

most significant pollutants originating from CAFOs (e.g., nitrogen, phosphorus, pathogens, and sediment), but it does not include values for potential water quality improvements expected due to reduced discharges of certain other pollutants discharged in lesser amounts, such as metals or hormones.

Research documented in the record and summarized in the *Benefits Analysis* shows that CAFO wastes may affect the environment and human health in a variety of ways beyond those for which benefits have been monetized. The following are examples of other types of potential impacts or potential benefits:

- Human health and ecological effects of metals, antibiotics, hormones, salts, and other pollutants associated with CAFO manure.
- Eutrophication of coastal and estuarine waters due to both nutrients in runoff and deposition of ammonia volatilized from CAFOs.
- Reduced human illness due to pathogen exposure during recreational activities in estuaries and coastal waters.
- Improvements to soil properties due to reduced overapplication of manure, together with increased acreage receiving manure applications at agronomic rates.
- Reduced pathogen contamination in private drinking water wells.
- Reduced cost of commercial fertilizers for non-CAFO operations.

EPA's *Benefits Analysis* does not include monetary values for these other areas of environmental improvements because data limitations preclude quantifiable estimates of the magnitude of improvement or it is difficult to ascribe an economic value to these benefits. Nevertheless, these environmental benefits may result in improved ecological conditions and reduced risk to human health.

3. Benefits From Improved Surface Water Quality

a. Freshwater recreational benefits.

EPA used NWPCAM to estimate the national economic benefits to surface water quality that will result as CAFOs implement the requirements of this rule. NWPCAM is a national-scale water quality model that simulates the water quality and benefits for various water pollution control approaches. NWPCAM is designed to characterize water quality for the Nation's network of rivers and streams, and, to a more limited extent, its lakes. NWPCAM can translate spatially varying water quality changes (improvements or degradation) resulting from different pollution control policies into terms that reflect the value

individuals place on water quality improvements. In this way, NWPCAM is able to derive the economic benefit of the water quality improvements that will result from reducing CAFO discharges.

For this rule, EPA used NWPCAM to simulate impacts due to reductions in pollutant loadings from Large CAFOs (nitrogen, phosphorus, pathogen indicators, BOD5, and TSS) on water quality in the Nation's surface waters. NWPCAM's national-scale framework allows hydraulic transport, routing, and connectivity of surface waters to be simulated for the entire continental United States with the exception of coastal and estuarine waters. Pollutant loadings from the CAFOs were used as inputs to NWPCAM. The CAFO loadings were processed through the NWPCAM water quality modeling system to estimate in-stream pollutant concentrations on a detailed spatial scale to provide estimates of changes in water quality that will result as CAFOs implement this new rule. The NWPCAM modeling output, simulating the improved water quality in the Nation's surface waters, was used as the basis for monetizing improvements to water quality, and as input to several of the other benefits analyses described later in this section.

The monetary value of the benefits associated with the changes in water quality are estimated using two valuation techniques. The first technique relates water quality changes to changes in the category of use the water quality can support (e.g., boatable uses versus fishable uses, or fishable uses versus swimmable uses), also referred to as the "water quality ladder" approach, and also considers the size of population benefitting from the changes in the types of use the water quality can support. The second method is similar to the first, but it uses a composite measure of water quality that is calculated from six water quality parameters (referred to as the "water quality index" approach). A key difference in the two approaches is that the water quality ladder approach assesses improvements using a step-function that attributes a monetary value to the water quality improvement only when changing from one use category to another (e.g., a change from boatable use to fishable use), while the water quality index method assigns values along a continuum of water quality improvement (e.g., the water use may remain designated as "boatable use," but improvements within that use category are assigned a monetary value). For both valuation approaches, the monetary value assigned to the benefits

is based on what the public is willing to pay for improvements to water quality.

Based on the NWPCAM analysis using the water quality ladder approach, the benefits of improved surface water quality resulting from reduced pollutant discharges from Large CAFOs are estimated to be \$166 million annually (2001 dollars). Using the water quality index approach, the benefits of improved surface water quality are estimated at \$298 million annually (2001 dollars).

b. Shellfish beds. Pathogen contamination of coastal waters is a leading cause of shellfish bed harvest restrictions and closures. Sources of pathogens include runoff from agricultural land and activities. Using *The 1995 National Shellfish Register of Classified Growing Waters* published by the National Oceanic and Atmospheric Administration, EPA estimated the improvements to shellfish bed harvesting that will result as CAFO discharges of pathogens are reduced by this rule. These data were used to determine the average per-acre yield of shellfish from harvested waters and to estimate the area of shellfish-growing waters that are currently unharvested as a result of pollution from AFOs. By combining the per-acre yield data with estimates of the acreage of currently unharvested shellfish beds that will become available for harvesting as discharges of pathogens from Large CAFOs are reduced, EPA calculates the value of improved shellfish harvests at \$0.3 to \$3.4 million annually.

c. Fish kills. Episodic fish kill events resulting from spills, manure runoff, and other discharges of manure from AFOs continue to remain a serious problem in the United States. The impacts from these incidents range from immediate and dramatic kill events to less dramatic but more widespread events. Manure dumped into and along the West Branch of the Pecatonica River in Wisconsin resulted in a complete kill of smallmouth bass, catfish, forage fish, and all but the hardiest insects in a 13-mile stretch of the river. Less immediate, but equally important, catastrophic impacts on water quality from manure runoff are increased algae growth or algae blooms, which remove oxygen from the water and can result in the death of fish. Manure runoff into a shallow lake in Arkansas resulted in a heavy algae bloom that depleted the lake of oxygen, killing many fish.

While the modeled estimates of surface water quality improvements have been used to monetize benefits associated with freshwater bodies, water quality modeling (i.e., NWPCAM) does