Chapter Three: The Kennebec River and Edwards Dam

History of the Kennebec River and Edwards Dam

The Kennebec River is one of Maine's greatest waterways. Extending 132 miles from Moosehead Lake in Greenville all the way to the ocean at Popham Beach in Phippsburg, the river has been a source of recreational and economic opportunities for hundreds of years. It is also the largest freshwater supply in the eastern United States north of the Chesapeake Bay (Costenbader, 1998). The river was at one time home to all ten species of migratory fish native to Maine, including Atlantic salmon, American shad, alewives, Atlantic and shortnose sturgeon, striped bass and rainbow smelt (American Rivers et al., 1999).

For the past several thousand years, the Kennebec River has provided its neighboring communities assets in the form of food, water, energy, power and transportation (Kennebec Coalition, 1999). The 1700's and early 1800's were a time of bountiful fisheries on the Kennebec River. Record numbers of salmon, shad and striped bass were caught every year as fishermen, both recreational and commercial, frequented the river. Salmon were so plentiful in the river that some early settlers grew tired of a diet consisting of so much fish (Kennebec Coalition, 1999).

Commercial fisheries on the Kennebec thrived in the early 1800's. Strong markets for Atlantic salmon, American shad, striped bass and smelt secured the settlement of the Kennebec River valley (American Rivers et al., 1999). A report from the United States Fishery Industries recorded numbers of 500 salmon caught in one season, 6,400 shad caught in one day, and 1,000 striped bass caught during a single tide (Kennebec Coalition, 1999).

Then, in 1837, despite opposition from Maine citizens fearing detrimental impacts to the river's fishery, the Edwards Dam was built by the Kennebec River Dam Co (www.americanrivers.org). Twenty-four feet in width and nine hundred and seventeen feet in length, the dam was intended to facilitate upstream navigation, and also provide power to nearby saw mills (American Rivers et al., 1999). Between the years of 1842 and 1846, the dam powered seven saw mills, a grist mill and a machine shop (www.americanrivers.org). Initial construction of the dam also included locks for boat passage and a fish ladder, but the fish ladder was washed away in a spring flood a year later.

Construction of the dam also resulted in an immediate loss of seventeen miles of spawning habitat for migratory fish species. Just two years after dam was built, fish stocks began to plummet. Alewife runs disappeared; salmon populations collapsed; the shad fishery failed; and sturgeon catches dropped from 320,000 pounds per year in the early 1800s to 12,000 pounds (Kennebec Coalition, 1999). One man who reported catching 500 salmon at Augusta in 1838, reported a dozen years later that four to five salmon a year was above average. Barging on the Kennebec was banned in the mid 1800's, so the navigational benefits formerly provided by the dam were nonexistent (American Rivers et al., 1999). By 1867, the commercial shad industry of Augusta had completely failed (Kennebec Coalition, 1999).

The 1900's were a time of declining water quality on the Kennebec. The combination of no pollution controls for paper mills, log drives filling the river with wood and debris, and wastewater and sewage dumping from towns alongside the Kennebec dramatically decreased water quality, and commercial and recreational fishing opportunities. In 1966, it was reported by the Maine

Environmental Improvement Commission that "although the Kennebec has been highly polluted for a number of years, the present day pollution has never been paralleled in its severity" (Kennebec Coalition, 1999).

The late twentieth century saw major improvements to the river. The Clean Water Act of 1972, the banning of log drives in 1976 and state-initiated fish restoration programs all helped to raise water quality (Kennebec Coalition, 1999). Ceased operation of the last mill on the river in the 1980's led to a realization that all of the dam's original purposes had been eliminated (American Rivers et al., 1999). Additional wastewater treatment plants added to the water quality restoration process. Heightened public awareness and concern regarding the past and present effects of Edwards Dam on the Kennebec River fishery led to the creation of the Kennebec Coalition in 1989. It was then that consideration of dam removal began.

Removal of Edwards Dam

The Federal Energy Regulatory Commission (FERC), established in 1977, is an independent agency responsible for the regulation of interstate transmission of electricity, natural gas and oil. FERC also reviews and licenses (or denies licensing of) hydropower projects (www.ferc.gov). When the license to operate the Edwards Dam expired in 1993, FERC was responsible for determining whether or not Edwards Dam would continue to generate electricity. An application for renewal of the Edwards Dam license was submitted by its owners, and review began by FERC in 1995.

The National Environmental Policy Act, originally created in 1969, requires that FERC complete an environmental impact statement (EIS) as part of the dam relicensing process (www.americanrivers.org). An EIS is used by

federal agencies in their decision making processes by incorporating environmental values and the potential environmental impacts of proposed actions, as well as alternatives to those actions (www.epa.gov). The Draft EIS (DEIS) for the Edwards Dam project was issued in January of 1996.

This DEIS included a benefit-cost analysis of the dam removal project. From this benefit-cost analysis, the DEIS recommended relicensing of Edwards Dam with fish passage capabilities. One study which contributed to the recommendation of this DEIS was written by Boyle et al. (1991). The paper concluded that construction of fish passage at Edwards Dam and removal of the dam would provide exactly the same recreational fishing benefits.

Following the DEIS, extensive comments were filed by the Kennebec Coalition. These filings presented information arguing that dam removal instead of relicensing should have been the selected alternative (www.americanrivers.org). These filings were partially based on two papers written by A. Myrick Freeman III (1995; 1996).

Freeman (1995) estimated the economic benefits that would accrue from the removal of Edwards Dam by using the data collected in a survey conducted by Boyle et al. (1991). This study used willingness-to-pay questions to elicit the value Maine resident and non-resident anglers would hold for the fishery in both the scenarios of fish passage construction and complete dam removal. The survey and following report by Boyle et al. along with the two papers written by Freeman are discussed in greater detail in the following section.

Following the comments filed by the Kennebec Coalition, FERC released a final Environmental Impact Statement for the Edwards Dam project in 1997. The final EIS reversed FERC's initial decision, and recommended dam

decommissioning and removal of Edwards Dam (Costenbader, 1998). A settlement was made between the State of Maine and Edwards Manufacturing Co. (dam owners at the time), and ownership of the dam was transferred to the State of Maine on January 1, 1999 (www.americanrivers.org).

The costs of dam removal were then agreed to be borne by upriver dam owners in exchange for a delay in their construction of fish passage (Heinz Center, 2002). In February of 1999, the hydropower generating equipment was sold at a public auction and in late May, mobilization of equipment began for dam removal (www.americanrivers.org). Between July and October, 1999, the dam was removed. In fall 1999, the dam was completely removed allowing anadromous fish species to reach spawning habitat that had been unavailable for the previous 160 years.

A-Priori Benefit-Cost Analysis

The papers that contributed to the eventual removal of Edwards Dam are presented in this section. The Kennebec River Study, administered by Boyle et al. in 1990, provided the necessary data for the resulting report entitled *Economic Benefits Accruing to Sport Fisheries on the Lower Kennebec River From the Provision of Fish Passage at Edwards Dam or From the Removal of Edwards Dam* (Boyle et al., 1991). This study and paper are described here as well as two papers written by A. Myrick Freeman III. Freeman used the data from the survey by and report Boyle et al. in 1995 and then again in 1996.

The Kennebec River Study

The Kennebec River Study was a mail survey sent out to Maine inland fishing license holders. Section A of the survey included questions aimed at the

general fishing activity of the respondent in Maine. These questions reported the first time the respondent fished in freshwater or saltwater in Maine, how often they fished in fresh or saltwater in Maine, the type of water body most often fished by the respondent and which fish species the respondent targeted while fishing in Maine.

Section B questioned fishing effort on the Kennebec River between Milstar Dam in Waterville and Chops Point on Merrymeeting Bay. The respondent was asked if they had fished this section of the Kennebec since 1984 (respondents answering 'No' to this question were asked to skip to section C), the first time they had fished this section of the river and how often they fish this section. The next three questions concerned the section of the Kennebec River between the Milstar Dam in Waterville and Edwards Dam in Augusta; respondents were asked whether they had fished this section (those answering 'No' here were asked to skip the next five questions), why they chose to fish this section, what fish species they targeted in this section of the river and how many trips they took per year to this section.

The next question asked what the respondent's total expenditure was for an average fishing trip to this section of the river was. Responses to this question were broken down into expense categories of transportation, public transportation, food and beverages, lodging, guide fees, bait and other expenses. The next question asked respondents their willingness-to-pay for a fishing trip to this section of the river. The next six questions of Section B concerned the section of the Kennebec River between Edwards Dam in Augusta and Chops Point on Merrymeeting Bay. These six questions were identical to those described above.

The next three questions of the survey concerned the entire stretch of river between Milstar Dam in Waterville and Chops Point on Merrymeeting Bay. Respondents were asked which factors reduced their fishing efforts in this section of the river, what the was the most important factor that would have to change to increase their efforts in this section, and how certain management programs would change their decision to fish this section of the river.

Section C of the survey attempted to find out why respondents did *not* fish the section of the Kennebec between Milstar Dam in Waterville and Chops Point on Merrymeeting Bay. Respondents were asked if they had fished this section before 1984 (respondents answering 'No' to this question were asked to skip to Section D), if they had ever fished this section ('Yes' responses here led to a request to skip the next question), what was the primary reason for never fishing this section, how a set of fishery management options would change their decision to fish this section, and finally whether or not the respondent would ever fish this section. Respondents answering 'Yes' were asked what the most important factor that would have to change for them to fish this section in the future was. Respondents answering 'No' were asked what the most important reason why they would never fish this section in the future was.

Section D of the survey attempted to place a value on improved sport fisheries on the Kennebec River between Kennebec between Milstar Dam in Waterville and Chops Point on Merrymeeting Bay. A brief description of the history of the Kennebec River fishery and how it has changed was given. Then, a paragraph describing the two possible options which would provide upstream passage for migratory fish species were given: construction of fish passage at Edwards Dam or complete removal of Edwards Dam.

Scenario I (fish passage at Edwards Dam) was then presented by describing the intended effect on the Atlantic salmon, striped bass, rainbow smelt, American shad and brown trout populations of the Kennebec River. Fish passage was expected to allow Atlantic salmon to reach substantial upstream spawning habitats by 2002, and could also begin to support an Atlantic salmon sport fishery by 2020. Fish passage was expected to have no effect on the striped bass fishery, no effect on the rainbow smelt fishery, substantially increase the American shad population, and significantly increase the brown trout population.

Next, a description of a theoretical nonprofit corporation whose goal would be to improve sport fisheries on the Kennebec was presented. Respondents were told that the primary goal of this corporation would be to accomplish the objectives of Scenario I.

Respondents were then asked the most they would pay for a supporting membership of this corporation. Next, respondents were asked if they would fish the Kennebec River between Milstar Dam in Waterville and Chops Point on Merrymeeting Bay if the river was improved as described by Scenario I from fish passage. Respondents who answered 'No' were asked to skip the next question. Then, respondents were asked how many trips they would take per year on average to this section of the river if the Kennebec River was improved as described by Scenario I from fish passage.

Scenario II (removal of Edwards Dam) was presented next in similar fashion to Scenario I. Descriptions of the intended effect on Atlantic salmon, striped bass, rainbow smelt, American shad and brown trout populations of the Kennebec River were then given. The descriptions presented here were slightly

different than those of Scenario II. Complete removal was expected to open up substantial spawning habitat for Atlantic salmon, possibly supporting a sport fishery by 2020, increase striped bass spawning habitat from 20 to 38 miles, possibly resulting in a "premier striped bass fishing river …by 2004," significantly increase rainbow smelt populations and reduce mortality rates of American shad resulting in a significant increase in shad populations. This increase in population would lead to an American shad sport fishery starting in 1999. Finally, the removal of Edwards Dam would also lead to reduced mortality of juvenile brown trout and, with increased management, an enhanced brown trout fishery. Following the intended effects of removal, the same questions which followed the description of Scenario I was given. Section D finished with a question asking how important the respondent felt improved sport fisheries for American shad, Atlantic salmon, brown trout, rainbow smelt and striped bass were in their decision to fish the Kennebec River between Milstar Dam in Waterville and Chops Point on Merrymeeting Bay.

Section E concluded the survey and asked the respondent's age, sex, zip code, highest level of education, primary occupation and approximate total 1989 income.

Economic Benefits Accruing to Sport Fisheries on the Lower Kennebec River From the Provision of Fish Passage at Edwards Dam or From the Removal of Edwards Dam (Boyle et al., 1991)

The study described above collected the necessary data for the analysis conducted by Boyle et al. in 1991. The objectives for this research were to "estimate the economic benefits of improved sport fisheries in the lower

Kennebec River watershed with fish passage provided at Edwards Dam in Augusta, Maine; and [to] estimate the economic benefits of improved sport fisheries in the lower Kennebec River watershed with removal of Edwards Dam…" (Boyle et al., 1991: 1). These estimates could then be used in "trade-off analyses designed to determine whether providing fish passage or removing Edwards Dam is economically feasible" (Boyle et al., 1991: 1).

The paper details the surveying method described above, as well as the sample to which the survey was administered to. The survey was sent by mail to samples of resident and non-resident Maine inland fishing license holders. Citing high-costs, the authors did not conduct personal, on-site interviews of the survey. From their survey sample, the authors created two independent samples of licensed resident anglers: "adjacent anglers," anglers who live in communities adjacent to the Kennebec River, and "nonadjacent anglers," those anglers who did not live in communities adjacent to the Kennebec River (Boyle et al., 1991). Nonresident anglers made up a third survey sample group.

Response rates for the study were the following: 72% of adjacent anglers responded, 60% of nonadjacent anglers did, and 67% of nonresident anglers returned their survey. The total combined response rate for the survey was less than 70% however (Boyle et al., 1991).

The survey also returned interesting results in terms of how many anglers fished the Kennebec River. In total, only 43% of adjacent respondents fished the Kennebec River. Even less nonadjacent and nonresident anglers fished the Kennebec; only 7% of nonadjacent anglers fished the river and 5% of nonresident anglers fished it. These fish rates corresponded to 17 and 11 total

individual anglers, respectively. Consequently, Boyle et al. could only characterize fishing data from the adjacent anglers.

These adjacent anglers reported that the five most sought after fish species in the section of river between Milstar Dam in Waterville and Edwards Dam in Augusta were, in descending order, brown trout, largemouth bass, smallmouth bass, brook trout and chain pickerel. In the section of the Kennebec between Edwards Dam in Augusta and Chops Point on Merrymeeting Bay the most sought after fish species were, in descending order, striped bass, rainbow smelt, bluefish, Atlantic salmon and brown trout.

Boyle et al. also derived average direct economic impacts per angler per trip from adjacent anglers to be $9.31 for the section of the Kennebec between Milstar Dam and Edwards Dam, and $16.68 for the stretch between Edwards Dam and Chops Point; these values led to annual direct economic benefits estimate of $79.61 and $104.86, respectively (all dollar amounts reported in the above summary are in 1991 U.S. Dollars). Aggregate annual economic benefits were then made by multiplying these values by the estimated number of licensed anglers fishing the respective stretches per year. Total annual economic impacts by adjacent anglers were then $122,520 from fishing activity between Milstar Dam and Edwards Dam and $303,844 from fishing between Edwards Dam and Chops Point.

Another important set of results from the survey related to the two scenarios described in the survey. Scenario I would provide fish passage at Edwards Dam and Scenario II would remove the dam completely. Mean willingness-to-pay for Scenario I was $15.81 for adjacent anglers, $10.27 for nonadjacent anglers and $5.59 for nonresident anglers. Mean willingness-to-

pay for Scenario II was $15.97 for adjacent anglers, $12.09 for nonadjacent anglers and $10.45 for nonresident anglers. Boyle et al. also note that 41% of adjacent anglers, 60% of non adjacent anglers and 70% of non-resident anglers responded that they would pay $0 for Scenario I. In addition, 45% of adjacent anglers, 62% of nonadjacent anglers and 67% of nonresident anglers would not pay any money for Scenario II.

The most important resulting implication from these findings was a comparison of the values placed by anglers for Scenario I and for Scenario II. Boyle et al. used pair-wise comparison of these mean values to determine the difference in economic value anglers held from fish passage construction and complete removal of the dam. Boyle et al. then concluded that providing fish passage at Edwards Dam and complete removal of the dam would "provide exactly the same sport fishing benefits to licensed Maine anglers" (Boyle et al., 1991: 35).

This is probably the most important conclusion made by Boyle et al. The draft EIS constructed by FERC for the Edwards Dam project used this conclusion in their decision to recommend relicensing of Edwards Dam.

Finally, by multiplying the number of licensed Maine anglers by the survey response rate and then by the aggregate annual economic benefit estimates for each angling group, Boyle et al. concluded that the "aggregate annual benefit of improving sport fisheries … via increased management and provision of fish passage is $1.49 million per year" (Boyle et al., 1991: 37). It should be emphasized that this benefit estimate was concluded to be the same for provision of fish passage or complete dam removal.

The results from this survey led to the Draft Environmental Impact Statement which recommended relicensing of Edwards Dam. This recommendation, as noted above, was very controversial and led to extensive filings of comments. The comments filed in response to this DEIS were based around the conclusions made by Freeman in the papers described next.

The Economic Benefits of Removing Edwards Dam (Freeman, 1995)

In 1995, A. Myrick Freeman III returned to the Kennebec River Survey and the results of the paper produced from the survey to review relevant information regarding the decision of whether or not to remove Edwards Dam. Freeman was asked by the Kennebec Coalition to evaluate the conclusions made by Boyle et al. and certain other issues relating to the economic benefits of removal of Edwards Dam. Freeman wrote that the estimated aggregate economic value of enhanced fisheries due to dam removal as provided by Boyle et al. in 1991 was an underestimate because the survey sample did not include saltwater anglers; their analysis did not identify and exclude protest zeros; and their extrapolation assumed that those anglers who did not respond to the survey held no value for the enhanced fishery.

Freeman further concluded that Boyle et al. did not properly establish there was no difference in value between provision of fish passage and complete removal of the dam. This is an important conclusion, as it refutes the results from the paper by Boyle et al. and is also at odds with the recommendation of the Draft Environmental Impact Statement issued by FERC in 1996.

The basis for this conclusion is detailed in the paper. Freeman cites the proposed changes to the fishery that would result from dam removal as one

factor that may have led to an underestimate of the value from dam removal. He notes that the willingness-to-pay responses to Scenario II (dam removal) may be underestimates because the good which respondents were valuing was one which would not be realized for years in the future. The survey described a salmon fishery that would be restored in 30 years, and a striped bass fishery that would be restored 14 years in the future.

In addition, the survey did not reach those anglers who do not require an inland fishing license. Even though marine fishing does not require a fishing license, marine anglers might place a high value on the improved fishery that would result from the dam removal.

Freeman also notes that Boyle et al. did not attempt to identify and remove protest zeros. A respondent who rejects some aspect of the survey and indicates this by entering a '0' has responded with a protest zero. Inclusion of protest zeros in the calculation of means results in a downward bias.

The above problems, combined with questions concerning the validity of the assumptions of the success of fish passage and also the way in which the two scenarios were described, led Freeman to question the conclusion made by Boyle et al. that there was no statistically significant difference between the mean economic benefits of Scenario I and Scenario II. In fact, Freeman writes, "in my judgment, FERC should not rely on this conclusion in reaching a conclusion on the relicensing issue" (Freeman, 1995: 9).

Freeman's concern with the validity of the fish passage success assumptions are in part based around the premise that Atlantic salmon and shad would have complete fish passage. If this premise did not hold (that is, if

neither, or just one, of these species did not make significant use of the fish passage), then the reported values by Boyle et al. would be an overestimate.

Freeman also notes that the descriptions of the two scenarios (fish passage construction and complete dam removal) made it hard for respondents to distinguish the important differences between them. The main objective of the study by Boyle et al. was to estimate the *difference* in economic benefits that would arise from the two scenarios. The survey did not emphasize the important differences that would occur to the fishery from the two scenarios. The first important difference that was not emphasized dealt with Atlantic salmon use of fish passage. The descriptions of the Atlantic salmon fishery provided were nearly identical and did not include information that fish passage would have a capacity of only 250 salmon per year. Complete removal would have no limit to the amount of salmon that could pass.

Second, the given description for Scenario II (dam removal) stated that removal "…would increase riffle habitat…creating more fishing sites…" Compared to a report by the Maine State Planning Office (1993, 98-100) which stated a 10 fold increase in riverine fishing opportunities for Atlantic salmon would arise were the dam removed, the given description does not accurately depict the extent to which river habitat would be improved. Freeman also emphasizes that because not all of the potential benefits of removing Edwards Dam have been estimated and the measures available (those from the Boyle study and report) did not correspond to the exact resource enhancement that would arise, it would only be possible to place a *lower bound* on the benefits of removing the dam.

Freeman uses the aggregate annual benefit estimate of $1.7 million from Boyle et al., and determines that the present value of a 40 year (starting in 1995) stream of the annual aggregate benefits estimate accruing from dam removal, discounted at 4%, would be $36.4 million. Citing estimates of the cost of replacement energy from the dam, Freeman also states that the environmental costs are less than 1% of the lower bound estimate associated with dam removal. Finally, Freeman concludes that the estimate of aggregate annual economic benefits from removal was an underestimate and that Boyle et al. did not establish that no difference in benefits between fish passage and dam removal would arise.

This paper was completely at odds with the conclusions made by Boyle et al. in 1991 which were used in FERC's Draft Environmental Impact Statement (DEIS). The submission of this paper and the paper described next to FERC led to the reversal of the recommendation provided in the DEIS and eventually removal of Edwards Dam.

Review and Critique of FERC's Benefit-Cost Analysis for the Edwards Dam Project (Freeman, 1996).

The following year, the Kennebec Coalition again retained Freeman's services; this time to evaluate the benefit-cost analysis and other economic information that was presented in the DEIS for the Edwards Dam project issued by FERC in 1995. Specifically, Freeman offered his professional opinion on the following issues related to dam removal:

- Whether or not the benefit-cost analysis for the Edwards Dam project took into account "non-power" economic values.

- If these non-power values were not included in the benefit-cost analysis, was the methodology used in the DEIS valid, in terms of providing FERC and the public with an understanding of the implications of the economic benefits that would arise from dam removal?
- What changes should be made to FERC's benefit-cost analysis concerning non-power economic values?

The benefit-cost analysis provided in the DEIS by FERC contended that the cost of dam removal was roughly twice as costly as relicensing the dam. The benefits and costs FERC used in this analysis, Freeman wrote, were the benefits of the power that was or would be produced by the dam, and the costs of operation and maintenance of the dam (Freeman, 1995: 4). These were the only costs and benefits included in the analysis. Nowhere in the analysis were non-power economic values; i.e. recreational benefits to the public. By excluding these non-power economic values, "FERC makes it literally impossible for the dam removal alternative to ever show a net economic benefit to society" (Freeman, 1996: 5). Failure to include these values was a fatal methodological flaw in the analysis, and was at odds with credible, modern welfare economic theory.

Non-power economic benefits estimates available for the benefit-analysis of the Edwards Dam project could be obtained from the study by Boyle et al. (1991). Here, Freeman cites the study and his 1995 paper as sources to be used in the benefit section of the benefit-cost analysis of dam removal. He again emphasizes that the estimate of $1.7 million dollars was a lower bound estimate for the value of the fishery from dam removal. Freeman also asserts

that FERC has no credible reason to not use this estimate for the annual economic value of the recreational fishery that would arise from dam removal.

Freeman goes on to note some other non-power economic values that could arise from dam removal. He briefly discusses the economic benefits that might arise from increased recreational boating opportunities, but notes that since no data on these values exists, FERC should not attempt to estimate them. Freeman also notes that costs associated with dam removal would arise from fisheries management costs and the cost of burning natural gas as a substitute for the hydroelectric power the dam would have provided.

Another important issue discussed in this paper was the value that should be attached to the alternatives to dam removal proposed and valued in FERC's benefit-cost analysis of the DEIS. Freeman held that the alternatives "Staff Alternative" and "Edwards Revised Proposal," which both would add fish passage technologies, would hold benefits much smaller in comparison to the $1.7 million per year estimate for dam removal.

Freeman concludes his paper by stating that the benefit-cost analysis presented in the DEIS by FERC was critically flawed, and in following, FERC should include the benefits estimate from Boyle's study. Freeman stresses that the estimates made by Boyle et al. represent a lower bound of the economic value of the recreational fishery; the estimates should indeed be used, but as underestimates.

This paper was submitted to FERC, and in 1997 FERC released its final EIS. This EIS recommended decommissioning and removal of the Edwards Dam. The Kennebec River Survey, the resulting report by Boyle et al. and

Freeman's two papers were major contributions to the removal process of Edwards Dam and ultimately led to its complete removal in 1999.

Since removal, there has been no study to determine whether the estimates made by Boyle et al. and then Freeman were credible or accurate. The study at hand is an ex-post analysis of the economic value of the Kennebec River fishery post-dam removal. The survey's methodology and results are presented in the remaining chapters.