996) as a grade II whitewater run that is seldom suitable for rafts. There is no hydrometric gauge on the Panther River and consequently paddling suitabilities from the RTRC were plotted versus the discharge of the Red Deer River below Burnt Timber Creek that is downstream from the junction of the Panther and Red Deer rivers (Figure 8). Based on that analysis, minimal and preferred flows were estimated as 17 and 23 m^3/s, respectively. These values are very similar to the estimates for the upper Red Deer River indicating that when flows are suitable for paddling along the upper Red Deer, they will also be fairly similarly suitable along the Panther River for canoes and kayaks.

Smith (1996) also describes Burnt Timber Creek, another tributary of the upper Red Deer River, as a grade II paddle. However, its small size would generally restrict use to canoes and kayaks. Four River Trip Report Cards were submitted for this creek and similar to the conclusion regarding the Panther River these limited data suggest that when flows along the upper Red Deer River are suitable for paddling, Burnt Timber Creek will also be paddleable. Its small size would generally restrict use to canoes and kayaks. This creek has no hydrometric gauge and thus the depth discharge method could not be applied. We might expect that this small tributary would have a much more limited paddleable season than the upper Red Deer River. However, Smith (1996) indicates the paddleable season as May through August, similar to the Panther River and only slightly shorter than the May through September that is recommended for the upper Red Deer River.

The Little Red Deer River joins the Red Deer River shortly downstream from Dickson Dam in the transitional reach (Figure 2). Three RTRC were submitted for the Little Red Deer River reporting that flows were much too low, low, and just right with discharges of 1.8, 8.1, and 10.5 m^3/s, respectively.

The Little Red Deer River should be suitable for the depth discharge method for recreational instream flow needs determination since it has a hydrometric gauge near the mouth. The application of that approach was complicated by insufficient stage and discharge data at the low end of the ratings curve and provided a minimal flow estimate of 16 m^3/s. That value seems very high for a stream with a mean annual discharge of 2.6 m^3/s since for smaller tributaries in the Oldman River Basin, mean annual discharges were very similar to minimal flows for paddling (Rood and Tymensen 2001, Rood et al. 2002). Based on the limited RTRC data we might estimate the minimal flow for the Little Red Deer River as about 8 m^3/s but more data are required for a confident determination.

We did not find information about recreational instream flow needs for the Medicine River or Blindman River, two small tributaries near the City of Red Deer. No RTRC were submitted and although the Blindman River is described in the paddling guide by Travel Alberta (1978) no flow recommendation is provided. The two rivers have mean annual discharges of 3.2 m^3/s (Blindman River near Blackfalds, 1916-1999) and 4.7 m^3/s (Medicine River near Eckville, 1962-1999), and would thus be fairly similar in size to the Little Red Deer River. Since paddleable flows for the small Oldman River tributaries approximated the mean annual discharge, it might be expected that minimal flows for these two small rivers might be about 5 m^3/s.

The Rosebud River is the largest tributary along the lower Red Deer River and we know that it is occasionally paddled and even considered for club trips of the Bow Waters Canoe Club of Calgary. The Rosebud River receives irrigation return flows from the Western Irrigation District that supplement the natural flow and may influence paddleability during the summer months. No RTRC were submitted for the Rosebud River and we are not aware of any expert opinion recommendations regarding this tributary. The mean annual discharge of the Rosebud River is 2.85 m^3/s at Redland (1951-1999, near Rosebud) but this is in the order of 50 km upstream from the river's junction with the Red Deer River. More information is required to determine recreation instream flow needs for this paddleable tributary.

There are also some other tributaries that are probably occasionally or even regularly paddleable. The lack of input into the RTRC program indicate that these are not extensively used by the large paddling clubs but regional residents may use and value the paddling opportunities provided by these smaller tributaries.

CONCLUSIONS AND RECOMMENDATIONS

The present study demonstrated very close agreement in estimates of recreational instream flow needs (R-IFN) for different reaches of the Red Deer River based on different methods. The different subjective approaches generated relatively consistent values that were also consistent with estimates based on a hydraulic modeling method involving a combination of depth criteria and stage-discharge analysis. The consistency across methods strengthens the confidence in the values that were determined. Insufficient data were collected to reveal recreational instream flows for the tributaries of the Red Deer River. Although these tributaries would receive less recreation use than the Red Deer River, they probably offer recreational resources that deserve future study and are probably particularly valued by regional residents.

Acknowledgments

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Table 1. Characteristics of river reaches in the Red Deer River Basin, Alberta.

Segment #	River Reach	Discharge (mean Q) (m^3/s)	Gradient (m/km)	Grade of Difficulty	Hydrometric Gauge[a]	River Trip Report Cards (RTRC) # Cards	# Boaters
	Red Deer River						
	upper reach						
I	Banff Boundary to Highway #40 Bridge	16.4	7.5	II	Below Burnt Timber Cr. (1973)	40	532
2	Highway #940 Bridge to Gleniffer Reservoir	21.3	5.5	II+	Below Burnt Timber Cr.	173	1530
	transitional reach						
3	Dickson Dam to Red Deer	48.7	1.1	I+	Red Deer (1912)	7	36
	lower reach						
4	Red Deer to Highway #27 Bridge	48.7	0.8	I	Red Deer	81	394
5	Highway #27 Bridge to Highway #884 Bridge	56.6	0.4	I	Drumheller (1915)	39	341
	tributaries						
	Blindman River	3.2	0.6	I	Near Blackfalds (1916)		
	Burnt Timber Creek		8.5	II	N/A	4	19
	Little Red Deer River	4.5		I	Near the Mouth (1961)	3	20
	Medicine River	4.7		I	Near Eckville (1962)		
	Panther River		8.0	II	Below Burnt Timber Cr.	19	149
	Rosebud River	2.9		I	At Redland (1951)		
	total					366	3021

[a] This represents the hydrometric gauge used for data analysis for each reach and first year of hydrometric record is included. In the case of the Panther River, the gauge used was located on the Red Deer River.

Table 2. Publications related to recreational paddling in the Red Deer River Basin.

Author	Type	Year	Description
Bloomfield and 5 others	Report	1984	An analysis of preferred river flows for rivers in the South Saskatchewan River Basin based upon hydraulic criteria.
Breeze, R.	Guide Book	1981	Includes maps and characteristics of whitewater reaches. Does not suggest flows.
Lund, M.	Guide Book	1997	Includes river description for paddler; maps, potential hazards, camp sites and flows.
MacDonald, J.	Guide Book	1985	Describes river characteristics and descriptions of features encountered while paddling. Does not suggest flows.
Roth, C.	Guide Map	1999	Guide maps of the Red Deer River from Drumheller to the South Saskatchewan River. Suggests minimum flows.
Roth, C.	Guide Map	2001	Guide maps of the Red Deer River from Dickson Dam to Drumheller. Suggests minimum flows.
Smith, S.	Guide Book	1996	Describes whitewater reaches, as well as the optimal paddling seasons and suggested flows.
Travel Alberta	Guide Book	1978	Describes river reaches of the Red Deer River basin by providing physical characteristics.
Wood Bay Consulting	Report	1994	A hydraulic analysis of preferred flows for a variety of recreational uses along the Red Deer River downstream of Dickson Dam.

Table 3. Minimal flows for recreational paddling along river reaches of the Red Deer River, as determined by various subjective methods. The 2nd to 4th columns are from publications listed in Table 2. RTRC = River Trip Report Card. The averages exclude the Wood Bay Consulting values.

River Reach	RTRC	Bloomfield	Lund	Roth	Smith	Wood Bay Consulting	Average
	m³/s						
upper Red Deer River							
Banff Boundary to Highway #40 Bridge	14		25		30		23
Highway #40 Bridge to Gleniffer Reservoir	18		25		30		24
transitional reach							
Dickson Dam to Red Deer		25	20	20		20 to 40	22
lower Red Deer River							
Red Deer to Highway #27 Bridge	25	30	20	20		10 to 27	24
Highway #27 Bridge to Highway #884 Bridge	27	35	20	20		4 to 27	26

Table 4. Minimal flows for recreational paddling as determined by subjective methods (Table 3) and by the depth, discharge method (DDM), with a depth criterion of 60 cm, along with mean annual discharges and various ratios of these parameters. Q = discharge.

River Reach	Mean Subjective	DDM	Mean Minimal	Subjective/ DDM	Mean Q	Mean Q/ Mean Min.
	(m³/s)				(m³/s)	
upper Red Deer River						
Banff Boundary to Highway #40 Bridge	23		23			
Highway #40 Bridge to Gleniffer Reservoir	24	20	22	1.20	21.3	0.97
transitional reach						
Dickson Dam to Red Deer	22	35	29	0.63	48.7	1.68
lower Red Deer River						
Red Deer to Highway #27 Bridge	24	35	30	0.69	48.7	1.65
Highway #27 Bridge to Highway #884 Bridge	26	20	26		56.6	2.18
average				0.8		1.60

Table 5. Preferred flows for recreational paddling along the Red Deer River as determined by various subjective methods and by the depth, discharge method (DDM) using a depth criterion of 75 cm. RTRC = River Trip Report Card.

River Reach	RTRC	Lund	Smith	DDM	RTRC/ DDM
	m³/s				
upper Red Deer River					
Banff Boundary to Highway #40 Bridge	20	30	30		
Highway #40 Bridge to Gleniffer Reservoir	26	30	30	32	0.81
transitional					
Dickson Dam to Red Deer		30		50	
lower Red Deer					
Red Deer to Highway #27 Bridge	52	30		50	1.04
Highway #27 Bridge to Highway #884 Bridge	62	30			
average					0.93

Figure 2. Map of the Red Deer River and it's tributaries. *= Hydrometric gauges.

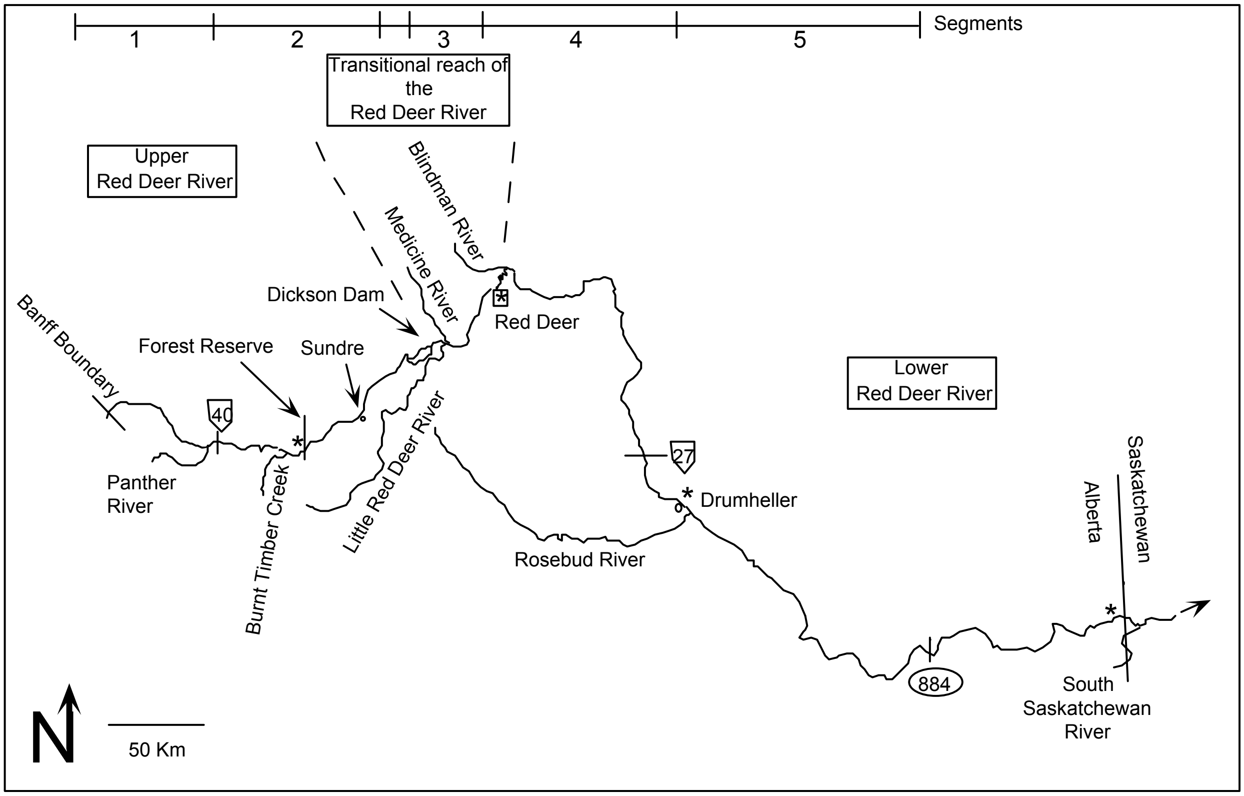

Figure 3. Map of Alberta's ecoregions.

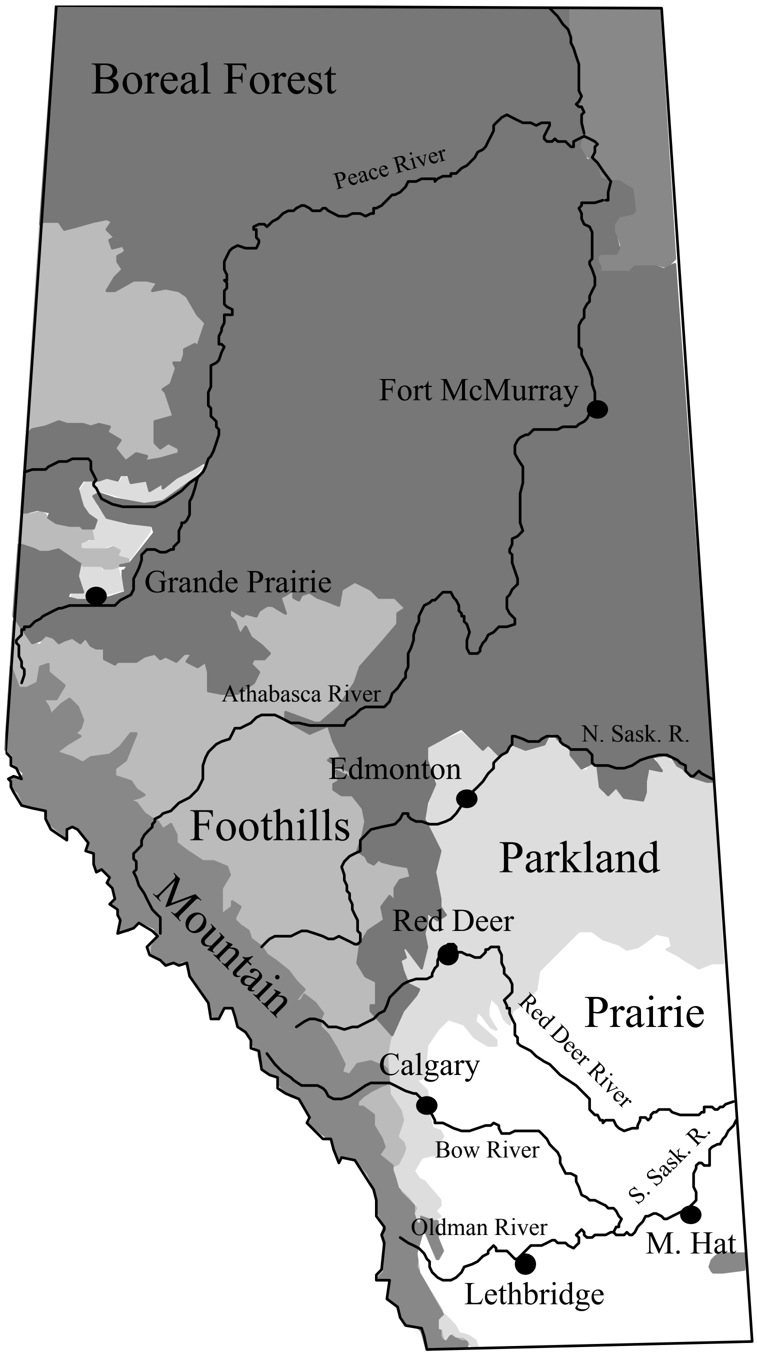

Figure 4. The River Trip Report Card (RTRC).

RIVER TRIP REPORT

RIVER(S)________ PUT IN POINT________ DATE ______ TIME______

PULL OUT POINT ________ DATE ______ TIME______ NO. IN PARTY______

NO. AT EACH SKILL LEVEL: Beginner ____ Novice ____ Intermediate ____ Advanced ____

NO. OF EACH CRAFT: Open Canoe ____ Covered Canoe ____ Kayak ____ Raft ____ Other ____

WATER LEVEL GENERAL: Impossibly Low ☐ Much Too Low ☐ Low ☐
Just Right ☐ A Little High ☐ Much Too High ☐ Dangerously High ☐

WATER LEVEL AT RAPIDS: Impossibly Low ☐ Much Too Low ☐ Low ☐
Just Right ☐ A Little High ☐ Much Too High ☐ Dangerously High ☐

ACTIVITIES: Fishing ☐ Swimming ☐ Camping (locations) ________

Other ________

CLARIFICATIONS AND COMMENTS: ________

04/87/3M

Figure 5. Plotted data for the River Trip Report Cards (RTRC) submitted for the Upper Red Deer River upstream of the highway #40 bridge. The dashed lines represent the suitabilities that correspond with the minimal flows (suitability = 3) and the preferred flows (suitability = 3.5). Additional values were provided for higher discharges but are not included in the plot shown.

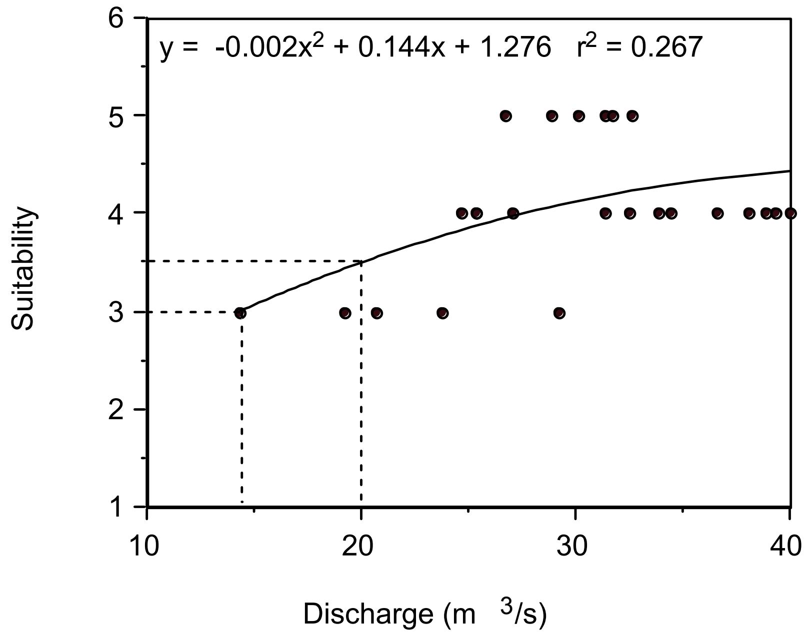

Figure 6. Plotted data for the River Trip Report Cards (RTRC) submitted for the Upper Red Deer River downstream of the highway #40 bridge. Additional values were provided for higher discharges but are not included in the plot shown.

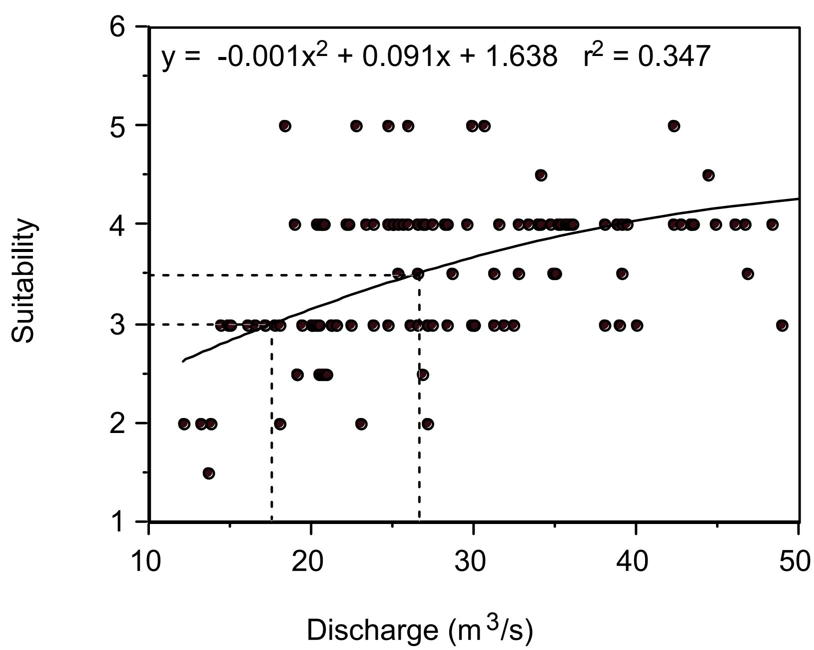

Figure 7. Plotted data for the River Trip Report Cards (RTRC) submitted for the lower Red Deer River reach through Red Deer. Additional values were provided for higher discharges but are not included in the plot shown.

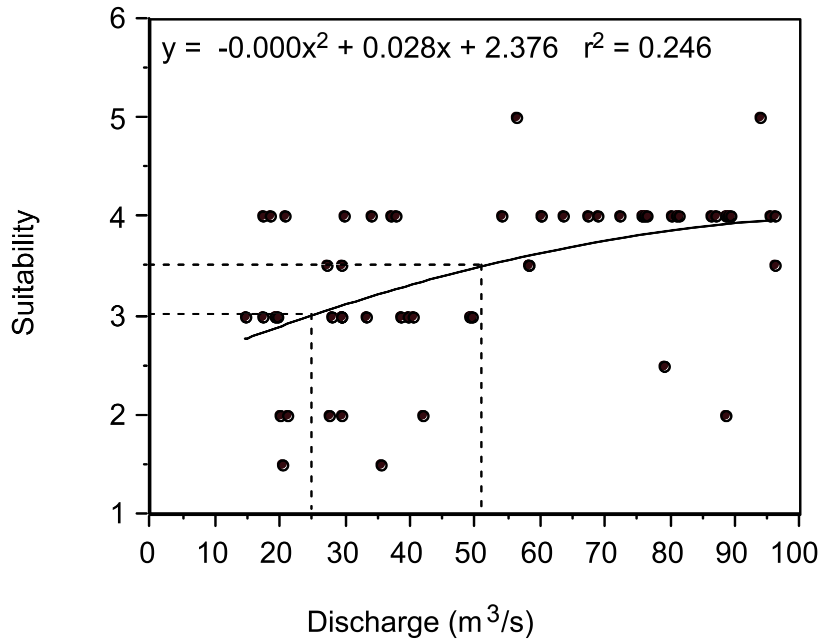

Figure 8. Plotted data for the River Trip Report Cards (RTRC) submitted for the lower Red Deer River reach through Drumheller. Additional values were provided for higher discharges but are not included in the plot shown.

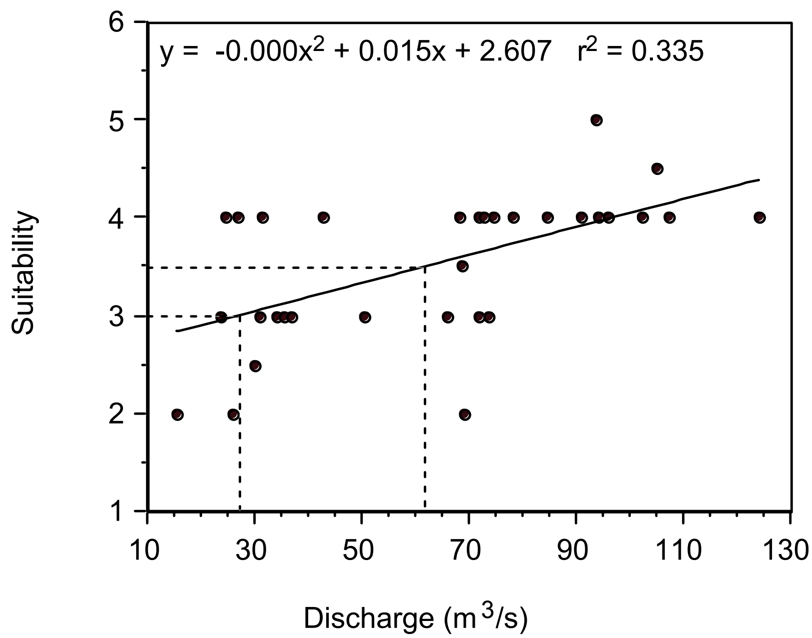

Figure 9. Plotted data for the River Trip Report Cards (RTRC) submitted for the Panther River based upon discharges of the Red Deer River at the Below Burnt Timber Creek hydrometric gauge. Additional values were provided for higher discharges but are not included in the plot shown.

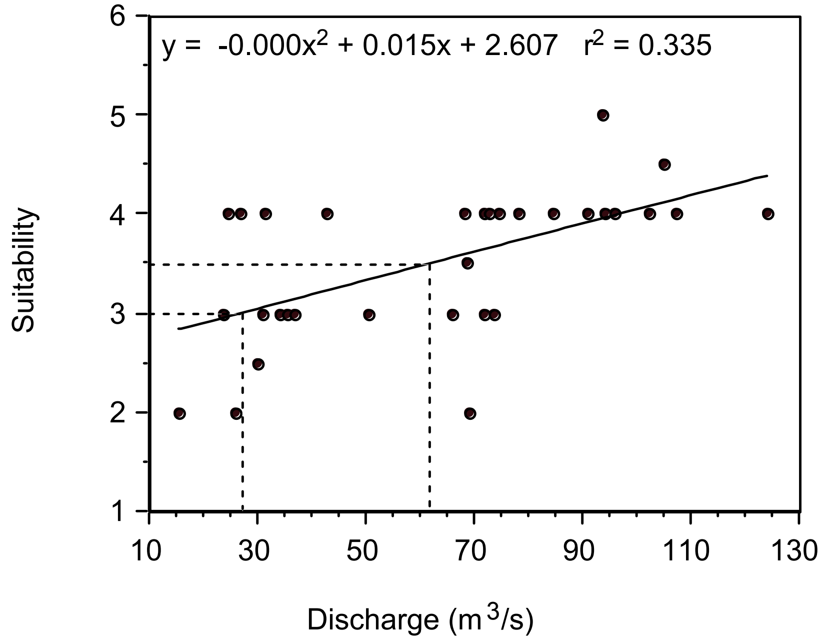

Figure 10. Plotted ratings data for the Red Deer River at the Below Burnt Timber Creek hydrometric gauge. The dashed lines represent the stages (depths) that provide a minimal flow (0.6 m stage) and preferred flow (0.75 m stage).

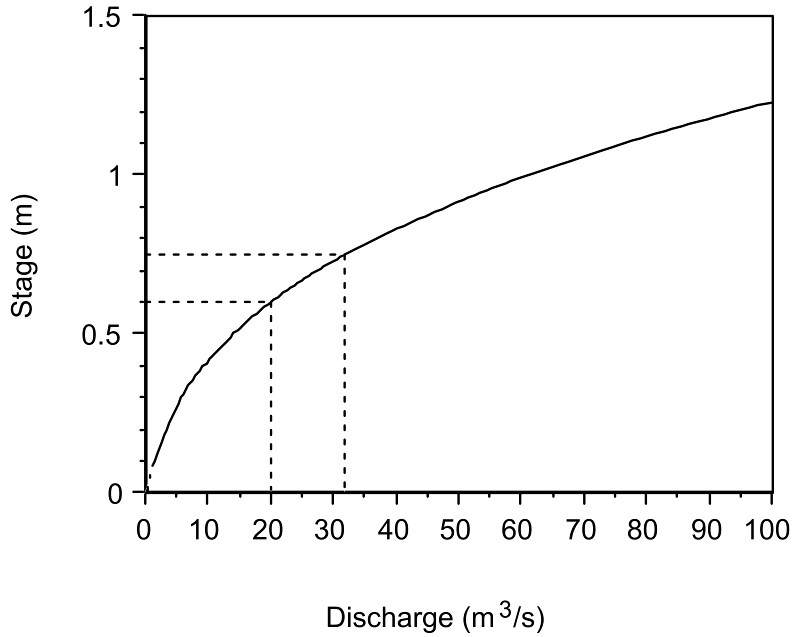

Figure 11. Plotted ratings data for the Red Deer River at the Red Deer hydrometric gauge.

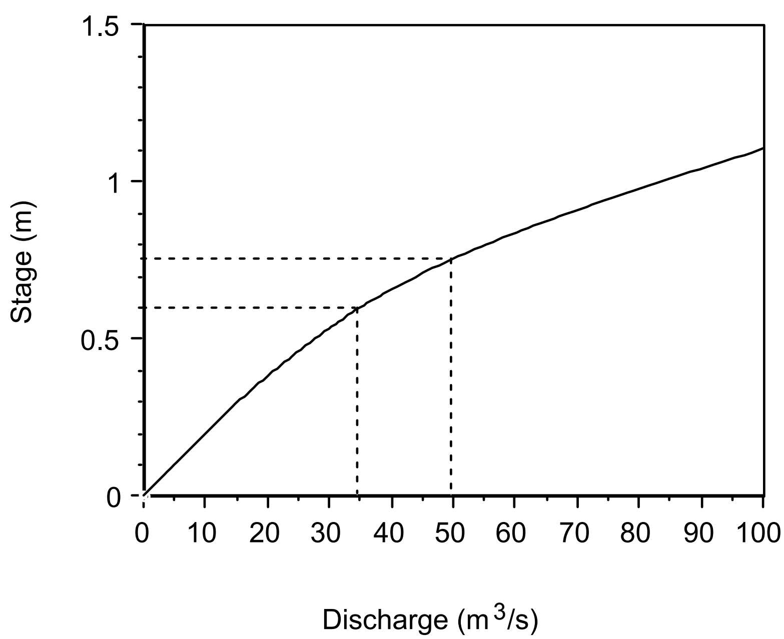

Figure 12. Plotted ratings data for the Red Deer River at the Drumheller hydrometric gauge.

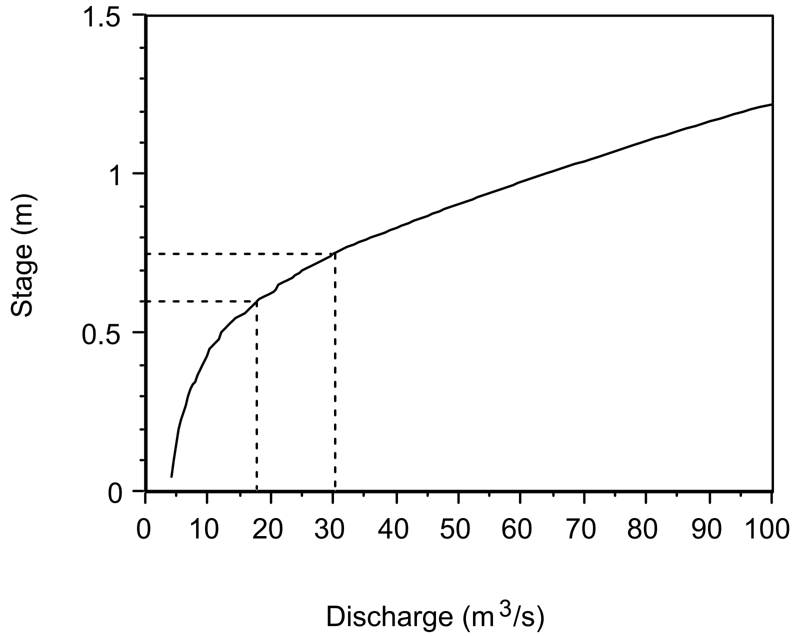

Figure 13. Plotted ratings data for the Little Red Deer River at the Near the Mouth hydrometric gauge.