Section 9

Intrinsic Benefits

Intrinsic benefits are all benefits that are associated with a resource, which are not specifically related to current direct use of that resource. Although these non-user benefits are not directly observable, it is important to emphasize that they are as real and economically important as the more easily measured user benefits.

Briefly, intrinsic benefits can be categorized as the sum of option (bequest) values, existence value, and aesthetics.[a] Option value is defined as the amount of money, beyond user values, that individuals are willing to pay to insure access to the resource (or a level of environmental quality) in the future when there is uncertainty in resource availability and/or individual use (demand), regardless of whether the individual is a current user. Option benefits reflect the value of reducing uncertainties and of avoiding irreversibilities. When option values reflect intergenerational concerns they are referred to as bequest motives. Bequest values are defined as the willingness to pay (WTP) for the satisfaction associated with endowing future generations with the resource. Existence value is defined as the willingness to pay for the knowledge that the resource is available and ecosystems are being protected, independent of any

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[a] For an in depth discussion of intrinsic benefits and their estimation, see RTI, 1983; Freeman, 1979; Fisher and Raucher, 1982; Mitchell and Carson, 1981.

anticipated use by the individual. These values are distinct from aesthetic benefits and concerns over retaining the option of future use. Aesthetic values pertain to enhanced appreciation of water-related (instream vs. near stream) experiences. Given that improved water quality could enhance the aesthetic values of users as well as non-users of the resources, there could be an aesthetic component in both use benefits and intrinsic benefits.

Definitions of bequest values tend to obscure the distinction between existence and option values in the literature. Sometimes bequest values are placed in a separate category of intrinsic values; sometimes they are treated as part of existence values and at other times they are considered as option values. For example, Freeman (1979) considers the utility of the expectation of future use by descendants as a bequest form of vicarious existence benefits. Yet, bequest values can be considered for long term potential use where there may be uncertainties associated with future demand and supply. Hence, this concept may be treated as part of option value. Mitchell and Carson (1981), for example, separate option value into current and bequest categories.

Although the distinction between user and intrinsic benefits is often unclear, there is substantial agreement that these intrinsic benefits may account for a large portion of all pollution abatement benefits (see Fisher and Raucher, 1982). Intrinsic benefits are usually derived from demand functions. Data for these functions are most frequently obtained from surveys, questionnaires, and voting referenda. Assuming that people are willing to pay for these values, these techniques are intended to yield information on the prices that consumers are willing to pay for cleaner water even though they do not intend to use the resource directly. This generated price information is used to construct demand equations from which the welfare changes associated with cleaner water can be measured. Despite the criticisms leveled at this contingent valuation approach, due to several potential biases, the survey method represents the best available technique to quantify all these benefits.

Property value data may also be used to infer estimates of intrinsic benefits. The property value approach is based on the hedonic valuation method, which relates the price or value of a property to a variety of discrete characteristics. These characteristics include site and neighborhood characteristics, socio-economic factors, and environmental quality variables such as degree of water pollution. A major limitation of the property value technique is that it neglects the benefits to those who do not own property near the affected water body. The approach also records the response of property owners to an actual change in water quality, a change which may not necessarily reflect what property owners would be willing to pay for potential improvements in water quality, or for improved water quality at other locations. As a result, a significant fraction of value, in the form of consumer surplus, may be omitted when applying this technique. In addition, the hedonic approach may produce biased benefit estimates because of the difficulty in disaggregating the benefits between use (recreation, for example) and nonuse. There have been several attempts to model this relationship despite the extensive data required for this technique. One such effort, described in Feenberg and Mills (1980), uses property values derived from a study by Harrison and Rubenfeld (1978).

9.1 Methodology

Intrinsic benefits are difficult to measure and value. A number of studies have attempted to measure intrinsic values using the WTP survey approach. We know of no specific study that can be applied directly to the entire Boston Harbor or that can be associated with the range Of pollution abatement options which accurately relates either dichotomous or incremental changes in water quality to corresponding changes in intrinsic values. The most recent willingness to pay surveys measure benefits to users and non-users of rivers (RTI, 1983; Cronin, 1982) and are inappropriate to apply to a marine resource such as Boston Harbor. The Gramlich (1977) study, which measures willingness to pay for improving water to a swimmable level in the Charles River, cannot be applied to Boston Harbor because Gramlich's bids are averages across both users and nonusers, representing total values, and because the Charles River is not a marine resource.

Other researchers have attempted to establish a relationship between intrinsic values and user values (see Fisher and Raucher, 1982, for a critical review). Results from this approach suggest that intrinsic values are substantial: they generally are at least one-half as great as recreational user benefits. Because of the lack of appropriate WTP survey data which can be applied to the different control options in the study area, estimates of intrinsic benefits were made by assuming that these non-user benefits are one-half as great as recreational user benefits.

9.2 Benefits Estimates

Intrinsic benefits for the CSO and STP pollution control options are accordingly based on one-half the benefit estimates derived from the recreational benefits estimated in Section 6.[a/] These benefit values

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a/ Includes swimming participation (logit model plus Quincy, Weymouth, Hingham, Hull and Nantasket estimates), boating, fishing, and Boston Harbor Islands recreation. For swimming the user day value ($11.06) derived in the logit model is applied to increased user day figures (see text in Section 6 for user day values for other recreational activities).

incorporate both current and future benefits from water quality improvements and are presented in Table 9-1. The range of values represents a very rough approximation of non-user benefits.

Table 9-1
Annual Intrinsic Benefits
(Millions 1982$)

		Pollution Control Option	
		CSO plus Ocean Outfall	CSO plus Secondary Treatment
50% of Recreation Benefits	High:	21.8	23.2
	Low:	10.1	10.7
	Moderate:	15.9	17.0

9.3 Limits of Analysis

Non-user benefits are especially difficult to measure and project, and estimation of these benefits is limited by both methodology and data. Appropriate willingness to pay surveys and property studies were not available to estimate benefits from the variety of pollution control options. As a result, these benefits may be biased because they might be capturing benefits calculated under other categories such as fishing, swimming, or boating (i.e., double counting).

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Section 10
Ecological Effects

Several of the pollution abatement options considered are expected to have a positive influence on the ecological processes in the estuarine areas of Boston Harbor because of significant reductions in pollutant loadings and corresponding reductions in concentrations of fecal coliform, suspended solids, organic toxics, heavy metals, and increases in the level of dissolved oxygen. Implementation of the ocean outfall option is also expected, on the one hand, to beneficially impact the ecological processes in Boston Harbor while, on the other hand, to detrimentally affect the ecological processes in Massachusetts Bay because of removal of pollutants from the Harbor to the Bay.

It is not easy to capture the ecological costs and benefits of these pollution control options because of the lack of information linking pollutant transport and dispersion to specific dose-response relationships, and the difficulty in expressing these changes and effects in monetary units. Therefore, the following discussion of the ecological effects of the different treatment options will be presented qualitatively, as opposed to the quantitative benefits and costs described in previous chapters.

10.1 CSO and Secondary Treatment Options

It is likely that the CSO and STP pollution abatement options will positively influence the biological ecosystem within Boston Harbor, particularly the highly productive saltmarsh habitats. Phytoplankton, benthic organisms and the communities of shellfish, finfish and lobster will be specifically affected. This positive effect will occur because both treatment options will reduce loadings of BOD, suspended solids and fecal coliform to the Harbor area, as well as reducing concentrations of heavy metals (see Table 2-3) and possibly organic toxics such as pesticides and PCBs.[a/] Although none of Massachusetts' major saltmarshes are located in Boston Harbor, it does contain a significant amount of marsh acreage. Quincy Day has 209 areas of saltmarsh, Dorchester Bay 363 acres, Hingham Bay 644 acres and there is also Belle Isle Marsh along the inlet in Winthrop. These marshlands play an important role in the biological productivity of the adjacent coastal waters as well as performing other useful functions. It is well documented (Odum, 1961; Teal, 1962) that these areas are the most efficient primary producing environments on earth and provide natural spawning, nursery and feeding habitat for many species of fish and invertebrates. The sheltered waters and grasses provide food and cover for furbearing animals, shorebirds, and waterfowl, From two-thirds to three-quarters of the commercially or recreationally important finfish, such as herring, striped bass and flounder, and shellfish spend part of their lifecycle in saltmarshes.

Marshlands tran form carbon dioxide water into oxygen and food. They are highly productive of organic matter; because of the tides, wastewater

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a/ In general, the STP secondary option will reduce conventional and non-conventional pollutant loadings to a greater extent than the CSO option, although the greatest difference in reduction are changes in BOD and suspended solids.

products are regularly removed and organic material and nutrients are added. It has been estimated that a saltmarsh produces 10,000 pounds of organic matter per acre per year (Odum, 1961). These lands concentrate and recycle carbon, nitrogen and phosphorus and are important to the global cycles of nitrogen and sulfur. Marsh areas have a very high value as providers of tertiary sewage treatment since they remove and recycle inorganic nutrients.

Saltmarshes are also important for stabilizing the shoreline. They provide a buffer zone which limits coastal erosion by flood, wave, and wind action. Marshes act as reservoirs during flooding and absorb sediments and wave energy during storms which aids in keeping harbors open and in preserving beaches.

Attempts have been made to estimate the economic value of saltmarshes by valuing the productivity of the marsh, by valuing the role of the marsh as a factor of production, and by estimating the cost of duplicating the functions of a marsh, such as providing tertiary wastewater treatment. Annual values ranging from $100 to $4,000 per acre were developed in one study (Gosselink, Odum and Pope, 1973). These types of values have been criticized as representing total value rather than net benefits and much smaller values ($.25-$.30 per acre) were estimated for marsh areas as factors of production (Lynn, Conroy and Prochaska, 1981). Another study points out the many functions of the marsh are not included when only the productivity of the marsh is valued (Westmore, 1977). In any case, if, for illustration purposes, such a range of values is applied to the total marsh acreage of Boston Harbor (1216+ acres), an economic value ranging from $121,600 to $4,864,000 per year is estimated.

Whatever value of marshland is selected, the problem for this case study is determining the impact of the pollution abatement option on the marsh. For the most part, the studies cited above and others are concerned with development that will destroy the marsh by dredging or filling. Here, the concern is with the impact of pollutants (and their abatement) on the functioning of the marsh. It is known that large amounts of untreated organic materials greatly stress marshes and reduce dissolved oxygen to undesirable levels. However, smaller amounts of these materials may enhance marsh productivity. Chlorinated hydrocarbons, and organophosphorous pesticides have been measured in the Harbor in sufficient concentrations to have sublethal or lethal effects on adult crustaceans, larval mollusks and embryonic and larval forms of finfish. Other effects on saltmarsh flora and fauna are unknown.

The proposed pollution abatement options under consideration in this study will control coliform bacteria, pesticides and some heavy metals in Harbor marshlands. The connection between the levels of control and the effect on the functioning of the marshlands, however, is unknown. Since we are unable to measure the extent of the impacts, these marshland benefits must be considered nonmonetizable.

The effects on the plankton and benthic communities throughout the rest of the Harbor generally will be the opposite of those described below for the ocean outfall option. Reduction in conventional loadings may increase species diversity and there will be a shift whereby pollution sensitive-species will replace many of the pollution-tolerant species now dominating the Harbor. These community changes will influence the abundance and diversity of species who feed on these organisms in the lower portion of the food chain, leading to a shift towards pollution-intolerant species. For example, yellow tail flounder may replace winter flounder who prefer organically enriched sites.

Reductions in metals and possibly organic toxicants will have a positive effect on many species in the Harbor, particularly the shellfish and finfish who tend to bioaccumulate toxic substances such as PCBs and organically complexed metals such as mercury and lead.[a] These effects may include a reduction in disease (such as finfish erosion), increases in juvenile survival and increases in productivity and community stability.

10.2 Ocean Outfall Option

The ocean outfall plan is expected to have negative effects on the biological ecosystem of a portion of Massachusetts Hay. As discussed in Section 2 of this report, the pollution abatement plan calls for an ocean outfall diffuser system to discharge the combined, treated effluent from Deer and Nut Island plants into Massachusetts Bay, 7.5 miles (12.1 km) northeast of Deer Island. This discharge area will not provide for sufficient

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a/ It is important to note however, that although the pollution abatement options under consideration will eliminate some of the toxic substances and metals in the Harbor waters, significant concentrations of these pollutants reside in the harbor sediment and are constantly being re-suspended It is not known what the flushing rate is for Boston Harbor but the rate is probably considerably reduced because of the very shallow depths of all the harbor waters. Thus, many of these pollutants will remain in the sediment and water columns for many years to come and continue to negatively affect the ecological communities.

transport and dispersion of the diluted wastewater and particulates because, it is topographically depressed. This, in turn, will restrict circulation and dilution and will lead to an accumulation of BOD and suspended solids, and several toxic pollutants. In addition, the proposed discharge of suspended solids is expected to violate the Commonwealth's dissolved oxygen standard.

Discharge from the proposed outfall is expected to negatively affect the structure and function of many of the components of the marine ecosystem in this area including phytoplankton, benthic invertebrates, and communities of lobster, crab and finfish. It is also possible that several species of whales, including the endangered Right whale, will be influenced by discharge of pollutants into Massachusetts Bay.

10.2.1 Plankton

The proposed ocean discharge of BOD and suspended solids (which include toxic pollutants) is predicted to significantly enrich the waters within the immediate 2.4 square miles surrounding the diffuser and extend to a much larger zone of 166 mi^2 and thus greatly increase the levels of available nutrients such as nitrogen (the most limiting nutrient in marine waters) and phosphorous. Increased amounts of these nutrients will consequently stimulate phytoplankton productivity and lead to increases in phytoplankton biomass, as well as resulting in an adverse shift from pollutant-intolerant phytoplankton to pollutant-tolerant species. The composition and distribution of the zooplankton populations are not expected to be significantly affected because of the increased limited dilution and because the zooplankton community is inherently able to quickly recover from pollutant stress. As discussed in the waiver documents (Tetra Tech, 1980; US EPA, 1983) the most polluted of waters appear to depress numbers of zooplankton without measurably altering species composition or distribution. The only effects from these increased pollutant loadings would be a proportional decrease in actual numbers of individuals of all species.

10.2.2 Benthos

The benthic community in the proposed ocean outfall area is currently dominated by high densities of surface-deposit feeders, to the exclusion of other more pollution-intolerant species. The structure and density of this existing benthic community suggests that the site is already organically enriched. The effect of the large amounts of discharge on the benthic community is predicted to be significant. The additional nutrient levels and decreasing oxygen levels would exceed the assimilative capacity of the community and would result in major structural and functional alterations in the macrobenthos. These include major reductions in total density, species richness, diversity and eveness. Pollution-sensitive species would be greatly reduced or eliminated resulting in a shift to highly pollution-tolerant species. Major effects are likely to appear in the immediate 2.4 square mile area surrounding the diffuser, and moderate effects would extend over a much larger area (166 square miles) of Massachusetts Bay.

10.2.3 Finfish/Lobsters

The proposed ocean outfall option is expected to negatively affect local populations of finfish and lobster for a number of reasons. The anticipated changes in the benthic community are expected to have a negative impact on the finfish and lobster who feed on these benthic organisms. The resulting alterations in diversity and structure of the benthos will reduce the amount of food which is available to the finfish and lobsters (Ennis, 1973) and thus will reduce finfish and lobster population within the immediate zone of intial dilution. This effect may extend over a much larger area of Massachusetts Bay. Lobsters may be more negatively influenced than the finfish by the increased organic loading from the discharge, as was observed near another wastewater discharge north of Boston Harbor (Tetra Tech, 1981).

A slight shift in the distribution and abundance of the finfish community may also occur because of the increased amounts of organic loading. The settling of these effluent solids is predicted to alter the substrate composition of the site to one preferred by winter flounder. As a result, it is expected that the winter flounder will replace other finfish species, particularly the now-dominant yellow tail flounder.

The discharge into Massachusetts Bay will also contain toxic materials including some heavy metals and PCBs. These toxic pollutants can affect marine organisms in a number of ways. Acute exposure can lead to death, while exposure to lower concentrations can induce sublethal effects such as reduced survival of young, lowered resistance to disease and deleterious changes in behavior. These sublethal, chronic concentrations can, in turn, reduce species distribution and abundance.

The toxicity of certain heavy metals is influenced, however, by the chemical form taken by the metal. Acute, short-term effects are more likely to occur when the metals are in ionic form while chronic, long-term effects are most likely to occur when metals are complexed in organic form and are relatively non-ionic. It is in this chemical state that the metals will accumulate within body tissues and can be transferred to other organisms through the food chain.

Bioaccumulation of toxic substances is even more likely to occur with organic toxicants, such as certain types of pesticides and PCBs, because their neutrally charged organic form allow a much easier passage across cellular membranes. In addition, many of these organic compounds are very resistant to degradation. As a result, these long-lasting residues will pass through the food web, ending up in commercially and recreationally important species of fish, and will be transferred to humans when these fish are consumed.

The proposed ocean outfall option will remove about the same percentage of metals, pesticides, PCBs and other toxic materials as does the existing STP (see Table 2-3 in Section 2). This means that metals such as cadmium, chromium, copper, lead, mercury and zinc will, at most, be reduced by 40 percent from their influent concentrations. Based on data collected near the current Deer Island and Nut Island outfalls (US EPA, 1983) annual average concentrations of three metals, copper mercury and silver, were found to exceed EPA water quality criteria.[a/] It was also found that PCBs were appearing in the effluent at 19 to 320 times the EPA criterion. A study of the toxic chemical concentrations in the tissues of lobster and winter flounder near the discharges indicated that PCBs are bioaccumulating in the edible tissues of these species. It was shown, however, that the other chemicals sampled--DDT, mercury, silver, cadmium, copper and lead--were not

a/ (See US EPA, 1983 and 45 Fed. Reg. 79318, November 38, 1980.)

bioaccumulating in fish and lobster tissues, although this does not mean that these organisms are otherwise not being negatively influenced by concentrations in the water column.

Finally, the discharge from the ocean outfall is expected to contribute to the problem of fin erosion in demersal fish. Although the exact cause of fin erosion is not known, there is evidence to suggest that fish develop the disease when they come into constant contact with contaminated sediments, particularly those contaminated with PCBs (Sherwood, 1979; US EPA, 1983). There is evidence that current MDC discharges into Boston Harbor are contributing to fin erosion, particularly in winter flounder, and thus it is likely that the proposed discharge of effluent into Massachusetts will have a similar negative effect in local fish populations.

10.2.4 Endangered or Threatened Species

The ocean outfall option may adversely affect transient threatened or endangered species which appear in or obtain nutrients from the waters of Massachusetts Bay. The affected organisms include several species of whale, and are listed below:

Blue Whale	*Balaenoptera musculus*
Finback Whale	*B. physalus*
Sei Whale	*B. borealis*
Minke Whale	*B. acutorostrata*
Humpback Whale	*Megaptera noveanglias*
Right Whale	*Eubalaena glacialis*
Loggerhead Sea Turtle	*Caretta caretta*
Leatherback Sea Turtle	*Dermochelys coriacea*
Shortnose Sturgeon	*Acipenser brevirostrum*
American Peregrine Falcon	*Falco peregrinus anatum*

All of these species are migratory, particularly the whales who travel from the Gulf of Maine down the coast to Delaware Bay and southward to Georgia and Florida. Two endangered species, the Right and Humpback Whale, and the threatened Fin Whale are known to feed in summer along the shoreline areas of Massachusetts and Gape Cod Bay on their migration along the East coast. Their food sources include fish, krill or related crustaceans, and zooplankton, which, as discussed previously, are likely to be negatively affected by the conventional pollutants or by toxic pollutants discharged into Massachusetts Bay. Although it is impossible to quantify these effects on these species of whale and on the other species, it is likely that heavy metals and the organic toxics will have the most deleterious impacts on these endangered/threatened organisms.

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Section 11
Secondary Effects

The benefits associated with the previously discussed pollution abatement options which accrue from increases in recreational activity, commercial fishing and other activities, are all primary benefits; that is, they are direct impacts of the proposed projects. Another type of benefit--secondary benefits--measures the net increase in economic activity generated by the direct impacts and indirectly attributable to the treatment alternatives. Secondary benefits are added to the primary benefits of a pollution abatement project only if there is widespread unemployment nationally or regionally and only if it is expected that these unemployed resources would be used in the economic activity thus generated. Otherwise, it can be assumed that any increased economic activity stimulated by the project would represent only a transfer of productive resources from one use to another and would not be a net benefit. The rules and procedures governing the inclusion of secondary benefits are found in Section XI 2.11 of Water Resources Council, "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (1983).

These Principles and Guidelines state that conceptually any employment of otherwise unemployed resources that results from a project represents a benefit but that difficulties in identification and measurement may preclude any but those labor resources employed onsite in the construction of the project be counted. For this case study, the construction options have not been sufficiently developed to categorize types of labor resources required. Instead, some of the other indirect employment categories are discussed.

Since unemployment is often cyclical, secondary benefits may not accrue to the proposed projects over the long-run unless structural unemployment (unemployment unaffected by normal cyclical upturns in the economy) is alleviated. A detailed labor market analysis is required to determine the types of unemployed resources that exist and whether the mix of skills required for the economic activity generated by the pollution abatement options would use those resources. Even in a less than full-employment economy, as is currently the case, some resources that would be employed to meet the increase in economic activity would be transferred from other productive uses either within the region or outside the region (e.g. outside Massachusetts or New England). If this were the case, these effects, although they might be very important to the region, would not represent net benefits from a national perspective (unless structural unemployment was affected, as mentioned before). This section, therefore, refers to the indirect impacts attributable to the treatment alternatives as secondary effects and presents a method for their valuation. Under certain conditions these effects may be considered benefits but the labor market analysis required for this determination is beyond the scope of this case study.

11.1 Methodology

Secondary effects can accrue to a region from increased activity in any local industry. For example, additional wages are spent on food, clothes, rent, etc. and increased business production requires additional purchases of materials used in production. These purchases stimulate increased economic activity. For every additional dollar of direct income or of total output (sales) from the industry, a certain dollar amount of associated economic activity is generated; these amounts are known as multipliers for that industry and provide a way to estimate the economic value of secondary effects. Multipliers for estimating increased economic activity in an area usually cover three kinds of effects: direct, indirect and induced. Direct effects are the changes in income to households resulting directly from the changes in output of the industries of interest. Indirect effects are additional economic activities stimulated by the direct impacts of the project, i.e., changes in activity in all industries which supply goods and services to the primary impact industries. Induced effects are those that result when consumers adjust their consumption patterns in response to changes in income. All three effects may be of interest in this case.

Two types of multipliers are used to estimate increased economic activity generated by an industry. The output multiplier is used to compute the total value of economic activity generated. Not all of this value remains in a community or region, however (and, as discussed before, much of it may represent a diversion of resources rather than a net gain). Some goods and services purchased by businesses or by employees are produced locally and others are produced outside the area. The income multiplier measures only the portion of the economic activity generated which remains in an area as income to residents. For the purpose of measuring secondary benefits from pollution abatement options, the best measure would be the output multiplier as we are interested in national welfare rather than regional effects.

To estimate the secondary effects which would accrue to the Boston Harbor pollution abatement options, multipliers are used that have been estimated from economic input-output analyses. Input-output models represent the economy of an area and the transactions which occur among industries located there. From such a model it is possible to estimate the effects of a change in one industry on all the other industries. The advantage of input-output' analysis over other methods of estimating multipliers is that it provides both comprehensive and detailed coverage of the industries of interest.[a/] The disadvantage of this and other methods is that only gross changes are estimated; net effects exclusive of transfers of resources are not measured.

11.2 Benefit Estimates

The multipliers used to estimate secondary effects should correspond to the type of data available on the impact of the pollution abatement options. In this case, it is easier to estimate the impact on the output (sales) of an of an affected industry (such as shellfishing or boating) than to estimate the impact on direct income (wages). Thus, the multipliers shown in Table 11-1 estimate the total direct, indirect and induced effects of a one dollar change in the sales of each impacted **industry.**[b/]

A range of multipliers has been included in Table 11-1. The multipliers for the shellfishing and related industries come from three studies, one of Cape Cod, one of the Southern New England Marine Region (SNEMR), including Rhode Island, Cape Cod and parts of Southeastern Massachusetts and Connecticut, and one of the State of Maine (Cape Cod Planning and Economic

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[a/] Other types of multipliers have been developed. For example, E. Wong (1969) has estimated a multiplier for shellfish which computes the value added by harvesters, wholesalers and retailers both inside and outside the community. This kind of multiplier would not capture the indirect or induced effects of the shellfish industry the way an input-output derived multiplier would.

[b/] They could be converted for use with direct income impact data by dividing by factors which show the effect on direct income of a one dollar change in output for each industry.

Table 11-1

Multipliers Showing Direct, Indirect and Induced Effects
Per $1 Change in Output

Industry	Cape Cod Study Income Multipliers	Cape Cod Study Output Multipliers	SNEMR Study Income Multipliers	Wisconsin Study Output Multipliers	Maine Study Income Multipliers
Commercial Shellfishing	1.1749	3.0010	1.1441	-	1.54
Fish Processing	-	-	.7027	-	
Clam and Worm Processing	-	-	-	-	1.65
Shellfish Whole-saling	1.0772	3.6444	-	-	-
Seafood, Whole-saling and retail	-	-	.7781	-	-
Eating and Drinking Establishments	.5158	2.0179	.7997	2.2705	-
Marinas and Boatyards	.6829	2.4971	.7037	-	-
Charter Sport-fishing	.9038	2.8200	.7982	-	-
Tourist[a]	-	-	-	2.1741	-

[a] Weighted average of impacts of tourist expenditures on all industries.

Sources: Briggs, Townsend and Wilson, 1982; Cape Cod Planning and Economic Development Commission, 1978; Grigalunas and Ascari, 1982; Strang, 1971, Development Commission, 1978, Grigalunas and Ascari, 1982, and Briggs et al., 1982).[a]

Both output and income multipliers are available from the Cape Cod study while only income multipliers are available from the SNEMR and Maine studies. As can be seen from the table, the Cape Cod output multipliers are about three times greater than the income multipliers for the same study. Although it was not possible to calculate output multipliers for the SNEMR or Maine studies because of lack of data, the difference between income and output multipliers would be less for these studies than for the Cape Cod study. The reason for this is that both the State of Maine and the SNEMR region are larger and more self-sufficient and would therefore retain more earnings and import fewer goods and services.

There were no input-output analyses available for marine activities in the Boston area. Since the structure of harvesters, wholesalers and retailers of soft shelled clams in the Boston area is probably similar to those of Maine, Cape Cod and the SNEMR, the multipliers presented in Table 11-1 can be used to provide a range of secondary effects estimates for the pollution abatement options as shown in Table 11-2.

Although, as mentioned earlier, income multipliers measure only income remaining in an area and, therefore, understate the total national welfare impacts of the pollution abatement options, they are included as part of the range in Table 11-2 for two reasons. First, Boston area output multipliers

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[a] Multipliers from two other input-output analyses, an earlier SNEMR study and a Rhode Island study, were presented in Grigalunas and Ascari. Unfortunately, they were of the form that is multiplied by direct income rather than by sales, and data were not available to convert them to the form useable here. In the form that they were available, however, these multipliers fell between the Cape Cod and SNEMR figures, and so would probably lie within the range shown in Table 11-1.

Table 11-2. Secondary Effects Estimates
(Thousands $1982)

Industry	Estimated Change in Sales for Each Pollution Abatement Option (Thousands 1982$)				Multiplier Range ($)	Secondary Effects Range for Each Pollution Abatement Option (Thousands 1982$)			
	CSO			STP		CSO			STP
	Constitution	Dorchester, Neponset	Quincy	Ocean Outfall or Secondary		Constitution	Neponset/ Dorchester	Quincy	Ocean Outfall or Secondary
Commercial Shellfishing									
Harvesting	94.2	149.2	72.1	885.6	1.14-3.00	107.4- 282.6	170.1- 447.6	82.2-226.3	1,009.6- 2,656.8
Distribution and Processing a/	74.0	117.2	56.7	695.8	0.70-3.64	51.8- 269.4	82.0- 426.6	39.7-206.4	487.1- 2,532.7
Restaurants a/	104.3	165.2	79.8	980.3	0.80-2.02	83.4- 210.7	132.2- 333.7	63.8-161.2	784.2- 1,980.2
Subtotal	272.5	431.6	208.6	2,561.7	-	242.6- 762.7	384.3-1207.9	353.8-583.9	2,280.9- 7,169.7
Recreation									
Swimming b/	103.3	704.7	540.1	111.6	0.80-2.27	82.6- 234.5	563.8-1,600	432.1- 1,226.0	89.2-253.3
Other b/				201.6					161.3-457.6
Boating c/	- - - - - - - - - - - - - - - - 538.6-1,457 - - - - -				0.70-2.50	- - - - - - - - 377.0-3642.5- - - - - - - - - - -			
Fishing c/	- - - - - - - - - - - - - - - - - 29.9-949.3				0.80-2.82	- - - - - - - - - 23.9-2,677 - - - - - - - - - - -			
Subtotal d/	103.3	704.7	540.1	313.2	-	82.6-234.5	563.8-1,600	432.1- 1,226.0	250.5- 710.9
TOTAL d/	375.8	1,136.3	855.6	2,874.9	-	352.2-997.2	948.1- 2,807.9	785.9- 1,809.9	2,531.4- 7,880.6

a/ Sales per bushel for Distribution and Processing and Restaurants assumed to maintain the same relation to harvest sales per bushel for Boston Harbor as for Resources for Cape Ann study.

b/ $1 per visitor-day assumed spent on food and beverages. Visitor days are average of upper and lower bounds for swimming from Table 6-6 and for "other" from Table 6-12.

c/ Ten percent of boating and fishing benefits (see Section 6) assumed as sales for marinas and boatyards and for charter sportfishing, respectively. Based on Table 6-10 (boating) and 6-11 (fishing).

d/ Not including fishing and boating sales and secondary effects.

would probably be closer to Boston area income multipliers for the same reasons as mentioned above for Maine and the SNEMR. Second, as discussed above, even in a less than full-employment economy, some resources that would be employed to meet the increases in economic activity generated by the pollution abatement options would be transferred from other productive uses and thus would not represent net benefits. A multiplier which underestimates secondary effects is therefore appropriate.

Besides secondary effects generated from increased shellfish harvesting, a certain level of economic activity may also be stimulated in the distribution and processing and restaurant sectors for each additional bushel harvested. m estimate these effects it was assumed that the level of sales generated in the distribution and processing and restaurant industries as compared to the harvesting industry would be the same for Boston Harbor as for the Cape Ann area (see Resources for Cape Ann, 1982) and that this relationship would be maintained across price changes.[a/][b/] Since Boston is a major market area for shellfish, this is a conservative assumption. Secondary effects can therefore be estimated for these two industries as well as for harvesting.

Recreation multipliers in Table 11-1 come from the Cape Cod and SNEMR studies and, for comparison purposes, from a study done for a county in Wisconsin which has a significant tourist industry (Strang, 1971). This study was included because there is no data available on sales generated by swimmers

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[a/] Thus, at a price of $31.41 to the digger, for example, each bushel of clams harvested would generate $90.86 of sales (total sales divided by number of bushels harvested). Of this, $31.41 would be harvesting sales, $24.68 distribution and processing sales, and $34.77 restaurant sales. These per bushel sales figures are multiplied by the increased harvest to estimate the changes in sales shown in Table 11-2.

[b/] The $31.41 per bushel harvest price and the other per bushel sales figures given in footnote [a/] are prices for 1980 from Resources for Cape Ann, 1982, updated to 1982 prices using the soft shelled clams price index from National Marine Fisheries Service, NOAA, 1982.

argued that secondary effects should not include direct income effects. If this were the case, then the shellfish harvesting secondary effects estimates shown in Table 11-2 would be reduced by about 60 percent, the related shellfish industries by approximately 20 percent and the recreation activities by around 50 percent. However, it does not appear that the direct income effects would be double counting either the willingness to pay for improved recreation experiences or the changes in producer or consumer surplus due to increased shellfish harvest.

In evaluating the range of secondary effects estimated in Table 11-2, and in addressing the question of whether and how much of the secondary effects should be added to the primary benefits to derive the total benefits associated with each pollution abatement option, the important consideration is the level and type of unemployed resources assumed. If there is widespread, long-term unemployment, then the full amount of the secondary effects could be counted and the upper bounds in Table 11-2 used. If there is a full employment economy, then secondary benefits would be either zero or the difference between the value that the resources currently earn compared to what they would earn if they were employed in activities stimulated by the abatement option, if these values are different. As mentioned above, the kind of detailed labor market analysis that would be required to estimate this difference is beyond the scope of this study. If some unemployment exists as is the present situation and if a labor market analysis showed that it was likely to be long-term and composed of the skill levels required by the economic activity generated, then the lower bounds in Table 11-2 may be the best estimates to use and would represent a moderate benefit level.

11.3 Limits of Analysis

The major problem in carrying out this analysis is determining whether the secondary effects that can be estimated should be counted as benefits and added to the primary benefits of the pollution abatement options. The data are lacking to estimate the degree to which resources required for the increased economic activity generated by the pollution abatement options would be otherwise productively employed in the long run. Since we are interested in estimating net benefits, transfers of resources already occupied to activity stimulated by the pollution abatement options should not be counted. Even given high unemployment as is the case in the current recession, it is difficult to appropriately handle this problem.

Another limitation of this analysis of secondary effects is the lack of an input-output model of marine related activities for the Boston area. A related problem was the lack of data to compute output multipliers for the SNEMR. The availability of these data would have produced a better range of estimates of secondary effects.

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Section 12
Charles River Basin Benefits

The Charles River Basin has been designated by the MDC as one of the four CSO planning areas. The Charles River Basin includes the Rack Ray Fens, the Muddy River, Alewife Brook and the Charles River itself. The basin is mixed fresh and salt water and is used primarily for non-contact recreation, both on the water and at the water's edge. There is little or no fishing in the Charles River Basin. The Charles River is the major water resource in the Charles River Basin and draws the greatest number of recreators. For this reason, as well as data limitations, we have chosen to estimate benefits only for the Charles River.

12.1 The Charles River

The Charles River is 80 miles long, with a watershed of 300 square miles. The portion of the Charles that is contained in the Charles River Basin CSO planning area runs from the Watertown Dam to the Charles River Dam near the mouth of Boston Harbor (see Figure 12-1). This section of the River has an average annual level of 2.38 feet, and contains approximately 675 surface acres of water. The length of the River within this stretch is 8.6 miles. The Charles River is an important water-based recreation resource, especially to the towns through which it flows. Although there is currently little swimming in the river (and none predicted with the proposed CSO plans), the river plays host to a variety of boaters. Sailing and motorboating are extremely popular, especially at the wider portions of the river, near the Harbor. There is also a significant number of people who

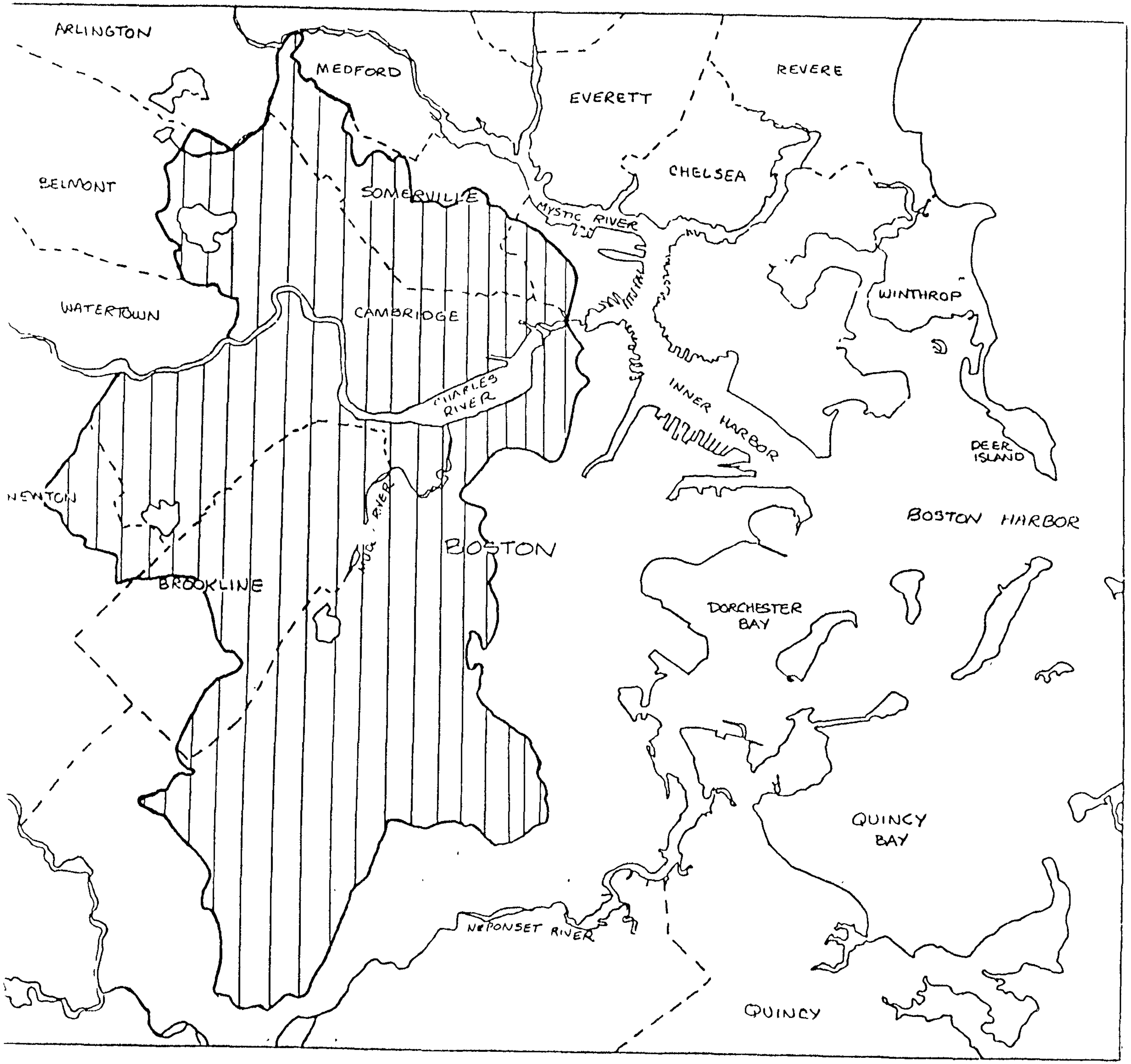

Figure 12-1. Map of Charles River Basin

Charles River Basin Planning Area

scull on the Charles. Every major college and university in the Boston area has a boat house along the river; their crew members practice almost daily during the spring and fall months. The river is also an aesthetic focal point for other recreation-based activities. An MDC bikeway follows the course of the river and doubles as a running path. Picnickers, sunbathers, and strollers also take advantage of the open space provided by the river. Major cultural events such as crew regattas, formal and informal concerts, and city festivals take place along the river's edge and attract thousands of residents and sight-seers.

The Charles River violates the state water quality standards. Those standards (a rating of "C") allow non-contact recreational use. The river is polluted with extremely high levels of coliform counts, odors, floatables, debris, and turbidity. The recommended CSO plan (see Section 3.5) includes capturing, transporting, and storing overflow from the CSOs and is predicted to result in 50 to 80 percent removal of suspended and floatable solids, coliforms and BOD_5. Water quality will improve greatly although swimming will still not be permitted.

It is difficult to quantify the instream and near-stream user benefits to be gained from improving the water quality in the Charles because of data and methodological limitations. Unlike swimming benefits, there are no good travel models or data available to predict how user participation and utility will increase. There are also few intrinsic value studies which are applicable to the Charles River area. We have chosen two techniques and two studies to evaluate user and non-user benefits from abating pollution along the Charles River. User benefits to boaters are estimated using a boating participation model developed by Davidson _et al_. (1966) while both intrinsic and user benefits are developed by applying results from a contingent valuation survey (RTI, 1983).

12.2 Boating

The effect of water quality on the level of recreational boating has been studied. The results of the Davidson _et al_. study (1966) show that the number of participants within a given population as well as the number of days of boating participation per year show significant increases with improvement in the quantity and quality of available waters. Davidson's approach to estimating boating-related benefits includes calculating (a) the change in the probability of boating participation among the general population as a result of improvement in water quality and availability and (b) the change in number of days of participation per year. The Davidson model attributes most of the benefits of water quality improvement to new participants. It does not capture any benefits accruing to current boaters. The Davidson model estimated, in a study of the Delaware Estuary, that each increase in recreational boating water of one acre per capita resulted in a 38 percent increase in participa- tion rates (i.e., the probability of an individual participating in boating increased by 38 percent). The portion of the function describing boating participation, which is applicable to this study, can be expressed in the following reduced form:

$$BP = 0.38485(\Delta W) + 0.03142(\Delta FPS)$$

where : BP is the probability of boating participation
w is the per capita acreage of recreational water available
FPS is the recreational facility rating.

The FPS variable represents an index of the quality of boating facilities. A rating of "1" implies "no facilities," while a rating of "5" suggests "very good facilities."[a] Socioeconomic variables were included in the regression, including education, income, occupation, age, and race, but were not well correlated with boating participation. Davidson et al. also assumed that elimination of pollution discharges into the Delaware Estuary would produce a minimal one point improvement (from 2.0 to 3.0) in the FPS rating.

12.2.1 Methodology

It is possible to apply this model to the Charles River. Estimation of boating-related benefits involves the following steps:

a. Estimate the increase in recreational boating water and boating facilities from improving water quality in the Charles River as a result of implementation of the CSO plan;

b. Estimate the change in the probability of boating participation in the general population as a result of improvement in water quality and availability of boating facilities;

C. Estimate change in total participation attributable to water quality improvements;

d. Estimate the value of the additional boating days.

The first step involves estimating the increase in recreation boating water (ΔW) and facilities (ΔFPS) as a result of improving water quality. Although ΔW is the key explanatory variable in the Davidson equation,

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[a] Davidson et al. used fishing facilities rather than boating facilities because the former were not available for their sample area.

the value of the variable is quite small for the Charles River. The Charles River has only 675 acres of water available for boating of all kinds. Although the Charles is polluted, there appear to be few portions of the river which are unboatable because of pollution. Therefore, the change in acreage of recreational water available per capita following water quality improvements is essentially zero. Although this assumption of zero change in water acreage might appear to be too conservative, even if we were to assume that all 675 acres of the river were previously unboatable, a ΔW of 675 acres would only lead to a very small per capita acreage increase of from 0.0317 to 0.0318.[a/] It is, therefore, apparent that the variable FPS will have the greatest effect on predicting the change in boating participation. Davidson *et al.* assumed that eliminating pollutant discharges into the Delaware estuary would produce a minimal one point improvement in the recreational facilities from a rating of "2" to a rating of "3." The same assumption was used for the Charles River, that ΔFPS is 1.

Calculating the total additional boating days requires information on current boating use of the Charles River. As described in the swimming section, recreation statistics on attendance and days per participant are not officially recorded by the MDC. We have, therefore, used a number of sources to estimate a range of boating participation on the Charles. Information from a study by Binkley and Hanemann (1975) indicates that 850 visits were made to two sites along the Charles River during the summer season, and that 5.6 percent of the visits were boating-related. Results from the study

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a/ Depending on a range of 183,000 -1,680,800, boating participants as described in Appendix E.

suggest that it is correct to assume that the survey sample was statistically representative of the entire Boston SMSA. These 850 survey visits can be extrapolated into 68,000 family visitor days and approximately 183,000 visitor days (see Appendix E). This is probably an understated estimate because only two sections of the entire length of the Charles River were sampled.

An alternative method is to apply the approach used in the previously-described swimming section which is based on regional recreation studies. This method assumes that (1) 40 percent of the population goes boating, (2) a user population of 764,000 (see Appendix E for details), and (3) users go boating an average of 5.5 days per year. The resulting boating days are 1,680,800. The Binkley-based estimate of 183,000 vistor days is used as a lower bound, and the recreation study-based estimate of 1,680,800 is used as an upper bound. The lower bound estimate appears to be the more reasonable.

Additional boating days can be estimated multiplying the previously derived ΔW and ΔFPS value by the estimated number of general population boaters (see Appendix E for details). The increase in visitor days ranges from 5,750 to 52,810.

12.2.2 Benefit Estimates

Boating benefits from improved water quality resulting from implementation of CSO plans can be estimated by valuing the increase in visitor days developed and described above. The range of user day values that have been developed for boating are presented in Appendix B (Table B-1)[a]. By applying this range of values ($9.27-$18.14) to the projected increase in boating days, we can arrive at an estimate of boating benefits, presented in Table 12-1.

Table 12-1. Annual Recreational Boating Benefits

(1982$) $/Boating Day	Number of Additional Boating Days	Total Annual Boating Benefits (Thousands 1982$)
High 18.14	52,810	958
Low 9.27	5,750	53

Boating-related benefits from improving water quality on the Charles River are modest because the estimated increase in number of boating days is small and because boating day values which are applicable to this study represent the lower, rather than upper, end of the range of user-day values.

12.2.3 Limits of Analysis

Calculation of boating-related benefits is limited by the methodology employed, the data base, and the numerous assumptions made. The application of the Davidson *et al.* boating model may lead to biased benefit estimates. First, the model only measures benefits which accrue to new participants and does not capture benefits of increased participation or increase in utility

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[a] We have chosen not to use the boating value of $45.19 derived from the NPA in conjunction with Charbonneau and Hay because we believe that it overstates the particular value of boating on the Charles River. This is because the greater portion of boaters who use the river do so in small-powered craft (such as sculling shells, kayaks, small sailboats, canoes, and low horsepower motor boats), rather than large-powered craft.

to existing users. Second, the model may not, for a number of reasons, be easily applied to an urban area. The key explanatory variable in the model is the supply of boatable water that is expected to increase following water quality improvement. In the case of the Charles River, the value of this variable is extremely small because virtually all 675 acres of river are currently used for boating. Even assuming that all acres were previously unboatable, the increase of 675 acres would only lead to an increase of 0.0317 acres per capita and, therefore, would account for only an 0.012 change in boating participation. The second variable in the model--change in recreational facility rating--then becomes the key explanatory variable of the increase in boating participation. There are few places along the urbanized riverfront of the Charles available for development or expansion of marinas and, thus, we have assumed that the one point change in facility rating reflects the improvement in boating facilities. This assumption, however, is difficult to verify.

Other problems with estimating boating benefits from CSO pollution control plans along the Charles lie in the available recreational data. There is scant information about days of boating participation along the Charles and the percentage of the entire population in the Boston Metropolitan area who boat there. The use of user-day values is also likely to bias the benefits estimates. The lower range of available user day boating values ($9-$18/day) was used to calculate benefits because of the nature of boating (in non-motorized and small-powered craft) on the river.

12.3 Intrinsic (Non-User) and User Benefits

An alternative method for computing the benefits from CSO pollution control plans on the Charles River is to apply the results of a contingent valuation survey, which captures the amount users and non-users are willing to pay for improved water quality. As mentioned previously, the Charles River is a major aesthetic focal point for recreation-based activities. It is difficult to estimate the exact number of people who are not direct users of the River but who, instead, ride, picnic, run, or stroll along the Charles' shores. It is safe to assume, however, that there are probably few families or individuals in the towns through which the river runs who have not enjoyed the river at least once. Calculating benefits which accrue to these "non-users" is a necessary part of developing total benefits.[a]

We have chosen the results of a contingent valuation survey described in detail in RTI (1983) to capture instream, near-stream and intrinsic benefits from improving water quality through upgrading CSO's in the Charles River Basin area. A study conducted by Gramlich (1974) to determine the willingness to pay for improving water quality in the entire 80 mile length of the Charles River was not considered applicable here, because the survey only recorded results for willingness to pay for obtaining a swimmable level of water quality (classification "B"). The CSO plans and their costs have been developed only for improving the river to a level "C," or boatable use. Also, the results from the Gramlich study cannot be disaggregated by user and non-user.

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[a] For a discussion of non-user (Intrinsic) values and estimation methodology, see Section 9.

12.3.1 Benefit Methodology and Estimates

Estimates of willingness to pay for improving Charles River water quality can be derived by applying the results of a study conducted by RTI, along the Monongahela River in Western Pennsylvania. The RTI study used a contingent valuation approach to measure willingness to pay for improved water quality. Results from the RTI study suggest that user and non-user households are willing to pay $18.68 (1982$) for water to go from boatable to fishable conditions.[a/] In order to calculate total benefits, it is necessary to multiply this dollar WTP value per household times the regional household population.

For the Charles River area, an upper bound was established by including residents of towns bordering or very close to the Charles River: Cambridge (95,000), Somerville (77,000), Watertown (34,000), Newton (83,000), Brookline (55,000), Boston, (560,0000) or a total of 905,000.[b/] Assuming an average household size of 2.69,[b/] an upper bound household population figure is calculated to be 336,000. A lower bound can be developed by assuming that only one half the populations of these towns benefit from CSO-based water quality improvements, or 452,000 people, which translates to a lower bound of 168,000 households. Multiplying the RTI-derived WTP values of $18.68 by the range of applicable households results in significant benefits, presented in Table 12-2.

[a/] This is based on a direct question framework, users and non-users. See page 4-32, RTI, 1983.

[b/] Based on data from 1980 Census.

Table 12-2. Annual Estimated Willingness to Pay for Fishable Charles River (1982$)

	Population	Persons per Household	Willingness to Pay Value	Annual Willingness to Pay Value
High	905,000	2.69	18.68	6.28 million
Low	452,000	2.69	18.68	3.14 million

12.3.2 Limits of Analysis

Benefits to instream users, near-stream users and non-users of the Charles River are substantial. These results should be interpreted wih caution, however, for a number of reasons. The accuracy of benefit values is constrained by use of off-the-shelf models. The willingness to pay values used here are derived from a study area which may be sociologically, economically and educationally different from the population within the Charles River Basin planning area. People in the northeast, for example, recreate more often than those in the central regions of the east (1979 Survey of Recreation). The Charles River population is also more highly educated and has higher income on average than that in the Monongahela study area. The geographical nature of the two areas is also different. The Monongahela River, and the region surrounding it, are larger and much more rural than the Charles River and its study area. The urban setting of the Charles, the relative scarcity of other close by recreational rivers, and the previously mentioned socio-economic differences suggest that the Charles River population in Cambridge and other towns might be willing to pay a higher price for river cleanup. Benefits are also understated because consumer surplus was estimated only for the Charles River portion of the Charles River Basin CSO plan; the methodology therefore does not capture benefits accruing to recreationists in the Back Back Fens, the Muddy River or Alewife Brook. The upper bound figure of $6.3 million is probably the more reliable estimate of total benefits.

12.4 Summary

The benefits of improving the water in the Charles River in the CSO Charles River Basin Planning Area are many. Benefits accrue to instream users (boaters) and near-stream users (picnickers, strollers, bikers, etc.) alike. Best annual boating benefit estimates total $958,000 and probably understate all boating benefits. Results from a contingent valuation survey capture both user and non-user benefits by applying willingness to pay values derived from a study of the Monongahela River. The upper value of $6.3 million is probably the more reliable estimate of total benefits from improving water in the Charles River, although this figure may also understate all benefits.

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