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**Natural
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Conservation
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Part 612 Water Quality
National Resource Economics Handbook

Chapter 5 Benefit Categories

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Contents:

Examples

Chapter 5 Benefit Categories

612.0500 Introduction

Changes in water quality may impact producer costs and benefits in agriculture, industry, and commercial fishing. For example, an improved quality water supply may result in enhanced livestock health and production. Water quality improvements can save costs for maintaining navigation and for municipal and community water provision. Consumer surplus changes stem from recreational uses, human health impacts, fish and wildlife habitat changes (that consumers value), aesthetic values, existence values, and other non-market values.

612.0501 Water for agriculture

Agricultural water quality benefits are measured by net income effects.

(a) Domestic animal water use

Poor water quality can cause productivity and efficiency problems for domestic animals, such as reduced milk production, decreased fertility, weight loss, and increased mortality. Measurable economic effects include associated changes in veterinary bills, decreased marketable products, foregone use of by-products, or increased replacement costs.

Poor water quality can also shorten the useful life of equipment, such as pumps and other metal parts regularly exposed to water. For example, grit and suspended solids damage pump impellers. Improved water quality benefits for equipment generally consist of cost savings for operations, maintenance, and replacement.

Example 5–1 illustrates water quality benefits for a beef cattle operation.

Example 5–1 Water quality benefits for a beef cattle operation

In this example poor water quality impairs the water's usefulness for consumption by livestock. The proposed project would influence both quantity and quality of water.

Description of impairment Livestock producers in the Matzoth area face poor water quality due to high salt content in the soils. Matzoth is predominantly a cow-calf ranching area. Small ponds and dugouts hold rainwater. In low rainfall months, water levels drop and the water becomes very salty.

Treatment Without the project, the current water supply system includes the normal water supply plus an emergency water supply in drought years. The project would add a pipeline system. The proposed pipeline would bring higher quality water to the area.

Impacts The benefits of the project as a result of better water quality would be increased calf weaning weights and increased forage consumption because of more accessible and higher quality water. The producers currently wean calves at 500 pounds and they wish to increase weaning weights to 550 pounds. Local university research shows poor water quality causes stress on animals. Reducing this stress would increase weaning weights by 30 pounds per calf. An additional weight gain of 20 pounds would result from higher water consumption and improved grazing systems implemented with a new and better quality water supply.

The project would also change the costs of the overall water system. The cost of a pipeline water supply (including production input costs), and the cost of the current system of wells, dugouts, and reservoirs, including the cost of the emergency water supply (reduced variable production costs), would need to be determined and compared for a complete analysis. The difference in the cost with and without the pipeline system would be a benefit of the pipeline project.

Focusing on the increased calf weaning weights, the onsite market impacts for the producer would be an increase in over-all weights, and an increase in sale price per pound. Sales data for the last 5 years indicate an inverse relationship between weight and price per pound of feeder calves. A 500-pound calf sells for 99 cents per pound, and a 550-pound calf sells for 95 cents per pound.

The increased value per calf would be:

$$(550 \times .95)-(500 \times .99) = \$27.50 \text{ per calf}$$

The average annual benefit per calf for the new pipeline, including changes in the grazing systems and in water consumption, would be $27.50. These are National Economic Development benefits according to section 2.3.3(e) of Principles and Guidelines.

(b) Crop production

Water quality affects the quantity and quality of crop production. At some levels, nutrients in water may actually increase the production of some crops. High levels of pollutants, such as other chemicals or minerals (salt, iron) reduce yields. Refer to the Conservation Practice Physical Effects in the Field Office Technical Guide to determine the water quality effects of individual conservation practices. Physical and biological scientists need to be consulted to provide site specific information on the effects of practices for irrigation, drainage, animal waste management and land treatment practices.

Yield responses are estimated from case studies, when possible. The monetary effects of these changes can be measured using crop budgets which are available from USDA Extension Service. Natural Resources Conservation Service analysts often use the Cost and Return Estimator program (CARE) for crop budgeting. Project area farmers can verify crop budgets for appropriateness and accuracy. The Conservation Options Procedure (COP) described in the draft of part 622 of the forthcoming Economics Handbook provides a framework for evaluating crop production changes.

Example 5–2 is for potato crop production benefits from improved water quality.

Example 5–2 Crop production benefits from improved water quality

In this example, runoff from flood-irrigated potato fields increases dredging costs from offsite sediment impacts. In addition, erosion attributable to the irrigation system is causing long-term productivity losses. The proposed treatment, a change to sprinkler irrigation, will permit land that was formerly in ditches to be planted in crops, reduce weed control costs, reduce nitrogen use, reduce sediment damage to growing crops, change capital and operating costs, and reduce offsite impacts.

Impacts on water quality from present flood irrigation system

Often, adequately flood irrigating the lower end of a field can cause deep percolation in the upper end. This is caused by the long set (detention) times necessary to spread water over the entire field. Sediment from flood irrigation that runs off the land into nearby water can degrade surface water. Excessive leaching of nitrogen from the over-application of nitrogen and irrigation water can degrade ground water.

Treatment

Conversion from flood irrigation to sprinkler systems is proposed. Sprinkler systems have higher installation and energy costs and are more labor intensive. However, they use less water and use it more efficiently (less evapotranspiration).

Example 5–2 Crop production benefits from improved water quality—Continued

Onsite benefits of project Crop budgets were used to measure the difference in net returns per acre for changing from surface to sprinkler irrigation.

	Annual changes
Increased revenues per acre (includes revenue from cropland that was formerly in ditches, 1 acre per 40 acres @ $200 per acre = $5)	$ 205
Reduced water purchase (1 acre foot per acre @ $5)	5
Reduced OM&R on concrete ditch	66
Siphon tubes no longer needed $ .90 per tube & 12 tubes per acres x .093683[1/]	1
Reduction in irrigation labor (1 hour per acre)	8
Long term productivity loss from irrigation erosion	2
Reduced weed control costs @ $4 per acre	4
Reduced nitrogen use 75 lb @ $ .20 per lb	15
Reduced sediment damage to growing crops	3
Total onsite market benefits per acre	**$309**

[1/]Amortized at 8 percent for 25 years

Offsite market benefits of project

Item		Without conversion	With conversion	Change
		(Data provided by physical scientists)		
Nitrate leaching	(pounds)	225.0	150.0	75.0
Erosion	(tons)	46.0	2.0	44.0
Sediment yield	(tons)	4.0	0.1	3.9

Reduced dredging cost @ $4.87 per ton x 3.9 tons = $ 19

Offsite non-market benefits Converting flood irrigation to sprinkler systems could reduce adverse effects on surface and ground water.

Summary of costs and benefits Total benefits are valued at $309 per acre per year plus $19. These values are reported in the National Economic Development account. The new sprinkler system costs are subtracted from the National Economic Development account. The physical and environmental effects are reported in the Environmental Quality account.

(c) Agriculture waste management systems

Onsite benefits from improved agricultural waste management systems can include decreased disease-carrying pests (flies and rodents), improved animal health, changes in animal productivity, reduced onsite use of nutrients for crop production, and reduced labor requirements. If the nutrients are used, the farmer often avoids having to install alternative costly waste management systems. Offsite benefits may accrue to any of the benefit categories discussed in this guide if water quality is improved. The Conservation Options Procedure (COP) described in the draft of part 622 of the forthcoming Economics Handbook also provides a framework for evaluating animal waste management systems.

612.0502 Industrial water

Industrial water quality benefits are measured by net income effects. Industrial water uses are usually classified as boiler feed, cooling water, and process water.

Boiler feed is water that is boiled in thermal electric plants to make steam for space heating and use in industrial processes. Good water quality is important for boiler feed, consequently most boiler feed sources are treated before use.

Cooling water cools heated surfaces, primarily in producing electricity. Quality requirements for cooling water are not nearly as stringent as those for boiler feed; however, cooling water is sometimes treated to prevent scale and slime formations. Such formations require "blowdown" maintenance to remove them.

Process water removes or transports wastes, for example for vegetable rinsing and washing operations. Estimating a firm's producer surplus usually consists of estimating the improved water quality benefits from reduced water treatment costs.

Example 5–3 shows the industrial benefits from improved water quality. In this example, a utility uses water for cooling purposes. Water quality improvements reduce the frequency with which some filter screens need to be cleared. The utility saves money as a result. In the example, the water quality improvements come from better animal waste and cropland resource management systems.

Example 5–3 Industrial water benefits

This example shows industrial water benefits from a watershed project (Lake Konawa). Industry uses water to cool a natural gas electric generating facility.

Impairment

Significant amounts of nutrients enter the lake from cropland fields and concentrated livestock feeding operations. These pollutants produce large amounts of algae masses which clog filter screens and require back flushing of the screens. The backflushing must be done twice a day, which cost the utility company $500 per day in additional labor and added maintenance costs.

Treatment

The Konawa Watershed Plan consists of animal waste management systems and cropland resource management systems.

Impacts

If the Konawa Watershed Plan measures were installed, nutrients would be reduced by 50 percent and backflushing and additional maintenance by 60 percent.

Offsite market benefits

Present and future without plan treatment expenses were estimated to be:

$500 per day x 365 days per year = $182,500 average annual costs

Future treatment expenses with the Konawa Watershed Plan were estimated to be:

40% x $500 remaining labor and maintenance costs for backflushing x 365 days per year = $73,000 annual costs

The average annual cost savings in the treatment of industrial water were estimated to be:

$182,500–$73,000 = $109,500.

These cost savings are added to other plan benefits (onsite benefits of animal waste management systems, offsite non-market benefits from decreased nutrient loadings) in the National Economic Development account.

612.0503 Commercial fishing

Commercial fishery benefits are any net change in consumer and producer surplus because of an increase in catch per unit of effort. Changes in water quality can significantly influence commercial fish stocks and thus affect the fishing industry. Adverse impacts on commercial fisheries from poor water quality include:

- development of tumors or other growths or defects on fish,
- increased mortality rates caused by pollutant stress which leads to insufficient spawners,
- decreased body weight with lower sale price of fish,
- incorporation of toxics into tissues,
- pollutant stress that kills off macrophytes,
- sedimentation that leads to the destruction of the spawning habitat,
- disruption of spawning behavior or avoidance of the spawning habitat,
- pollution directly and indirectly disrupting the various trophic levels so that sufficient forage for commercial fish is no longer available, resulting in a reduction of adult spawning, and
- other impacts.

612.0504 Municipal and community water

Poor water quality often results in additional treatment costs for municipal water supply from costs of chemicals, more treatment processes, and additional energy needs, resulting in net income effects. Additional treatment costs are also incurred as the frequency of filter or screen flushing increases to clear accumulated suspended solids. Frequent flushing reduces the amount of processed water available, increases labor requirements and chemical use, and reduces equipment life.

Land use or crop rotation changes can effectively reduce the contaminants affecting domestic water supplies. An example of improved agricultural management resulting in cost savings for community and municipal water treatment is shown in example 5–4. An analysis of the changes using crop budgets could provide estimates of the costs of reducing contaminants.

Poor water quality could also impair the potability of water supplies (safety, taste, and odor). If this were the case, additional benefits would result from water quality improvements. Such improvements reduce or eliminate treatment costs, such as aeration systems, reverse osmosis, chemical additives, and granulated activated carbon filters. If water supply quality is extremely poor, alternative supply sources may be used for drinking water. In this case, benefit estimates would be based on the least costly replacement, such as a new rural water supply, bottled water imports, or other means of supplying potable water.

Example 5–5 illustrates how non-market benefits and municipal and industrial water treatment cost savings may both occur when better resource management systems result in improved water quality. In this example, acid run-off from an abandoned coal mine causes high treatment costs for reducing acidity of municipal water, and the acid water impairs fisheries. There are also differences with and without the project for hazardous substance disposal.

Example 5–4 Community water supply benefits from reduced cropland erosion and contaminant loading

This example shows the cost savings for treating the water for Hooper community when erosion management systems are installed.

Impairment

The agribusiness community of Hooper receives its water supply from nearby Lake Bed. Lake Bed has recently been subject to increased turbidity and phosphorus loadings from cropland sediment. The poorer water quality has resulted in increased water treatment costs. The community uses 170,000 gallons per day. The treatment cost is $0.0005 per gallon.

Treatment

Installation of the appropriate resource management system will decrease gross erosion by 30 percent.

Impacts

Published data indicate a 10 percent reduction in annual gross soil erosion will reduce the cost of treatment by 4 percent. A linear relationship is assumed, such that a 30 percent reduction in annual gross soil erosion would reduce the cost of treatment by 12 percent. The effect of the resource management system on the turbidity and phosphorous loadings is expected to be immediate. However, the time lag before there will be less phosphorus in the water supply is significant. For purposes of this example, suppose the benefits start to accrue in year four and the analysis is based on a 20-year project life of the resource management system.

Caution: A time lag of 4 years is unrealistically low. Sediment already in lakes is re-suspended during spring and fall turnover, reentraining turbidity and phosphorus. Reducing erosion by 30 percent slows the eutrophication process, but a lake management plan is required for treating the water body.

Offsite Market Benefits (cost-savings)

Reduced treatment cost = 170,000 gal per day x $.0005 per gal. x .12 (the cost reduction) x 365 days = $3,723.00 per year beginning in year 4. At 5% interest, the present value of a 16 year stream of annual payments of $3,723 is $40,350 (using a factor of 10.838, the present value of an annuity of $1 per year for 16 years). Discounting back to year one from year four yields a present value of $33,208 (using a discount factor of .823). The average annual cost savings are reported as benefits in the National Economic Development account.

Example 5–5 Municipal and industrial water quality benefits

Impairments

A tributary flows through an abandoned coal mine and enters a stream 2,000 feet above the intake for the local water supply. The stream carries excess amounts of alkaline substances, sulfate, iron, magnesium, and aluminum from the coal mine. Water treatment procedures are required to remove these by-products, which are classified as hazardous waste materials. The acid mine drainage and sediment from the coal mine negatively impact the potential for sport fishing in the stream.

Treatment

The most cost effective solutions were to install anoxic limestone drains, construct wetlands for the mine discharge, and use traditional land treatment methods for eroding areas. The cost for installing the project treatment is:

	Item cost		Annuity*		Annual cost
Anoxic drain + wetland	$1,200,000	@	.09569	=	$114,828
Land rights	30,000	@	.09569	=	2,871
Sediment treatment cost	20,000	@	.09569	=	1,914
O&M cost	4,000			=	4,000
Total annual cost					**$123,613**

* Amount of annuity for a present value of 1 at an 8.25% discount rate for 25 years.

Impacts

As a result of the project, water treatment costs are reduced, and hazardous substance disposal costs are eliminated. In addition, water quality is improved sufficiently to support sport fish in the stream system.

Offsite market benefits

The project results in cost-savings in water treatment and in substance disposal. Physical scientists and city officials provided the following information:

	Without project costs	With project costs	Avoided costs
Water treatment cost	$20,000	$ 1,000	$ 19,000
Disposal of substance	8,000	0	8,000
Estimated offsite market benefits			**$27,000**

Example 5–5 Municipal and industrial water quality benefits—continued

Offsite non-market benefits	The project reduces sediment damages to stream habitat and opens new areas to recreational fishing. City officials describe the offsite damages caused by sediment. From a contingent valuation study habitat damages are estimated at $10,000 annually without the project, and they would be reduced to about $500 annually with the project. The recreation benefits of the project are estimated at $150,000. (The value of the new recreational fishing opportunities could have come from a contingent valuation study or from a travel cost study.) The estimated non-market offsite benefits are $159,500.
Summary	The offsite benefits total $186,500. They are reported as National Economic Development account benefits. The project costs of $123,613 are reported as National Economic Development account costs.

612.0505 Navigation

Sediment and corrosive substances in water can increase maintenance and shorten the lives of and otherwise damage vessels and associated navigation structures, such as locks, wharves, and pilings. Dredging is sometimes required. Reducing these maintenance costs produces benefits to navigation. Example 5–6 illustrates reduced dredging costs to maintain a channel for barge traffic when water quality is improved.

Example 5–6 Navigation benefits

After the completion of Oregon's Lower Granite Dam on the Snake River in 1975, slackwater river barge navigation was extended to the Lewiston-Clarkston area. The Army Corps of Engineers was responsible for maintaining a 15-foot navigation channel to the area. The Corps had estimated sediment deposition at the rate of 2,000,000 cubic yards of sediment per year.

Impairment

To maintain the barge channel, the Corps dredged 800,000 cubic yards annually from the critical area around the Port of Clarkston. State and local fishery agencies set a work window (between December 15 and February 15) during which the Corps was permitted to perform the dredging with the least effect on fish migrations.

Treatment

The watershed contributed 26,000 cubic yards of sediment to the area being dredged annually. With the project, the watershed would contribute only 6,000 cubic yards annually.

Impacts

The following costs and benefits were associated with sediment removal. Geologists and Corps' engineers provided the information. The baseline rate of sediment removal was 800,000 cubic yards per year. Without the project, the barge traffic would have had to be shut down at a cost of $120,000 or $ .15 per cubic yard ($120,000/800,000 yd^3). With the project, barge traffic would be shut down for a shorter time. Assuming a constant removal rate, benefits to the project would be:

Future without project	=	26,000	x	$.15	=	$3,900
Future with project	=	6,000	x	$.15	=	$900
Reduced cost of shut down	=	$3,900	–	$900	=	$3,000

Each ton of sediment prevented from entering the stream system reduces dredging costs. Present dredging cost are $4.50 per ton. Assume there are 0.8 cubic yard of sediment per ton ,then present dredging costs are estimated as $5.625 per cubic yard.

Navigation benefits

Future without project	=	800,000	x	$5.625	=	$4,500,000
Future with project	=	780,000	x	$5.625	=	$4,387,500
Benefits for reduced dredging costs	=	$4,500,000	–	$4,387,500	=	$112,500
Total benefits	**=**	**$112,500**	**+**	**$3,000**	**=**	**$115,500**

Summary

The annual cost savings from reduced dredging would be offsite benefits from the sediment control project. Thus, $115,500 is entered as a benefit in the National Economic Development account. The costs of the watershed plan and its other benefits were not calculated for this example. They would also show in the National Economic Development account.

612.0506 Human health

Health benefits are the reduction of exposure to carcinogens and toxins by way of ingestion, inhalation, or dermal contact. Health benefits may be associated with drinking water and with other beneficial uses of water, particularly water-based recreation and the consumption of uncontaminated fin and shell fish. Qualitative health effects that also occur should be shown in the Other Social Effects account.

Total benefits to human health are extremely difficult to quantify monetarily. Lost wages and productivity costs can be measured, but they only represent part of the costs to human health. Theoretically, the economic value of health benefits that might result from water quality improvements (the consumer surplus) would equal the sum of the affected individuals' willingness to pay for the reduction in the risk of contracting an illness. These illnesses might include infectious hepatitis, diarrhea, fever, and gastroenteritis.

Contingent valuation and hedonic pricing both apply to the problem of valuing risks to health and life. The framing of contingent valuation questions is particularly challenging in this context. When evaluating existing studies, one must assess whether the questions were framed in a way that allowed subjects to understand the risk levels posed. Example 5–7 shows the results from one contigent valuation study. Hedonic pricing in the context of valuing health risks usually takes the form of wage differential studies, where higher-risk occupations typically command higher wages for otherwise similar categories of work. The riskier occupations must generally add a risk premium to wages to attract workers. A review of literature about valuing risks to health and life is given by Viscusi (J. of Economic Literature, Dec. 1993).

An example where reduced health risks need to be counted in the estimated benefits from improved agricultural practices is where nitrates contaminate ground water. For example, Giraldez and Fox (1994) used the CREAMS model to predict reduction in nitrate leaching from changes in agricultural practices for the Southern Ontario village of Hensall. The reduced contamination of well water by nitrates was estimated. Annual benefits of improved ground water quality were found by combining the physical impact information with estimates found by other studies (i.e., contingent valuation studies) of damages from well water nitrate contamination.

Example 5–7 Value of health risks from a contingent valuation study

Viscusi, Magat, and Huber (1987) conducted a contingent valuation survey in which respondents were asked to value a reduction from 15 per 10,000 to zero of morbidity risks from insecticide exposure. The values were:

$1,504 for reduced risk of skin poisoning

$1,742 for reduced risk of inhalation

$3,489 for reduced risk of child poisoning

612.0507 Recreation

Water quality affects boating, swimming, sport fishing, waterfowl hunting, birdwatching, photographing wildlife, sailing, water skiing, and other forms of direct water contact and noncontact recreation. Recreation benefits are derived from increased user participation and satisfaction resulting from the water quality improvements. A shift to the right of the demand curve for recreation indicates increased benefits (figure 2–1, chapter 2, curve D'D'). The benefits are measured by the change in consumer surplus.

Value ranges for recreational activities from past nonmarket valuation studies are summarized in Walsh, Johnson, and McKean (1988). For example, they show values for various hunting activities and for cold water and warm water fishing. These value estimates are not directly transferable to new situations.

Most states have comprehensive outdoor recreation plans that are helpful in determining the supply and demand for various recreational activities. Information from the plans can be used with the Travel Cost and Unit Day Value methods. Example 4–3, chapter 4, illustrated the use of the Unit Day Value method to estimate recreation benefits.

For further information on the recreation evaluation process and the three primary evaluation methods: The Travel Cost Method (TCM), Contingent Valuation Method (CVM) and Unit Day Value (UDV) method, refer to part 612.0403 of this handbook.

612.0508 Aesthetic benefits

Aesthetic benefits come from qualitative appreciation of water quality by those who visit or live and work around it. Odor, unsightly shore deposits, accumulations of scum, foam, surface slicks, or other visible pollutants can adversely affect how individuals and society value property near the shoreline. Aesthetics effects include changes in the quality of recreational experiences. Because aesthetic effects often are not measurably associated with the direct use (the quantitative measure) of the water, they pose measurement and valuation difficulties.

Aesthetic benefits from water quality improvements can accrue to all water-based and water-enhanced recreational activities. The Travel Cost, Contingent Valuation, and hedonic pricing methods are useful for evaluating aesthetic benefits. The environmental quality criteria in Unit Day Value Guidelines for Assigning Points For General Recreation may also be used (table VIII-3-2 in Principles and Guidelines). Leisure research studies also sometimes estimate the value of improved aesthetics. Example 4–4 of chapter 4 uses the Hedonic Pricing method to estimate aesthetic benefits from a water quality improvement.

612.0509 Fish and wildlife habitat

Fish and wildlife habitat benefits result from the positive impact on the ecosystem of improved water quality. Fish and wildlife benefits are usually divided into two categories: consumptive recreation and nonconsumptive use. For example, an improvement in water quality could support an aquatic ecosystem by providing food, cover, and other needed elements for the survival and propagation of various species. This could lead to increased duck hunting (consumptive recreation) and increased habitat for an endangered species (nonconsumptive).

Consumptive recreational use benefits can be measured using the Travel Cost, Contingent Valuation, or Unit Day Value methods. Consumptive benefits may also be measured with market values depending on the specific species and existing markets. The effects on nonconsumptive uses would be described in the Environmental Quality and/or Other Social Effects accounts. If economic benefits from the nonconsumptive uses have been estimated from a contingent valuation study, these estimates might be reported in the National Economic Development account, depending upon study validity.

612.0510 Wetlands

Wetlands quantity and quality may be enhanced by project action. Contingent valuation studies can indicate how much the public is willing to pay to create wetlands, preserve wetlands, or improve wetlands quality in a region.

612.0511 Existence values

Existence values are those values that are not related to the current or expected future use of a resource. Existence benefits are derived from the knowledge that a resource (or some quality level of the resource) exists and will continue to exist. The value people hold for preserving endangered species, apart from any potential future commercial or hunting benefits they may derive, is an example of existence benefits.

Presently, only the Contingent Valuation Method is used to measure existence values. The Travel Cost Method does not assign benefits to existence values and will underestimate total value when existence values are present. However, the Contingent Valuation Method's use for estimating non-use values is controversial. If contingent valuation estimates are available for the total value of a water quality improvement, it may be helpful to comment on the extent to which non-use values are reflected in the contingent valuation estimates. Existence benefits should be described in the Environmental Quality account. Value estimates would be added to the National Economic Development account.

612.0512 Option values

Option values can be present if benefits of a project are uncertain or will occur in the future. In this case, the value of waiting before irreversible development takes place (the option value) may be undercounted by the Travel Cost Method. However, no empirical studies are available of the magnitude of this potential source of error.

612.0513 Other non-market items

Monetary values are difficult and sometimes impossible to place on some non-market goods, such as anxiety, distress, and other sentiments. These kinds of items can be discussed in the Other Social Effects or Environmental Quality accounts.