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DATA NEGOTIATION

INTRODUCTION

At the heart of most environmental controversies lies a dispute over the likely future consequences of a proposed action. In the Grayrocks Dam case, the parties argued over the probable effect of the dam on wildlife and farming downstream. In the Brown Paper case, the parties argued over the necessity of installing expensive air pollution control technology. In the Holston River case that follows, the Environmental Protection Agency and the Tennessee Eastman Company had very different opinions about both the cost and the beneficial impact of the agency's proposed water pollution control efforts.

Making predictions about impacts that will occur well into the future necessarily involves a fair degree of scientific and technical analysis. To forecast the effect of construction of the Grayrocks Dam required knowledge of seasonal variations in the North Platte River waterflow, the hydrological characteristics of the dam, and the migratory habits of the whooping crane. Similarly, in order to isolate the effect of construction of a new bark boiler on the Berlin, New Hampshire, air quality region required a sophisticated understanding of the distribution of smoke plumes in rough terrain. Although we can predict the operation of a few natural systems quite accurately—the rise and fall of the tides is a good example—our understanding of how most ecosystems operate is fairly limited. As a result, our predictions are at best approximations of reality.

Regulatory decisions more frequently than not turn on mathematical models that are based upon simplifying assumptions. This produces a situation ripe for conflict. Because modeling is expensive, there is a trade-off between accuracy and cost. Government models are constantly subject to challenge by outside experts who claim that their industry-funded models are more accurate. Moreover, because different people are inclined to make different assumptions, environmental disputes often become battles between experts hired by the opposing parties to defend a particular set of premises.

The Holston River case that follows is a good example of such a dispute. At the root of the conflict between EPA and the Tennessee Eastman Company was a dispute over the validity of the models used by EPA to estimate the capacity of the river to absorb pollutants. In reading the case, think carefully about how access to information and expertise influenced the bargaining strength of the parties. Would the outcome have been any different if Tennessee Eastman's experts worked for EPA and vice versa?

THE HOLSTON RIVER CASE

This case was originally prepared by Alexander Jaegerman. It has been substantially edited and revised.

Introduction

In October, 1972, Congress passed the Federal Water Pollution Control Act Amendments over the veto of then President Richard Nixon. The law declared that all pollution discharges into U.S. waters were illegal unless specifically authorized in kind and quantity by a permit issued by the EPA. Under the law, the agency is required to set standards and issue permits by reference to the technology available to control pollution. By July 1, 1977, the National Pollution Discharge Elimination System (NPDES) was supposed to reduce discharges to the level achievable through application of the "best practicable technology (BPT) and operating practice, taking into account costs of implementation and benefits derived." By July 1, 1983, discharges are to be reduced further to the level attainable through use of the "best available technology" (BAT) economically achievable.

The NPDES standards vest a tremendous amount of discretion in the hands of EPA officials. Determining BPT and BAT requires not only an assessment of the state of the art of pollution control technology but also a balancing of the costs and benefits of alternative control strategies. In practice, these are difficult decisions that are scrutinized closely by industry and environmental groups alike. The stakes are high for all parties; controversy is not uncommon.

In late 1972, shortly after adoption of the Clean Water Act amendments, the Tennessee Eastman Company submitted an NPDES application to EPA. Tennessee Eastman is a major chemical processor. Its plant in Kingsport, Tennessee, occupies over 400 acres on the Holston River and employs close to 12 thousand people (see Figure 7). The plant produces an array of chemical products, including Kodel polyester fibers and Kodak films and chemicals. Chemicals are processed in vast quantities; on an average day, over 700 million pounds of materials are handled in the plant. Not surprisingly, Tennessee Eastman is

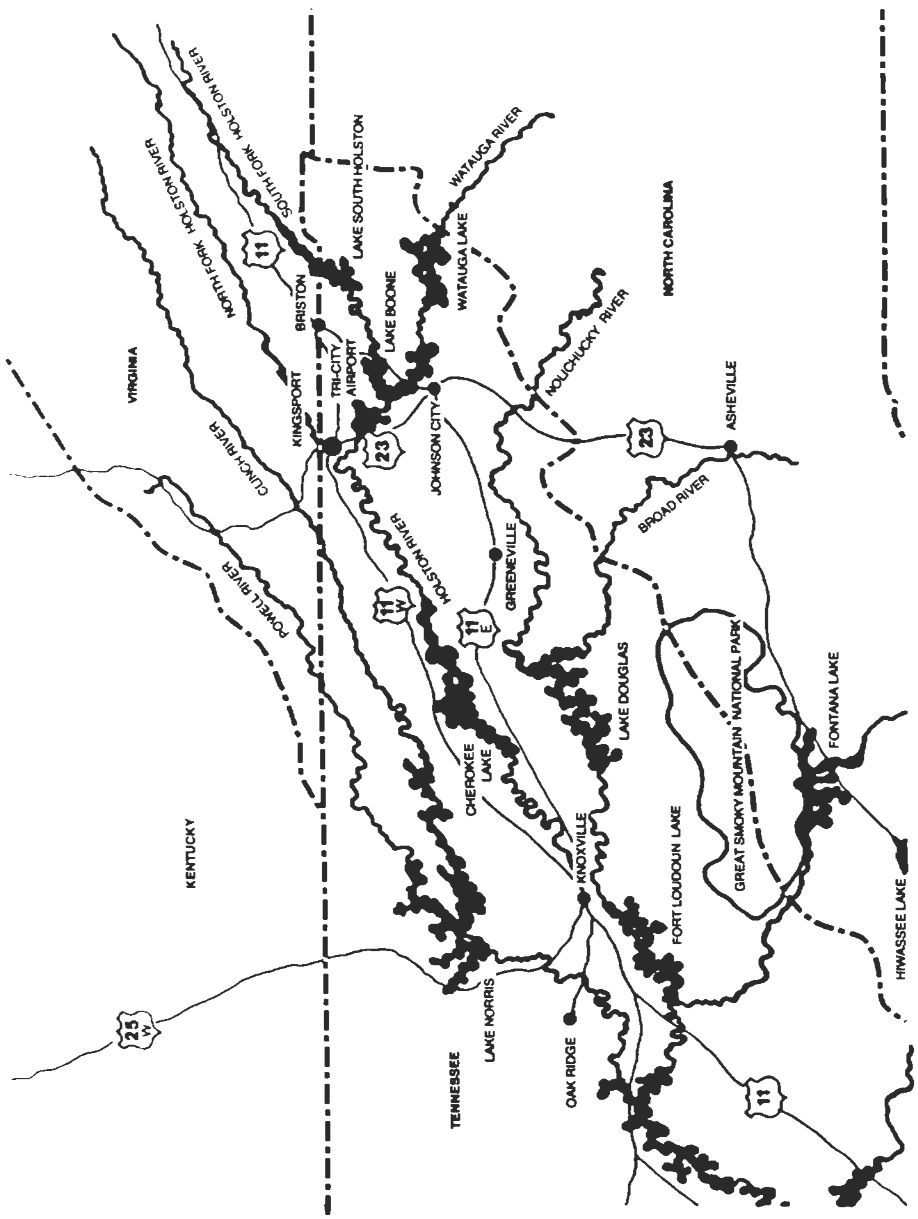

FIGURE 7. Northeastern Tennessee. (From "Water-Borne Effluent Limits," by Tennessee Eastman Company, September, 1978, III.2.)

also a major producer of chemical waste. At the time of its application for an NPDES permit, the company was discharging 400–500 million gallons of treated wastewater into the Holston River daily—about the same amount of wastewater produced by a city of 5 million people, and at times equal to the entire flow of the river.

The Tennessee Eastman NPDES application posed a number of difficult problems for EPA. First, the company was one of five major dischargers along this stretch of the Holston River, albeit by far the largest one (see Figure 8). Effluent limits had to be established in an equitable manner.

Second, setting effluent limits involved making complex determinations about the capacity of the Holston River to assimilate pollutants. EPA's models were certain to be challenged by Tennessee Eastman's experts. Third, Tennessee Eastman had substantially greater technical resources at its disposal than did EPA. It employed over 1,800 scientists, engineers, and support personnel in five laboratories located on site. Moreover, it had the capacity to hire the best consultants in the field. Fourth, the criteria specified in the statute for granting NPDES permits were inherently ambiguous. Although this ambiguity gave EPA a fair amount of latitude to fashion a permit, it also gave Tennessee Eastman room subsequently to challenge any permit it regarded as excessively strict on the grounds that EPA had misinterpreted its statutory mandate. Finally, as a major employer essential to the economic health of the region, Tennessee Eastman was capable of mustering substantial political support in favor of its position if the NPDES permit discussion blossomed into a full-scale public dispute.

Setting Effluent Limits Under the NPDES

The purpose of effluent limits permits under the NPDES is to ensure maintenance of minimum water quality in the nation's waterways. Water quality is generally measured along a number of dimensions, including color, odor, turbidity, and the presence of toxins, pathogens (e.g., viruses), surface scum, oil, or foam. The presence of dissolved oxygen is also an important indicator of water quality. When organic matter is discharged into a stream, a decomposition process occurs in which microorganisms digest the waste, breaking it down into its essential elements—generally nitrogen, phosphorous, and carbon. During this process, which is called *waste assimilation*, the oxygen that is disolved in the streamwater is consumed; as more waste is assimilated, more oxygen is drawn from the stream. If waste enters a stream in large quantities, the oxygen supply will be depleted in the decomposition process. As the level of dissolved oxygen falls below three to five parts per million (ppm), fish are adversely affected. If the oxygen level drops to zero, anaerobic digestion occurs, killing all fishlife and causing odorous gases to be emitted.

The oxygen available for waste assimilation at any point in a stream varies

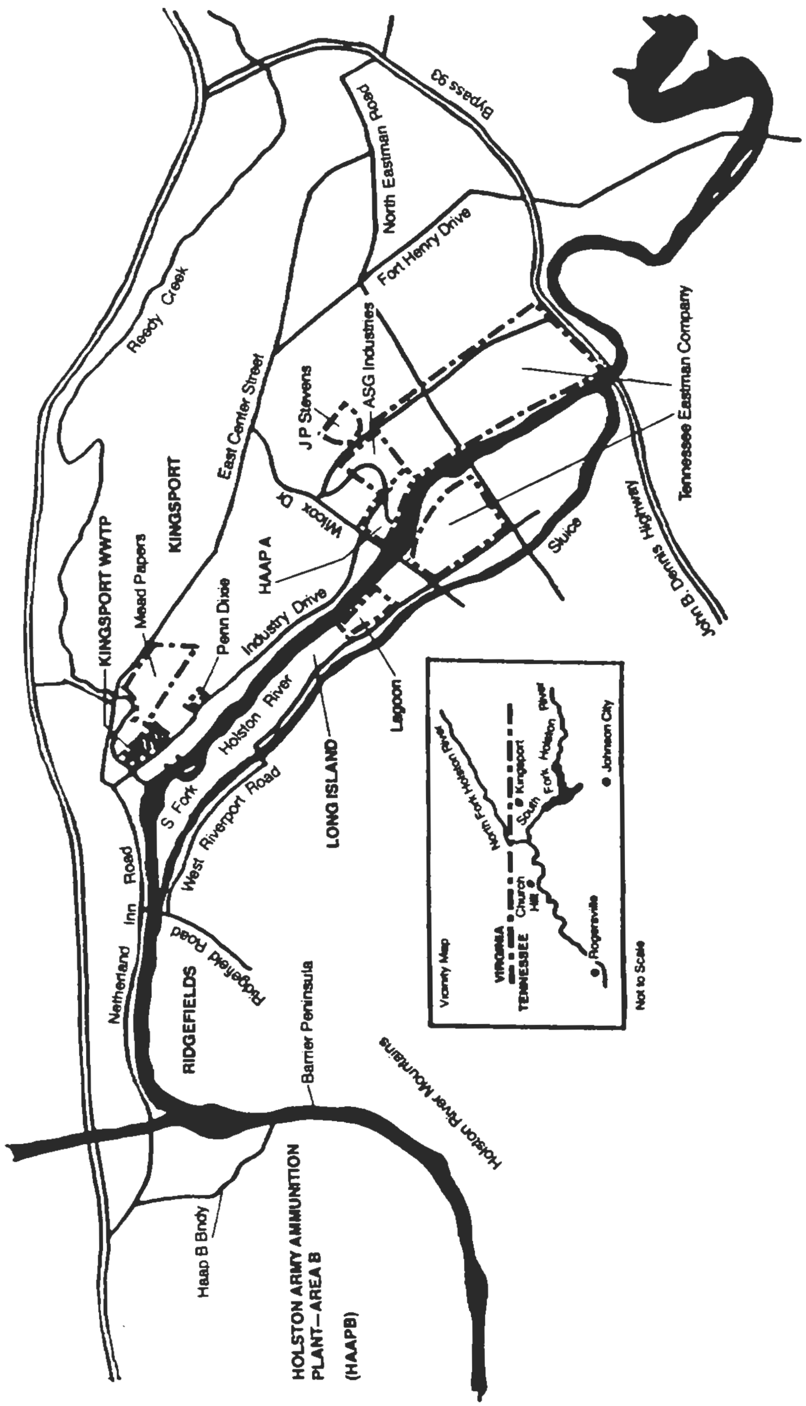

FIGURE 8. Location of industries on Holston River. (From "Water-Borne Effluent Limits," by Tennessee Eastman Company, September 1978, III.13.)

with a number of factors, including temperature (colder water supports more oxygen), turbulence, depth, upstream conditions, bottom deposits, aquatic weeds, and the like. The precise way in which these factors interact to influence the level of disolved oxygen is not perfectly understood. As a result, competing models exist to describe the impact of waste discharges on the availability of disolved oxygen downstream.

The responsibility for modeling the water quality of the Holston River in the Tennessee Eastman case fell to Douglas Lankford, a sanitation engineer employed by EPA with a recent masters degree in engineering from Vanderbilt University. Lankford used a waste load allocation model to specify discharge limits for the various firms along the Holston River. The basic assumption of such a model is that the stream can assimilate a certain waste load and still have an adequate supply of dissolved oxygen to maintain water quality. Given the biological oxygen demand (BOD) represented by a particular discharge, the model will describe the downstream effect on the oxygen deficit in the river, including the minimum oxygen concentration known as the *oxygen sag*. Later, during the months of negotiation, Lankford found himself defending his model from vigorous attack by several of his former professors.

EPA began to assemble the information needed to run the model with three trips to the Tennessee Eastman plant in late 1972. Of particular interest were the magnitude and composition of Tennessee Eastman's waste discharges. In giving consent to EPA to do sampling at the plant, James Mitchell, executive vice president for manufacturing, indicated that Tennessee Eastman would collect and analyze duplicate samples to those taken by EPA. In so doing, Tennessee Eastman was sending a clear signal to EPA that it was prepared to challenge the technical underpinnings of any effluent limitations that it believed to be unacceptable.

EPA returned to the Holston River in January and February to gather more data on heavy metals, monitor stations, BOD generation, and previous pollution control measures. This information was used by the Region IV EPA staff to formulate the permit limitations. The results of these information-gathering and modeling efforts were published in a report entitled *Waste Source Investigations—Kingsport, Tennessee.*" The report was distributed to Tennessee Eastman as well as state water quality officials. At the same time, EPA sent to the state (but not to Tennessee Eastman) a preliminary draft of the NPDES permits for the Kingsport area with a request for review and comment.

Negotiations Begin

When a copy of the previously mentioned report was received by Jim Edwards, manager of the Clean Environment Program at Tennessee Eastman, he responded quickly with a letter to EPA. The text of the letter set the tone for many of Tennessee Eastman's subsequent communications and emphasized the complex nature of determining effluent limitations; it urged that Eastman be given opportunities to discuss the permitting process, particularly before EPA went to public notice with the permit conditions. Tennessee Eastman was insistent in the months that followed that they and EPA should resolve their differences through discussions before bringing the matter before the public.

In July, 1973, EPA sent to Tennessee Eastman a NPDES Fact Sheet and Public Notice that delineated most of the permit details. Edwards responded by phone and by mail to Howard Zeller, chief of EPA's permit branch, suggesting again that a meeting should be arranged to discuss the proposed effluent limitations that "present a serious and urgent situation for us and the communities of northeast Tennessee." He went on to say that

> the proposed limitations . . . would require a major reduction of Tennessee Eastman Company's employment and production. We know of no waste-water treatment system that is technically and economically feasible which will reduce the water-borne wastes to levels comparable with the proposed effluent limitations . . . Therefore, we request a meeting with you and your staff to determine procedures and schedules for developing and presenting factual data and meaningful information concerning the proposed effluent limitations. . . . It is essential to complete this discussion before public notice.

The insistence upon staff-level discussions, out of the public eye, reflected a desire by the company to resolve difference on scientific or technical grounds. Although the effluent limitations certainly raised issues of social choice—for example, whether it was reasonable to provide such a high degree of protection for waters that were inaccessible to the public—most of the subsequent discussions centered on technical questions such as the validity of the model, the effects of nutrient discharges on weed growth and dissolved oxygen variation, and the reliability of a particular treatment technology for removing nitrogen from wastes.

There are a number of reasons why Tennessee Eastman may have decided to restrict its challenge to technical issues. Budding trial lawyers are taught that the first line of defense in any case is the facts. If the facts are not with you, then argue the law. And if the law fails, argue policy. By trying to shape the discussion in technical terms, Tennessee Eastman was adhering to this old adage. Although the company was prepared to argue that it was noneconomic to protect a river that was inaccessible to the public (one Tennessee Eastman report contained a map showing how far downstream the riverbanks are either on industry-owned property or are restricted for military security reasons), the law clearly provided for the protection of inaccessible rivers. Moreover, conducting the debate on

technical grounds favored Tennessee Eastman because of its vast technical resources and its access to experts in the field.

As requested by Edwards, a staff meeting was held in Atlanta between Tennessee Eastman and EPA at which the company argued that the proposed effluent limitations were intolerably and unjustifiably strict. During this meeting, Tennessee Eastman agreed to submit a counterproposal to EPA that would address the subject of long-term effluent limitations from the company's perspective. Tennessee Eastman prepared this report in house and submited it to EPA in the fall of 1973. The report, entitled *Water-Borne Effluent Limits*, quite predictably proposed effluent limitations that were substantially higher than those contemplated either by EPA or the Tennessee Water Quality Control Board (TWQCB). (Tennessee Eastman was required to obtain permits from both EPA and the TWQCB. Although the EPA kept the state informed of its activities, the two permitting processes proceeded separately, notwithstanding Tennessee Eastman's efforts to telescope them into one single regulatory process.)

Table 1 compares the initial bargaining positions of the three principals. The table is revealing in at least three respects. First, for effluents in which both proposed limitations, the state and EPA were in close agreement (with the exception of nitrates and nitrites.) Second, the differences in the substances to be regulated and the way in which they were to be measured indicate the lack of coordination between the state and EPA. Finally, the major disagreements between EPA and the company centered on limits for BOD, the nutrients nitrogen and phosphorous, and on pounds per day of total suspended solids. There was substantial agreement on the other limitations.

Tennessee Eastman also hired two consultants, Peter Krenkel and Vladimir Novotny, who prepared a report entitled *The Assimilative Capacity of the South Fork Holston River and Holston River below Kingsport, Tennessee*. The report critically reviewed EPA's modeling efforts and pointed out a number of potential weaknesses in the EPA analysis: an alleged exaggeration of the depth of the river; a failure to verify the results of the model against observed values of the river water quality parameters; and a possible miscalculation of the reaeration coefficient—the rate at which oxygen is reintroduced into the stream from the atmosphere. The report also pointed out that the EPA model did not account for the effect of aquatic weed growth on dissolved oxygen levels. In respiration, aquatic plants at times consume oxygen and at other times release oxygen into the water, causing diurnal variations in dissolved oxygen (DO) levels. Lankford did not try to model this variation, in part because the EPA was imposing very strict standards for nutrient discharges—primarily nitrogen and phosphorous—on the assumption that reduced nutrient discharges from Tennessee Eastman would significantly reduce the magnitude of the nuisance weed problem and simultaneously eliminate the diurnal variation in DO. This assumption became a

TABLE 1. INITIAL POSITIONS OF THE PARTIES

Units	Effluent constituents	TWQCD proposed limitations		EPA proposed effluent limitations		TEC proposed effluent limitations	
			lb/day net	Daily average	Daily maximum	Max. monthly average	Max. day
pounds/day	Biochemical oxygen demand (BOD)		3350	2230	3350	10,000	17,000
	Total Kjeldahl nitrogen (TKN) as N		400	270	400	9,000	18,000
	Total nitrogen (TN) as N		3310	—[a]	—	—	—
	Ammonia nitrogen as nitrogen		400	—	—	—	—
	Nitrates plus nitrites as N		2910	100	700	7,500	11,000
	Phosphates as P		213	140	210	800	1,500
	Total dissolved solids (TDS)		1,200,000	—	—	650,000	1,200,000
	Total suspended solids (TSS) (gross)		—	2230	3350	6,000	15,000
	Zinc as Zn		250	125	250	125	250
	Phenols		100	10	20	100	175
	Iron as Fe		1000	—	—	300	1,000
	Manganese as Mn		—	100	200	100	200
		Daily average	Instantaneous maximum			Monthly average	Max. day
mg/l[b]	Total suspended solids (TSS)	40.0	50.0	—	—	40	100
	Chromium	0.05	0.075	—	—	0.05	0.1
	Copper	0.02	0.03	—	—	0.05	0.1
	Mercury	0.005	0.0075	—	—	<0.005	<0.0
	Lead	0.05	0.075	—	—	0.08	0.5
	Dissolved oxygen (DO)	≥5.0		≥5.0	—	5	—
ml/l	Settleable solids	0.5		—	—	<0.5	0.5

[a]For entries that contain a dash (—), no value has been specified.
[b]Measured by concentration in each process discharge.

source of heated debate in subsequent negotiations. Not surprisingly, if the consultants' assumptions were substituted for Lankford's, the model suggested that the river had much higher assimilative capacity than originally calculated by EPA.

At this point in the process, it appeared that the battle lines were drawn. In a letter to EPA's Howard Zeller, Tennessee Eastman's vice president for manufacturing, James Mitchell, indicated that the company stood behind its consultants' analysis of effluent limitations:

> It is not our intention to propose limits with the anticipation of negotiating them. This is not to say that we have closed minds on the subject; however, we have determined the best that we can do and what is necessary to protect the river and we are prepared to support our proposals. . . . The Tennessee Eastman river protection program will require a great effort on our part and will involve very substantial costs. It will also accomplish our mutual objective of providing proper protection for the river.

In response, EPA gathered more information, sent the Tennessee Eastman consultant's report around for critical review, and reassessed its own model in light of Krenkel and Novotny's criticism.

Five months later, on February 1, 1974, EPA made its second attempt to procede with Public Notice for the Tennessee Eastman permit. Upon receipt of a draft of the proposed permit and a tentative Public Notice date of February 25, Tennessee Eastman Vice President Edwards again appealed to EPA, stressing that Tennessee Eastman still had serious problems with the terms of the proposed permit and again asking for more technical discussions prior to Public Notice. Edwards succeeded. EPA postponed the Public Notice until after a technical meeting could be held between experts for both sides. The meeting was scheduled for early March in Atlanta, the site of EPA's regional office.

The Atlanta Meeting: The Experts Confer

The March technical meeting was a major event in the negotiating process. Tennessee Eastman assembled an army of consultants including Peter Krenkel (Vanderbilt University), W. A. Drewry (University of Tennessee), Wesley Eckenfelder, Jr. (Vanderbilt University), Carl Adams, Jr. (president, Associated Water and Air Resources Engineers), and Ruth Patrick (chairman, Academy of Natural Sciences). Tennessee Eastman also brought along an equal number of company scientists and engineers as well as a stenographer who kept a record of the proceedings. EPA was represented by its own bevy of experts, including four scientists from its National Field Investigation Center (NFIC) in Denver, three staff members from the regional office (including Doug Lankford, author of the EPA model), and several other EPA and state of Tennessee officials. Represenitives of the Tennessee Valley Authority also participated at the meeting. Paul raina of EPA presided.

The substantive part of the meeting began with George Harlow of EPA escribing the permit and indicating areas where there might be room for comromise. Lankford followed with an explanation of the model and justification or the proposed permits. The model indicated that the river could assimilate bout 8,000 lb of BOD and still have 5 mg/l of dissolved oxygen at low flow (800 t³/sec or cps). EPA had allocated the 8,000-lb capacity to the five major users on he river in a way that required each discharger to treat its waste to the same ercentage of the difference between best practical technology and best available echnology. According to this formula, Tennessee Eastman would be limited to ,156 lb of BOD. Krenkel, the author of the report that was critical of Lankford's nodel, pointed out that the assimilative capacity of a stream is generally greater n the winter than in the summer because of increased flows and lower temeratures. Using a single year-round limit based on worst-case (summer) condiions would preclude utilization of the river's increased winter waste assimilative apacity. EPA's Traina responded that EPA would be open to consideration of ariable winter/summer limits that were eventually written into the permit.

Generally, the BOD restrictions did not engender much heated discussion. The nutrient limits were another story. EPA was committed to relatively strict itrogen and phosphorous limits in the belief that (1) nuisance weed growth ould be brought under control, and that (2) the alleged eutrophication problem n the Cherokee Reservoir located about 50 miles downstream from Tennessee astman could be alleviated. Tennessee Eastman contested every point relevant o the nitrogen limits—the need for nutrient restrictions, the technology for reatment, and the legality of the proposed limits.

EPA's argument for restricting nutrient limits rested on a laboratory test of iver water that suggested that nitrogen and phosphorous discharges were contribuing to downstream weed growth. Patrick, one of Tennessee Eastman's consulants, disagreed, claiming that other limiting factors existed that had not been onsidered. For example, a plentiful supply of nutrients existed independently of Tennessee Eastman's discharge, both from bottom deposits and from the North ork Holston River. These sources were not likely to be regulated in the future. Thus, Tennessee Eastman argued, it made little sense to impose expensive ontrols on the company if unregulated sources of nutrients would continue to roduce weed and eutrophication problems.

The parties also disagreed on the feasibility of alternative strategies to conrol nutrient discharges. Because the actual permit limitations would be deterined by EPA's interpretation of what constituted BAT and BPT, these disgreements were critical. EPA argued that treatment techniques that had been eveloped and demonstrated in municipal plants could be successfully transerred to chemical waste streams. In practice, several different systems exist for

removing nitrogen from chemical wastes. If the nitrogen is in the form of ammonia, a chemical process called ammonia stripping is used. The ammonia is literally blown out of the waste stream. EPA had proposed a biological treatment, nitrification/denitrification, for the Tennessee Eastman Company. This treatment involves an activated sludge system in which any ammonia must first be combined with oxygen to form nitrates. Then, during denitrification, the treatment removes the nitrogen from the waste stream by converting it to nitrogen gas. These biological processes work better in warm temperatures—in Lankford's words, "in the winter the bugs get sluggish"—thus necessitating different winter and summer standards as with BOD.

Tennessee Eastman's consultants doubted whether these processes would be effective in TEC's waste stream because the organisms that achieve the necessary reactions are sensitive not only to temperature but also to the presence of inhibiting chemicals. The company was reluctant to invest in a treatment system that eventually might prove ineffective. EPA's solution was to set the nutrient limitations contingent on completion of a pilot plant that would demonstrate the feasibility of the treatment technology.

The Atlanta technical meeting ended with a glimmer of a possible voluntary resolution. EPA had indicated a willingness to yield on two major points: the importance of different winter–summer limits and the decision to make the nitrogen restrictions contingent on the effectiveness of a pilot plant. Although neither party made any other concessions during the meeting, the limits that were proposed on certain effluent categories had changed somewhat from those proposed earlier. For example, both sides had backed away from earlier positions on BOD to the point where they now stood only 2,884 lb per day apart. (Earlier they had been 7,770 lb apart.) With the possiblity of different seasonal limits, a resolution to the BOD dispute was within reach. The dispute over nitrogen and phosphorous limitations persisted, but the propsect of contingent limits provided some potential for compromise. And although Tennessee Eastman did not move from its initial position on total suspended solids (6,000 lb) EPA had narrowed the gap by increasing its proposed limit from 2,230 to 4,500 lb. These gains, however, did not come easily. The struggle had been uphill and had left the participants strained and tired. Arguements had been heated at times, often over minute details. In his closing remarks, Paul Traina of EPA acknowledged that some items remained in dispute, particularly the issue of nutrient limitations, and that at the very least the parties could "agree to disagree."

The regional EPA office was anxious to wrap up the Kingsport Holston River permits. The negotiations had gone two rounds. The parties had made some headway, but in small increments. Although Tennessee Eastman's array of consultants grew larger with each round and included some of the big names in the field, EPA had no additional technical resources upon which to draw. The state wanted a strict permit but was not actively assisting EPA. There were other

TABLE 2. FINAL DEMANDS AND TERMS OF AGREEMENT

Units	Effluent characteristics	EPA draft permit[72]		TEC draft permit[72]		Final permit[73]	
		Daily avg	Daily max	Daily avg	Daily max	Daily avg	Daily max
lbs/day	BOD_5 (summer)[a]	3,200	6,300	4,000	8,500	4,000	8,500
	BOD_5 (winter)[b]	4,500	8,350	6,000	13,000	6,000	13,000
	Total suspended solids	4,500	8,350	6,000	15,000	6,000	15,000
	Total dissolved solids	650,000	1,200,000	650,000	1,200,000	650,000	1,200,000
	Total nitrogen[b] (summer)	680	1,350	3,000	6,000	3,000	6,000
	Total nitrogen[b] (winter)	970	1,800				
	Phosphorous, total	150	300	300	600	300	600
	Zinc, total	125	250	125	250	125	250
	Phenols	50	65	50	65	50	65
	Iron, total	300	1,000	300	1,000	300	1,000
	Manganese, total	100	200	100	200	100	200
ml/l	Settleable solids	NA	0.5	NA	0.5	NA	0.5
mg/l	Chromium, total	0.05	0.1	0.05	0.1	0.05	0.1
	Copper, total	0.05	0.1	0.05	0.1	0.5	0.1
	Lead, total	0.08	0.5	0.08	0.5	0.08	0.5
	Mercury, total	0.005	0.0075	0.005	0.0075	0.005	0.0075

[a] Summer and winter as designated in the EPA draft permit were May 1 to October 31 and November 1 to April 30, respectively. The TEC draft and final permit differed by a month, with summer May 1 to September 30 and winter October 1 to April 30.

[b] There was a caveat on these limits to allow TEC to test the technology in a pilot plant. The final permit contained the following notation: "If TEC can demonstrate to EPA by July 1, 1975 that these total nitrogen and total phosphorous limits are unattainable by TEC's currently planned wastewater treatment plant and currently planned in-plant controls, these limits will be revised accordingly by EPA. The revised limits will make proper allowance for seasonal and operational variabilities." (Doc. 625) This wording closely resembles that suggested by TEC in the comments.

issues even though they recognized that these issues were often proxies for larger social choice questions. Why did the parties seek to define the dispute in purely technical terms? Why were they reluctant to discuss the real underlying question: How much should Tennessee Eastman be required to spend to clean up the Holston River? What were the consequences of restricting the agenda in this manner? In retrospect, would EPA have been better off with a broader debate?

2. Both sides claimed that what kept them at the bargaining table was a desire to resolve their differences before going public with the permit. What was so bad about conducting this debate in the public eye? Why was the threat of judicial intervention so onerous?

3. Analyze the strengths and weaknesses of the parties as they appeared at the outset of the negotiations. Was there a clear-cut winner in this dispute? Would the outcome have been different if EPA had been represented by Tennessee Eastman's experts and vice versa? Was the cost of nonagreement symmetrical? Were the differences between the parties ultimately resolved purely on the basis of technical considerations or did other factors influence the outcome?

4. Parties to negotiations often try to influence the willingness of their opposition to compromise by flaunting their own intransigence. Tennessee Eastman tacitly did this when it collected duplicate water samples to those taken by EPA, thus giving notice that it was prepared to challenge any analysis based on those samples. Contrast this rather clear signal with the company's later statement to EPA "that it is not our intention to propose limits with the anticipation of negotiating them." If you were the EPA official who received this letter, how would you have interpreted this statement?

5. Recall Thomas Schelling's discussion of commitment as a means of building bargaining power from chapter 2. We have a good example of this tactic in this case. When EPA notified Tennessee Eastman on April 11, 1974, that it had given public notice on the NPDES permit, it was, in effect, committing itself publicly to its last bargaining position. What risks were involved in this move? Did Traina misread the situation? What signals did this action provide to Tennessee Eastman? Did it provide any signals to anyone else? Would EPA have been better or worse if it had threatened Tennessee Eastman with public notice before actually going public?

6. Tennessee Eastman was not the only discharger located on the Holston River; it was just the largest. Would EPA have been better off trying to negotiate all of the NPDES permits for the river simultaneously? Should it have tried to negotiate with the smaller dischargers first?

Judicial Review of Technical Decisions

In the Holston River case, the parties were clearly reluctant to have a court decide the complex issues involved in modeling the assimilative capacity of the permits to attend to in the Southeast, and staff time was limited. For whatever reason, the EPA chose to play a card that had previously been held back. On April 11, 1974, George Harlow sent Mitchell a copy of the latest draft of the NPDES permit, and with it, notification that EPA had gone to public notice on the permit.

This letter marked the third cycle of proposed permit discussion. Tennessee Eastman responded in much the same manner as it had previously (by indicating serious concern with certain aspects of the permit) and by registering dismay that EPA had gone to public notice while differences still remained. On May 7, 1974, Tennessee Eastman sent a letter accompanied by a 74-page document entitled *Comments by Tennessee Eastman Company*. The tone of the letter was severe and threatening. It covered the major areas of disagreement and closed with the following statement:

> The Tennessee Eastman Company position is environmentally, technically, and legally correct. Any more stringent limitations are not in accordance with the law, are not necessary to protect the environment, will waste valuable natural resources, and will cause adverse economic and social consequences in the region. . . . The Company has been advised by the foremost authorities in the field of water quality management and wastewater treatment technology. . . . They have stated that the proposals by Tennessee Eastman Company represent application of the best available technology economically achievable and are appropriate for protecting the South Fork Holston River and Holston River for fish and aquatic life as well as for industrial water supply. . . . Eastman is prepared to defend, to the extent necessary, the limits which the Company and recognized authorities have determined to be appropriate.

The letter concluded with a suggestion that EPA and the company resolve their differences before the public hearing. Traina sent copies of the letter to the EPA staff present at the Atlanta technical meeting and directed them to prepare the EPA's case for the May 29 hearing. Traina's memo to the staff stated that "this is a major discharger which we should be fully prepared to respond to and carry our case forward."

The Public Hearing and the Final Permit

An NPDES permit is a complex document that specifies all the limitations required of a plant and establishes a schedule for reaching them; it also includes information on requirements for monitoring and sampling. The real bite of the Tennessee Eastman permit, however, was embodied in the limitations that the company had to achieve by July 1, 1977. Tennessee Eastman included in its comments a copy of the draft NPDES permit that was marked up to correspond to the permit that the company considered to be acceptable. The more than 70

pages of comment also detailed every aspect of the permit that the company found unacceptable. Table 2 presents the main features of the debate on the effluent limitation in the permit. The table shows EPA's position, the company's response, and the limitations actually included in the permit after the public hearing.

The hearing was held on May 29, 1974. Apart from the usual newspaper articles and some specific notices to certain parties, EPA did not try to generate additional attendance. Tennessee Eastman, on the other hand, brought two of its consultants, Krenkel and Eckenfelder, to give statements. Local business and political personalities also spoke on behalf of the company. Aside from the EPA staff, only two persons testified in support of EPA's strict limitations. One of them, Phyllis Pierce of the League of Women Voters, explained why others did not attend:

> Many citizens—even well-educated ones—are intimidated by the mass of technical data, by the formalized procedure, and by the town and industry leaders in their suits and ties; particularly they are intimidated by the "experts" the industrialists bring along to study their case.

One might ask whether EPA also was intimidated by those experts. As Table 2 reveals, the company prevailed on every limit that was in dispute prior to the hearing. Certainly, there was much give-and-take throughout the negotiations, but EPA "gave" on the last interaction. There are a number of reasons why.

First, the technical questions and issues favored the company. The nitrogen debate had centered on the viability of a treatment process that depended on either isolation of the nitrogen waste stream or on elimination of chemicals that disrupt the biological neutralization process. By the end of the negotiations, it was clear that these processes were not economically achievable. Consequently, EPA's bargaining position was not legally defensible, given the NPDES effluent criteria.

Second, the differences over the other effluent limits were attributable to the debate over the validity of the stream models. If EPA had pushed much harder, it would have been forced to defend its model in an evidentiary hearing, and perhaps ultimately in court. Although neither side wanted to litigate the terms of the permit, this outcome was particularly onerous to EPA. Litigation would have tied up valuable staff time; it would have dealyed the processing of permits for other, smaller dischargers; and perhaps most important, it would have further delayed the Tennessee Eastman NPDES permit. In the end, senior EPA officials decided to settle because the costs of continuing the dispute were just too great in light of the potential benefits.

Study Questions

1. This case is extraordinarily technical. (Indeed, in editing it, we have simplifyed it greatly.) Both sides worked hard to limit bargaining to technical

river. To get a feel for what both sides feared, read the following excerpt from *South Terminal Corporation v. EPA* in which the court succeeded in goring the ox of both sides. This case was decided while Tennessee Eastman and EPA were negotiating the Holston River NPDES permit. Although the case deals with compliance with air quality standards, the central issue—the accuracy of EPA's modeling efforts—is common to both cases. As you read the case, think about the following questions. Was the reluctance of the parties in the Holston River case to let the issues go to trial justified by the actions of the court in South Terminal? Was the court comfortable deciding the technical issues? Is it likely that the parties in South Terminal could have improved on the outcome dictated by the court if they had negotiated among themselves? Why do you suppose that they failed to do so?

South Terminal Corporation v. EPA
504 F.2d 646 (1st. Cir. 1974)

Under the Clean Air Act, EPA is charged with promulgating ambient air quality standards for each pollutant having an adverse effect upon the public health or welfare. Each state, however, has responsibility for designing a program to see that the ambient standards are met. Typically these state implementation plans limit allowable pollution from stationary sources like factories, power plants, and incinerators as well as from mobile sources like cars, trucks, and planes. The Clean Air Act provides that if a state fails to implement necessary measures to comply with the ambient air standards, EPA may impose an implementation plan on the state. When Massachusetts failed to adopt a transportation control plan to limit emissions from mobile sources, EPA stepped in to fill the gap. Through extensive modeling, EPA concluded that if Boston were to comply with national ambient standards, emissions of hydrocarbons would have to be reduced in metropolitan Boston by 58 percent, and carbon monoxide emissions by 40 percent. To achieve these reductions, EPA proposed that off-street and on-street parking spaces be frozen or cut back, and the construction of new parking facilities regulated. It also proposed special bus and carpool lanes and a computer car pooling system. A vehicle maintenance and inspection program was also mandated. South Terminal Corporation was one of a number of plantiffs that filed suit to overturn the EPA transportation control plan on the ground that the underlying technical analysis was deficient. The court's discussion of the adequacy of the modelling as well as the legality of the transportation control plan follows [All footnotes and citations have been omitted.]

I. The Scope of Judicial Review

. . . The questions about the plan on review are of two types: the rationality of EPA's technical decisions [such as its determinations of local photochemical oxidant and carbon monoxide levels and the amount of reductions required to meet national standards] and the rationality of EPA's "control strategy," that is, the measures adopted to reduce emissions. The former present peculiar difficulties for nonexperts to evaluate. Yet "our inquiry into the facts is to be searching and careful," . . . and we must assure ourselves as best we can that the Agency's technical conclusions, no less than, others are founded on supportable data and methodology and meet minimal standards of rationality. . . .

Assuming EPA's technical determinations are reasonably based, we must decide whether the selected controls are arbitrary or capricious. In so doing, we must bear in mind that Congress lodged with EPA, not the courts, the discretion to choose among alternative strategies. Unless demonstrably capricious such as much less costly but equally effective alternatives were rejected or the requisite technology is unavailable, the Administrator's choices may not be overturned.

III. Whether EPA Committed a Clear Error of Judgment in Computing the Need for Emission Reductions.

. . . [The plaintiffs'] arguments can be divided into attacks on EPA's data and methodology as to (1) photochemical oxidants in the Metropolitan Boston Interstate Region; (2) carbon monoxide in the Boston core; (3) carbon monoxide at Logan Airport (East Boston).

1. EPA is said to have overestimated the photochemical oxidant problem in the Boston region. Most pertinent are petitioners' arguments that the key ambient air quality reading taken on one day at a monitoring device located at Wellington Circle must have come from a defective instrument. This single reading, inserted by EPA in its so called rollback formula (or "model"), was the basis for a region-wide estimate of the amount of hydrocarbon reduction required. If it was incorrect, so were the conclusions about how much reduction was necessary to achieve the primary standard. Petitioners point to a computer printout taken at that monitoring station: it contains a high number of "9999" readings which may indicate instrument malfunction. EPA's response is that the designations may also result from "instrument calibration, instrument zeroing, transmissions loss and depletion of span gas, all of which causes are unrelated to any malfunction." But petitioners contend that the irregular readings occurred too often to be attributable solely to innocent causes. On the present record, we cannot say with confidence that the use of a single reading from a machine as to which objective readings suggest a substantial possibility of malfunction is sufficient to support EPA's photochemical oxidant determination.

We find less persuasive petitioners' attack on the accuracy of the rollback model itself because of its purported failure to take account of local topography and meteorology. EPA's technical support document appears to consider these influences, and the only expert to stress Boston's unique features did not include gasoline in his analysis. Petitioners further claim that EPA incorrectly related oxidant concentrations directly to emission of hydrocarbons, relying in part on an extra record document never brought to the Agency's attention. Photochemical oxidants are a secondary pollutant derived from the reaction of two primary pollutants, hydrocarbons and nitrogen. To reduce oxidant concentration, it is therefore necessary to control hydrocarbon emission and EPA has advanced plausible reasons for choosing the ratio that it did. . . . Finally, petitioners object to the determination that regionwide controls, rather than controls in only a few heavily polluted sections, were necessary to bring oxidants down to a reasonable level. But background reports indicate that automobile use is heavy, particularly in the outlying manufacturing areas. The technical support document presents the view that the necessity for regionwide controls stems from the nature of the pollutant; petitioners' contention that contrary conclusions can be drawn from the data does not lead us to suspect that EPA committed clear error. To the extent different conclusions could be drawn, the Agency was entitled to draw its own.

2. Carbon monoxide data is attacked as unreliable. EPA determined that its national primary standard requiring the average amount of carbon monoxide in the air over an eight hour period not to exceed 9 ppm is not being met in the Boston core and will not be met by mid-1975. It did this by a series of calculations which have as their essential element an ambient air quality reading obtained on one day in 1970 from a monitor at Kenmore Square. Although petitioners attack use of the rollback model itself as unsophisticated, we are mainly impressed by the contention that the crucial figure for determining required emission reduction may be unrepresentative. At the time the plan was designed the next highest reading at Kenmore Square was nearly 50 percent lower than that utilized. EPA points to readings elsewhere even higher than that used in the rollback model, recorded after the plan was announced, as evidence that it may have "underestimated the extent of the CO problem." But petitioners claim these high readings are also freak events. . . . Here again, on the present record, we have no basis to say with judicial conviction that such a slender base, without further justification, is sufficient to support EPA's conclusion as to carbon monoxide in the Boston core.

3. In the best documented of the challenges to EPA technical data, South Terminal and Massport attack the carbon monoxide determinations at Logan Airport (East Boston). [EPA determined that it was necessary to reduce carbon monoxide emissions at the airport which is located across the harbor from downtown Boston without actually sampling at the airport. The same Kenmore Square air quality figure, inserted in the rollback model, was used to project the required reductions at Logan. Massport, which runs the airport, objected and conducted its own test which suggested that federal primary standards were being met. Moreover, the Massport report concluded that the concentrations of carbon monoxide at Logan were substantially lower than at other Boston sites. EPA responded by citing a different study which indicated that carbon monoxide levels at the airport were roughly equivalent to those measured elsewhere in the region, and exceeded federal standards. After reviewing the conflicting evidence the court reached the following conclusion.]

The method of sampling at Logan, Massport's own testing, and the lack of monitoring in East Boston, collectively, on the present record, prevent us from holding that the data are sufficient to support EPA's conclusion as to carbon monoxide in East Boston.

4. While we are unable at this time to uphold EPA's conclusions as to photochemical oxidant and carbon monoxide levels and reductions, we do not say that they are necessarily incorrect. Petitioners forcefully contend that the Agency's measurements are without reliable foundation, and hence, in effect, arbitrary and capricious. . . . But as laymen we are in no position to know how much ultimate weight to give to these arguments, based as they are on technical assumptions. We can only say that the objections as to data and methodology seem too serious to us simply to pass by; they demand investigation and answer. While reviewing courts are not to substitute their judgment for an agency's, they are to establish parameters of rationality within which the agency must operate. A court would abdicate its function were it, when confronted with important and seemingly plausible objections going to the heart of a key technical determination, to presume that the agency could never behave irrationally. It has a duty to see that the objections are faced in a proper procedural setting and satisfactory answers provided demonstrating careful agency consideration. [The court consequently remanded the case to EPA for an explanation of the agency's measurement procedures.] . . .

V. Whether Transportation Controls are Arbitrary and Capricious

1. The "freeze" boils down to the requirement that no new parking spaces be created after October 15, 1973, in the more congested protions of Boston, Cambridge, and some other outlying areas. There are important exceptions: residential parking spaces adjacent to homes, apartments, condominiums, etc.), employee parking outside the Boston core (so long as it complied with the separate employee parking restrictions), and free customer parking. Our role, of course, is not to decide whether the freeze device is an ideal solution; Congress delegated to EPA the authority . . . to select the preferred means. We cannot say that such a freeze is arbitrary and capricious assuming EPA is able to support by credible data its position as to the magnitude of the need for carbon monoxide emission reductions in relevant segments of the region. Indeed, the enlargement of parking facilities in areas where the public health requires curtailing the flow of traffic would itself seem irrational. The exemption for residents, customers and, in part of the area, employees, would seem a reasonable attempt to ameliorate the hardship upon individuals and businesses.

[The court went on to uphold other aspects of EPA's plan that included a ban on on-street parking between the hours of 7 to 10 A.M. weekdays, a reduction in the availability of off-street parking, a regionwide 25% reduction in parking provided by employers, and a requirement that if parking was to be expanded at Logan Airport by more than 10%, such increases must be offset by retiring spaces elsewhere in the freeze zone. Finally, the plaintiffs contended that the entire transportation control plan was arbitrary because the EPA had paid too little attention to its economic and social impact. The court rejected this argument as well.]

The material portions of the Clean Air Act itself do not mention economic or social impact, and it seems plain that Congress intended the Administrator to enforce compliance with air quality standards even if the costs were great. Particularly in the case of primary standards—those set as "requisite to public health"—Congress' position is not extreme or unprecedented. Minimum public health requirements are often, perhaps usually, set without consideration of other economic impact. Thus, insofar as petitioners claim that either EPA or ourselves would be empowered to reject measures necessary to ensure compliance with primary air quality standards simply because after weighing the advantages of safe air against the economic detriment, we thought the latter consideration took priority, petitioners would be incorrect. Congress has already made a judgment the other way, and EPA and the courts are bound.

Courts and Technical Issues

As so often happens in lawsuits, the decision in the South Terminal case did not please either side. The court reprimanded EPA for what it viewed as shoddy technical analysis. EPA's numbers were called into question, and consequently, so was EPA's authority to regulate emissions of hydrocarbons. (If the reading taken at Wellington Circle proved inaccurate and Boston was in compliance with ambient standards for photochemical oxidants, EPA would lack authority to act.) On the other hand, the court rejected the petitioners' arguments that the severe measures ordered by EPA were either unnecessary, excessively costly, or otherwise illegal. To the contrary, the court ruled that EPA had broad discretion to fashion the appropriate response. In many ways, the court's decision was predictable. As we have noted before, the judges are reluctant to second-guess decisions of federal agencies.

As the South Terminal case suggests, courts are often uncomfortable rendering decisions in cases that turn on highly technical or scientific issues. Judges are first and foremost generalists. They hear an extraordinary range of cases dealing with issues as diverse as Indian land claims, antitrust matters, products liability actions, and civil rights complaints. On succeeding days, a federal judge may be forced to serve as an amateur historian, economist, sociologist, psychologist, or scientist. Except for those judges who sit in Washington, D.C., where a large number of regulatory cases are filed, most judges will hear only a handful of complex environmental cases in their careers on the bench. Thus, the challenge

for an attorney arguing such a case is to teach the judge enough science so that he can understand the merits of the attorney's argument. Because the attorney is himself or herself usually a layman, this is a very difficult task.

Unfortunately, judges have relatively little opportunity to consult with experts in the field. Our adversary system leaves it to the litigants to call expert witnesses; they, in turn, inevitably offer testimony favorable to the side that has called them. Although the federal rules of evidence do permit a trial judge's own expert witness to be summoned, this procedure frequently does nothing more than generate a third expert opinion for the judge to consider (although it is the opinion of a disinterested party). Moreover, some cases like South Terminal are appealed directly from an agency to the Court of Appeals. Because appeals courts must base their decisions entirely on the written record developed during the course of the regulatory process (and the oral argument of counsel), appellate judges do not hear any expert testimony firsthand. Conscientious judges who would like to consult privately with experts often finds themselves thwarted by the canons of judicial ethics that greatly limit such discussions.

The one resource to which judges have ready access is their clerks. Federal District, Circuit, and Supreme Court judges each employ from two to five clerks to assist in legal research and drafting of opinions and orders; typically, these clerks are high-ranking recent graduates of prestigious law schools. Often judges take a liberal view of what constitutes legal research. (For example, when the Supreme Court was deliberating the Brown v. Board of Education desegregation case, a group of clerks was charged with the task of mapping out every home in Spartanburg, South Carolina, to see how readily the existing white and black schools could be integrated. Similarly, in environmental cases, the task of mastering the vast technical record often falls to the clerks. If a judge knows in advance that he will be hearing a lengthy and complex case, he may seek a clerk with special expertise, but this is a rare luxury. Clerks, like judges, tend to be generalists.

Largely because the courts lack the capacity to make substantive policy decisions, the law of judicial review limits the circumstances under which a reviewing court may overturn a decision of the executive branch. Administrative law attempts to draw a distinction between questions of substance and questions of procedure or law. Agencies have a comparative advantage in deciding the former, whereas courts are better equipped to decide the latter. Accordingly, the law admonishes courts to defer to the judgment of agencies on substantive matters and only permits judicial reversal of an agency decision if the court finds that the agency: (1) exceeded its jurisdictional mandate; (2) did not comply with a procedural requirement (e.g., the agency failed to hold a statutorily required hearing prior to rendering a decision); (3) violated a statutory duty (e.g., the agency ignored its obligation to consider alternatives that might be less harmful to the environment); (4) acted in an unconstitutional manner; or (5) abused its discretion or otherwise acted arbitrarily or capriciously. The latter requirement empowers courts to reverse only for gross errors of judgment and is rarely envoked.

Distinctions between substance and procedure and questions of law and questions of fact are more easily stated than they are made in practice. For example, in the South Terminal case, the question of whether EPA acted properly in imposing a transportation control plan on Boston was nominally a question of law; the agency had legal power to do so only if Boston was not in compliance with ambient air standards. But to make such a determination, the court was forced to review EPA's testing procedures, a highly technical inquiry that the court was clearly uncomfortable in performing. Similarly, many regulatory statutes are written in such a way that they thrust reviewing courts into the position of second-guessing the substantive decisions of agencies.

This is a situation that, like the weather, everyone complains about, but no one seems capable of rectifying. Two general types of reforms are commonly suggested: better precision in drafting of statutes by Congress and the creation of courts with special substantive expertise.

The first reform clearly stands little chance of success. In theory, if Congress was capable of being more precise in giving guidance to regulatory agencies, the courts would have less of a substantive nature to review. For example, had Congress been more precise in specifying the procedures to be followed in determining whether a municipality was in compliance with the Clean Air Act, the court in South Terminal would not have had to wade through a mass of technical material to decide the case. But, in practice, Congress appears incapable of greater precision for at least two reasons. First, the legislature frequently vests discretion in the hands of executive agencies like EPA precisely because they possess the expertise that Congress lacks. Just as judges throw up their hands in frustration in trying to determine the proper procedures for assessing air quality, so do senators and congressmen.

Second, Congress, for political reasons, is often not interested in being more precise. Acts of Congress represent the result of a political bargaining process that relies upon logrolling to achieve consensus. In this process, ambiguity and obfuscation often are helpful in building a coalition. For example, it may be much easier to gain support for a bill that charges an agency like EPA with setting air and water quality standards than it is to get legislators to support a bill in which the standards are specified. The second type of bill is unpopular because regulatees who are likely to be adversely affected by the specified standards will come out of the woodwork to oppose the bill. (Indeed, this is precisely what happened to the EPA in the 301(h) case discussed in chapter 7; EPA had to set standards for secondary treatment of municipal wastewater and every municipality that was affected by the proposed standards registered its objections.) Usually, it is easier for congressmen to delegate many of these difficult policy judgments to agencies. By so doing, they avoid direct responsibility for the decision, and they may still criticize the agency if the decision adversely affects their constituency. Unfortunately, this process also thrusts the courts into the position of reviewing agency judgments to insure that agency decisions conform to the vague guidelines set down by Congress.

The second reform—endowing courts with special expertise—has been adopted for other types of problems. For example, we have special tribunals for handling bankruptcy matters, tax cases, and claims brought against the federal government. Arthur Kantrowitz has advocated the creation of a national science court for resolving policy questions that turn on highly technical issues. The court, which would consist of scientists, would issue opinions on questions submitted to it by Congress and the executive branch. Similarly, from time to time, proposals surface for the creation of special environmental courts consisting of judges who would hear only environmental cases.

Do you think a science court would be a good way to resolve the kinds of technical issues that arose in the Holston River case? Do you think we would have fewer disputes of a technical nature if such a court existed? (For a thorough discussion of the advantages and disadvantages of specialized courts see "The Environmental Court Proposal: Requiem, Analysis, and Counterproposal," 123 *U. Penn. L. Rev.* 676, 1975.)

The Elusive Nature of Facts in Environmental Cases

We began this chapter by noting that most environmental disputes involve disagreements over how ecosystems are likely to respond to various types of human activities. If policymakers posessed the proverbial crystal ball, the range of disagreement in environmental controversies would be narrowed substantially. Instead of arguing over the impact of Tennessee Eastman's discharge on the Holston River, we would simply debate whether the costs of achieving a given reduction in discharge were justified by the resulting benefits. Although this would still not be a trivial dispute to resolve, at least the parties would be arguing from the same basic set of facts.

In an article entitled "The Technical and Judgmental Dimensions of Impact Assessment," 1 *Env. Impact Assess. Rev.* 109, 115–120, 1980, Lawrence Bacow has suggested that policymakers typically overestimate the degree to which science can supply unambiguous answers to complicated environmental questions. Although we would like to believe that science is dispassionate and value free, Bacow has argued that, in fact, the process of modeling is often very subjective. Although the article is concerned with the role of subjective analysis in impact assessment, it also sheds light on how technical analyses often mask important judgments in other types of environmental decisions. As you read the following excerpt, consider these questions:

1. If Bacow's thesis is correct, what are the implications for environmental dispute resolution?
2. What is the appropriate role for experts in the dispute resolution process?
3. Should everything be negotiated, including science?

Conceptually, making predictions about the future consequence of a proposed action involves three distinct activities. First, the analyst must decide where to focus his attention. Since analytic resources are always in short supply, choices have to be made about which impacts will be documented in depth, which will be analyzed only briefly, and which will be ignored entirely. Second, a prediction must be made of how the ecosystem or social system under study will evolve over time in the absence of the proposed project. Finally, an estimate must be made of how the proposed action will cause these systems to depart from their normal evolutionary patterns. The difficulties encountered in specifying the impacts to be studied can best be illustrated by telling a story. For many years, the Massachusetts Department of Public Works has considered widening Route 2, a major artery linking Boston with its affluent northwest suburbs. Widening the highway from two to four lanes would affect the natural environment in a lot of different ways. Land would be consumed. Some flora and fauna would be lost. Noise levels would increase during the construction period. Increased traffic would generate more noise and more air pollution along the route. The highway would also have a number of less obvious effects. Increasing access to the suburbs would probably increase development on the current suburban fringe, thus affecting employment patterns among suburban construction workers. If the new development would have occurred elsewhere but for the widening of Route 2, then widening of the highway will have affected employment patterns in other parts of the Boston metropolitan region as well. Similarly, since Route 2 is an integral link in an interdependent transportation system, increasing its traffic capacity will also affect traffic density (and air pollution and noise pollution) in other parts of the transportation network. It is possible to keep working back through this maze of probable impacts almost indefinitely. It is like pulling on a loose thread of a knitted fabric; it just keeps unraveling. Although it is easier to illustrate interdependencies for impacts that affect social systems like transportation networks, ecologists are quick to point out that ecological systems are perhaps even more interdependent.

Given the multitude of possibilities, which impacts should the author of an environmental impact statement address? It is tempting to say all of them. But the resources available to assess impacts are not limitless. Moreover, even if it were possible to produce a truly comprehensive EIS, its sheer size would ensure that it would never be read. Thus we must somehow define the boundaries of analysis for assessing impacts. If we are only going

to assess a limited number of impacts, then the rational strategy would be to concentrate our efforts on "the most important impacts".

[Bacow argues that each constituency affected by a project is likely to have a different opinion of which impacts are the most important. If the modeling effort relies upon the modelers to scope the impacts, important value judgments will be masked, and the model is likely to be criticized for being biased or uninformed.]

Even if we are unanimous in our view of what is important, it still may not be obvious how to evaluate these impacts. Suppose in the Route 2 example, people are concerned about air quality and noise. Although we may be able to say that these conditions have changed as a consequence of the highway widening, it is often very difficult to state unambiguously whether they have gotten better or worse. For many environmental conditions, there is no single accepted index for evaluating the state of the condition. Consider the problem of assessing air quality. We care about air quality because air pollution affects human health, aesthetics, plant and animal life, and the durability of materials exposed to air. A given change in air quality will affect each of these conditions to a different degree. It is not possible to construct a single index for air quality unless we are first willing to weigh each of its components—a process that necessarily depends upon the preferences of the person constructing the index. Even if we cared about only one aspect of air quality—its effect on human health—it still would be difficult to construct a single objective index because of the complex way individual pollutants interact to produce air pollution. For example, the relationship between the airborne concentration of a pollutant and human health may be nonlinear. Similarly, two pollutants may interact synergistically. In some cases, controlling one source of pollution, such as carbon monoxide from internal combustion engines, may actually increase the level of another pollutant, specifically, nitrogen oxide. Assessing the environmental impacts of noise is even a more difficult task than evaluating air quality. Technically, noise is measured as the ratio of energy transmitted across a unit surface to the minimum energy that can be perceived in the air. What is bothersome about noise, however, is not just the amount of energy transmitted. The annoyance value of noise is determined not only by amplitude but by pitch, frequency of occurrence, the information content of the noise, background sounds, and the dispersion capacity of the physical environment. For example, it may be far more difficult to sleep if a truck rumbles by every 20 minutes than if there is a steady, uninterrupted stream of trucks. Similarly, although almost inaudible, a small scratch on an otherwise perfect recording of a Beethoven concerto is likely to be extremely annoying even to someone who is not an aficionado of classical music. The point to be made is that even the simple task of measuring change in the environment forces the analyst to make judgments about the relative importance of the different components of the change. Moreover, these are not trivial decisions: different indices can lead to different conclusions.

Reaching agreement on the impacts to be studied and the proper form of their measurement does not get us out of the forest. Before we can predict the impact of a development on the environment, we must first be able to describe how the environment is likely to evolve without the development. In practice, our ability to describe accurately the evolution of physical and social systems is limited by our understanding of how such systems operate as well as our ability to predict changes in technology, regulatory policy, market forces, and human preferences.

If nature were static, impact assessment would be a much easier task. But the natural environment changes considerably without human intervention. Species come and go as evolution runs its course. The elements both erode and create land. While some of these events occur gradually, and consequently are predictable, others occur with little warning and may change the character of the environment suddenly and radically. Forest fires, hurricanes, earthquakes, droughts, and volcanoes are all naturally occurring events whose incidence and effect can only be predicted imperfectly. Thus, although we can safely say that a hurricane of the magnitude of Dora may strike the East Coast once every hundred years, we cannot predict its specific environmental consequences without knowing its precise location, the distribution of development in the affected area at the time of the hurricane as well as the relative stability of the affected ecosystem. Consequently, our long-term predictions about the natural state of the environment are necessarily couched in terms that reflect our relative ignorance about future states of the world. We would expect that during the next 25 years a hurricane will strike the Gulf states with sufficient force to reduce the population of the Mississippi sandhill crane by at least 80%.

Our ability to predict the marginal impact of a particular development on the natural environment is also affected by our capacity to predict changes in the natural environment occasioned by the normal development of social systems. To go back to a previous example, if we are interested in predicting the increase in air pollution that would result in 1985 if Route 2 were widened, we have to be able to predict traffic density on Route 2 in 1985 given a highway of current dimensions. But such a prediction requires knowledge of the likely growth in suburban housing demand as well as suburban job opportunities—two large determinants of traffic density. At present, we only imperfectly understand what makes cities grow or not grow, so predictions about likely growth in traffic density will again be imprecise. Further complicating the analysis is our ability to predict changes in other conditions that influence traffic density. For example, traffic density varies as a function of the cost of driving relative to other modes of transportation—as the price of gasoline has increased, at least some people have left their cars at home and taken public transportation. So if we are to predict traffic density, we need to know not only the future price of fuel, but also the behavioral relationship that constitutes the demand curve for gasoline.

Moreover, in many cases it is difficult to predict the natural evolution

of the environment without making some assumptions about the future impact of regulation and technological change. For example, future air quality in urban areas will be determined, in large part, by the success (or failure) of federal efforts to produce a nonpolluting car. Thus, our ability to predict the evolution of the atmospheric environment is directly related to our ability to predict the success of regulation or the rate of change in technological innovation.

Because our predictions of what the world would look like *without* any additional government intervention are so uncertain, it is difficult to isolate changes that are attributable solely to new projects. Furthermore, our capacity to make confident predictions about impacts varies in a rather perverse way with the controversialism of the issue. While we can state quite conclusively that the U.S. Air Force's new long-range radar station on Cape Cod will destroy 10 acres of flora, we have little knowledge of the long-term effects of prolonged exposure to low-level ionizing radiation—and that is what everyone on the cape is upset about.

In practice, it is unreasonable to expect impact statements to be anything more than synthetic documents. We rarely have the time available to do new research necessary to answer the questions that lie at the root of controversy over development proposals. Instead, we are forced to cull the available evidence to draw conclusions. More frequently than not, however, the available evidence is ambiguous; it can support a host of different conclusions. In some cases, we simply do not understand causal relationships well enough to draw inferences about stimulus and response. In other cases, the consequences of intervention are subtle and difficult to document. And, in still other cases, synergistic interactions make it hard to determine why something has changed. The kinds of inferences people are willing to draw from such ambiguous evidence varies with both their professional training and their personal stake in the outcome. Scientists tend to be a very conservative lot—they are reluctant to conclude, for example, that an observed increase in the cancer rate is attributable to exposure to a particular chemical unless they are at least 95% certain that the increase is not attributable to chance. In contrast, people at risk are far more willing to conclude that a hazardous condition exists on the basis of information that the scientist would deem inconclusive. Thus, it should not be surprising that the process of collecting information about impacts is divisive: the information collected is grist for the mill of both sides. Instead of looking for opportunities to resolve differences between competing interests, we have created a system that amplifies existing differences. Moreover, we have done so because we have underestimated the degree to which impact assessment is a subjective, judgmental, nontechnical activity.