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THE EFFECTS OF COMPLIANCE UNCERTAINTY ON FLEXIBLE ENVIRONMENTAL PERFORMANCE STANDARDS: TOTAL MAXIMUM DAILY LOADS IN MICHIGAN

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THE EFFECTS OF COMPLIANCE UNCERTAINTY ON FLEXIBLE ENVIRONMENTAL PERFORMANCE STANDARDS: TOTAL MAXIMUM DAILY LOADS IN MICHIGAN

By

Lorie Srivastava

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ABSTRACT

THE EFFECTS OF COMPLIANCE UNCERTAINTY ON FLEXIBLE ENVIRONMENTAL PERFORMANCE STANDARDS: TOTAL MAXIMUM DAILY LOADS IN MICHIGAN

By

Lorie Srivastava

Interest in flexible environmental performance standards for regulating nonpoint source pollution has been increasing. This rise in interest is partially due to such perceived benefits as the provision of dynamic incentives that allow firms to be technologically innovative, improving the cost-effectiveness of environmental regulations. These cost savings that may arise are due to decreases in compliance costs for the regulated firm, and are termed *innovation offsets* by Porter and Van der Lynde in the *Porter Hypothesis*.

In the case of nonpoint sources of pollution, however, transaction costs – due to compliance uncertainty – may be so high that they may negate any possible benefits, limiting the feasibility of flexible environmental performance standards as a policy tool. Regulators and farmers suffer from compliance uncertainty. Regulators experience compliance uncertainty due to (a) unobservable effluent, (b) incomplete knowledge on their behalf with respect to understanding the fate and transport of effluent from nonpoint sources and its stochastic characteristics, and (c) opportunistic behavior by farmers due to asymmetric information leading to moral hazard. Farmers suffer from compliance uncertainty with respect to whether their actions or effort will be deemed sufficient for

compliance with flexible performance standards. Even if farmers would like to comply, liability issues may prevent them from innovating. With moral hazard, poor understanding of the fate and transport of pollutants, and possible free riding, farmers may face liability issues that are not due to their own efforts. In this case, they may prefer to forgo investments and not innovate. Furthermore, they may decide to shift liability costs to the regulator by demanding that the regulator specify design standards.

A model is developed to examine total maximum daily loads, authorized under the Clean Water Act to control nonpoint sources of pollution. This analysis of total maximum daily loads, which can be implemented by flexible performance standards, reveals that transaction costs due to compliance uncertainty affect the effort level of farmers, their costs, and their benefits from induced innovation. This analysis finds that under certain conditions, as the compliance uncertainty increases, two things occur: the amount of farmer effort expended is greater, and the cost to the farmer increases. Under certain conditions, cost savings from induced innovations are secondary to the cost-savings from decreased compliance uncertainty.

Once assumptions with respect to compliance uncertainty, expected penalties, and farmer liability that are taken for granted – implicitly or explicitly – in the customary examination of flexible performance standards are relaxed, and relevant transaction costs are included in the analysis, flexible performance standards may not be more cost-effective than design standards.

To my husband James McQueen, and to Mum and Dad, for their support and love.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
Introduction

Nonpoint sources of pollution have been identified by the Environmental Protection Agency (EPA) to be the main cause of the remaining surface water quality problems in the United States (EPA 1998). Furthermore, since agricultural production is the largest nonpoint source of water pollution in the U.S. (EPA 1998), it is being subjected to increasing policy attention. This policy attention has resulted in the search for an appropriate set of regulatory tools and programs to reduce agriculture's negative effect on water quality. Certain types of environmental regulatory measures have been promoted over others by most economists. For example, flexible environmental performance standards are believed to be potentially more cost-effective than the regulatory measures that have been historically employed in the United States. Most proponents of these measures, however, have not adequately accounted for uncertainty and its resulting transaction costs. This study examines these issues with respect to nonpoint sources of pollution in Michigan in the context of the Clean Water Act's Total Maximum Daily Loads (TMDLs) program.

1.1 Flexible Environmental Regulations

Historically, environmental management in the U.S. has been based upon a *command-and-control*[1] philosophy. A command-and-control regulation would be the case where the regulations specify both "what is to be done" and "how" the goal is to be

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[1] Some authors have argued that the nomenclature surrounding environmental policies is not truly reflective of environmental regulations. For instance, Russell and Powell contend that command-and-control is a pejorative term that does not adequately describe the range of environmental policies, since few regulations specify both what is to be achieved (i.e. command) and how it is to be achieved (i.e. controlled) (Russell and Powell 1996). See also Russell 2001. Driesen argues that the command and control/economic incentive dichotomy must be replaced with a more nuanced analytical approach to both types of programs in order to create a more dynamic and effective environmental law (Driesen 1998).

achieved. An example would be the requirement of a particular air scrubber to meet an air emission standard or a prohibition of a polluting activity. Although this approach has led to environmental improvements over the last three decades (Adler 1999; Houck 1999), economists have criticized the command-and-control framework for being expensive, inflexible, and more importantly, for stifling technological innovations. As a result, policymakers have begun searching for new pollution prevention approaches; and they have focused increased attention on programs based upon flexible incentives.

It has been argued that under certain conditions, agro-environmental policies that incorporate flexible incentives may allow farmers to attain desired environmental goals in a cost-effective manner (Batie and Ervin 1999; Segerson 1999a; Portney and Stavins 2000). Flexible incentives are "environmental management tools that specify objectives but ... do not dictate how the environmental objective is to be achieved" (Batie and Ervin 1999, p. 56). This flexibility has the potential to allow policymakers to accommodate diverse natural resource conditions, heterogeneous production systems, and other factors that may vary spatially and temporally. Furthermore, flexible incentive-based environmental regulations remove the onus on regulators to determine the "best" technology that must be used by the regulated firms.

One policy instrument that incorporates this flexibility is a *flexible environmental performance standard*. An environmental performance standard establishes the environmental limit for potential pollutants. Typically, an environmental performance standard is designed to achieve a policy target, where the goal is based upon either human health criterion, or an ecosystem criterion, or a combination of both. For instance, with water quality, an ambient performance standard specifies the ambient concentration of a pollutant, such as phosphorus, in a body of water. Deviations above the allowed concentration result in penalties.

Flexible environmental performance standards are differentiated from other types of environmental standards. With a *design standard*, particular technologies must be adopted by the polluter are prescribed;[2] an example in agriculture would be the required adoption of conservation tillage. In contrast, a *technology based performance standard* refers to the amount of pollutant allowed in an effluent, but it is based upon the best outcome of a given technology. *Effluent performance standards* are source specific and refer to the allowable level of a pollutant that a polluter can emit. Finally, an *ambient performance standard* refers to outcomes such as ambient water quality.

With a *flexible* environmental performance standard, no design standards or specific technologies are prescribed. Thus, flexible ambient and effluent performance standards are both examples of a flexible environmental performance standard. A flexible environmental performance standard allows farmers to implement the technology or production method that is most cost-effective for their situation.

The two most significant potential advantages of flexible environmental performance standards over the traditional command-and-control approach are: (1) they create dynamic incentives for technological innovation and its diffusion, and (2) they may be more cost-effective (Stavins 2000). In some cases, this dynamic incentive for technological innovation for nonpoint pollution may even allow farmers to increase their profits. The concurrent outcomes of environmental improvements and a reduction, or

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[2] Design standards are also referred to as "technology specifications" by others and occasionally the term design standard refers to a performance standard (e.g. Russell 2001). Throughout this study, however, a design standard refers to a prescribed technology by the regulator.

offset, in compliance costs through the adoption of new technology is defined as an *innovation offset*. If farmers are actually able to generate innovation offsets while meeting an environmental performance standard, then their costs to comply with the environmental regulation may decrease, making the flexible environmental performance standard – either ambient or effluent – potentially more attractive to farmers than environmental regulations based upon design standards.

The potential for innovation offsets is an important implication of the "Porter Hypothesis" (Porter and Van der Linde 1995). According to the Porter Hypothesis, "policies mandating strict environmental compliance have [the] potential to make American firms and industries more competitive" by encouraging technological innovations and change (Thurow and Holt 1997 p. 20). By inducing firms to innovate, the Porter Hypothesis contends that environmental regulations can provide necessary dynamic incentives for technological innovations. Researchers have debated as to whether the Porter Hypothesis does in fact hold (e.g. Gardiner and Portney 1994; Palmer, Oates, and Portney 1995; Jaffe and Palmer 1997). These studies, however, have examined the manufacturing sector; they have not focused on agriculture.

One of the few journal articles that examines innovation offsets in the context of animal agriculture is by Thurow and Holt (1997). Dairy farmers were required to adopt certain technologies to meet water quality regulations in the Okeechobee, Florida. Thus, flexibility was not embodied in the environmental legislation. But some farmers also adopted non-required production-enhancing technologies.[3] Thurow and Holt, however,

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[3] Boggess, Johns, and Meline (1997) state that compliance costs $1.14 per hundred weight of milk were offset by a 13 per cent increase in milk production when farmers complied with the Dairy Rule in Florida. But they did not examine induced innovation or innovation offsets specifically in this article.

found that, although these investments increased revenue, they were not associated with phosphorus runoff reduction; consequently these innovations did not result in innovation offsets, as defined above. This study departs from Thurow and Holt's examination in that innovation offsets in the context of flexible environmental performance standards in agriculture are investigated, with a focus on the effects of compliance uncertainty and resulting transaction costs. The basic thesis underlying this focus is that the incentive to innovate as a result of environmental performance standards may be undermined when significant transaction costs exist.

1.2 The Effect of Transaction Costs

A transaction cost can be defined to include "the costs of gathering and processing the information needed to carry out a transaction, of reaching decisions, of negotiating contracts, and of policing and enforcing those contracts" (Williamson 1981). In other words, transaction costs are the costs of coordinating and motivating an economic system (Milgrom and Roberts 1992).

Whether flexible performance standards can achieve environmental outcomes at a lower cost compared to design standards depends upon transaction costs (Batie and Ervin 1999; Norris and Thurow 1999). But what type of transaction costs are relevant? With flexible environmental performance standards, transaction costs associated with coordination and motivation – or incentives – are of significance; specifically, these transaction costs are due to informational incompleteness and informational asymmetries (Milgrom and Roberts 1992). Transaction costs arise because of a lack of sufficient information – the pervasive uncertainty in the world prevents firms and individuals from making perfectly informed decisions. These informational problems lead to compliance uncertainty which complicates the implementation of flexible environmental performance standards.

1.2.1 Transaction Costs Incurred by Regulators

With nonpoint source pollution, compliance uncertainty stems from a variety of factors attributable to imperfect information and the stochastic nature of nonpoint source pollution. For regulators, transaction costs such as information, monitoring, and enforcement costs can be significant with flexible environmental performance standards. Regulators have imperfect information with respect to assessing the efforts undertaken by farmers. This informational constraint, or uncertainty, can be due to such factors as technological or personnel limitations. Additionally, with nonpoint sources, the effects of discharges are not often observed immediately; these effects can be spatially and temporally removed from the pollutant source. This diffuse and stochastic characteristic of nonpoint source pollution is the cause of an additional informational problem – namely the limited understanding of the transport and fate of pollutants from nonpoint sources. This informational constraint seriously constrains the regulator's ability to determine the farmer responsible for nonpoint pollution and about his degree of responsibility (Shortle, Horan, Abler 1998).[4]

This high degree of compliance uncertainty may lead to *moral hazard*. Moral hazard arises when the regulator can not observe the actions of individual farmers and thus can not determine the effluent from each farm, nor each farmer's pollution abatement efforts (Xepapadeas 1991; Tirole 1995). Rather, the regulator can only observe

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4 The author recognizes that there are many women farmers, but the masculine pronoun will be used for simplicity.

the outcome of all farmers' actions in the ambient pollution level of a body of water, for instance. Essentially, unobservable effluent from farm operations mean that farmers' performance in the public interest can not be directly observed (Shortle, Horan, Abler 1998). Consequently, each farmer can increase his profits by choosing a lower level of abatement effort, since his actions can not be monitored effectively by the regulator (Xepapadeas 1991).

Given these transaction costs, it can be challenging for regulators to even determine what "being in compliance" means from an enforcement perspective. When flexible performance standards are applied to agricultural nonpoint source pollution, regulators do not specify technologies to be used by regulated farms; consequently the regulator does not check the farm operation to see whether a specific technology is being used. The regulator may only be able to check indirectly whether a firm is in compliance. For instance, the regulator may sample the impaired water body to measure the ambient pollutant level. If the ambient level exceeds the specified standard, the regulator only knows that the aggregate effluent level must be reduced; this observation does not help the regulator answer questions like: "Which farms, if any, are responsible for this outcome?" and "How much must each farm cut back?"

Although the regulator could use a computer model to estimate effluent from farms, this method entails costs for the regulator. For example, the software has to be developed and maintained by technically trained staff, and data must be gathered. Scientific information, which must exist on the linkages between farm practices and ambient water quality, may be absent. Consequently, it may be difficult for the regulator to define compliance at an operational enforcement level. In addition, the use of a computer model to estimate effluent and determine fines may not be defendable in court. Compliance uncertainty thus poses a challenge for regulators in managing nonpoint sources of pollution with a flexible performance standard.

In contrast, design standards tend to be easier to administer, thereby reducing monitoring costs for the regulator. Once the design standard is specified, the regulator simply has to observe whether each farm is in fact employing the required technology. If a farm is not, it is in violation of the environmental regulation; if it does use the technology, then the farm is in compliance. The actual ambient pollutant level is of secondary importance with regulations that employ design standards. Administration and political difficulties may arise, however, if the water quality fails to improve, and the regulator, following an adaptive management path, "readjusts" the required technology.

This lack of focus on environmental outcomes with design standards is not a surprising result; when measuring performance for individual agents is costly, then decision-makers create institutions that reduce the importance of accurate performance measurements. That is, procedures-based approaches, such as design standards, are desirable when uncertainty and complexity make it difficult to predict performance (Milgrom and Roberts 1992). This observation provides an important explanation as to why, in the context of nonpoint source pollution, design standards have been the preferred policy instrument in the U.S.

On the other hand, flexible environmental performance standards may reduce some informational costs for regulators relative to design standards. With flexible performance standards, regulators do not have to bear search costs nor undertake research efforts of their own to determine the best technology that farmers must use to reduce nonpoint source pollution. With flexible performance standards, farmers now have to determine the best technology or production method to use for their own situation. Consequently, flexible performance standards allow the regulator to shift these transaction costs onto farmers. This reduction in informational costs may become significant in the long term as environmental constraints and technology change and become more complex.

1.2.2 Transaction Costs Incurred by Farmers

There is an advantage from flexible environmental performance standards for farmers; farmers can choose the technology that is best suited to their operation and surrounding ecosystem requirements. A farmer does not have to implement a technology that may be too expensive or inappropriate for his circumstances, and may be able to benefit from innovation offsets from his technological choice.

Nevertheless, flexible environmental performance standards also result in transaction costs for farmers. Informational costs dominate. In order to comply with flexible performance standards, farmers must possess knowledge about the nature and extent of effluent from their farm at their source, as well as the relative cost-effectiveness of different pollution prevention management practices. In fact, many resource management decisions that can have a significant effect on the environment are too costly to monitor or verify (Shortle, Horan, Abler 1998), especially for farmers who are not trained in determining and assessing technical scientific information. This information can be made available to the farmer – for instance, through a computer model. But, at the least, the farmer must learn how to interpret the results of the model, and more importantly, he must trust the results of the model.

Stochastic weather events can compound the uncertainty surrounding links between management practices and environmental outcomes. In fact, it has long been recognized that nonpoint source pollution is inherently stochastic (Shortle and Dunn 1986). The diffuse nature of nonpoint source pollution compounded by stochastic weather events also makes it difficult for farmers to determine whether they are in compliance with the flexible performance standard. Consequently, the farmer may unintentionally cause environmental degradation as a result of his management practices since he can not link his own management practices to any deviation from the environmental performance standard.

Thus, in practice, it is difficult for farmers to ascertain whether they are in compliance with a flexible environmental performance standard due to the nature of nonpoint source pollution. This difficulty can be contrasted with compliance with environmental regulations based upon design standards. In the case of design standards, the farmer is told what pollution prevention technology to use, so he clearly knows whether he is in compliance. If he does not adopt the specified technology, then he is not in compliance, otherwise he is in compliance. Thus, certain informational transaction costs that the farmer must bear with flexible performance standards are eliminated with environmental regulations based upon design standards.

It would appear that economic theory suggests that the feasibility of flexible environmental performance standards to control or minimize nonpoint source pollution is ambiguous. On the one hand, such standards provide incentives for technological innovation, and they may reduce compliance costs through ensuing innovation offsets; on the other hand, transaction costs due to compliance uncertainty may be so high with respect to nonpoint sources, that they may negate any possible benefits, rendering flexible environmental performance standards infeasible as a policy tool to control nonpoint sources of pollution. The paucity of empirical experiences has limited the resolution of this ambiguity.

Clearly, compliance uncertainty creates transaction costs for regulators and farmers, since both agents have difficulty linking farmers' actions with compliance to the environmental performance standard. This compliance uncertainty and the resulting moral hazard may prevent farmers from complying with the flexible performance standard, thereby reducing the likelihood that water quality goals will be met.

1.3 Total Maximum Daily Loads

The United States Environmental Protection Agency is now attempting to control nonpoint sources of pollution throughout the country under provisions of the Clean Water Act by way of a process called total maximum daily loads (TMDLs). TMDLs can be considered to be flexible environmental performances standards for surface water.[5] Consequently, Michigan, along with other states with delegated authority, are beginning to implement TMDLs to meet state water quality goals and comply with the Clean Water Act. In fact, given the rise in the use of flexible performance standards through the Clean Water Act, it would appear that federal policymakers are undaunted by the transaction costs associated with them, or feel that they are low enough so as to not be a significant impediment, or hope that transaction costs will be quickly lowered in time through advances in information and monitoring technology. This study will examine whether

[5] TMDLs have been authorized since 1972 in the Clean Water Act, but they have only recently been implemented. This is explained in further detail in Chapter 2.

flexible performance standards are effective in controlling nonpoint sources of pollution in the presence of transaction costs related to uncertainty.

Nutrients from nonpoint sources are major pollutants that impair lakes and reservoirs throughout the nation, and agriculture is the leading source of pollution in assessed surface waters (EPA 1998). In fact, agriculture contributes to 59 percent of reported water quality problems in impaired rivers and streams (EPA 1998). The pollutant of interest in this study with respect to total maximum daily loads is phosphorus. Most phosphorus from agricultural lands is transported with sediment since it binds to soil (Parker 2000). Recent research, however, has indicated that soluble phosphorus runoff can result if the amount of phosphorus bound to soils is very high (Sims 1998). These two facts compound the effect of stochastic events such as weather and the transport and fate of phosphorus, and thus the control of phosphorus from nonpoint sources.

Phosphorous is of interest because it becomes a pollutant when it enters surface waters in substantial amounts; it contributes to the excessive growth of algae and other aquatic vegetation, leading to the accelerated eutrophication of lake habitats and ecosystems. Eutrophication is the process by which a body of water becomes rich in dissolved nutrients, and hence deficient in dissolved oxygen. This resultant oxygen depletion can lead to fish kills and other water quality problems. In fact, phosphorous is most often the limiting nutrient in freshwater aquatic systems (NRC 2001). Water bodies impaired due to excess phosphorus are costly and difficult to restore and take many years to recover (Lemunyon and Daniel 1998). Thus, excessive phosphorous can damage intricate habitat interrelationships, thereby degrading the complex Great Lakes ecosystem.

Little empirical research has been conducted to resolve this lack of knowledge (Schmitz *et al.* 1995; Thurow and Holt 1997). Although data shortcomings were highlighted by both the General Accounting Office and the National Research Council in their assessments of TMDLs, the effect of compliance uncertainty on the successful implementation of TMDLs and the issue of innovation offsets were not specifically examined (GAO 2000, NRC 2001). Consequently, this study contributes to this nascent literature by examining whether flexible performance-based agro-environmental policies will effectively address nonpoint sources of pollution in meeting water quality goals in Michigan.

1.4 Research Questions

Flexible environmental performance standards are potentially more cost-effective than design standards and thus tend to be preferred by economists. They have the potential to be more cost effective because, as noted by the Porter Hypothesis, the flexibility makes possible induced innovation and innovation offsets. Innovation offsets may reduce compliance costs for regulated firms, and they potentially reduce search and informational costs for the regulator, since the regulator no longer has to determine and specify a design standard for regulated firms.

Despite the increasing regulatory interest in flexible environmental performance standards, there is a dearth of knowledge as to how cost-effective they will be in controlling nonpoint sources of pollution when compliance uncertainty is taken into account. This study examines the effect of uncertainty and its resulting transaction costs on the cost-effectiveness of flexible environmental performance standards to curb nonpoint source pollution. This examination will be guided by an *ex ante* analysis of the implementation of total maximum daily loads by Michigan regulators to control phosphorus. This study is an *ex ante* study because Michigan has yet to implement a TMDL process. This analysis can provide insights into the regulatory process that attempts to reduce nonpoint source pollution from agriculture in order to meet water quality goals in Michigan.

As such, the two key research questions that will be examined are:

1. ***How might compliance uncertainty affect the effort level of Michigan livestock farmers, their costs, and their benefits from induced innovation?***

2. ***Can flexible environmental performance standards ensure induced innovation in the context of compliance uncertainty, and what are the implications for the Porter Hypothesis?***

These research questions will be analyzed in terms of total maximum daily loads, which if implemented as flexible environmental performance standards, are the only example of flexible performance standards that currently exist for agriculture in Michigan.

The agricultural sub-sector to be examined is the dairy sub-sector. This study focuses on the Michigan dairy industry because it's the highest ranked agriculture sub-sector in terms of market value of agriculture sales, contributing to 18 per cent of all agricultural sales in the state. Furthermore, the dairy sub-sector will be affected by the implementation of total maximum daily loads as it may be a significant source of phosphorus (Census of Agriculture 1997).[6] With approximately 300,000 dairy cattle, Michigan ranks eighth in the country in terms of numbers of dairy cattle. Once assumptions with respect to compliance uncertainty that are taken for granted – implicitly or explicitly – in the customary analysis of flexible performance standards are relaxed, and the transaction costs are included in the analysis, flexible performance standards may not be more cost-effective than design standards.

1.5 Dissertation Outline

This dissertation proceeds by providing a foundation of the effects of compliance uncertainty on the implementation of flexible environmental performance standards by examining key components in each of Chapters 2 through Chapters 5. Specifically, Chapter 2 provides an historical overview of the institutional context, that is, of the Clean Water Act and TMDLs. The effect of uncertainty and its resulting transaction costs on both regulators and farmers with respect to flexible performance standards is then analyzed in detail in Chapter 3. Chapter 4 examines the Porter Hypothesis component, specifically, the innovation offsets that may be induced by flexible performance standards. These components are weaved together into a game theoretical framework in Chapter 5 to stylistically depict the regulator and the possible actions of a farmer who must contend with a flexible environmental performance standard in the face of compliance uncertainty. Chapter 6 builds upon this framework to develop a conceptual model to examine the differing levels of cost-savings due to farmer innovation that potentially result from various levels of compliance uncertainty with a flexible

[6] Information on the actual amount of phosphorus from dairy farms or other livestock farms in Michigan is limited.

performance standard. Specifically, this model is used to investigate the implementation of a TMDL to control phosphorus from dairy nonpoint sources in the presence of compliance uncertainty. Using data collected through interviews with state regulators and focus groups with Michigan dairy farmers, empirical corroboration of the results from Chapter 6 is presented in Chapter 7. Finally, Chapter 8 summarizes the major findings of this study. Policy and research implications of this analysis are discussed as well.

CHAPTER 2

The Clean Water Act and Total Maximum Daily Loads

If total maximum daily loads – implemented as flexible performance standards – can cost-effectively address the degradation of water quality in the Great Lakes ecosystem in Michigan from the livestock agricultural sub-sector, then environmental quality policymakers can be encouraged that they are following the right course. But if TMDLs do hold such a promise, why were they not implemented before? Why are they just being implemented now? How are they being implemented? To answer these questions, a brief overview of federal U.S. water regulations is necessary.

2.1 History of Early Federal Water Pollution Regulations

Federal involvement in controlling water pollution began in 1899 with the Rivers and Harbors Act – commonly known as the Refuse Act.[7] This act, however, did not address water pollution as thought of today; rather, it prohibited the discharge of refuse of any kind into the navigable waters of the United States. Congress enacted the first federal legislation to explicitly contend with water pollution in 1948 – the Federal Water Pollution Control Act (FWPCA). The federal government, however, had no authority to establish water quality standards, limit discharges, nor engage in any enforcement. Indeed, the Act specifically recognized states' primary authority over water pollution.

The FWPCA was amended five times between 1948 and 1972. Water quality standards were first included in federal law in amendments in 1965.[8] With these amendments, federally approved water quality standards were required for interstate

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[7] This section is adapted from Freeman 2000, and Battle and Lipeles 1998.
[8] The Water Quality Act of 1965.

waters.[9] Nevertheless, by 1970 it was apparent that the FWPCA was ineffective in improving the waters of the United States. A dramatic symbol of the lack of success of the FWPCA occurred on June 22, 1969, when the heavily polluted Cuyahoga River in Cleveland burst into flames.

The revisions that Congress made to the FWPCA in 1972 were significant. The Senate committee that reported the 1972 amendments found that "there had been an almost total lack of enforcement of the FWPCA and that new measures were required to curtail the use of rivers, lakes, and streams as waste treatment systems" (Battle and Lipeles 1998, p. 13).

2.2 Inclusion of Total Maximum Daily Loads in the 1972 Amendments

In 1972, due to reports of deteriorating water quality from around the U.S., a new political view began to prevail – water pollution was a national problem that required federal involvement (Houck 1999). In drafting their versions of the Act, however, the Senate and House committees took different approaches.

As Houck (1999) recounts, a number of Senators felt that because water quality standards had completely failed as a policy tool since first enacted in federal law in 1965, they should be abandoned, and only technology-based standards should be in the *Act*. Thus, the Senate promoted technology-based standards in its version of the new federal water act (S. 2770). States and industry representatives, however, did not want to implement technology standards. As the House was historically more influenced by state and industry views, it passed H.R. 11896, retaining the emphasis on state primacy and

[9] This summary draws heavily from Houck (1999). For a thorough legal history of the Act, see Houck.

water quality standards. In order to make its water quality standards program more defensible, however, it added Section 303(d), among other provisions.

2.2.1 The 1972 Amendments and Section 303(d)

The role of state water quality standards – pushed by the House – versus technology standards – pushed by the Senate – was at the heart of the debates of the 1972 Amendments. The Senate did not yield on the technology approach, but, in the end, it did compromise. House Section 303, with its water quality criteria and standards, total maximum daily loads for polluted waters, and implementation plans was adopted, but only as a backup if technology standards proved to be insufficient in meeting water quality goals. That is, Section 303(d) added a prescription for using water quality standards to improve those waters that remained polluted *after* the application of technology-based requirements, through the use of total maximum daily loads.

This section was a conscious response by the House to address the perceived failings of the FWPCA, as well as recognition of the strong criticism that state performance and water quality standards regulation were receiving from the Senate and a strong minority of House members (Houck 1999). Additionally, there was support for retaining water quality provisions by some environmental groups who did not want to rely solely on technology-based standards.

Briefly, Section 303(d) requires the states to undertake three steps: 1) identify waters that are, and will, remain polluted after the application of technology standards, 2) prioritize these waters, accounting for the severity of their pollution, and 3) establish total maximum daily loads for these waters at levels necessary to meet the applicable state water quality standards. The total maximum daily loads must account for seasonal variations and allow a margin of safety to reflect the lack of certainty about discharges and water quality (Houck 1999).

There were essentially two objectives behind Section 303(d): 1) to involve both the states and the EPA, and 2) to specify the steps required to improve degraded waters. Thus, Section 303(d) provided *both* a mandate and a framework for using water quality standards to improve polluted waters, a departure from past FWPCA amendments (Houck 1999).

Despite its compromise, the Senate did not take Section 303 seriously; indeed, Senator Muskie, principal author of the Senate bill, told the EPA administrator to "assign secondary priority" to Section 303 when it came to allocation in the years ahead (Houck 1999, p. 24). Thus, the EPA and the states essentially ignored Section 303 for decades, and focused on technology-based standards.

2.3 Implementation of the 1972 Amendments

Following the passage of the FWPCA Amendments of 1972, the EPA was fully occupied in promulgating technology standards under the CWA and defending them in court. The Agency had little inclination to implement Section 303(d) before technology requirements were in place (Houck 1999, p. 49). In fact, the EPA focused on technology standards only for *point sour*ces, and virtually ignored *nonpoint sources* (Houck 1999).

2.3.1 Definition of Point and Nonpoint Sources

The Clean Water Act defines a *point source* to be "any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container. It also includes vessels or other floating craft from which pollutants are or may be discharged. By law, the term point source also includes concentrated animal feeding operations..." (EPA 2002). Concentrated animal feeding operations (CAFOs) are currently defined as 1,000 animal units, which translates into 700 milking cows. Thus, under the federal Clean Water Act, all dairy operations with 700 milking cows or more are considered a point source under the Clean Water Act, and are regulated entities.

The EPA has defined *nonpoint source* pollution as pollution that "is caused by diffuse sources that are not regulated as point sources and normally is associated with agricultural, silvicultural and urban runoff, runoff from construction activities, etc. Such pollution results from human-made or human-induced alteration of the chemical, physical, biological, and radiological integrity of water. In practical terms, nonpoint source pollution does not result from a discharge at a specific, single location (such as a single pipe) but generally results from land runoff, precipitation, atmospheric deposition, or percolation" (EPA 1987). The term nonpoint has commonly come to be used when referring to pollution from agricultural sources.

In 1977, Congress included an exemption for farms in the Clean Water Act, and redefined point source to exclude return flows from irrigated agriculture. In 1987, Congress exempted all agricultural stormwater discharges. Due to these exemptions, from the standpoint of the Clean Water Act, farms have been free to discharge soils, animal wastes, fertilizers and other pollutants into surface waters under the Clean Water Act (Ruhl 2000); however, other legislation, such as state rules, may apply to such effluent.[10]

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[10] In Michigan, the Natural Resource and Environmental Protection Act (1994) prohibits such discharges, but investigations of violations are complaint-driven. Critics claim that there are many unregulated releases of livestock-related pollutants into Michigan waters (Sierra Club, 2000)

Thus, with the exception of concentrated animal feeding operations, few restrictions on agriculture specified by the Clean Water Act were enforced.[11]

2.3.2 Slow Implementation of Section 303(d) and Declining Water Quality

The Act specified that Section 303(d) could be implemented only after the EPA formally identified pollutants appropriate for water quality analysis and TMDLs. Once these pollutants were identified, states had 180 days to submit their lists of degraded waters, priorities for cleanup, and TMDLs. Yet, the EPA did not identify the pollutants. Section 303(d) was ignored for two reasons: 1) assessing compliance was difficult, and 2) ignoring it seemed possible (Houck 1997). Lawsuits were filed in the late 1970s, however, challenging the absence of TMDLs for parts of the Colorado River and South Dakota, but they failed on the grounds that the EPA had not identified the pollutants.[12]

A court order in 1978, however, required the EPA to publish a final identification of TMDL pollutants. In the notice of its required regulations, the EPA explained that it did not consider this list to be a high priority, since it felt that many of the practical results of TMDLs were being accomplished through basin planning (Houck 1999).The EPA told states that nonpoint source contributions did not need to be considered in setting priorities since the "relative significance of point and nonpoint sources would not be determined until TMDLs were developed." (Houck 1999, p. 51). Thus, due to the low priority given to TMDLs by the EPA, along with its preoccupation with technology

[11] This situation continues to largely be true today.

[12] The Environmental Defense Fund filed a lawsuit, but the EPA did not specify salinity as a pollutant until December 1978, allowing states until June 1979 to submit TMDL calculations. Similarly, the case in South Dakota also failed since the EPA did not identify pollutants.

standards and controlling point sources, states did little or nothing to address nonpoint sources.

But by the later 1980s, a consensus was growing among states, Congress, environmentalists, and industry over the need for improvements to the CWA; a primary focus was the return to water quality standards for a chronic and unsolved problem – namely nonpoint source pollution.[13]

At the same time, was becoming clear that technological controls on nonpoint sources of pollution was insufficient for waters affected by multiple dischargers (some regulated, others not) and multiple pollutants. For instance, a program in 1972 to address nonpoint source pollution via state and watershed planning through the CWA only produced studies, but no measurable improvements in water quality (Houck 1999).

2.4 Implementation of Total Maximum Daily Loads

Throughout the 1980s, state agencies and the regulated community continued to insist that water quality standards should be used to control water pollution; this insistence was unnecessary since they had the authority and mandate to do so under Section 303(d). But Section 303(d) was largely ignored for the first twenty years – since the 1972 amendments to the Clean Water Act – due to inaction by the states and the lack of enforcement pressure by the EPA (Battle and Lipeles 1998; Stephenson, Shabman, Geyer 1999; Ruhl 2000). Most states focused on bringing point sources of pollution into compliance (NRC 2001). States did not undertake any of the steps specified under Section 303(d); they did not: 1) submit inventories of polluted waters, 2) they did not

[13] Toxic water pollution was the other area problematic area of concern.

prioritize these waters for cleanup, and 3) they did not promulgate TMDLs. In the 1980s, citizens' groups' – or third-party groups' – lawsuits accelerated, accusing the EPA of failing to implement and enforce the total maximum daily load process (NRC 2001).

Yet the EPA did not readily comply. When the EPA was initially sued in the early 1980s, it argued that Congressional intent was to rely on the states to set the TMDL machinery in motion because, under Section 303(d), there is no explicit requirement for the EPA to act in the absence of state inaction. That is, the EPA argued that their intervention is called for only in response to *inadequate* state performance, but not in response to *no* state performance. (Houck 1999).

Thus, the EPA and states effectively continued to ignore TMDLs until they were faced with a "virtual avalanche of litigation in the mid-1990s" (Battle and Lipeles 1998).[14] This wave of lawsuits established that ignoring Section 303 was no longer possible, and that continued state inaction constituted action, requiring EPA to respond. The issues in these cases have tracked the literal requirements of the statute, first raising the failure to list state waters, then the inadequacy of these lists, and then the failure to prepare TMDLs.[15] To date, there have been 40 legal actions in 37 states. The EPA is under court order or consent decree in many states to ensure that TMDLs are established, either by the state or by the EPA (EPA 2003). This timeline of events with respect to Michigan is summarized in Figure 1.

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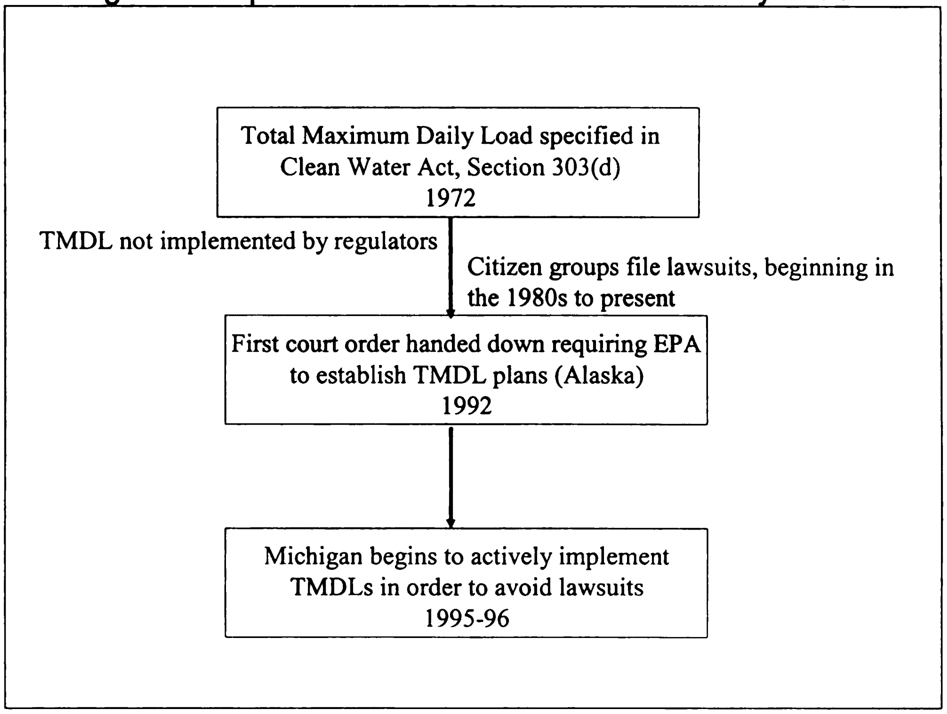
[14] TMDL lawsuit information is available from the EPA at http://www.epa.gov/OWOW/tmdl/lawsuit.html.

[15] See http://www.epa.gov/owow/tmdl/lawsuit1.html for a summary of court decrees and consent decrees with implementation timetables ranging from 5 to 20 years; there is one case where no schedule has been specified (for Alaska). This list was last updated on 21 October 2003.

These earlier violations were procedural, and the courts were able to avoid the issue of the content of the TMDLs themselves. This avoidance has begun to change, however, as more recent lawsuits have begun to question the substance of TMDLs. Under Section 303 and EPA regulations, a TMDL must include the sum of point source waste load allocations and nonpoint source load allocations plus a margin for error for uncertainty and a margin for future growth.

Figure 1: Implementation of Total Maximum Daily Loads



Source: U.S. EPA website, various pages.

Many states, however, have not incorporated nonpoint sources in their TMDLs. For example, New York and Louisiana were sued for only focusing on point sources and ignoring nonpoint sources. In Louisiana, load allocations from nonpoint sources were never accounted for, even in cases where they were "inescapably" the dominant source of water quality degradation (Houck 1999). More citizen lawsuits can be expected over the contents and implementation of TMDLs.[16]

The EPA first began to take its TMDL responsibilities in earnest in 1991. In April of that year, it issued a document entitled "*Guidance for Water Quality-Based Decisions: The TMDL Process*." Further pressured by lawsuits, the EPA began to take TMDLs much more seriously, and issued two guidance documents in late 1997. The first document clarified the scope of listed waters, and for the first time, schedules for load allocations from nonpoint sources, and their contents were specified in the second document. In October 1997, the EPA issued a memorandum to its Regional Administrators entitled "*New Policies for Establishing and Implementing TMDLs*", which for the first time specified its enforcement options to secure state compliance in print (Houck 1999).

With these guidance documents, the EPA specified three things: 1) a schedule for the development of all TMDLs by states and a deadline, 2) a focus on waters polluted primarily or exclusively by nonpoint sources, and 3) the tools that it would use to enforce implementation of nonpoint source TMDLs.[17]

2.5 The Total Maximum Daily Load Process in Michigan

Thus, although the TMDL process was specified under Section 303(d) in the 1972 amendments, it was not enforced since the Clean Water Act has primarily been used to control point sources of pollution – not nonpoint sources – over the last 30 years. In

[16] As an indication that the environmental community will continue to pressure TMDL implementation, see National Wildlife Federation guide, entitled "Saving our Watersheds: A National Wildlife Federation Field Guide to Watershed Restoration Using TMDLs", at http://www.nwf.org/watersheds/fieldguide/about.html.

[17] The EPA's main TMDL website is http://www.epa.gov/owow/tmdl.

response to the EPA requirement that the TMDL process to come into effect by October 2001, the Michigan Department of Environmental Quality (MDEQ) developed Michigan's TMDL implementation schedule (began in 2000, ends in 2011).[18] The MDEQ was delegated authority from the EPA to implement TMDLs in Michigan.

Section 303(d) requires states to identify and rank water bodies for which technology-based effluent limitations have not been successful in reaching or maintaining water quality standards. These water quality standards have been set by the Michigan Department of Environmental Quality (MDEQ) to protect surface waters based upon intended uses, that is, recreational, public water supply, agricultural, or industrial uses. The list of impaired waters is known as the "303(d) list" or the "dirty waters" list. States must then develop a TMDL plan or process for each of these impaired water bodies so that they attain their state-designated water quality standard.[19]

The TMDL process requires states to do a number of things: 1) set the maximum amount of pollution that a water body can receive without violating state-designated water quality standards (including a margin of safety to account for technical uncertainties); 2) develop a quantitative assessment of water quality problems, pollution

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[18] A Michigan pilot program is underway in Lake Macatawa in Ottawa County. The Michigan Department of Environmental Quality (MDEQ) received a grant from the EPA in October 1996 to develop a phosphorus TMDL for Lake Macatawa. Phosphorus is the limiting nutrient in Lake Macatawa and nearly always the nutrient which controls the eutrophication level of lakes in Michigan. See http://www.deq.state.mi.us/documents/deq-swq-gleas-tmdlmacatawa.pdf.

[19] The Year 2002 303(d) report for Michigan provides an updated list of Michigan water bodies that are threatened or do not meet Michigan's Water Quality Standards and require a Total Maximum Daily Load (TMDL). It is available at http://www.deq.state.mi.us/documents/deq-swq-gleas-303_d_Rpt2002b.pdf. The Michigan Department of Environmental Quality's web site that deals with TMDLs is at http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-12464--,00.html. The latest Section 303(d) list fact sheet for Michigan that summarizes Michigan's TMDL program and the impaired waters is for the year 2000 and is available at: http://oaspub.epa.gov/waters/state_rept.control?p_state=MI. Also see the Elton R. Smith web site for discussion of TMDLs and an EPA-Universities Workshop on TMDLs: http://www.aec.msu.edu/agecon/smith_endowment/alternatehome.htm.

sources, and required pollutant reductions; and 3) address *all* pollution sources – both point sources such as factories and municipal plants, and nonpoint sources such as runoff from agricultural lands, forests, and roads. States are given flexibility in allocating the required load reductions amongst sources. For instance, at the extreme, states could make point sources responsible for the entire required load reduction in a watershed; or, in implementing TMDLs, states can choose to mandate technologies for firms, even though technologies are not required by the Clean Water Act.

Consequently, TMDLs can be implemented as flexible performance standard since the legislation does not specify the technology that must be used by farms of a certain size. In the case of non-CAFO dairies – that is, dairies with less than 700 milking cows – a TMDL could be specified as a flexible ambient or effluent environmental performance standard. If such standards were to be used, innovation offsets may result within agriculture. Thus, potentially TMDLs provide an opportunity for flexible environmental performance standards to be applied to agriculture.

Nevertheless, the cost-effective use of flexible environmental performance standards may be hampered by uncertainties and resulting transaction costs. It is this component of performance standards that is addressed next in Chapter 3, *Uncertainty and Transaction Costs*.

CHAPTER 3

Uncertainty and Transaction Costs

The implementation and management of public policies involves transaction costs (Griffin and Bromley 1982). Whether flexible environmental performance standards are actually empirically superior to technology-based agro-environmental policies depends upon the effects of uncertainty and resulting transaction costs. Regulators and farmers do not have perfect information about current conditions or how the future will unfold; this lack of perfect information, or uncertainty, creates transaction costs; indeed, the level of uncertainty affects the magnitude of transaction costs in agro-environmental policies (McCann and Easter 2000).

Agro-environmental policy design will affect who bears the transaction costs – the regulator or the farmer. The cost burden is based upon the property rights structure that assigns responsibilities for environmental outcomes (Batie and Ervin 1999). Flexible environmental performance standards can be implemented so that either the regulator bears the bulk of the transaction costs, or the farmer, or the costs could be shared by these two decision makers. Different institutional structures – or the implementation details of the regulation – result in differential incidence of transaction costs (Bromley 1986). Since the incidence of policy costs will determine the political feasibility of flexible performance standards, the manner in which the policy is designed matters.

3.1 Transaction Costs and Agro-Environmental Policy

Transaction costs were first related to environmental policy by Coase in "The Problem of Social Choice" (Coase 1960); Coase argued that pollution abatement costs and transaction costs should be considered when evaluating alternative environmental policies. Transaction costs can be defined as the costs of coordinating and motivating economic agents (Milgrom and Roberts 1992). The coordination problem in agro-environmental policy is to determine what pollutants should be reduced, how they should be minimized, and who should undertake appropriate actions. The motivation problem is to ensure that farmers willingly do their parts, both in reporting information accurately to allow the best policy to be designed, and to act as specified by the policy (Milgrom and Roberts 1992).

McCann and Easter (1999) state that transaction costs (including administrative costs) may be particularly high for nonpoint source pollution due to the high cost of monitoring effluent from numerous polluters. These higher costs are a contributing factor as to why point sources historically have been emphasized in water quality legislation as opposed to nonpoint source pollution. In the context of agro-environmental policy for nonpoint source pollution, an examination of transaction costs is important because they may affect which policy alternative attains an environmental goal at least cost, and their examination may lead to the design of policies and institutional arrangements which lower some transaction costs (McCann and Easter 1999). Aside from uncertainty (Section 1.2.1), there are two other sources of transaction costs that are relevant for this study of nonpoint source pollution agro-environmental policies, namely bounded rationality and opportunistic behavior.

3.1.1 Sources of Transaction Costs: Bounded Rationality

Bounded rationality describes the limited capacity people have to process information. As Simon illustrated, the mind is a scarce resource (Simon 1978). Thus, economic agents – both regulators and farmers – are rational, but only in a limited fashion; they only use a subset of the information available to them when making decisions. Individuals therefore often make decisions based upon incomplete knowledge of all possible alternatives and their likely outcomes (Ostrom, Schroeder, and Wayne 1993). Limited foresight and the costs of calculating solutions help to explain the existence of bounded rationality.

Bounded rationality helps to explain why farmers do not pursue all profitable opportunities for new production processes.[20] The set of information considered by farmers is influenced by such factors as market prices, institutional factors such as business customs and culture, social culture, and property rights. Changes in any of these institutions or market prices – perhaps due to citizen movements, political responses, or changes in property rights – can cause farmers to widen their information set and change their optimizing behavior; for example farmers may respond by searching for innovative production processes that reduce water pollution.

On the other hand, due to bounded rationality, they may not. Even though there may be profitable paths that farmers can pursue now within a new institutional environment, they may explicitly choose not to do so due to other concerns, for instance, due to a certainty payback threshold. An example of a payback threshold may be that the farmer wants to earn, say, six per cent above his costs per year, and will only consider those enterprises that can guarantee that level of revenue. Simple measures like certainty payback thresholds help farmers focus their attention by allowing them to deal with a subset of their entire knowledge. Bounded rationality thus can affect innovation choices.

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[20] This section is adapted from Srivastava, Batie, and Norris (1999).

Regulators also are subject to bounded rationality; they may not pursue all significant optimal opportunities to improve environmental outcomes. The set of information considered by regulators is influenced by such factors as market prices, institutional factors such as regulatory customs and culture, social culture, property rights, and political pressures. As with farmers, changes in any of these institutions or market prices may force regulators to change their information set and their optimizing behavior.

3.1.2 Sources of Transaction Costs: Opportunistic Behavior

With complicated issues such as nonpoint source pollution, another source of transaction costs is opportunistic behavior. Opportunism is the deceitful behavior intended to improve one's own welfare at the expense of others (Ostrom, Schroeder, and Wynne 1993). Due to informational asymmetry – in this case, the regulator does not possess perfect information with respect to farmers' production practices and behavior – farmers have an informational advantage. They may take advantage of this informational asymmetry and behave strategically, or *opportunistically*.

When those with critical information have interests different from those of the policy maker, they may fail to report completely and accurately the information needed to make decisions (Milgrom and Roberts 1992). For example, a farmer may, strategically, fail to disclose aspects of his management practices to regulators, or he may disguise or even distort information regulators need to effectively control nonpoint source pollution. This opportunistic behavior leads to the problem of *moral hazard*. Moral hazard arises when one agent, here the regulator, is imperfectly informed of the actions of another agent, here the farmer. If the regulator can not ascertain which farmer is generating pollution and which farmer is not – and farmers know that this is the situation – some farmers may choose to behave opportunistically and not comply with the TMDL.

The regulator does possess some information about the nonpoint source pollution problem, such as an estimate of the fate and transport of pollutants or the number of farmers in a watershed. The regulator, however, does not possess detailed, perfect information regarding each farmer's production process. Conceptually, if the regulator's set of information is denoted Ω_r and the farmer's is denoted Ω_f, then due to information asymmetry, these information sets will not be equal, that is, $\Omega_r \neq \Omega_f$. Moral hazard thus implies that if the farmer's production process is represented by a production function $f(\bar{x})$, where $\bar{x}$ is the vector of inputs that the farmer chooses, the regulator does not know what $f(\bar{x})$ is, although the regulator does form expectations of $f(\bar{x})$. Consequently, if the regulator's expectation of the farmer's production process is $f_r(\bar{x}_r)$, then $f_r(\bar{x}_r) \neq f(\bar{x})$ – either because the regulator does not know what the functional form is, and/or the regulator does not know the farmer's input vector. The unequal information sets allow the farmer to behave opportunistically.

The possibility of opportunistic behavior by some farmers increases the transactions costs of agro-environmental policies not just for regulators, but other farmers as well. Regulators must design agro-environmental policies to provide incentives that reward farmers while simultaneously constraining their behavior in such a manner that they internalize the social costs that they generate; that is, the agro-environmental policies must align social and private objectives. This alignment is no easy task when farmers are able to behave opportunistically. It is unlikely that all farmers will behave opportunistically; some will comply with the requirements of the agro-environmental policies and will reduce water pollution from their operation. Some farmers, however, will choose to behave opportunistically. It is due to this latter group that monitoring and enforcement measures must be implemented; thus, farmers who do comply have to endure monitoring and enforcement hurdles since the regulator can not easily distinguish one group from the other.

3.2 Types of Transaction Costs

Williamson (1985) identified two types of transaction costs, *ex ante* transaction costs, and *ex post* transaction costs. *Ex ante* transaction costs are largely co-ordination costs that exist to a greater or lesser extent in long-term economic relationships, like those that arise from agro-environmental policies (Ostrom, Schroeder, and Wynne 1993). Since unforeseen situations arise and all future contingencies can not be envisioned, transaction costs also occur in long-term economic relationships that involve multiple agents, for instance, after an agro-environmental policy is implemented (Ostrom, Schroeder, and Wynne 1993). These costs are *ex post* transaction costs. Thompson categorizes transaction costs for environmental policies into six areas: 1) research and information, 2) enactment, 3) design and implementation, 4) support and administration, 5) monitoring, and 6) prosecution (Thompson 1999).

3.2.1 Transaction Costs Incurred by Regulator

The regulator can incur both *ex ante* and *ex post* costs when implementing a flexible ambient environmental performance standard due to a lack of information. Research and information, enactment, design and implementation, and support and administration are types of *ex ante* transaction costs. The *ex ante* costs that the regulator could incur are outlined in Table 1; selected costs associated with a TMDL are used as an illustration.

In order to implement the TMDL process, the regulator must gather biophysical data to ascertain the appropriate level of phosphorus for a specified body of water, given its designated water uses; then the regulator must process that information in order to determine the allowed ambient level of phosphorus. Finally, the regulator must decide how to allocate the allowed polluted effluent amongst the dischargers into the body of water.

Table 1: Selected *Ex ante* Transaction Costs Incurred by Regulator

Data Gathering Costs	Data Processing Costs	Decision Costs
- Data to determine appropriate ambient phosphorus level - Data to determine actual phosphorus level - Data to determine who is discharging, and their effluent levels	- Determination of appropriate ambient phosphorus level - Determination of actual phosphorus level - Determination of who is discharging, and their effluent levels, or monitoring activities	- Determination of how TMDL will be allocated amongst dischargers - Evaluating performance - Determination of penalty level

Some of these *ex ante* transaction costs can be high with respect to nonpoint source pollution. Of special interest are the *information search* costs – the data gathering and processing costs that the regulator must bear in order to determine individual discharge sources' effluent levels, since the diffuse nature of nonpoint source pollution makes it difficult to determine the sources, let alone how much effluent each discharger is releasing. In response to these *ex ante* transaction costs caused by uncertainty, the regulator may implement flexible ambient performance standards in a manner that reduces these costs, or it may pursue a command-and-control strategy such as requiring the adoption of on-farm technologies that control or prevent pollution. The cost-savings from these differing compliance measures are explored in detail using a simple conceptual model in Chapter 6.

Similarly, Table 2 illustrates selected *ex post* transaction costs that the regulator might incur. Under Thompson's categories, *ex post* costs include implementation, support and administration, monitoring, and prosecution. With the TMDL example, the regulator must monitor the water body to ensure that the specified phosphorus level is maintained, again incurring information search costs; additionally, the regulator must enforce any required reductions and assess relevant penalties. If subsidies are used as an incentive measure, then they must also be assigned. Since the regulator does not know the production function of each farmer, and can only form expectations of the production process, it can not easily determine the effluent from each farm. Due to this uncertainty generated by nonpoint source pollution and the possibility for farmers to behave opportunistically, regulators will have difficulty in determining who is in compliance, resulting in *ex post* transaction costs.

Table 2: Selected *Ex post* Transaction Costs Incurred by Regulator

Monitoring Costs	**Enforcement Costs**
- Monitoring ambient phosphorus level	- Enforcing required reductions
- Monitoring effluent from discharge sources	- Assessing penalties/subsidies
- Determining who is or is not in compliance	

In fact, this uncertainty results in large *ex post* costs for the regulator, both in terms of monitoring and enforcement costs. Nonpoint source pollution implies numerous, diffuse sources of nutrient effluent or loadings, making it almost impossible to perfectly monitor behavior and enforce the ambient pollution level (Hanley *et al.* 1997). Moral hazard and opportunistic behavior result because the information sets of the regulator and the farmer are not the same, $\Omega_r \neq \Omega_f$, and the regulator only can form expectations regarding a farmer's production function, which will not be accurate ($f_r(\bar{x}_r) \neq f(\bar{x})$).

Where moral hazard exists, where costs of compliance are great, and where farmers believe they can free-ride, some farmers may decide to avoid any abatement effort. In fact, in order to "perfectly enforce" the TMDL in such a situation, in-field pollution "police" would have to be stationed permanently at all fields that received manure applications (Innes 1999). But, such "perfect enforcement" is obviously neither politically nor financially feasible. As a consequence, the regulator may wish to reduce these significant *ex post* transaction costs by increasing compliance certainty. For example, the regulator could implement the TMDL as an effluent standard or a design standard instead of an ambient standard.

These high *ex ante* and *ex post* transaction costs imply that that regulator may be unable to effectively implement the TMDL process, or any flexible ambient performance standard, potentially resulting in failed environmental outcomes such as diminished water quality. If water quality does not improve due to poor TMDL implementation, the regulator becomes vulnerable to lawsuits from citizen groups for failing to implement the Clean Water Act. Griffin and Bromley (1982) recognized that litigation costs must be considered along with monitoring and assessment in policy transaction costs. The possibility of lawsuits against the agency may cause the regulator to seek ways to minimize compliance uncertainty when implementing the TMDL process. Consequently, mandating and enforcing strict environmental compliance with a flexible ambient performance standard may not be possible with nonpoint source pollution.[21]

3.2.2 Transaction Costs Incurred by Farmers

Similarly, farmers also face uncertainty with respect to the pollution that they generate and compliance with the total maximum daily load process that is implemented as a flexible ambient standard.[22] Unlike the regulator, however, they do not incur any *ex ante* transaction costs. Farmers react to the flexible ambient standard – thus they only incur transaction costs after TMDLs are in place. Until the TMDL is implemented, water degradation has no pecuniary value, so farmers are unlikely to consider most of the degradation costs associated with their production process.[23]

Once the TMDL is in place, farmers incur *ex post* transaction costs, due to compliance uncertainty. It is difficult, and hence costly, for farmers to link the effects of their management practices to runoff from their lands. For instance, even if farmers spread manure onto their lands at a rate below the upper limit specified in Michigan animal waste guidelines, a severe storm can result in significant soil erosion into the water body.[24] Phosphorus binds to soils, so if enough soil is washed into the water body,

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[21] The Porter Hypothesis maintains that strict enforcement of a binding standard is necessary to encourage technological innovations.

[22] Farmers may also face uncertainty by a flexible effluent standard, depending upon how much information the regulator shares with the farmer.

[23] This argument is not to say that the farmer will not care about any of the social costs of the water degradation; he may well consider the effects of any water degradation that he causes even though he does not directly pay for the degradation. He may consider these effects due to his own ethical beliefs, or due to legal liability concerns.

[24] Under the Michigan Right to Farm Act (1981), the Michigan Commission of Agriculture develops and adopts Generally Accepted Agricultural and Management Practices (GAAMPs) for farms in Michigan. These are voluntary practices meant to protect farmers from nuisance suits. The Manure Management and Utilization GAAMPs can be viewed at:
http://www.michigan.gov/documents/MDA_manureRedlineStrikeout2003_67615_7.pdf.

the phosphorus limit enforced by the TMDL process may be exceeded. The level of these costs depends upon how the regulation is implemented. For instance, the regulating agency could allow the standard to be exceeded for some portion of the year, to allow for extreme weather events, or the regulating agency or the government could provide financial and or technical assistance to the farmer to reduce these transaction costs.

Since the total maximum daily load process is specified as an ambient standard, the penalty system may be based upon this ambient standard.[25] But with a flexible ambient environmental performance standard, even if livestock farmers make expensive investments in manure management systems, regulators will find it difficult to distinguish the effects of each farmers' actions ($f_r(\bar{x}_r) \neq f(\bar{x})$ for each farmer), so an individual farmer may still be found to be out of compliance due to the aggregate effluents from a group of farmers, regardless of his own efforts.

This informational deficiency could reduce the chances that a farmer will comply with a total maximum daily load unless the expected penalty for noncompliance is very high. Some farmers may choose to not comply with the flexible ambient performance standard because they may be tempted to *free ride* – to let others undertake pollution abatement measures while they share in the benefits of reduced nutrient loadings in the body of water. These farmers may choose to free ride due to the compliance uncertainty that exists for regulators. As a consequence, in the absence of a high expected penalty for non-compliance, significant compliance uncertainty may dissuade farmers from making investments in innovative technology. Thus, it would appear that strict compliance by

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[25] States have the flexibility to convert this ambient-based penalty system to another type, such as an effluent system.

farmers may not be possible with a flexible ambient environmental performance standard targeted at nonpoint source pollution.

If, however, the regulator could perfectly monitor and enforce the ambient standard embedded as a TMDL, the regulator would know perfectly each farmers' actions and the environmental effects of each farmers' actions. Conceptually, this situation would be as if its expectation of the farmer's production function coincides with the farmer's actual production function, so $f_r(\bar{x}_r) = f(\bar{x})$. In this case, moral hazard would not be an issue, and depending upon penalties and compliance costs, the incentive for farmers to behave opportunistically would decrease, as would the motivation to free ride. With perfect monitoring and enforcement, compliance uncertainty for regulators is eliminated, and farmers have greater motivation to comply since their efforts would be correctly recognized and they would not be wrongfully penalized.

Even without perfect monitoring and enforcement, some farmers may be interested in complying with nonpoint source policies due to recent legal battles in the livestock industry, if compliance uncertainty is reduced. Under the Clean Water Act, a third-party can sue a farmer or any other firm for violating the Clean Water Act. This situation is particularly relevant for Michigan, where in the summer of 2000, the Sierra Club gave "notice to sue" to five dairies in the state, effectively increasing those farmers' expected penalty for noncompliance. If compliance uncertainty is eliminated, so that it is easy for regulators and third parties to determine who is in compliance with a flexible ambient environmental performance standard, then some farmers will be interested in complying in order to reduce the likelihood of being sued. Farmers thus may seek ways to increase compliance certainty.

3.3 Flexibility and Compliance Certainty Trade-off

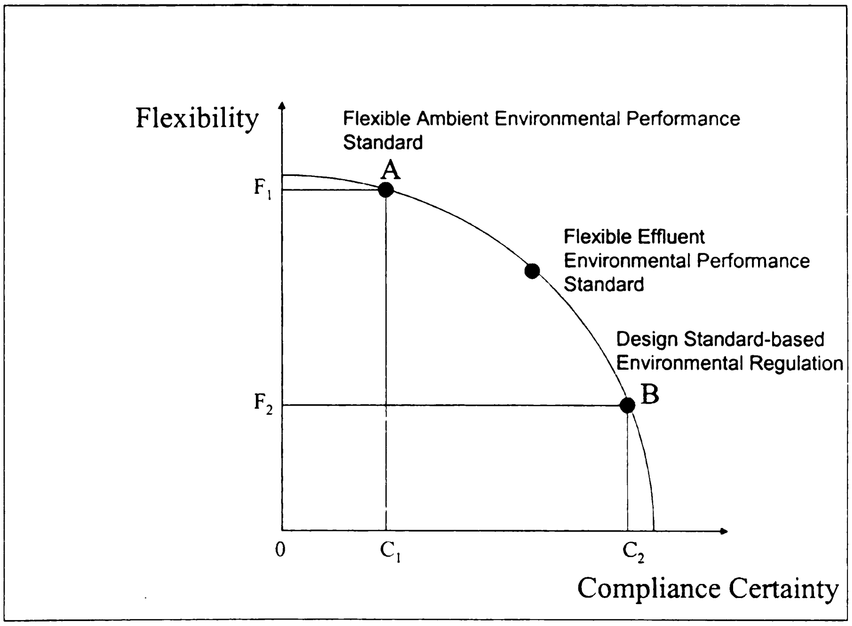
Thus, "flexibility" in flexible environmental performance standards contributes to compliance uncertainty and this compliance uncertainty, in turn, results in transaction costs.[26] Contrast this case with a design standard, where both the regulator and farmer can easily determine compliance; the regulator simply checks whether the farmer has adopted the specified technologies, and the farmer knows he is in compliance as long as he implemented the required technologies. Design standards, however, may not correlate well with improved environmental conditions. There appears to be trade-offs between flexibility and compliance certainty embodied in those environmental performance standards that address nonpoint source pollution. From a policy point of view, Michigan regulators need to decide how much flexibility to embed into the TMDL process to control phosphorus pollution from dairy farms in the state, since the flexibility and certainty characteristics will affect the success of this approach, and ultimately the policy's ability to encourage induced innovation and innovation offsets.

One way to analyze this trade-off when regulating nonpoint source pollution with a TMDL strategy is via a *production possibilities frontier* (PPF), illustrated in Figure 2. The frontier curve shows the various combinations of compliance certainty and flexibility that can be provided by, or "produced" by an environmental regulation. The inputs are employed, or allocated, efficiently. Compliance certainty is measured on the X-axis; it increases as one moves from left to right. Compliance refers to farmer compliance with the legislation as implemented through mandatory regulations. Flexibility – on the Y-axis – is defined as the ability of the farmer to be free to determine how to become compliant

[26] The stochastic nature of nonpoint sources of pollution and moral hazard also contribute to this uncertainty.

with the regulations. The production possibilities frontier is downward-sloping because of the trade-off between flexibility and compliance certainty; there is an opportunity cost in producing one good over the other. Additionally, it is assumed that there are specialized inputs in the production of each good and differing factor intensities for common inputs. Thus, for an environmental legislation to "generate" – or allow – more compliance certainty, the level of flexibility produced – or allowed – by it declines.

Figure 2: Flexibility and Compliance Uncertainty Frontier



Note that this trade-off may not exist, but only in the extreme case of perfect monitoring and enforcement by the regulator. In this situation, the regulator would know the exact effect of the inputs and technology used by the farmer on water quality, or $f_r(\bar{x}_r) = f(\bar{x})$. While the farmer has the flexibility to meet the standard in the most cost-effective manner for his farm operation, the regulator incurs an extremely high cost of information gathering. This avenue is prohibitively expensive, however. In the case of imperfect monitoring and enforcement, there will be a trade-off between flexibility and compliance certainty.

Consider Figure 2. As one moves north along the Y-axis, the amount of flexibility produced by the environmental regulation increases, while compliance certainty decreases. As such, point A corresponds to a flexible ambient environmental performance standard since the amount of flexibility allowed is quite high – F_1 – and it results in a relatively low level of compliance certainty, C_1. At point A, regulators can take advantage of this regulatory flexibility by accommodating diverse natural resource conditions and heterogeneous production systems; additionally, flexible environmental regulations remove the onus on regulators to determine the "best" technology to be used by farmers. For farmers, the flexibility provides dynamic incentives for technological innovation and cost-effectiveness through possible innovation offsets.

Point B on the frontier corresponds with an environmental regulation that uses a design standard with a greatly diminished level of flexibility (F_2) but a much higher level of compliance certainty, C_2. At point B, some compliance uncertainty is removed so some transaction costs decline, but at the cost of reduced flexibility for farmers. Also, the regulator must now specify the approved technologies. Despite the diminished level of flexibility at this point, and less certainty with respect to resulting ambient water quality improvements, both regulators and farmers may prefer point B if enough of their transaction costs are sufficiently reduced.

A third point is depicted on the frontier, labeled *Flexible Effluent Environmental Performance Standard*. With this type of standard, the regulator specifies some level of effluent that can leave the farmer's operation, but the farmer is free to choose whatever technology he wants to meet his effluent performance standard. Consequently, this case lies between Points A and B in the amount of certainty and flexibility produced by this type of compliance measure or environmental regulation; there is greater certainty – and no flexibility – in terms of what is expected of the farmer, but he still has flexibility – and uncertainty – in how he achieves his effluent standard.

If the regulator is willing to trade-off flexibility in order to reduce some of its *ex ante* and *ex post* transaction costs through an increase in compliance certainty. If point A represents a flexible ambient standard – incorporating a lot of flexibility but no certainty – and point B represents a design standard – incorporating a lot of certainty but no flexibility – the regulator may choose to choose to move from point A to B and convert the flexible ambient standard into a design standard. By dictating to farmers what technology to use, to an extent, the regulator has increased information to farmers; institutional arrangements that help to generate or distribute information serve a crucial role in reducing some transaction costs (Ostrom, Schroeder, and Wynne 1993).

In fact, some farmers may prefer point B to point A due the *ex post* transaction costs that they incur and because they gain compliance certainty. At point A, they have to bear information costs in seeking out a technology that will allow them to reduce their pollution loadings or effluent. Additionally, due to compliance uncertainty, a farmer may be mistakenly penalized and/or sued for water degradation despite the technology that they have sought and implemented, since it is difficult for the regulator to link management practices to environmental performance with nonpoint source pollution and an ambient standard. Even if farmers would like to undertake abatement efforts, liability issues may prevent them from innovating.

In such a situation, if farmers face liability issues that are not due to their own efforts, they may prefer to shift liability costs to the regulator by demanding design standards specified by the regulator. By then following the design standards, farmers may be able to reduce their compliance costs, without having to be innovative. Consequently, some farmers may feel that their information search transaction costs are not worth incurring, and thus may prefer the greater level of compliance certainty provided by a point like B. The transaction costs associate with a flexible ambient standard may affect the benefits that farmers could receive through induced innovation, and thus affect the likelihood that an innovation could occur.

Which point will regulators and farmers prefer? Will compliance certainty be more important or flexibility for each as they contend with total maximum daily loads? Whether regulators will prefer to shift the informational transaction costs of determining the best technology to use onto farmers through flexible performance standards, or whether they would rather prescribe design standards and increase some compliance certainty is unknown. Similarly, whether farmers will embrace the flexibility aspect of flexible performance standards and seek out least-cost pollution abatement technologies, thereby benefiting from possible innovation offsets is unknown in the presence of compliance uncertainty since they also have to contend with possible lawsuits. The objectives of each agent will determine whether induced innovation and innovation offsets will occur, as will the relevance of the Porter Hypothesis in the face of compliance uncertainty.

If the Porter Hypothesis is relevant for agriculture, then the political feasibility of TMDLs may be enhanced since environmental quality improvements are achieved in conjunction with some benefits to farmers through possible innovation offsets. Farmers become an integral part of the overall strategy to resolve agro-environmental problems once they have the incentive to maintain a healthy, sustainable, and agriculturally productive Great Lakes region. A closer examination of the Porter Hypothesis and innovation offsets will provide insights into whether innovation offsets are possible when total maximum daily loads are used to control nonpoint source pollution in the face of compliance uncertainty. The Porter Hypothesis and its application to nonpoint pollution is the subject of Chapter 4.

CHAPTER 4

Porter Hypothesis and Innovation Offsets

The Porter Hypothesis has generated considerable debate. Porter and van der Linde contend that innovation offsets are likely to be common and large, while others have disagreed (Gardiner and Portney 1994; Palmer, Oates, and Portney 1995; Thurow and Holt 1997; Jaffe and Palmer 1997). For example, Palmer *et al.* (1995) note their strong dispute with the Porter Hypothesis; they argue that environmental regulation does indeed involve trade-offs, and that the cost of regulation will be neither negligible nor non-existent. Which of these arguments will be true in the case of TMDL standards being applied to control nonpoint source pollution from dairy farmers? Will innovation offsets occur when flexible environmental performance standards are used to manage nonpoint source pollution? These issues are examined and clarified below.

4.1 Behavior Implications

How will farmers react to a new flexible ambient environmental performance standard? Can farmers offset decreased profits which stem from compliance with a new TMDL water quality requirement? Hicks' induced innovation hypothesis provides theoretical insight:

> *A change in relative prices of the factors of production is itself a sign to invention, and to invention of a particular kind -- directed to economizing the use of a factor which has become relatively expensive* (Hicks 1932).

The change in property rights due to the new water quality requirements has caused the relative cost of water to increase for farmers. It follows from Hicks' induced innovation hypothesis that a farmer will choose a technology that changes his production process and reduces the amount of water that his farm uses for pollution disposal. A profit-maximizing farmer has an incentive to invest in ways to meet his new constraint at lower costs.

Is Hicks' induced innovation hypothesis – which focuses on inputs – relevant for an environmental performance standard, an output-based measurement? Yes, because water quality is affected by the production process; that is, through his production process, the farmer creates joint goods. For a dairy farmer, the joint goods are milk and water pollution. Before an ambient environmental performance standard is implemented, water quality has no value or cost to the farmer, so using a lake or a river as a sink for nonpoint source pollution is costless or free for him. The imposition of the flexible ambient environmental performance standard, however, causes water pollution to become a cost for the farmer; in other words, water is no longer a free input into the farmer's production function. This cost is a portion of the social cost of water pollution that the farmer creates and is now being forced to internalize due to the ambient environmental performance standard.[27] In essence, water quality is like an input that now has a cost for the farmer. Hicks' induced innovation hypothesis states the farmer will substitute away from using water for waste disposal.

The implications of Hicks' induced innovation hypothesis, however, is not so straightforward in the case of nonpoint source pollution. In this situation, the farmer's action in response to the environmental regulation may not result in innovation offsets. With nonpoint source pollution, the occurrence of innovation offsets depends upon the

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[27] If the ambient performance standard is set at the socially optimal level, then the farmer internalizes the full social cost of the water degradation that he causes. How much of this internalized cost is ultimately borne by the dairy product consumer and how much is borne by the dairy farmer will be determined by the elasticities of supply and demand.

effect of compliance uncertainty. Due to moral hazard and compliance uncertainty, it is difficult to link investments and abatement efforts with positive environmental outcomes, thus a farmer may not be given credit for economizing on his use of water as a disposal sink; without this benefit, and in the absence of a sufficiently high, certain penalty, the farmer may not seek out innovative ways to reduce water pollution, thereby precluding innovation offsets.

Instead, farmers may ask for a list of specific approved technologies from the regulator to reduce their compliance uncertainty-related transaction costs. If the regulator also wishes to increase certainty and reduce some of its compliance uncertainty transaction costs, then the flexible environmental performance standard may be converted into a design standard. Since specified technologies preclude induced innovation and innovation offsets, the question is: will compliance uncertainty offset the incentive for farmers to innovate and thus prevent innovation offsets from occurring? Will innovation offsets be a straightforward result of strict environmental regulations as Porter and Van der Linde assert? Or will they be negligible? Do trade-offs exist? A graphical model is presented next to help answer these questions.

4.2 A Simple Model of Innovation Offsets

Much of the debate over the Porter Hypothesis is due to a lack of clarity regarding the baseline to be used in determining whether innovation offsets can occur as a result of environmental regulations. The following simple model clarifies this question and provides a straightforward definition of innovation offsets.[28]

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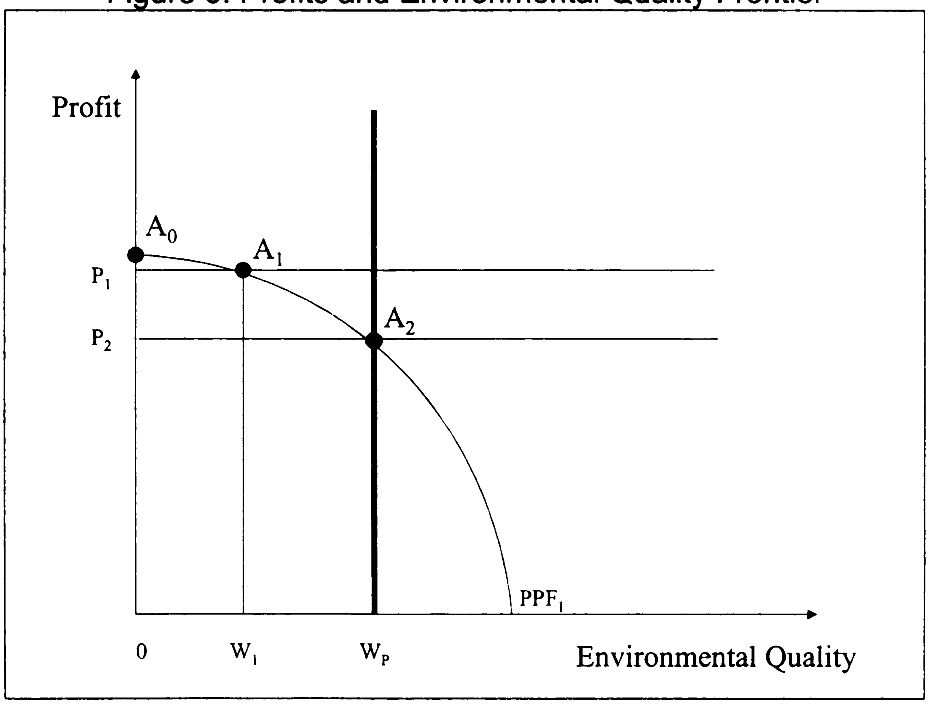
[28] Adapted from Batie 1997.

With the implementation of the environmental regulation, and the change in property rights, pollution is now a cost for farmers. Economic theory predicts that a farmer will reduce his use of water in order to minimize costs due to the new flexible ambient environmental performance standard. Figure 3 illustrates the initial effect of this change in property rights. The production possibility frontier (PPF) depicts the feasible set of water quality and profits that are produced by a livestock farm, say Farm A, with a given technology.

Figure 3: Profits and Environmental Quality Frontier



Adapted from Srivastava, Batie, and Norris (1999).

The production possibility frontier is used because it is an important tool for analyzing the simultaneous production of two outputs. The curve demonstrates that there are many possible allocatively efficient combinations of profit and water quality and that producing more of one necessitates a reduction in the production of the other; in short, there is an opportunity cost to each point on the frontier. In Figure 3, environmental quality is water quality, and is measured on the X-axis; it increases as one moves from left to right. Firm profit is on the Y-axis, and increases as one moves north.

Inputs are characterized to be allocatively efficient when the only way to increase the output of one commodity is to decrease the output of the other. The frontier is the locus of allocatively efficient points and implicitly defines the relationship between profits and environmental quality. The farmer is assumed to be allocatively efficient and is thus on the frontier. As in Figure 2, the production possibilities frontier is downward-sloping because it is assumed that there are differing factor intensities for common inputs.

This production technology describes the method in which inputs are combined to produce outputs, in this case profits and water quality. This conceptual abstraction of technology encompasses different processes, capital, and management practices – essentially different methods of production. Farm A uses the same technology as long as it is on the same production possibility frontier, and is able to produce different levels of water quality and profits using this technology.

Before the environmental regulation, Farm A is on some point on the production possibility frontier labeled PPF_1. Economic theory does not predict where on the frontier Farm A will be; it depends upon the farmer's utility function. Farm A will be on the point on the frontier that is tangent with the farmer's highest utility function. If the only parameter in the utility function is profit, that is, the farmer is a profit-maximizer, then Farm A would be at point A_0. At this point, no resources are devoted to producing any positive water quality; consequently, profits are as high as possible with existing resources. Since environmental quality has no financial value for Farm A and using water as a sink is free for the farm, the profit-maximizing farm would be at A_0.

But, if the farmer's objective function is to maximize utility, and he cares about other issues, such as taking a defensive position due to the threat of lawsuits, or if he is concerned by the effects of water degradation, Farm A could be at a point like A_1. For illustrative purposes, let Farm A be at A_1 where it earns P_1 profits and generates a water quality level equal to W_1.

Now let a flexible environmental performance standard be implemented (Figure 3) through a TMDL process. Assume the TMDL specifies the maximum amount of ambient phosphorus that can be allowed from Farm A. Let the minimum level of ambient water quality that A must meet be W_P. Assume that the regulator is able to strictly and perfectly enforce the flexible ambient performance standard at the farm level. This assumption removes the compliance uncertainty for both the regulator and Farm A.

At point A_1, it is clear that Farm A is producing too much pollution and must move to at least A_2 along the frontier PPF_1. Here Farm A earns P_2 profits, which is less than P_1, but it produces less pollution. The difference in P_1 and P_2 is the cost Farm A incurs to be in compliance with the new flexible ambient performance standard; that is, P_1 - P_2 is Farm A's compliance cost of meeting the flexible TMDL standard.

If Farm A is able to increase its profits relative to P_2 through technological innovations, then it will be able to benefit from innovation offsets allowed by the flexibility embodied in the agro-environmental policy.

Farm A, however, is on the same production possibility frontier as before, so this reduction in profits shown in Figure 3 is not due to any technological change. Rather, it is the change in property rights that has forced Farm A to use its current technology to produce a different set of output levels than when it was owner of the property right to pollute. There is a trade-off between profits and improved environmental quality for Farm A since the TMDL compliance costs have reduced Farm A's profits.

4.3 Where Will a Farm Be?

If Farm A wants to increase its profits, Hicks' induced innovation hypothesis says it will seek out technologies that allow it to economize its use of water. Assume it has identified a suitable new technology, so Farm A shifts out to a new frontier. This shift in the production possibility frontier is an *induced innovation*. The new perfectly enforced flexible ambient environmental standard has provided Farm A with the incentive and the ability to be innovative. Figure 4 illustrates the effect of this induced innovative change to a new production possibility frontier curve labeled PPF_2.[29]

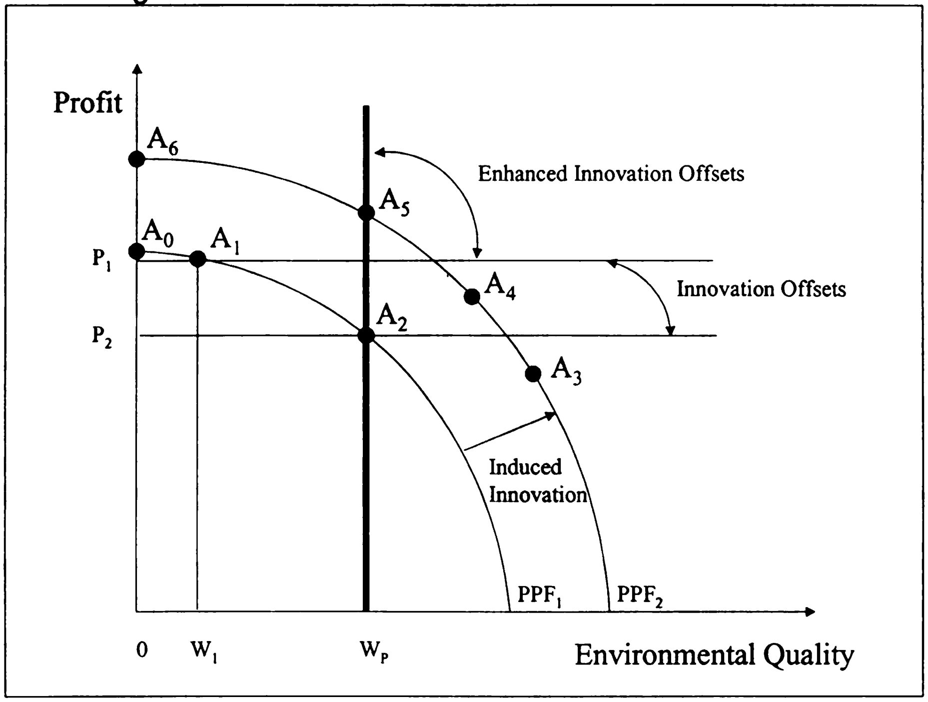
But where will Farm A be on the new production possibility frontier? Economic theory does not foretell exactly where Farm A will be on PPF_2. It is known, however, that Farm A must be to the right of W_P because of the flexible ambient performance standard. There are three possible cases for where Farm A may be on the outer production possibility frontier.

Case 1 – Below P_2: If it is on any part of PPF_2 below the horizontal line P_2, such as A_3, water quality does improve, but Farm A earns *less* profits than at A_2. At A_3, its compliance costs are greater than they were when Farm A used its original technology and complied with the flexible ambient environmental performance standard. Although water quality does improve, Farm A does not lower its compliance costs at points along this portion of PPF_2; thus, points like A_3 are **not** innovation offsets. It is unlikely, though,

[29] The technology that is adopted by Farm A could be biased towards profits or environmental quality, in which case the outer boundary would be closer to the respective axis. For illustrative purposes though, the production possibility frontier is assumed to take the shape shown.

that Farm A will undertake the expense of seeking and employing a new technology only to earn less profits than it did with the old technology; a profit-maximizing farm will not end up at a point like A_3 which is below P_2. A utility-maximizing farmer may be at A_3 for other reasons, but, in that case, he chooses to be there because it is deriving some benefit that offsets its higher compliance cost.

Figure 4: Induced Innovation and Innovation Offsets



Adapted from Srivastava, Batie, and Norris (1999).

Case 2 – Between P_1 and P_2: Assume Farm A moves to A_4 on the outer production possibility frontier. At A_4, environmental quality improves relative to A_2, as do profits. After the induced innovation has occurred, at a point like A_4, Farm A has reduced its compliance costs *and* improved profits relative to A_2. Such positions are defined to be *innovation offsets* since water quality has improved at the same time that the farm has managed to reduce its compliance costs due to induced innovation. Farm A's profits, however, do not improve relative to A_1, where Farm A earns P_1 level of profits *before* the TMDL is enforced. Thus the constraint of the TMDL has reduced Farm A's profits, so it is worse off than it was at A_1, though others in society are better off from the improved water quality.

Case 3 – Above P_1: Given the way that the production shifts in Figure 4,[30] a profit-maximizing farm will not choose points between P_1 and P_2, because it can earn a higher profit and still meet the water requirement at A_5. In fact, at points like A_4, it is providing a higher level of water quality than required, W_P while earning a lower level of profit than it can at A_5. Thus, a profit maximizing farm will choose to be at A_5. In fact, at A_5, the profit-maximizing Farm A is earning a higher profit than it could at A_0, before the TMDL standard was implemented. Farm A earns this higher level of profit at all points on PPF_2 that are to the right of the vertical line W_P and above the initial profit level. All points on this section of the production possibility frontier result in higher profits ***and*** improved water quality than at the initial unconstrained point. Points such as A_5 are defined as *enhanced innovation offsets* since the farm earns higher profits than its initial situation before implementation of the flexible ambient performance standard while also improving water quality.

A utility-maximizing farm may choose a point on the enhanced innovation offsets portion of PPF_2, depending upon the relevant utility function. As long as it is on this portion of the frontier – to the right of W_P and above P_1 – it will earn a higher profit and also produce a higher level of water quality than at A_1. Thus, a utility-maximizing farm may also benefit from a perfectly enforced flexible ambient environmental performance standard.

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[30] It is possible to draw the shift in the production function so that this case is not available to the farmer, and he must content himself with only innovation offsets which offset the cost of complying with W_P.

The flexible ambient performance standard has forced Farm A to W_P, but the flexibility in the environmental performance standard allows Farm A to reach the outer production possibility frontier, PPF_2. If the ambient performance standard was not enforced, a profit-maximizing Farm A could actually be at a point like A_6, where it generates the level of water quality that is most profitable, zero, and earns even a higher profit than at A_5. The difference in profit between A_6 and A_5 is an opportunity cost that the ambient performance standard forces Farm A to bear since it is constrained in meeting the water quality level W_P.[31] Nevertheless, the perfectly enforced flexible ambient performance standard provided the incentive to Farm A to innovate, resulting in the induced innovation. Without the standard, Farm A may not have reached A_6.

4.4 Are Innovation Offsets Possible?

Does this mean that Porter and van der Linde were correct and their critics wrong? Not so. Critics (Gardiner and Portney 1994; Palmer *et al.* 1995) are correct in stating that "we cannot have it all." This conclusion is seen from Figure 3 and Figure 4. There is an opportunity cost to any position along both frontiers, including PPF_2; there is a trade-off between profits and environmental quality due to scarcity of resources. In fact, this trade-off will always exist regardless of the technology that is adopted. If the flexible ambient performance standard did not have to be met, the farm could improve profits at the cost of lower water quality.

Regardless of this trade-off, however, under certain conditions the change in property rights due to the environmental legislation may make a farm more profitable if

[31] Similarly, a utility-maximizing Farm A could be at a point directly north of A_1 without the standard. Again, the difference in profits is an opportunity cost that Farm A bears due to the total maximum daily load standard.

previously unexploited technologies that result in enhanced innovation offsets can be identified and adopted. Indeed, despite the assumption of a trade-off between profits and environmental quality, induced innovations may be possible under certain conditions. Whether innovation offsets and enhanced innovation offsets will be common and large, or will be negligible, is an empirical question. The above simple analysis just clarifies that they can exist when the flexible ambient performance standard is strictly and perfectly enforced.

When this last assumption is relaxed, so that now there is compliance uncertainty, the resulting transaction costs may affect the possibility of induced innovation and innovation offsets. Bounded rationality and imperfect information may inhibit farmers from identifying a suitable technology that puts them on a production possibility frontier like PPF_2. Furthermore, compliance uncertainty prevents regulators from perfectly enforcing a total maximum daily load standard. Thus, the incentive for farmers to meet W_P, let alone seek a technology that will result in induced innovation, is removed. The transaction costs resulting from compliance uncertainty due to asymmetric information, moral hazard, imperfect information, and free riders may negate the potential benefits of flexible ambient environmental performance standards, namely induced innovation and innovation offsets.[32]

An alternative scenario would be the situation in which the regulator provides farmers with a list of approved practices, or a technical sheet to meet the flexible ambient performance standard in an attempt to minimize transaction costs resulting from compliance uncertainty. This technical sheet contains a list of practices that the regulator

[32] The effects of strict enforcement of a high penalty can provide the incentives to innovate. This possibility is examined in Chapter 6.

approves for use by dairy farmers. Farmers choose those practices that are best suited for their farm situation. The regulator may believe that the technical list assures that the specified water quality standard, W_p, will be reached, without too much concern for the compliance costs incurred by farmers.

If the regulator does provide a technical sheet to farmers, it has converted the total maximum daily load process from a flexible ambient environmental performance standard to a design standard. The manner in which the regulator implements the flexible environmental performance standard partially depends upon how significant the transaction costs resulting from compliance uncertainty are, and the regulator's objectives for improving water quality.

How will the regulator implement total maximum daily loads and how will farmers react when they must comply with a flexible ambient performance standard but face compliance uncertainty? With informational constraints, both agents have the incentive to behave strategically. The following chapter analyzes their actions within a game-theoretical framework to highlight the possible outcomes that may arise, given their different motivations.

CHAPTER 5

A Game-Theoretic Analysis of Farmers' Choices

Having examined in Chapters 2 through 4 the factors important to understanding the relationship between flexible environmental performance standards and compliance uncertainty, this chapter outlines the possible actions of the farmer who must contend with a flexible ambient environmental performance standard in the face of compliance uncertainty. The analytical framework developed in this chapter reveals the effects of uncertainty and its resulting transaction costs on the farmer's compliance and innovation choices.

5.1 A Game Theoretical Framework

Game theory attempts to study decision making where agents behave strategically; it thus lends itself well to the analysis of compliance uncertainty within the context of implementing total maximum daily loads as an environmental performance standard. In the real world, some economic agents like regulators and farmers make strategic decisions with respect to their actions. Strategic decisions are made because both regulators and farmers have imperfect information concerning the consequences of alternative actions.

A game can be defined to represent a competitive situation where two or more players pursue their own interests. Economic games are composed of: the players (or economic agents), the rules of the game, the payoffs of the game, and the information conditions that exist for the duration of the game.[33] Specifically, the player is a decision-making unit and can be an individual or an organization. The rules of the game describe

[33] Adapted from Mansfield 1988.

how the resources can be used. A strategy is a complete specification of what a player will do under each contingency of the game. Players receive a payoff which specifies the game's outcome for the players. Each player's payoff depends upon the strategies that each player chooses to follow.

A simple game can illustrate the effect of compliance uncertainty and its resulting transaction costs on the actions of Michigan dairy farmers – whose farms are examples of potential sources of nonpoint pollution – in complying with a total maximum daily load limit that is implemented as a flexible environmental performance standard.

5.1.1 The Players and the Rules of the Game

There are two players in the game, the state regulator and one farmer, farmer *i*. The resource of interest is a degraded surface body of water. The TMDL is the rule that describes how this resource can be used. In order to illustrate the consequences of compliance uncertainty, the TMDL will alternatively be implemented as an ambient performance standard, an effluent performance standard, and a design standard to control pollution from nonpoint sources. Once a total maximum daily load process is implemented, the level of pollutant can not exceed that specified by the TMDL standard. As long as the TMDL is not specified as a design standard – that is, it is always a flexible performance standard – those owning nonpoint sources of pollution can choose any method they wish to meet the standard.

For the purposes of illustration, in the following extensive-form game, the total maximum daily load limit is taken as given; in other words, the optimal level of the standard is not derived, and thus is exogenous to the model as are the economic benefits of pollution control. Note that the allowable level of pollutant specified by the TMDL and the associated benefits may not be efficient. As a consequence, economic efficiency – the maximization of net social benefits – is not the objective of this model. Rather, the regulator and farmer are in a second best world, where the goal is to achieve the TMDL standard cost-effectively.

In order to simplify the discussion, the following game assumes that the TMDL is implemented as a flexible ambient performance standard. The regulator only monitors the ambient level of phosphorus in the degraded water body, and if it exceeds the allowed limit, then all farmers who in the watershed will be penalized. In this illustration, the farmer's choice is depicted as a binary choice – comply or do not comply – when in actuality each farmer chooses an abatement level from a continuum of possibilities. This assumption is re-specified in the next chapter.

5.1.2 The Expected Payoffs of the Game

The expected payoffs are incentives for the players. *Ex ante*, each player considers the expected payoff because there are probabilities associated with the actual outcomes. The payoff to the farmer is measured in dollar values and is actually considered to be a cost. The farmer's objective function is assumed to be the minimization of his cost of his abatement effort plus an expected penalty that may be assessed if the ambient pollution limit is exceeded and if he does not make any effort to abate his effluent. The regulator takes the social welfare point of view which means she[34] values the resource owners' interests (the farmer) and environmental concerns. As such, the regulator is assumed to minimize her payoff (cost) which is the farmer's expected costs, subject to an environmental constraint that is defined by the TMDL standard.

[34] For notational simplicity, the regulator is assumed to be female.

5.2 Sequential Extensive-Form Games

A sequential extensive-form game is used in this *ex ante* analysis, similar to the analysis used by others such as Segerson (1999a, 1999b) and McCluskey (2000). The purpose is to visually illustrate the how compliance uncertainty affects the strategic behavior of the regulator and the farmer when they must contend with a total maximum daily load. Segerson uses this framework to analyze mandatory flexible incentives to control agricultural pollution (1999a), as well as comparing mandatory and voluntary approaches to food safety. McCluskey uses a similar game-theoretic framework to examine asymmetric information and policy issues relating to organic foods. In this type of game, each player moves in turn, they do not take actions at the same time.

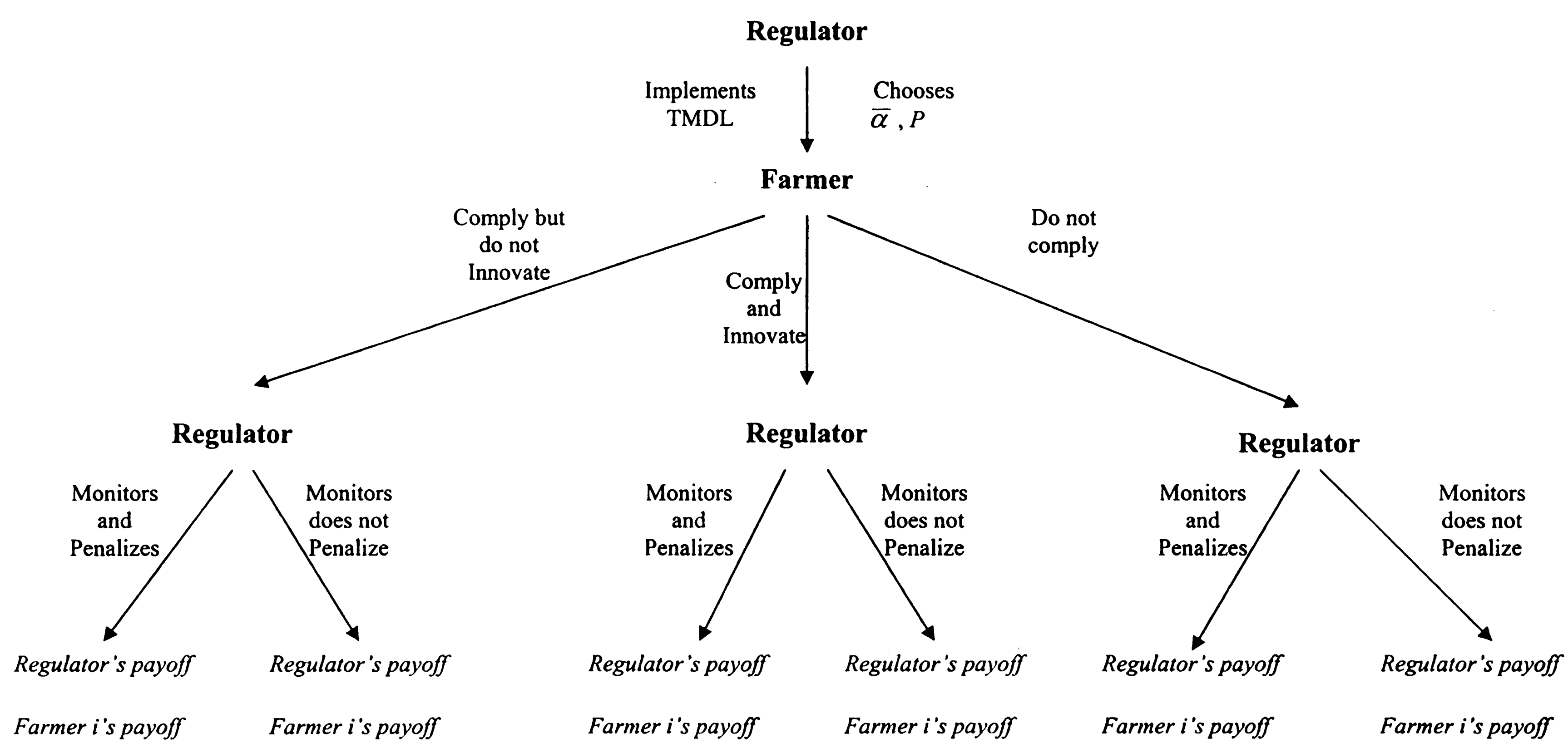
An extensive-form game is simply a decision tree representation of the sequential game. This visual depiction makes it easier to envision the sequence of actions and events, and will aid in understanding the more complex model to be presented in Chapter 6. The extensive-form game in Figure 5 stylistically depicts the possible outcomes when a TMDL is implemented as a flexible ambient performance standard for the special case of a single farm.

The process of TMDL regulation is modeled as a four-stage game. First, the regulator implements a TMDL process by choosing an ambient limit, $\bar{\alpha}$, as well as a penalty, P, in case the limit is not met. The regulator chooses the values of these variables in anticipation of the actions of the farmer. The limit, $\bar{\alpha}$, requires the nonpoint source to reduce its effluent of phosphorus loadings into the surface water body. This limit may actually differ from the target mandated by the TMDL. Why can these two – the actual limit and the TMDL target – diverge? The TMDL requires, states to ensure that the designated water quality standard is met. Yet, the regulator can make the limit more stringent than the designated standard. For example, if the regulator has little information regarding what farmers are doing, but must ensure that the TMDL-mandated standard is met, the regulator can make the actual limit more stringent.

In the second stage, the farmer chooses whether to comply and innovate, comply and continue to use his current technology, or he can choose to not to comply in order to minimize his compliance costs and the expected penalty.[35] Why is this latter choice possible? As Heyes (1998) states, since there is a cost associated with compliance, whether a pecuniary cost or a transaction cost or both, regulations have to be enforced; here, the environmental regulation has now increased the cost or price of water quality from zero for the nonpoint sources. That is, water is no longer an unpriced part of the farmer's production process. But since monitoring and enforcement are costly, they are usually incomplete. The farmer may take advantage of the situation and not comply if the expected gains from non-compliance are greater than the expected penalty. Consequently, some farmers are able to avoid compliance and may decide to free ride on the efforts of those farmers who do try to meet the TMDL requirements.

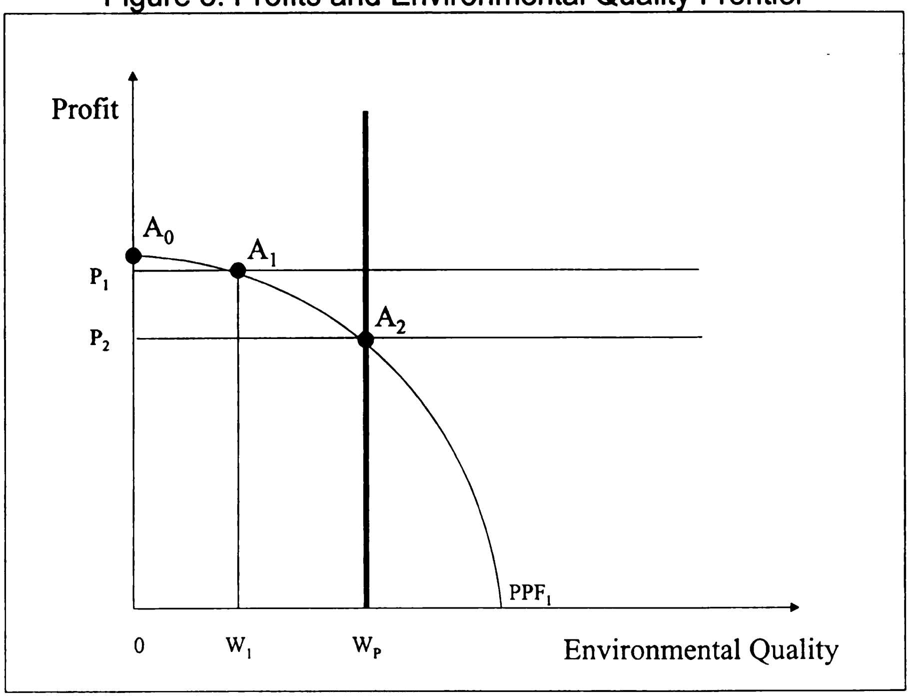
[35] Conceptually, the farmer chooses his degree of compliance to minimize his abatement costs plus the expected penalty. The next chapter models this situation more appropriately.

Figure 5: Possible Actions and Outcomes of a TMDL with Compliance Uncertainty



Thus, as shown in Figure 5, the farmer can choose to not comply due to the regulator's inability to perfectly enforce compliance. If the farmer chooses to not comply, he does not incur any compliance costs. If the farmer does comply with the TMDL standard, his costs increase, in other words his profits decline (P_1 to P_2), as shown in Figure 3, *Profits and Environmental Quality Frontier*, which is reproduced here for convenience.

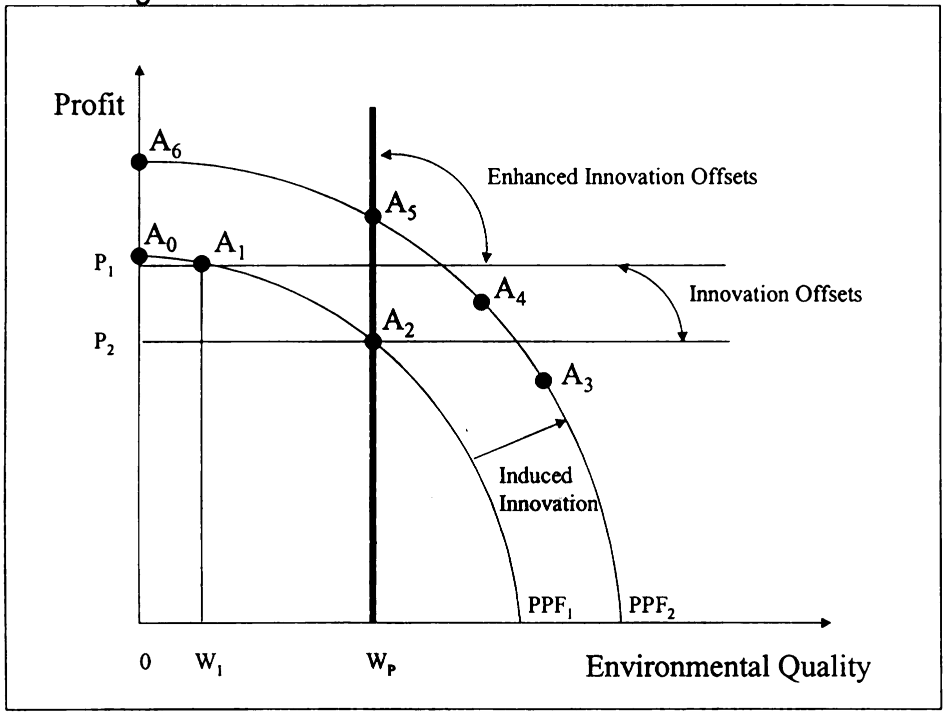
Figure 3: Profits and Environmental Quality Frontier



Adapted from Srivastava, Batie, and Norris (1999).

What are the incentives to comply and innovate in the face of compliance uncertainty? The farmer's is motivated to innovate in order to reduce his effort costs and his expected penalty, that is, reduce his total expected compliance costs. If he does innovate, then the Porter Hypothesis would in fact hold. Presumably the farmer chooses to innovate because he has estimated that his compliance costs are minimized by doing so. In this case, innovation offsets (at A_4) and perhaps even enhanced innovation offsets (at A_5) may be realized by the farmer as depicted in Figure 4, *Induced Innovation and Innovation Offsets*, which is also reproduced here for convenience.

Figure 4: Induced Innovation and Innovation Offsets



Adapted from Srivastava, Batie, and Norris (1999).

In the third stage, the regulator monitors the degraded water body to determine whether the ambient level of phosphorus exceeds the mandated level, $\overline{\alpha}$. The regulator experiences compliance uncertainty due to (a) unobservable effluent, (b) incomplete knowledge on their behalf with respect to understanding the effect of management practices and technologies on the generation of effluent and the fate and transport of effluent from nonpoint sources, (c) the actual fate and transport of effluent and its stochastic characteristics, and (d) because farmers can behave opportunistically due to asymmetric information between many actors and the regulator, resulting in moral hazard.

Since the regulator is only monitoring the ambient level of phosphorus in the water body, she does not actually know what each farmer is doing. Consequently, the regulator can mistakenly penalize a farmer who has undertaken abatement efforts. Thus, in the third stage, the regulator can monitor the ambient level and penalize the farmer or monitor the ambient level but not penalize the farmer.[36]

In the fourth stage, the payoffs are received. The top row is payoff to the regulator, and the second row is the payoff to the farmer. These payoffs are expected payoffs since the there are probabilities associated with each branch of the tree, so the payoffs are the products of the probabilities and the dollar amount. The desire to minimize his costs – that is, his expected payoff – is the incentive which motivates the farmer in his decisions.

Although not depicted in Figure 5, the effect of lawsuits from third-party citizens' groups can be an important factor on the farmer's decision. Third-party citizens' groups have been the catalyst in ensuring the implementation of total maximum daily loads by states and the EPA. Also, some third-party groups have used these lawsuits at the local level to motivate both regulators and farmers in complying with the requirements of the Clean Water Act. In Michigan, the Sierra Club has given lawsuit notices to Michigan dairy farmers, and this appears to have increased concerns amongst dairy farmers regarding their compliance decisions with environmental regulations (Jackson 2001). Even if farmers would like to comply, liability issues may prevent them from investing in the necessary research and development that may result in induced innovation and innovation offsets. That is, compliance certainty is costly to determine with an ambient

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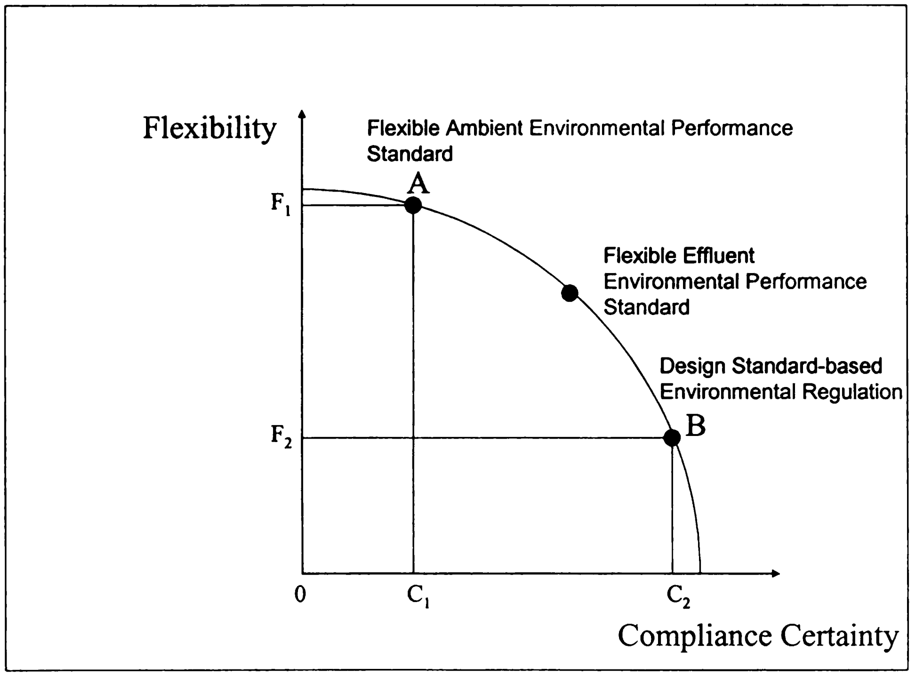
[36] If the regulator did not enforce the limit, then that would be an additional choice – to not monitor and not enforce. But since it assumed here that the regulator will enforce the limit, this option is not specified.

standard; for example, where free riding is a concern. This situation compounds the difficulty of knowing who has undertaken efforts in good faith. In this case, farmers may face liability issues that are not due to their own efforts.

In such a situation, they may prefer to not undertake the necessary research and development investments (i.e. they may not innovate), but would prefer to shift liability costs to the regulator by demanding design standards specified by the regulator. Then by following the design standards, farmers are still able to reduce their compliance costs, but without having to be innovative. Since the regulator wants to minimize the costs that farmers incur while ensuring that water quality is improved, the regulator may thus also be motivated to convert the flexible environmental performance standard into a design standard. If this is the case, then there will be no induced innovation, no innovation offsets, and the Porter Hypothesis will not in fact hold in the case where regulators try to control nonpoint source pollution because of compliance uncertainty. In essence, liability concerns due to compliance uncertainty could cause both the regulator and the farmer to search for greater certainty, and want to move from a point like A to B in Figure 2, *Flexibility and Compliance Uncertainty Frontier*, duplicated below.

The equilibrium concept used in this analysis is Nash equilibrium. A Nash equilibrium exists if each player is employing his optimal strategy, given all the other player's strategies. With a Nash equilibrium, no player has an incentive to deviate from its strategy, so the equilibrium is stable. Thus, with a Nash equilibrium, each player is satisfied that he has made the best decision possible for himself or herself, given the decision of other players, and has no incentive to change his or her decision. In deciding which course of action to take, the farmer compares his alternative payoffs, and chooses that one which allows him to minimize his costs, given his information set regarding the regulator's actions and the actions of other farmers, and the third-party citizen's group.

Figure 2: Flexibility and Compliance Uncertainty Frontier



Although Figure 5 outlines the possible courses of action that the farmer can take, as is, it does not conclusively distinguish what choices the farmer will in fact make. The course of action that the farmer chooses depends upon the likelihood he places on the different events occurring. Additional factors that affect his subjective probability are the degree of compliance uncertainty, the compliance measure, the regulator's monitoring and enforcement efforts, the expected penalty, and any expected legal costs. *Ex ante*, the farmer also forms a subjective probability that the actual level of phosphorus in the water body exceeds the limit, $\overline{\alpha}$, which in turn is a function of the actions of the farmers around the water body and stochastic environmental drivers.

This analysis is not intended to be a comprehensive reflection of all the intricacies in this situation; rather, it is intended to provide insight into the incentives that the farmer faces when flexible environmental performance standards are used to control nonpoint source pollution. In reality, farmers are not likely to make a dichotomous decision of complying or not complying. Rather they are more likely to undertake some level of abatement effort that will allow them to be in compliance at least cost. The next chapter – Chapter 6 – investigates this more realistic representation. Ultimately, the farmer's effort, his innovation decision, and whether the Porter Hypothesis holds for the case of nonpoint sources of pollution, depend upon the effects of compliance uncertainty and its resulting transaction costs, as shown in the next chapter, Chapter 6, *Environmental Standards and Compliance Uncertainty*.

CHAPTER 6

Environmental Standards and Compliance Uncertainty

The model developed in this chapter allows an examination of the differing levels of cost-savings due to innovation that result from various levels of compliance uncertainty with a flexible performance standard. Specifically, this model is used to investigate the implementation of a TMDL process to control phosphorus from dairy nonpoint sources in the presence of compliance uncertainty. The TMDL process is implemented alternatively as an ambient standard, an effluent standard, and a design standard to investigate and compare the incentives under each approach.

As implied by Porter's Hypothesis, flexible environmental performance standards may ensure that the desired environmental outcome is achieved while providing farmers with the incentive to seek out the least-cost set of effective pollution prevention practices for their unique farm situation. As discussed in Chapter 4, due to this induced innovation, farmers may be able to decrease their compliance costs through innovation offsets resulting in clear benefits for farmers while also improving environmental quality. It is unclear, however, whether these innovation offsets will be possible in the presence of compliance uncertainty.

The six sections of this chapter are divided as follows: the first section specifies the structure of the model, the second considers a base case of where there is no compliance uncertainty. The third section turns to the more realistic case of imperfect information and compliance uncertainty when a TMDL process is implemented as an ambient performance standard. The outcome of an effluent standard is investigated in the fourth section, while the fifth looks at the last case of a when the TMDL process is implemented as a design standard. The final section summarizes the findings from this chapter, providing a ranking of the costs from these different compliance measures. In so doing, Chapter 6 brings together the various factors and issues discussed in earlier chapters.

6.1 The Structure of the Model

This section introduces assumptions and notation used in the model that is analyzed. The focus throughout is on the effect of compliance uncertainty on the implementation of environmental performance standards. Despite the apparent advantages of flexible environmental performance standards in terms allowing induced innovation, the practical difficulties of this approach are highlighted once compliance uncertainty and its resulting transaction costs are taken into account.

6.1.1 Phosphorus in the Lake

It is assumed that the water quality of a lake is degraded by effluent by a single pollutant – phosphorus. The only sources of water effluent around the lake are nonpoint sources, and are all assumed to be dairy farms. Assume there are numerous dairy farmers, $i = 1,2, \ldots,n$, who each generate some quantity of phosphorus, r_i, as a result of their milk production. Phosphorus levels depend on a farmer's abatement efforts, x_i, on the current technological state, θ_i, and stochastic weather events, v_i; that is, $r_i = (x_i, \theta_i, v_i)$. Effort costs are denoted $c_i(x_i, \theta_i)$. Marginal costs increase when the farmer increases his efforts, $(\partial c_i / \partial x_i > 0, \forall i)$. Farmers are price takers in input and output markets, and farmers in the watershed are assumed to have no collective influence on input or output prices. Each farmer is assumed to be a risk-neutral, cost-minimizer.

Following Horan, Shortle, and Abler (1998), the observed ambient concentration of phosphorus is given by:

$$\alpha = \alpha(r_1,\ldots,r_i\ldots r_n, g, \lambda)$$

where α is the ambient concentration, r_i ($i = 1,2,\ldots,n$) is effluent from nonpoint source i $(\partial\alpha / \partial r_i > 0, \forall i)$, g represents stochastic environmental variables that affect the transport and fate of phosphorus, and λ is a vector of watershed characteristics.[37] Note that the ambient concentration is stochastic in nature since it is a function of g and r_i, each of which is stochastic.

The regulator's objective is to ensure that the TMDL standard is met in order to improve water quality. The regulator ensures compliance through monitoring and enforcement efforts by levying a penalty on those who do not comply.

6.1.2 Information Conditions

Following Horan, Shortle, and Abler (2002), let Ω be the information set that encompasses all relevant information about both random and non-random processes with respect to pollution of the lake. Neither the regulator nor the farmer will have full information; rather, each has access to only a subset of the information in Ω. Although, the regulator is unable to perfectly observe r_i, or the effluent, from the nonpoint sources at a reasonable cost, it can form *expectations* which are conditional on observations of the farmers' management practices and past weather information.[38] Denote the regulator's

[37] Phosphorus pollution is a dynamic process, but it is modeled here as a static process for simplicity.
[38] These expectations may be assisted by bio-physical models of nonpoint source pollution.

information set of the farmers' actions and the effects of their management practices on water quality as Ω_r.

Similarly, farmer i possesses an information set, $\Omega_i \in \Omega$, regarding his actions, the effluent process (both random and nonrandom components) and the effects of his management practices on water quality. For an ambient standard, this information set also pertains to the actions of others and their effect on ambient pollution levels. In general, the farmer has better information about his management practices and the regulator has better knowledge of the effects of these practices on the lake's water quality. The result is an information asymmetry between the two players:

$$\Omega_r \neq \Omega_i \ \forall i$$

and further,

$$\Omega_i \neq \Omega_j \ \forall i \neq j$$

where j is another farmer. As these information sets are incomplete, both the regulator and farmer will experience uncertainty regarding the exact specification of $r_i(\bullet)$. Additionally, since effluent from each farm i is a function of g, which represents stochastic environmental variables that affect the transport and fate of phosphorus, the uncertainty with respect to $r_i(\bullet)$ is exacerbated.

6.2 Performance and Design Standards with Compliance Certainty

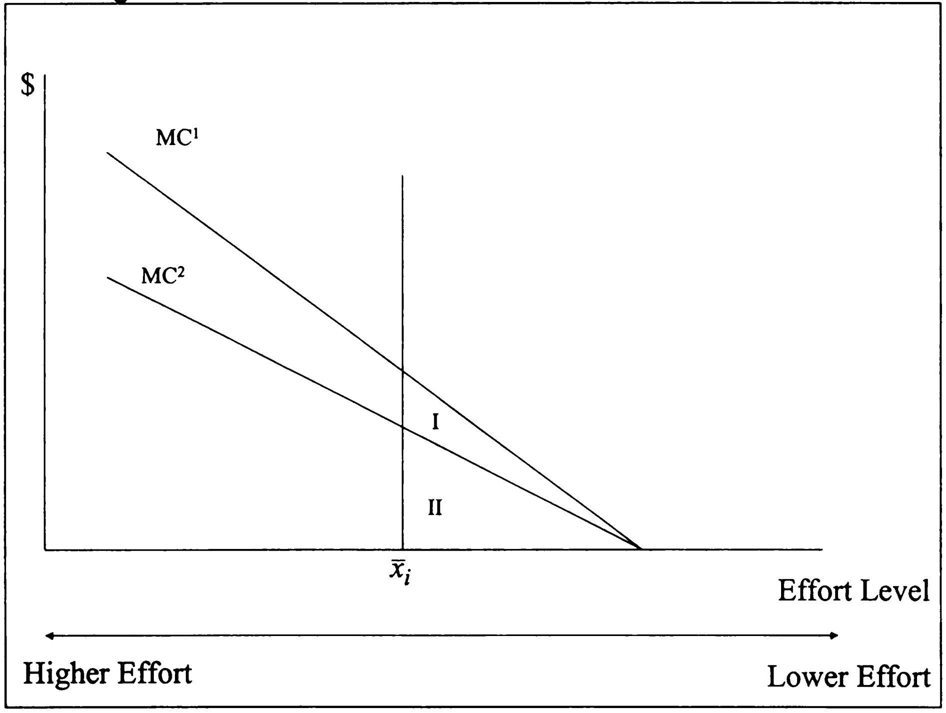
Initially, consider the case of compliance certainty to provide a benchmark to which to compare the effects of compliance uncertainty. Everyone has perfect information. All functional relations are known by all players, and there are no stochastic variables. Only when these assumptions are relaxed does compliance uncertainty emerge.

With compliance certainty, the regulator can impose a standard and know for certain whether each farmer complies. The farmer also has no uncertainty about the regulator's ability to enforce the standard, which she can easily do with a sufficiently large penalty for non-compliance. Under these circumstances, the ambient standard, and effluent standard, and a design standard could easily be set such that each farmer complies in a manner that achieves the TMDL cost-effectively. In other words, the outcome of a cost-effective design standard **under perfect information** will be the same regardless of the type of compliance measure; therefore the focus here is on the case of a design standard for simplicity since it is equivalent to the other two compliance measures.

A design standard in this simple model restricts $x_i = \bar{x}_i$, leaving the farmer with no flexibility in making effort choices. Farmer *i*'s associated effort costs are illustrated by area *I+II* in Figure 6 where MC^1 is his marginal cost of effort curve. If the farmer innovates in a way that reduces his marginal cost of effort, the corresponding curve will shift down, to MC^2; his costs are reduced to area *II*, for a cost savings equal to area *I* relative to his original technology. Hence, the cost savings of area *I* represents the farmer's incentive to innovate when there is no compliance uncertainty.

This assumption of perfect information, however, is unrealistic. The regulator does not have detailed information about each farmer's management practices nor his level of abatement effort; moral hazard is a problem in the real world. Additionally, farmers do not know what each other are doing. In the next section this assumption of perfect information is relaxed.

Figure 6: Effort and Innovation with Perfect Information



6.3 An Ambient Performance Standard with Compliance Uncertainty

The previous case showed that in the case of perfect information, a sufficiently high, certain penalty can provide farmers with enough incentive to innovate, leading to innovation offsets. In reality, however, the regulator's information set is not equal to that of the farmer's, and no farmer knows what others are doing – perfect information does not exist – and in fact there is compliance uncertainty ($\Omega_r \neq \Omega_i$ and $\Omega_i \neq \Omega_j$). Consider the case where the regulator implements the TMDL process as a flexible ambient performance standard. The regulator only measures the total ambient concentration of phosphorus in the lake, α, before making a decision on enforcement. But now with imperfect information, the regulator can not identify which farmer contributed the most or the least to the total ambient concentration due to the random variables involved and incomplete information regarding the fate and transport process. Additionally, with imperfect information and hence compliance uncertainty, no farmer is certain that his abatement efforts are sufficient to ensure that the ambient standard is met, and that he will not be penalized.

The regulator implements the total maximum daily load process as a flexible ambient performance standard to control phosphorus. The regulator's objective function is:

$$\underset{\overline{\alpha},Penalty}{Min} \sum_{i=1}^{n} c_i(x_i,\theta_i) \qquad (1)$$

$$\text{s.t. } Pr(\alpha > \alpha_{TMDL}) < z,\ \hat{x}_i^A(\overline{\alpha},Penalty)\ \forall i.$$

In Equation 1, α_{TMDL}, is the ambient phosphorus standard specified by the TMDL (the TMDL target), z is a probability target between 0 and 1, and $\hat{x}_i^A(\overline{\alpha},Penalty)$ is the regulator's expectation of farmer i's response to the policy variables. The environmental constraint is specified probabilistically due to the stochastic nature of the effluent and the ambient water quality level; additionally, the farmer may not be able (nor willing) to ensure that the ambient performance standard specified in the TMDL is met at every point in time. The limit, $\overline{\alpha}$, requires the nonpoint source to reduce its effluent of phosphorus loadings into the surface water body. The TMDL target may be different from what the regulator chooses to require the farmers to meet, $\overline{\alpha}$; for instance, $\overline{\alpha}$ may be more stringent than α_{TMDL} to increase the likelihood that the TMDL target is met. The regulator chooses the values of these variables in anticipation of the actions of the farmer.

The limit, $\overline{\alpha}$, and the TMDL target can differ because the state regulator can choose to set the limit to whatever level she wants; she just must ensure that the designated water quality standard is met, as specified by the TMDL target. Thus, if the regulator has little information regarding what farmers are doing, but must ensure that the TMDL-mandated standard is met and also wants to compensate for stochastic weather events, then she can choose to make the actual limit more stringent than the TMDL standard.

The regulator's optimization problem is also subject to the regulator's expectations of the farmers' responses to the penalty and $\overline{\alpha}$. The optimization problem is as it is because imperfect information forces her to form expectations of what the farmer will do based on her information set, Ω_r, resulting in the regulator pursuing a second-best outcome. A first-best outcome would minimize total costs subject to the environmental constraint, but not subject to the *expectations* of the farmers' responses since the regulator would know what these are. The first-best outcome, since it is based on better information, would be least cost over all second-best outcomes.

In the case of a flexible ambient performance standard, farmer *i*'s objective function is:

$$\underset{x_i}{Min}\; c_i(x_i,\theta_i) + \Pr(\alpha > \overline{\alpha} \mid x_1,\theta_1,x_2,\theta_2,\ldots,x_n,\theta_n) \times \Pr(enforcement \mid \alpha > \overline{\alpha}) \times Penalty.$$

Farmer *i* selects his level of effort so as to minimize his expected costs which is the sum of his costs of effort and the expected penalty; it is an expected penalty because recall, a penalty is only imposed if $\alpha \geq \overline{\alpha}$. The expected penalty in turn is the product of the farmer's subjective probability that the ambient level of phosphorus, α, exceeds the threshold specified by the regulator, $\overline{\alpha}$, the farmer's subjective probability that the regulator will enforce the penalty, and the pecuniary penalty.[39] The ambient level of phosphorus and hence the expected penalty faced by the *i*'th farmer is dependent upon the actions and technologies used by all *n* dairy farmers.

For notational ease, consider the case of Farmer 1. Given the initial state of technology, θ_1^1, his objective is to choose effort x_i, to minimize expected costs:

$$\underset{x_1}{Min}\; c_1(x_1,\theta_i^1)+\Pr(\alpha>\bar{\alpha}|x_1,\theta_i^1,x_2,\theta_2,...,x_n,\theta_n)\times\Pr(enforcement|\alpha>\bar{\alpha})\times Penalty.$$

The solution to Farmer 1's problem depends upon $\bar{\alpha}$, his technology state, the actions of all the other farmers since these jointly influence α, and the penalty level:

$$x_1(\bar{\alpha},\theta_1^1,x_2,\theta_2,...,x_n,\theta_n,Penalty). \qquad (2)$$

In a Nash equilibrium involving *n* farmers, the farmer's equilibrium solution is $x_1(\bar{\alpha},\theta_1^1,Penalty)$ because every farmer's solution depends upon what every other farmer is doing; this solution reflects this interdependence. Under an ambient standard, the regulator only monitors the ambient level of phosphorus and does not know with certainty the abatement effort that any individual farmer is undertaking in order to comply with the mandated limit, $\bar{\alpha}$; that is, she does not have enough information to perfectly estimate Equation 2.

In this case, if the regulator is facing pressure to ensure that the TMDL is being met, she may set the penalty very high to ensure effort levels are high enough to satisfy the TMDL standard. This possibility is consistent with the findings of Cabe and Herriges

39 There is no subsidy nor variable tax based upon a deviation from the TMDL standard. Subsidies can be used in combination with fines to ensure compliance efficiently, as shown by Xepapades (1991). Subsidies are not considered here to better reflect the intentions of the state of Michigan, where the Department of Environmental Quality is not considering any subsidy program to facilitate TMDL compliance.

(1992) who determined that, with an ambient performance standard, the penalty may have to be set very high to ensure compliance due to informational constraints; that is, Cabe and Herriges suggest a high penalty because each producer may not believe that his choices influence pollution levels at the margin, or he believes that the effect of his actions is small, much smaller than the actual effect.[40] In essence, the regulator is requiring Farmer 1 to over-comply by mandating a limit, $\overline{\alpha}$, that is more stringent than α_{TMDL} ($\overline{\alpha} < \alpha_{TMDL}$). Farmer 1 does know that the regulator is setting a high penalty, but he may not understand how the process works nor know the effects of his management practices on the ambient pollution level. He therefore forms expectations with respect to how conscientiously compliance will be enforced by the regulator. These expectations result in a steep expected marginal penalty curve denoted $EMP^{Ambient}$ in Figure 7.[41] The $EMP^{Ambient}$ curve is not vertical because of compliance uncertainty; that is, since there is no perfect information, $EMP^{Ambient}$ is Farmer 1's subjective marginal penalty curve. He knows the regulator cannot perfectly enforce the flexible ambient performance standard so he forms a subjective probability of enforcement. Additionally, without perfect information, Farmer 1 does not know the actions of the other farmers, so he can only form a subjective probability of whether the ambient level of phosphorus will exceed the allowed limit; these uncertainties are reflected in the non-vertical slope of the curve.

Farmer 1's initial marginal cost of effort is given by the curve MC^1. With a high degree of uncertainty, the amount of abatement effort Farmer 1 expends is x^A. The cost

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[40] The literature generally views ambient pollution-based incentives as providing poor motivations for pollution control (Cabe and Herriges 1992, Horan et al. 1998, 2002). Additionally, farmers must process a large amount of information in order to correctly evaluate incentives that ambient-based policies attempt to provide.

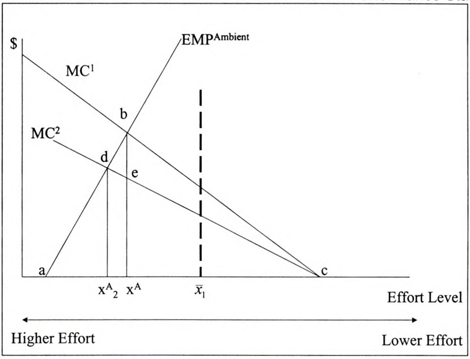
[41] A high penalty is not unrealistic; the Clean Water Act specifies a maximum fine of $25,000 a day for every violation.

that he incurs for this level of effort is equal to the area $x^A bc$, his expected penalty cost is equal to the area abx^A, for a total expected cost equal to area *abc*.[42] If Farmer 1 were to innovate, his objective function would now given by:

$$\underset{x_1}{Min}\ c_1(x_1,\theta_1^2)+\Pr(\alpha>\overline{\alpha}|x_1,\theta_1^2,x_2,\theta_2,...,x_n,\theta_n)\times \Pr(enforcement|\alpha>\overline{\alpha})\times Penalty$$

where θ_1^2 represents his technological state to reduce phosphorus loadings.

Figure 7: Effort and Innovation with a Flexible Ambient Performance Standard



Although Farmer 1 incurs some costs from searching, adopting, and learning the new technology – his effort increases to x_2^A – this innovation allows him to reduce his

[42] It is possible that Farmer 1 will be sued if the TMDL standard is not met. He can form expectations that his expected penalty – here the costs of the legal proceedings are included as part of his penalty – are so high as to make the marginal expected penalty curve extremely steep and close to the Y-axis (or at least rotated), where he could lose his farm. In order to avoid the possibility of losing his farm, he may take precautions by expending considerable effort to reduce his abatement, thereby incurring very high costs. If he can prove that he has met the limit, he may be able to shift the liability costs to the regulator. But proving that he met the limit would be difficult in the case of a flexible ambient standard due to the effect of the other *n-1* farmers on the ambient pollution level.

marginal costs, shifting his marginal effort cost curve to MC^2. If the farmer were to innovate in a way that did not affect his compliance uncertainty – in other words did not affect his expected penalty – he would reduce his total expected cost by area *bdc*. This cost savings from the innovation is Farmer 1's incentive to innovate.

Farmer 1's expected costs have declined relative to the situation prior to the innovation because now the cost of his effort is only area $x_2^A dc$ and his expected penalty has also been reduced to area adx_2^A. Note that part of what Farmer 1 used to pay – in terms of his expected penalty costs – is now instead part of his effort cost (area $x_2^A dex^A$), transforming this amount from an expected cost to a certain cost.

If the innovation reduced Farmer 1's compliance uncertainty, then his expected marginal penalty curve, $EMP^{Ambient}$, would shift down. This shift would reduce costs further, thereby increasing the incentives to innovate. With a flexible ambient performance standard, however, this shift is unlikely to happen, especially when *n* is large. If *n* were large, then at the margin, any increase in Farmer 1's effort would not likely change his subjective probability with respect to the ambient level of phosphorus exceeding the specified limit, nor his subjective probability of enforcement, nor the penalty level; that is, it is unlikely that there would be any agency response. A response from the regulator is unlikely because ambient pollution, and hence the likelihood of a fine, depends upon what the other *n-1* farmers are doing. Recall that an ambient-based fine such as this one is a group fine. If there are many farmers, with no one farmer being a major contributor to the pollution problem, then changes made by one farmer can be expected to have a minimal effect on ambient pollution levels.

These incentives to innovate under compliance uncertainty are greater than those arising under no compliance uncertainty due to the steep expected marginal penalty. The curve is steep due to the high level of compliance uncertainty, which results in the farmer being forced to expend too much effort. With perfect information, the standard set by the regulator is perfectly enforceable since the regulator knows what each farmer is doing, thus, there is no need for over-compliance, or no need for a steep expected marginal penalty curve. Consequently, while the cost-savings of area *I* in Figure 6 is the incentive that drives farmer *i* to innovate, he has neither the incentive nor the freedom to adjust his effort level further because by restricting farmer *i*'s effort level to $\bar{x}_i$, the standard in Figure 6 is like an inelastic marginal penalty curve. Even after the innovation, farmer *i*'s effort level remains at $\bar{x}_i$.

With compliance uncertainty, the situation is different since the incentives to innovate differ. A comparison is given in Table 3. Initially the farmer is at a higher effort level ($x^A > \bar{x}_1$) compared to the perfect information case because of the high expected marginal penalty.[43] If Farmer 1 does not adjust his level of effort after the innovation and remains at x^A, then his cost of effort would decrease since his marginal costs have declined ($x^Aec < x^Abc$, Table 3), but his expected penalty cost would remain at abx^A as before the innovation, resulting in total expected costs equal to area *abec* (Table 3). The incentives to innovate are equal to the area *bce* (his cost-savings); this area *bce* is greater than that for the case of perfect information or compliance certainty (area *I*, Figure 6) because of the higher effort level.

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[43] The restricted level of effort from Figure 6, $\bar{x}_i$, is reproduced in Figure 7, and is labeled $\bar{x}_1$ in reference to Farmer 1.

Table 3: Relative Ranking of Firm Incentives With and Without Uncertainty

	Pre-Innovation	**Post-Innovation without Adjustment**	**Post-Innovation with Adjustment**
Perfect Information			
Cost of effort	*I+II*	*II*	not applicable
Savings relative to pre-innovation	not applicable	*I*	not applicable
Compliance Uncertainty			
Cost of effort	$x^A bc$	$x^A ec$	$x_2^A dc$
Expected penalty cost	abx^A	abx^A	adx_2^A
Total expected cost	*abc*	*abec*	*adc*
Savings relative to pre-innovation	not applicable	*bce*	*bcd*
Savings due to effort adjustment	not applicable	not applicable	*bed*
Relative Ranking	3	2	1

Source: Figure 6, Figure 7

But there are additional incentives under compliance uncertainty. The marginal penalty curve is no longer vertical, so it imparts different incentives to farmers; specifically, now Farmer 1 is able to choose his effort level by equating his marginal cost of effort to his expected marginal penalty. With a vertical marginal penalty curve, Farmer 1 could not choose his effort level; he was required to expend $\bar{x}_1$ level of effort.

The expected marginal penalty is similar to an ambient pollution tax in that the farmer compares his marginal benefits and costs in choosing his effort level. Thus, in

Figure 7, Farmer 1 alters his level of effort after the innovation, and actually increases it from x^A to x_2^A. Although this increases his effort cost ($x^A ec < x_2^A dc$, Table 3), as with a tax policy, Farmer 1 can benefit from an adjustment to his effort level after innovating because this adjustment lowers his expected penalty costs ($adx_2^A < abx^A$, Table 3). By being able to adjust his effort level, Farmer 1 is able to reduce his expected penalty costs, capturing an additional cost savings equal to the area *bed* (Table 3), which is unavailable to him under the case of perfect information when he can not adjust his effort level. Consequently, since the incentives under compliance uncertainty – with adjustment in effort – provide the greatest cost-savings to Farmer 1 and hence the greatest incentives to innovate, it is ranked highest in Table 3.

Compliance uncertainty provides Farmer 1 with additional incentives – in that by adjusting his level of effort – he is able to reduce his expected penalty costs. These additional cost-savings and hence incentives do not arise under compliance certainty. While this analysis differs from traditional ones that assume no compliance uncertainty, it is analogous to the findings of Milliman and Prince (1989) who show that after an innovation has occurred and after the individual firm's marginal cost curve changes to reflect these changes in cost, the innovating firm re-equilibrates its emission level under a tax or other economic incentive. But such re-equilibrating does not occur under a design standard.[44] Milliman and Prince, however, do not highlight the role of compliance uncertainty as providing the incentive to firms to alter their level of effort.

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[44] Milliman and Prince use the term *direct control* for a design standard.

6.3.1 Special Cases of Interest

There are two special cases of interest to this model; specifically, there are two corner solutions possible in this model, one where the farmer does not comply and the second where he exits the industry. If the regulator chooses to not enforce the specified limit, $\overline{\alpha}$, and Farmer 1 knows this lack of enforcement to be the case, then his subjective probability of enforcement is zero, effectively removing the penalty. Then the expected marginal penalty curve will coincide with the X-axis; Farmer 1's abatement efforts will be at point *c*. At point *c*, the farmer does not comply with the specified standard, and puts no effort into reducing his phosphorus effluent. In this situation, farmers do not comply with a total maximum daily load requirement, since there is no incentive to do so, thereby negating any possibility of induced innovation and innovation offsets.

The other possible corner solution is that Farmer 1 could exit the industry. The regulator could set the penalty so high as to lead to a corner solution where the firm will cease to be profitable and will exit the industry (Cabe and Herriges 1992). If there is a great deal of compliance uncertainty – such as with lawsuits and ambient standards – the expected penalty could coincide with the Y-axis, so that the only way Farmer 1 could comply would be to be at the point where his marginal cost of effort curve, MC^1, intersects the Y-axis, where his abatement level is complete, or in other words, he exits from the market. But since the regulator wishes to minimize the costs of abatement effort by all farms, and not simply to drive all dairy farms out of business, a lower marginal expected penalty is preferred. This preference can be achieved by decreasing the level of uncertainty, thereby eliminating the need to set an extremely high expected penalty and the possibility of all firms exiting the industry.

6.4 An Effluent Performance Standard with Compliance Uncertainty

The regulator will seek to decrease the amount of compliance uncertainty for herself and for the farmer in order to encourage compliance at a lower cost, given the farmer's objective function (Equation 1). One possible way that Michigan can implement the TMDL process and increase compliance certainty is by converting the ambient standard into an effluent performance standard for each farm – perhaps by using a computer model.[45] An effluent performance standard refers to the estimated amount of phosphorous allowed from farm *i*, which is estimated based upon the production and pollution control choices made by the farmer. Such a standard is flexible because the farmer can choose any method he wants to ensure that he does not exceed the standard or threshold. Although Michigan regulators have not converted the TMDL ambient performance standard for the water body ($\overline{\alpha}$) into an estimated effluent performance standard for farmer i ($\overline{r}_i$), this case is considered since it is being done in other jurisdictions as a means to reduce informational and transaction costs. This standard is still a flexible environmental performance standard since the farmer is free to adopt any technology or production method. The difference is now he is told how much pollutant he can discharge from his farm operation.[46]

The conversion from an ambient standard to an effluent performance standard has been done for other environmental regulatory objectives with varying degrees of

[45] Some example computer models include EPIC, SWAT, AGNPS. All three models have been developed by USDA's Agricultural Research Service. For further information, see http://www.ars.usda.gov/is/AR.

[46] With an effluent standard, it is possible that Farmer 1 is sued if the TMDL is not met. The effect of the lawsuit would be to shift or at least rotate the marginal penalty curve up, so that the farmer has more incentives to choose a greater level of effort in order to ensure that he does not lose his farm. But if he can prove that he has met his effluent standard, he can shift the liability costs to the regulator.

complexity elsewhere, such as La Crosse County, Wisconsin[47] and in the Netherlands (Ondersteijn *et al.* 2001), in an effort to counter some of the transaction costs associated with nonpoint sources of pollution. The La Crosse County Department of Land Conservation has adapted a computer model developed by the University of Minnesota that estimates the amount of phosphorus that leaves feedlots through runoff. This model was adopted by the county to reduce monitoring costs. The Netherlands has adopted the Mineral Accounting System (MINAS) which tracks nitrogen and phosphorus flows on individual farms and individually taxes every farmer for any generated nutrient surpluses using a "farm gate balance approach." It calculates the difference between nutrients entering the farm (e.g. feed and fertilizers) and leaving the farm (Ondersteijn *et al.* 2001).

In developing a model that estimates phosphorus effluent from farms, the regulator must collect data – characteristics of the farm operation, bio-physical site specific data, management information – and develop a model that incorporates its assumptions. This *ex ante* informational transaction cost can be significant, but this may result in decreased compliance uncertainty for both the regulator and the farmer.

The effluent performance standard is differentially applied to all farmers; thus, the effluent performance standard for farmer i is not necessarily the same as that for farmer j. It is assumed that the regulator divides the total standard amongst all farms in a manner that accounts for herd size, the land area on which they apply manure, and various site specific bio-physical characteristics, thereby improving the political acceptability of the TMDL by farmers.

[47] Personal communication with Chuck Zauner (Department of Land Conservation, La Crosse County, Wisconsin) June, 14, 2000).

If the modeling was perfect and if the regulator shared this information with all farmers, then all parties – the regulator and all the dairy farmers – would have perfect information. In effect, if all farmers acquire the model and learn how to use it, each can get immediate feedback about the effects of his management practices on environmental outcomes; as a result, every farmer can make any necessary modifications and investments to ensure that he meets the effluent performance standard. Additionally, since it is the same model used by the regulator, the farmer is able to perfectly anticipate any forthcoming problems and take necessary actions to mitigate them. The results of this case are analogous to those discussed in 6.2, with no compliance uncertainty, and so are not investigated further.

But in reality, the modeling is necessarily imperfect, since for example, the information about the exact specification of the effluent from farm *i*, $r_i(\bullet)$ and the realized weather are not precisely known. This information limitation results in some degree of compliance uncertainty for both the regulator and the farmer. Additionally, sharing its information set and model with farmers entails costs for the regulator – for example by providing the computer software and training – as well as for the farmer. Furthermore, the farmer may not trust the model, so $\Omega_r \neq \Omega_i$.

Consequently, there are still at least three sources of compliance uncertainty. Let the effluent standard for each farm be estimated from the model. The first source of uncertainty stems from the weather. *Ex ante*, before the weather is realized, the farmer can use the model to learn the predicted (and allowed) effluent from his operation, given the regulator's understanding of his practices, site characteristics, the forecasted weather; and he makes his compliance decisions. *Ex post*, the weather is realized, and the regulator enters this information into the model, and the regulator determines if the farmer has been compliant. Thus, since compliance is determined after the farmer has made his decisions and once the weather is realized, he never knows whether he really is in compliance with the effluent standard. Essentially, despite the effluent standard, the farmer does not have a meter at the end of his fields that accurately tells him what his effluent is so as to be able to adjust his practices as necessary. It is this lack of certainty that makes him unsure of whether his abatement efforts are sufficient for him to be in compliance.

The second source of compliance uncertainty is the inability of the regulator to observe all the farmers' choices. Moral hazard forces the regulator to either trust or distrust what the farmer tells her that he is doing. If the regulator does not believe what the farmer reports that he is doing, she can audit him, or auditing can be done randomly to a selection of farms.

The third source of compliance uncertainty is the difficulty both the regulator and the farmer can experience in trying to understanding the model. This cost may be greater for the farmer, especially if he does not trust the model. Without intimate knowledge or understanding of how the regulator models his farm's operation, compliance uncertainty exists for the farmer. Nevertheless, this cost may decrease over time as both agents learn and understand how the model estimates and sets effluent standards.

Now that the regulator has a tool – the model – to assist in estimating the phosphorus effluent from each farmer's operation, she is able to assess his abatement efforts in complying with the TMDL process. With a flexible effluent performance standard, the regulator's objective function is now:

$$\underset{\bar{r}_i, Penalty}{Min} \sum_{i=1}^{n} c_i(x_i, \theta_i)$$

$$\text{s.t. } \Pr(\alpha > \alpha_{TMDL}) < z\,,\ \hat{x}_i^E(\bar{r}_i, Penalty)\ \forall i\,.$$

The second constraint, $\hat{x}_i^E(\bar{r}_i, Penalty)$ is the regulator's expectations of the farmers' responses to the policy variables, their individually prescribed flexible effluent performance standard and the penalty.

Faced with an effluent performance standard, Farmer 1's objective function is:

$$\underset{\theta_i^1}{Min}\ c_1(x_1, \theta_1^1) + \Pr(r_1 > \bar{r}_1) \times \Pr(enforcement|x_1) \times Penalty$$ [48]

where $\bar{r}_1$ is the flexible effluent performance standard specified by the regulator for Farmer 1's farm. It is still an expected penalty because of the stochastic environmental variables, and also since neither the regulator nor Farmer 1 have perfect information about each other's actions. The solution to Farmer 1's problem now is a function of the effluent performance standard, the technology he is using, and the penalty:

$$x_1(\bar{r}_1, \theta_1^1, Penalty)\,. \qquad (3)$$

The regulator makes an informed guess as to what Farmer 1's solution is (Equation 3) using the computer model. The investments needed to develop estimates of the effluent from Farmer 1's farm and the increased monitoring that must occur under an effluent-based standard result in less uncertainty for the regulator than would occur under an ambient-based system. With decreased uncertainty, the need for a very high penalty is

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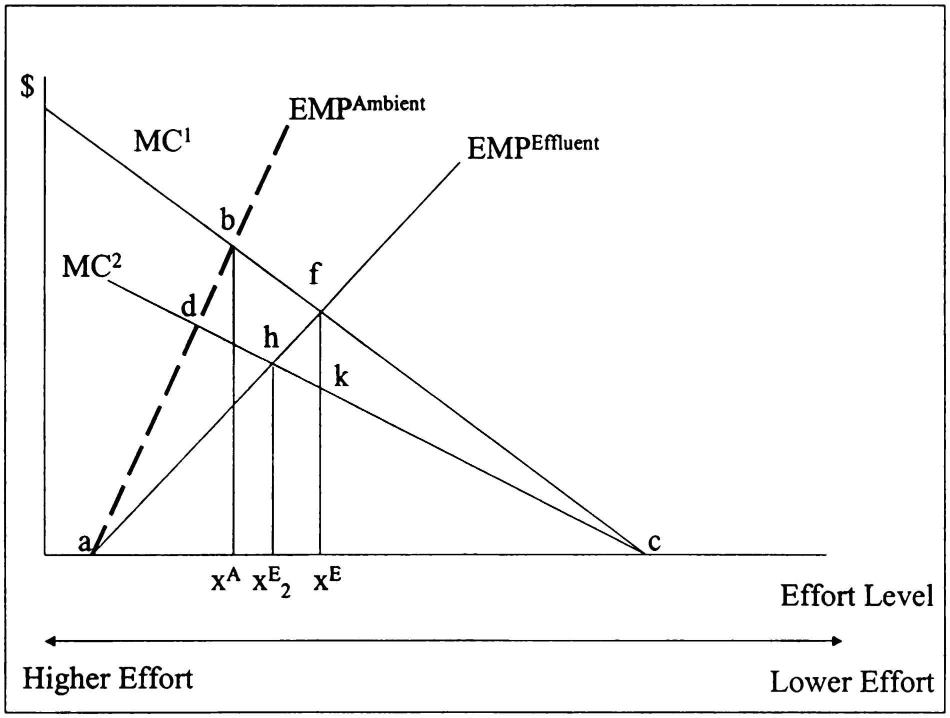
[48] The probability of enforcement only depends upon the farmer's individual actions. Ambient pollution levels could also influence this subjective probability, but it has a secondary effect, and for simplicity the focus is only on the primary effect.

reduced. Rather, the regulator can set a lower penalty, accordingly represented by $EMP^{Effluent}$ in Figure 8.[49]

Figure 8: Effort and Innovation with a Flexible Effluent Performance Standard



Farmer 1's abatement effort is given by x^E (which is less than x^A in Figure 7), his cost of effort is the area $x^E fc$, his expected penalty is area afx^E, for a total expected cost equal to the area *afc*. If Farmer 1 were to innovate, his objective function becomes:

$$\underset{x_1}{Min} \quad c_1(x_1, \theta_1^2) + \Pr(r_1 > \bar{r}_1) \times \Pr(enforcement | \alpha > \bar{\alpha}) \times Penalty$$

where θ_1^2 represents his new technological state to reduce phosphorus loadings. With a flexible effluent performance standard, his solution now depends upon his specified effluent standard, his new state of technology, and the penalty level:

49 $EMP^{Ambient}$ is shown as the dashed line in Figure 8.

$$x_1(\bar{r}_1, \theta_1^2, Penalty).$$

Assuming this innovation affects neither his subjective probabilities nor the penalty level, this innovation causes his marginal cost curve to shift down to MC^2, and results in a cost saving equal to the area *hfc*, despite an increase in effort level to x_2^E. Farmer 1's total expected costs have declined because his effort costs equal area $x_2^E hc$ and his expected penalty costs have decreased to ahx_2^E. The cost equal to area $x_2^E hfx^E$ is transferred from what was previously an expected penalty to a cost of effort; as would be expected, the higher effort level translates into a lower expected penalty. With the flexible effluent performance standard, since Farmer 1 wants to minimize his costs, he will choose to innovate.

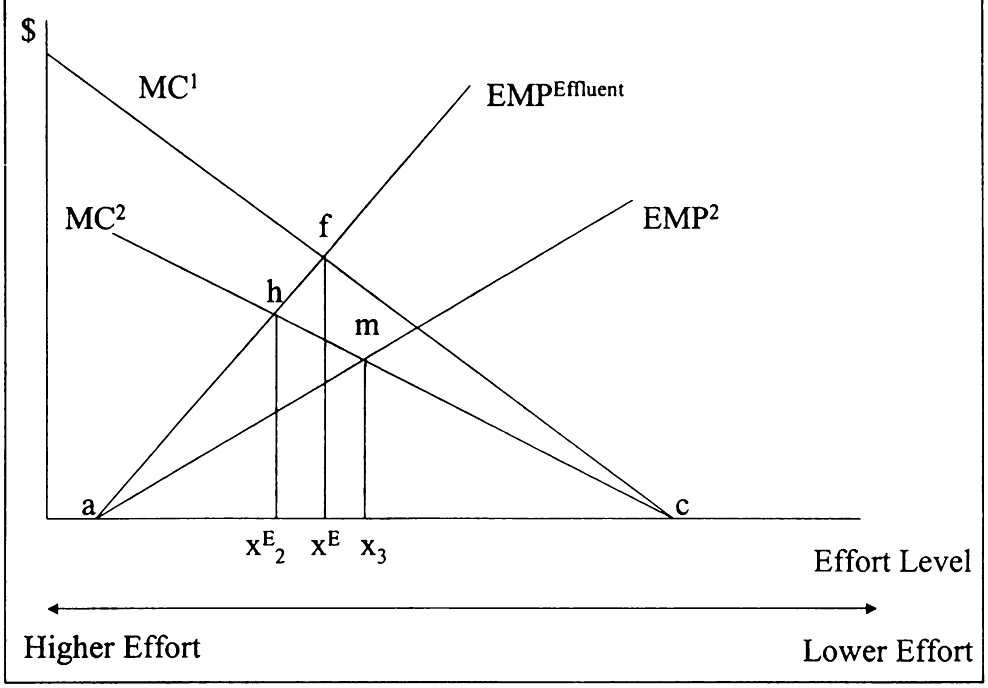
With an effluent standard, it is more likely that the innovation may affect Farmer 1's compliance uncertainty. If the technology were to cause effluent to decline for a given level of effort, and Farmer 1 believes that the regulator will be able to determine this change through modeling, then Farmer 1 would expect that the probability of being penalized will decrease. In other words, Farmer 1 would expect an agency response (Milliman and Prince 1989), causing his expected marginal penalty curve to shift down after the innovation to EMP^2, as illustrated in Figure 9.[50]

Now Farmer 1 actually decreases his level of effort relative to his effort level after the innovation (x_2^E) to x_3,[51] reducing his total expected costs to area *amc*.[52] As would be expected, this lower level of effort translates into a lower cost of effort, area x_3mc, and

[50] The original marginal cost of effort curve, MC^1, has been removed to simplify the diagram.
[51] In actuality, x_3 can be greater than or less than x^E since it depends upon the degree to which the expected marginal penalty curve shifts; the shift illustrated is one possibility.
[52] This is analogous to the agency response in Milliman and Prince (1989).

since the marginal penalty curve has shifted down, his expected penalty cost has also decreased, and now is equal to area amx_3. His expected cost savings relative to the case where this shift does not occur – in other words his additional incentive to innovate due to the shift – is equal to the area *ahm*. This additional incentive to innovate – area *ahm* – can be termed the *uncertainty-reduction effect*. This uncertainty-reduction effect essentially results in lower effort and lower associated expected costs for the farmer.

Figure 9: Effort and Costs with Uncertainty-Reduction Effect



As shown, these incentives to innovate under an effluent standard differ from both those arising under an ambient standard and the baseline case of perfect information. A summary of these incentives is presented in Table 4. Compared to the case of perfect information where the farmer cannot adjust his effort level, farmer *i* is initially at a higher level of effort ($x^E > \bar{x}_i$); but as with the ambient standard, the farmer has a greater incentive to innovate because compliance uncertainty allows the farmer to adjust his level of effort after the innovation.

Assuming no uncertainty-reduction effect – or that the expected marginal penalty curve does not shift – Farmer 1's incentives to innovate are equal to area *fck* (Figure 8) if he does not adjust his level of effort. This cost-savings is greater than his incentives to innovate under perfect information, area *I* in Figure 6, because of the higher level of effort that is required with the effluent standard due to compliance uncertainty. By adjusting his effort level, Farmer 1's total expected cost savings are equal to area *fch*.

Table 4: Comparison of Firm Incentives with Uncertainty-Reduction Effect

Expected Costs	**Ambient Standard**	**Effluent Standard**	
		Without uncertainty-reduction	**With uncertainty-reduction**
Pre-Innovation	*abc*	*afc*	*afc*
Post-Innovation	*adc*	*ahc*	*amc*
Change in expected costs (Incentive to innovate)	*bcd*	*fch*	*afcm*

Source: Figure 6, Figure 7, Figure 8, Figure 9

With the uncertainty-reduction effect – or when the innovation is such that compliance uncertainty is affected so that the expected marginal penalty curve shifts down – the farmer's incentive to innovate is even greater; it is equal to area *afcm*. Regardless of whether there is an uncertainty-reduction effect, Farmer 1's incentives to innovate are greater with the effluent standard than with the case of perfect information because of compliance uncertainty which results in the need for over-compliance through a steep expected marginal penalty curve.

In comparison to the flexible ambient performance standard, there is greater certainty, so Farmer 1's expected penalty costs are lower, requiring him to initially expend less effort with a flexible effluent performance standard ($x^A > x^E$). His initial total expected costs are less ($abc > afc$, Table 4) because his expected penalty costs are lower by area abf (Figure 8) and his effort costs are less as well with the flexible effluent performance standard ($x^A bc > x^E fc$). His effort level is less because the expected marginal penalty with the effluent performance standard is not as high as with the ambient performance standard since the regulator's level of uncertainty is lower.

The lower expected marginal penalty curve implies that even if the innovation causes the marginal cost curve to shift down in the same manner under both a flexible ambient and a flexible effluent performance standard, after the farmer re-equilibrates his marginal costs and his expected marginal penalty, his expected penalty and new level of effort after the innovation will be less under the flexible effluent standard, so $adc > ahc$ (Table 4) by area adh (Figure 8). Both his expected penalty costs (ahx_2^E) and the cost of his effort ($x_2^E hc$) are lower with the flexible effluent performance standard. Since his total expected costs are less under a flexible effluent performance standard, the farmer will prefer this compliance measure over a flexible ambient performance standard. Additionally, he will have greater incentives to innovate under both of these measures than if there is perfect information and no compliance uncertainty.

But if the innovation causes the expected marginal penalty curve to shift down – that is there is an agency response and an uncertainty-reduction effect – then the cost savings to Farmer 1 are even greater because his expected penalty and hence effort level have been further reduced. This lower effort level means both his effort costs and his expected penalty costs are also lower (*adc* > *amc*, Table 4). This relationship holds even if the expected marginal penalty curve shifts such that Farmer 1's new level of effort x_3 is actually greater than x^E.

Without a change in his expected marginal penalty curve, the flexible ambient performance standard provides more incentives to innovate – except for the special case of a corner solution. But, since his total expected costs are lower with the flexible effluent performance standard, the farmer will prefer this compliance measure over the flexible ambient standard – regardless of whether he believes his innovation results in an agency response as suggested by Milliman and Prince (1989). Furthermore, with the flexible effluent standard, if his innovation does decrease compliance uncertainty, then his cost-savings are even larger, possibly resulting in greater incentives to innovate than with the flexible ambient standard. Farmer 1 will choose those options that allow his expected marginal penalty curve to shift down, even if it results in $x_3 > x^E$, because x_3 still will be less than x_2^E. Given the ambiguity of the agency's response and movement of the expected marginal penalty curve, a clear ranking of these flexible compliance measures is not possible. Nevertheless, Table 5 does provide a ranking of these compliance measures, where 1 indicates the measure that provides the greatest incentive to innovate and 4 the least. The incentives to innovate reflect the cost-savings of the measures. Thus, the compliance measure that results in the greatest cost savings is ranked the highest. Since it is unknown whether the measure will result in an uncertainty-reduction effect, it is not clear whether the flexible ambient performance standard can be ranked higher than the flexible effluent performance standard; as such, the ambient and the effluent standard with the uncertainty-reduction effect are each ranked 1/2.

Table 5: Ranking of Compliance Measures

	Perfect Information	Ambient Standard	Effluent Standard	
			Without uncertainty-reduction	**With uncertainty-reduction**
Incentives to Innovate	4	1/2	3	1/2

Given Farmer 1's objective to minimize his compliance costs and the regulator's as well to minimize these costs across all farmers, both agents will want to have a lower marginal penalty curve. The following section examines a compliance measure that enables both parties to get the certainty that they seek.

6.5 A Design Standard to Reduce Compliance Uncertainty

When regulating nonpoint sources of pollution, the regulator can decrease compliance uncertainty by implementing the total maximum daily load process as a design standard. Here, the regulator provides farmers with a list of approved practices, or a technical sheet. This technical sheet contains a list of practices that the regulator endorses for use by dairy farmers.[53]

With a design standard, the regulator's objective function is now:

[53] By using a design standard to implement the TMDL process, the regulator has implicitly made it a *negligence rule*. With a negligence rule, the responsible agent is penalized only if it fails to comply with the "due standard care" regarding the pollution generating activity (Segerson 1995). A farmer who uses the technical sheet is deemed to have complied with due standard care.

$$\underset{\bar{x},Penalty}{Min} \sum_{i=1}^{n} c_i(x_i,\theta_i)$$

$$\text{s.t. } \Pr(\alpha > \alpha_{TMDL}) < z \text{ , } \hat{x}_i^D(\bar{x}, Penalty) \ \forall i$$

where the regulator is requiring farmers to choose a state of technology from an approved list, represented by $\bar{x}$. This approved technical sheet could be technologies that are approved by an agency like the Natural Resource Conservation Service (NRCS). The term $\hat{x}_i^D(\bar{x}_i, Penalty)$ is the regulator's expectations of the farmers' responses to the policy variables: the farmer's effort level, and the penalty. The expected response, $\hat{x}_i^D(\bar{x}_i, Penalty)$, may differ from the standard if there is imperfect monitoring.

Since there is a list of approved technologies from which Farmer 1 can choose what his best for him, he is able to choose his level of effort. Farmer 1's objective function is:

$$\underset{\theta_1}{Min} \quad c_1(x_1,\theta_1) + \times \Pr(enforcement|x_1) \times Penalty$$ [54]

where θ_1 is in the current state of technology. The solution to his problem with a design standard becomes:

$$x_1(\theta_1, Penalty).$$

Now Farmer 1's solution is only dependent upon the state of technology and the penalty level. By equating his marginal costs to the expected marginal penalty, Farmer 1 chooses his level of effort, x^D.

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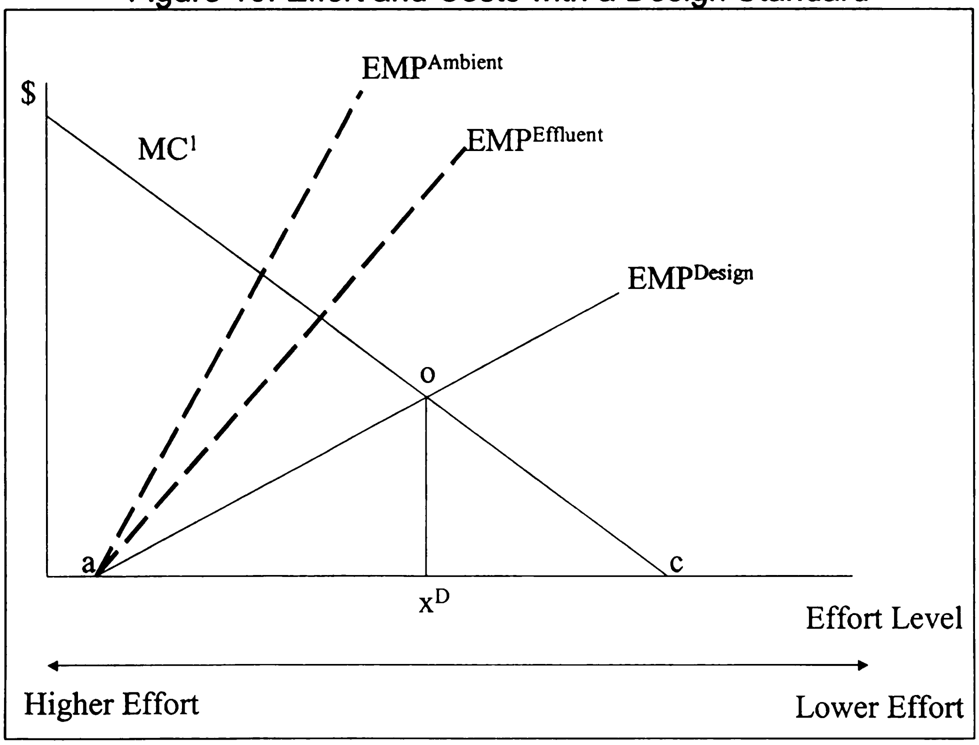
[54] Again, the focus is only on the primary effect – the farmer's individual actions – for this subjective probability.

With the technical sheet, the regulator removes much of her compliance uncertainty since now she can easily determine who is in compliance by simply ascertaining whether the farmer is employing practices specified on the technical sheet, thereby reducing some *ex post* transaction costs. Nevertheless, there are still sources of compliance uncertainty, from stochastic variables like weather. Additionally, monitoring will necessarily be imperfect since it is costly (Heyes 1998); consequently, farmers may be able to deviate from the mandated level of effort.

Figure 10: Effort and Costs with a Design Standard



Aside from the benefit of minimizing compliance costs for farmers, the regulator may prefer to convert the flexible environmental performance standard – both ambient and effluent performance standard – into a design standard, especially if she is interested in process and believes that the technical sheet will ensure that water quality goals are met. With this greater degree of compliance certainty, the regulator can set the policy parameters, $\bar{x}$ (the technical sheet) and the penalty such that the expected marginal penalty curve is not so steeply sloped, to EMP^{Design}, illustrated in Figure 10.[55]

What of the farmer? With the design standard, the farmer can determine easily whether he is in compliance with the total maximum daily load requirement since he is in compliance as long as he is using some subset of the practices on the approved technical sheet. In fact, the design standard with a technical sheet is the only compliance measure that allows farmers to determine for themselves whether they are in compliance with the TMDL process. Since the farmer does not incur any search costs when he is provided with a technical sheet, these informational transaction costs are reduced; in other words, his effort level is lower relative to the flexible performance standards.

Farmer 1's effort level is x^D and his expected total costs are equal to area *aoc*. By reducing some compliance uncertainty, a design standard decreases Farmer 1's compliance effort relative to the flexible ambient and flexible effluent performance standards ($x^A > x^E > x^D$), thereby reducing his associated total expected compliance costs (*abc* > *afc* > *aoc*). A technical sheet also reduces Farmer 1's subjective probability with respect to a penalty cost that includes legal costs from a lawsuit. Farmer 1 may face lawsuits if the TMDL standard is not met. But note that in providing a technical sheet, the regulator implicitly allows the farmer to shift liability costs to her, causing the farmer's marginal expected penalty curve to shift down towards the X-axis. The farmer can not be sued by a third-party group, since the regulator has approved the practices; if the farmer

55 The expected marginal penalty curve is drawn thusly for illustrative purposes. The expected marginal penalty curves for the ambient and effluent standard are also included.

happens to be sued by a third-party group, the farmer simply refers the aggrieved party to the regulator.

The increased compliance certainty provided by the technical sheet can be extremely important for the farmer if he is concerned with legal liability. Moreover, for a farmer who believes that liability concerns will likely result in him losing his farm, the ability to shift liability costs to the regulator may be the foremost benefit to him of the technical sheet. This improvement in compliance certainty may therefore improve the political acceptability of the TMDL process amongst farmers.

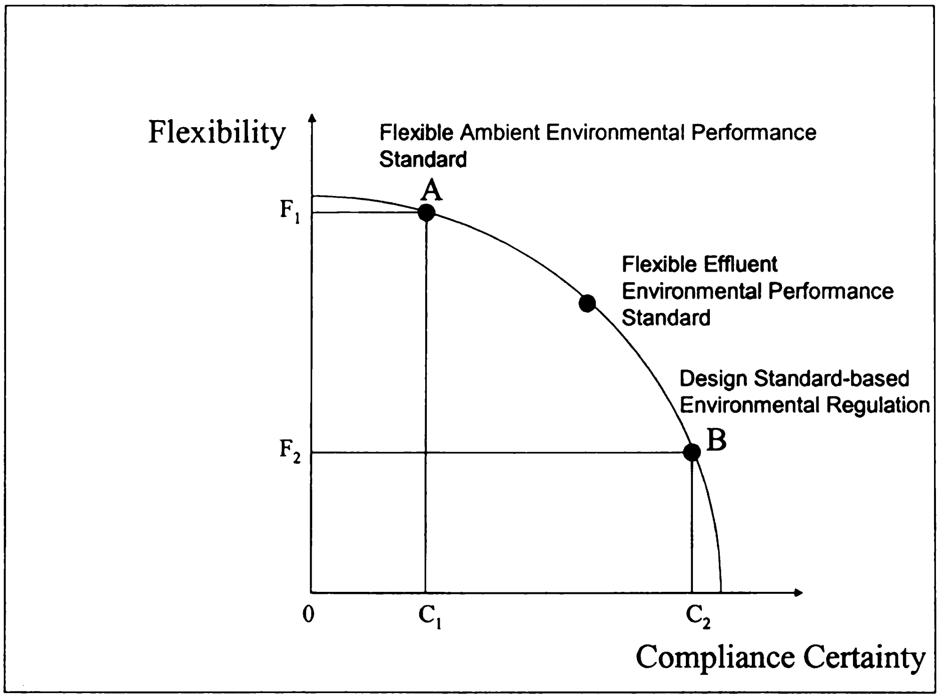
It is unknown whether innovations under flexible performance standards will shift Farmer 1's marginal cost curve in such a manner that his post-innovation cost-savings are greater than those that he enjoys under a design standard. Consequently, nothing can be said as to whether Farmer 1's expected total costs under a design standard will be less than his costs after an innovation with a flexible ambient or effluent performance standard. Nevertheless, it is clear that with the flexible performance standards, the incentives to innovate are greater than with this design standard. In fact, with this design standard, there is no room for innovation. Although Farmer 1 may discover a more cost-effective method to meet the standard or shift down or rotate his marginal penalty curve, he would have to get the innovation approved and placed on the technical list, and this requirement would take time, as is the current situation with NRCS-approved technologies.

If the farmer is able to innovate in a way that affects his compliance uncertainty – that is, causes a downward shift to his expected marginal penalty curve – then the flexible performance standard alternative that allows for this uncertainty-reduction effect may be preferred to a design standard; Figure 9 shows that the incentives to innovate – or the cost-savings – are substantial with the uncertainty-reduction effect.

6.6 Implications for the Porter Hypothesis

What of the Porter Hypothesis? Although some flexibility is retained with a technical sheet because farmers choose those practices that are best suited for their farm situation, there is no longer room for innovation. With a design standard, the regulator and farmer move from a point like A to B in Figure 2, *Flexibility and Compliance Uncertainty Frontier* (reproduced here) removing innovation as an option; however, the loss of the opportunity to innovate may not be as important as the need to reduce compliance uncertainty. This conclusion is especially true when lawsuits are possible. This *ex ante* analysis indicates that Farmer 1 may prefer compliance certainty over the opportunity to be able to innovate with a flexible performance standard – particularly with the threat of lawsuits and high penalties for non-compliance. He may prefer a design standard over a flexible performance standard, regardless of whether it is an ambient or an effluent compliance measure. This desire to decrease compliance uncertainty renders the Porter Hypothesis immaterial, innovations are precluded, as are innovation offsets. These analytical findings are corroborated with empirical data in the next chapter, Chapter 7, *Interview Findings*.

Figure 2: Flexibility and Compliance Uncertainty Frontier



CHAPTER 7
Interview Findings

The analytical outcomes in Chapter 6 were corroborated against interviews with state regulators and focus groups with dairy farmers in Michigan. The game theoretical framework developed in Chapter 5 was the foundation for the interview questions with Michigan regulators and dairy farmer focus groups. The analysis in Chapter 6 was corroborated with the results from these interviews. Both state regulators in Michigan and dairy farmers were consulted in order to ascertain the consequences of uncertainty on compliance with a TMDL process, and the effectiveness of flexible environmental performance standards to control nonpoint source pollution. The objective of these interviews was to determine how reasonable these outcomes were when compared with the concerns and goals of "real world" economic agents.

7.1 Data Collection from Regulators and Dairy Farmers

Informed interviews with representatives from the following agencies were conducted to determine how total maximum daily loads were being implemented in Michigan: Michigan Department of Environmental Quality, the Michigan Department of Agriculture, and the Natural Resources Conservation Service. These interviews were conducted from December 1999 until Spring 2000.

Data were collected through focus groups with dairy farmers in each of the six top milk-producing counties in Michigan: Clinton, Sanilac, Huron, Allegan, Ottawa, and Ionia. The participants were identified with the assistance of Michigan State University Extension Dairy Agents. In total, 47 dairy farmers participated in these focus group discussions, which ranged in size from 5 to 12 dairy farmers. While the selection process was not random and the focus groups are not statistically representative of dairy farmers in the state, the individuals interviewed had, for the most part, consistent conclusions and therefore may represent the views of many others. The average number of milking cows owned by the participating farmers was 163; the smallest herd was 15 head and the largest was 1550. The state average herd size is approximately 81, while the greatest number of milking cows are on farms in the 100-199 herd size range. (Census of Agriculture 1997).

7.2 Results of Interviews with Regulators

A list of the issues that was discussed with regulators appears in Appendix A. The topics discussed included such matters as: how will compliance be determined, how loading reductions will be divided amongst dischargers, and how monitoring and enforcement will be carried out. Across all the agencies, the definition of compliance was highlighted as being the most problematic issue, providing some empirical evidence for compliance uncertainty for regulators.

7.2.1 Few Implementation Details

Regulators indicated that few regulatory details had been thought out, let alone reached. They had not decided how the TMDL process would be implemented, whether it would be as a flexible ambient standard, a flexible effluent standard, or a design standard. The regulatory agencies confirmed that they have little or virtually no information on what farmers were doing. Consequently, the cases in Sections 6.3 and 6.4 with compliance uncertainty are reflective of the situation in Michigan, although the lack of information on farmers' practices suggests that a flexible effluent standard is unlikely to be the compliance measure in the immediate future.

The interviewed regulators were vague and unsure regarding the definition of compliance with respect to the total maximum daily loads process, regardless of the type of compliance measure. On the one hand, they expressed significant interest in the potential flexibility embodied within the process, since it would allow them to deal with different situations and site specific factors as necessary. They recognized that "one size will not fit all" farm and environmental situations. Nevertheless, it appeared that the regulators preferred to assess the practices – or the technologies – used to determine compliance, as opposed to actually monitoring ambient water quality in degraded water bodies as a means to reduce their transaction costs. This preference indicates that it is unlikely that a flexible ambient performance standard will be implemented, instead there is a preference for a design standard.

Indeed, at least one regulator claimed that he does not want a "Cadillac Plan" to monitor and enforce environmental performance standards; rather he wanted a technical list that could be used to easily check whether a farmer is in compliance. This desire may stem from the possible but faulty assumption held by the regulator that it is known which technologies will ensure that the desired water quality outcomes are met; hence regulators do not emphasize the need to check actual water quality outcomes. These remarks suggest that interviewed regulators want to implement the total maximum daily load process as a design standard, as examined in Section 6.5. In this situation, there would be no innovation, although some compliance uncertainty transaction costs are reduced for both the regulator and the farmer.

Regulators also felt that farmers want to know clearly what compliance means, that they want a streamlined system of determination, and need technical help to achieve compliance. A straightforward technical list of approved practices would fulfill these requirements for the farmers, as it is the only compliance measure which farmers can easily determine whether they are in compliance with the TMDL process. One regulator commented that such an environmental process would be more predictable for farmers than their neighbors. The implication was that an approved technical list would allow the farmer to minimize his exposure to liability from third-party groups (such as irate neighbors), and more easily plan expected business expenses. In addition, regulators feel that by using approved practices, farmers will be able to indicate to other levels of government that they are "sanctioned" by the state and are conducting their business as they should; for instance, this "sanctioning" may help them to meet township zoning requirements. A design standard increases certainty, lowering these types of expected costs for the farmer, lending evidence that the expected marginal penalty does decrease for the farmer, as discussed in Section 6.5, reducing the farmer's effort level and his associated costs, given his marginal cost of effort.

7.2.2 Minimizing Monitoring and Enforcement Costs

Regulators indicated a desire to minimize monitoring and enforcement costs. Although the level of enforcement will be determined by the public, one regulator mentioned that they did not want to be "policemen" looking to punish farmers. Indeed, it had not been determined which agency would undertake monitoring activities and various personnel indicated that the resources had not been allocated in their budgets; one regulator stated that monitoring activities may be contracted out to private firms.

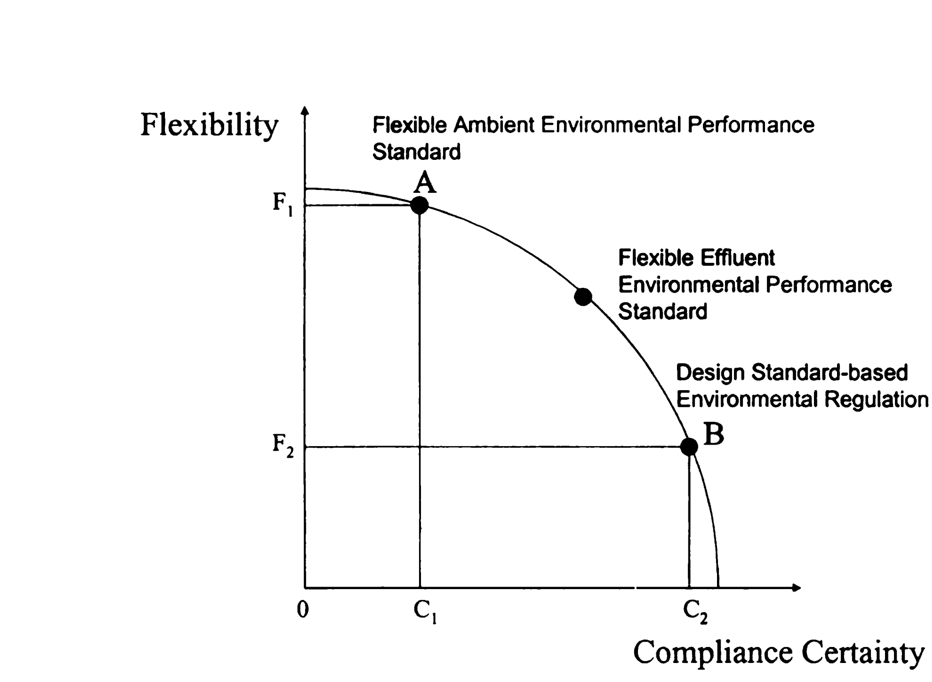
This desire to minimize monitoring and enforcement costs, coupled with virtually no information on what farmers are doing and no technical sheet, corresponds to the case of a flexible ambient standard in Section 6.3 in Chapter 6. By setting a very high marginal penalty, all the regulators must do is monitor the ambient level of phosphorus in a degraded water body to check if the imposed standard is exceeded. In order to minimize enforcement costs, the regulator can simply penalize every farmer who could potentially discharge into the water body.

But this desire to minimize *ex post* monitoring and enforcement costs suggests that regulators may prefer to use a design standard as the compliance measure, at least until they invest sufficient resources in human capital and the necessary infrastructure to implement a flexible performance standard. In order to implement a design standard, they could use the technical specifications available through the National Resource Conservation Service.

7.2.3 Move Towards a Design Standard

In terms of innovation, regulators clearly indicated that little room is envisioned for farmers to be innovative in terms of the technology that they can use to comply with the flexible environmental performance standard. Thus, these interviews suggests that Michigan regulators are interested in moving to a design standard, or implementing a TMDL process with an approved technical sheet, thereby removing a great deal of flexibility from the total maximum daily load process. Since innovation is not a priority for regulators, the loss of flexibility in the TMDL process is not a concern. Consequently, Michigan regulators seem to prefer point B in Figure 2, Chapter 3 to point A on the flexibility and compliance trade-off frontier (the figure is reproduced below). Although they want to decrease flexibility in the process, the trade-off is that they increase the degree of compliance certainty with the TMDL standard, and forgo innovation.

Figure 2: Flexibility and Compliance Uncertainty Frontier



But this desire by regulators for a design standard may only be true for the short run, when the TMDL process is first implemented. The lack of institutional surety in the compliance measure suggests that Michigan regulators are open as to how the TMDL process may be implemented, and allows for the possibility of an adaptive policy approach. The interviewed regulators felt that as they gain experience and knowledge in dealing with nonpoint sources and are able to reduce transaction costs associated with implementing the TMDL process, eventually a flexible performance standard that relates to water quality outcomes will be employed. In time, the necessary resources may be allocated to estimate runoff from farms, thereby implementing the TMDL process as a flexible effluent standard. Eventually, then, farmers may be able to benefit from induced innovation and innovation offsets.

7.3 Results of Dairy Farmer Focus Groups

Dairy farmers were also interviewed through a series of six focus groups. Each dairy focus group began with an explanation of what total maximum daily loads are, then focused on questions related to water quality issues, including third-party lawsuits. Participants were also asked to complete a short written survey, individually, after the discussion. A copy of the focus group script and the written exit survey is in Appendix B.

The farmers in the focus groups expressed numerous concerns with regard to the implementation of total maximum daily loads. These concerns ranged from how these water quality regulations will affect their farm practices and profits, to how these rules will be implemented, as well as whether these efforts will actually result in improved water quality. The details of these discussions were published in the Michigan Dairy Review.[56] Despite the wide range of concerns that were expressed across the focus group discussions, a common theme emerged relating to uncertainty.[57]

7.3.1 Desire to Reduce Uncertainty

Participating farmers wanted to know *What will compliance with total maximum daily loads mean for my farm?* As of now, the answer is not known because the TMDL process is just beginning in Michigan. The participants mentioned aspects of the regulatory process that they believe must be included to reduce uncertainty. These criteria

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[56] See http://www.aec.msu.edu/agecon/smith_endowment/documents/Dairy.PDF or http://www.msu.edu/~mdr/archives/mdrvol6no1.pdf for a copy of the article.

[57] It should be understood that a summary of the comments made is presented. Not all participants even necessarily agreed with these comments, and some disagreed.

are shown in Table 6, and include such things as clear water quality goals and the desire for guidelines as to how to comply.[58]

As predicted, the desire for certainty was also identified by the participants when asked why they would undertake abatement efforts with a TMDL process in the exit survey (Appendix B). Table 5 shows the rankings of the top three motivations. Participants indicated their desire to be responsible stakeholders as the main reason for undertaking efforts out of ten possible reasons. Nevertheless, farmers rated the need to avoid lawsuits as a close second. Avoiding government fines and penalties and the desire to reduce their subjective probability of being caught out of compliance were tied for farmers for third place. As highlighted in Chapter 6, this desire suggests that with considerable uncertainty, farmers will expend considerable effort.

Table 6: Perceived Criteria Necessary to Reduce Uncertainty

1. Regulators must clearly tell farmers what is expected of them
2. Clear guidelines should be given to farmers on what they can do to comply with the total maximum daily load process
3. These guidelines should be comprised of common sense practices, they should be affordable, they should *not* be mandatory, allowing farmers to do what they think is best for their operation
4. Farmers want to know the penalties for a violation of the TMDL process
5. Farmers want assurance that if they are in compliance with a TMDL, they will be safeguarded against future regulatory changes and local zoning requirements
6. If they have to make any necessary investments both in terms of time and money, farmers want assurance that the water quality regulations will result in improved water quality outcomes
7. Farmers must not be punished for past environmental investments that they have made in good faith
8. Ideally, the regulations would allow farmers to self-monitor their performance so that they can clearly see the results of their management practices and make any necessary changes in a timely manner

[58] The Generally Accepted Agricultural and Management Practices (GAAMPs) specified under the Michigan Right-to-Farm Act could reduce some uncertainty for farmers since they specify voluntary approved manure management practices. Yet interestingly, few participating farmers mentioned the GAAMPs as an existing set of voluntary guidelines that can help them fix any known problems, and/or reduce regulatory uncertainty by reducing the possibility of pollution runoff.

In light of the recent lawsuit notices given by the Sierra Club against five Michigan dairies – all of whom had discharges as recorded by Michigan public agencies – it is not surprising that farmers are anxious to avoid third-party lawsuits.

Table 7: Ranking of Reasons Farmers Would Comply with TMDL

Reason	Importance
I need to protect our water resources for future generations	1
I want to avoid lawsuits	2
I want to avoid penalties and fines	3
I want to reduce the chances of being caught out of compliance	3

Most interviewed farmers were more worried about lawsuits than government fines because they believed a lawsuit could drag on and potentially put them out of business, whereas government fines typically will not. Additionally, most participants felt that the state government is more willing to work with farmers, unlike third-parties such as neighbors and citizens' groups.

Farmers were asked if they would be prefer to hire consultants to assist in compliance. Feelings were mixed regarding how helpful consultants could be. The main concern was whether consultants would "stick their necks out" and assume responsibility for what they told farmers to do. Many interviewed farmers felt that whoever provides technical information, whether it be a government agency person or a private consultant, should take on some legal liability responsibility, since they have advised farmers on how to come into compliance. Understandably, farmers want to be able to shift their liability transaction costs onto others. This concern illustrates the relevance of lawsuits to farmers' preference for compliance measures, as mentioned in Chapter 6. A technical sheet increases their certainty, causing a lessening of their subjective probability of being sued, shifting their marginal penalty away from the Y-axis – corresponding to them exiting the industry due to bankruptcy – down towards the X-axis. The ability to shift liability costs to the regulator appears to be the foremost benefit to farmers of the technical sheet by reducing their abatement effort and associated costs.

Further evidence for the desire for certainty arose within focus group discussions. For instance, many participants felt that if a farm is found to be in violation of the TMDL standard, the farmer should be told what the problem is, told how he can fix it, be provided with adequate technical assistance to tailor a solution to his farm, and be given an adequate amount of time to fix the problem. Otherwise, it would be unfair to penalize the farmer. In essence, farmers again indicated a desire for a technical sheet of approved practices to be provided. This technical sheet is a proxy for compliance certainty, and was preferred to a flexible environmental performance standard.

Even farmers who simply did not trust any type of approved practice put forth by government regulators – since they felt such efforts have been ineffective and expensive in the past – did want certainty with respect to compliance. One farmer said he wished there were accurate measures of pollution runoff. Then, if there was a meter at the end of his fields that could clearly tell him whether he exceeded his phosphorus limit and how much he had to reduce his effluent, he would have no need for an approved list.

> *Well...if ...there's a meter there right next to the creek that's telling us that we got to reduce 10%, so when the meter dips 10% we know where it is. So I guess I trust my own ideas as much as I would anything the government is going to come up with...Those approved lists are going to strap you to more expense. Where if you did it on your own and the meter*

is there at the other end that [tells you that] you've dumped 10% then I'd be confident [in my own judgment].

This farmer wants a technology – a meter – that provides him with compliance certainty and the ability to limit his liability exposure, while enabling innovation. This statement suggests that this farmer wants a flexible effluent standard, provided he has timely and high quality "feedback" information regarding his effluent in relationship to his effluent standard.

7.3.2 The Paradoxical Desire for Design Standards and Flexibility

Paradoxically, the interviewed farmers expressed a strong desire for certainty, but also wanted flexibility in the regulations. On the one hand, they wanted clear guidelines for what they must do to be in compliance and be protected against lawsuits, but on the other hand, they wanted these guidelines to be flexible (Table 6, point 3). They did not recognize the trade-off between flexibility and compliance certainty illustrated in Figure 2, Chapter 3, reproduced on page 107.

This evidence from focus groups and the rankings in

Table **7** illustrate the farmers' desire for certainty and a technical list, and it lends evidence that farmers want to move from point A (i.e. a flexible ambient performance standard) to point B (i.e. a design standard-based environmental regulation) in Figure 2, reproduced on page 107. The loss in flexibility is traded-off against the ability to shift legal liability onto the regulator. The liability rules specified by the TMDL was also a concern for the focus group participants.

7.3.3 Equity Concerns

The farmers in the focus group discussions felt that the regulations, monitoring efforts by the regulators, and enforcement of the water quality rules should not be arbitrary. As one farmer noted:

"You want to see [the rules] be fair to everybody"

For example, participants stressed that monitoring of lakes and streams by state regulators should be fair and should reflect reality. It was suggested that water samples should not be taken during extreme storm events, and samples of every lake or stream should be taken at several places, and at different times of the year. By using this method, it is less likely that a farmer using effective manure management practices will be wrongly accused of discharging. This finding provides evidence that farmers do not want a flexible ambient standard, where all farmers are penalized if the specified ambient standard is exceeded, since it contradicts their sense of fairness. The participants felt that those who undertake efforts to reduce effluent from their farm should be given credit, and those who do not should be penalized.

From the focus groups, it appears that farmers want the TMDL process to be implemented with a negligence rule. With a negligence rule, the farmer is penalized only if he fails to comply with the "due standard care." Thus, a farmer who complies with the TMDL process in good faith will not be fined. In addition, these farmers' desire for a negligence rule and sense of fairness implies that they want regulators to measure the effluent from each farm. State regulators need to collect information from farmers about their management practices in order to ensure that only farmers who do not undertake sufficient abatement efforts – as specified by the compliance measure – are penalized. In essence, these farmers would like to see the TMDL process implemented as an effluent standard. But this is contrary to the current state of affairs in Michigan, where regulators are not actively gathering information regarding farmers' practices.[59]

Farmers felt that they should not have to bear any penalties in addition to their own compliance costs. Their cost concerns and level of abatement effort are illustrated in Table 8. In the exit survey, farmers were asked to rate reasons why they would *not* comply with a total maximum daily load process. Cost considerations ranked amongst the top three in terms of importance. If costs and fairness are important issues that affect whether farmers will follow water quality regulations, then these discussions with farmers imply that with high compliance uncertainty, some farmers may free ride rather than expend a lot of effort in complying, especially if they feel that the regulator is not really going to be monitoring and enforcing the TMDL standard. Thus, a corner solution as discussed in Section 6.6 may be a real possibility.

Table 8: Weighted Ranking of Reasons Farmers Would not Comply with TMDL

Reason	Weighted Ranking Value
1. I have to carefully consider the costs of suitable water protecting practices	75
2. Current milk prices affect the water-quality related practices that I can undertake	72
3. I have to consider the costs of a consultant because of financial constraints	57

[59] Regulators do visit farms if a nuisance complaint is filed, but this data is gathered in response to a complaint. Regulators do not otherwise know what choices farmers are making with respect to pollution abatement.

CHAPTER 8

Summary and Conclusion

This analysis indicates that flexible environmental performance standards may not be cost-effective when applied to nonpoint sources of pollution when compliance uncertainty results in significant transaction costs, thereby contributing an improved understanding in the economic literature of the limitations of flexible environmental performance standards. This chapter summarizes the contribution of this research to the literature while answering the two research questions, outlines the policy implications, discusses the caveats of this research, and suggests areas for future research.

8.1 Contribution to the Literature

The environmental economic literature has contended that flexible performance standards are potentially more cost-effective than design standards and thus are preferred by economists. They have the potential to be more cost effective because, as noted by the Porter Hypothesis, the flexibility makes induced innovation and innovation offsets possible. Innovation offsets may reduce compliance costs for regulated firms, and they potentially reduce search and informational costs for the regulator since it no longer has to determine and specify a design standard for regulated firms.

Yet, the economic literature that promotes flexible performance standards does not sufficiently account for the effect of compliance uncertainty and its resulting transaction costs in assessing the cost-effectiveness of flexible environmental performance standards in controlling nonpoint sources of pollution. Compliance uncertainty, due to imperfect information and the stochastic nature of nonpoint source pollution, results in transaction costs that can overcome the benefits of flexible environmental performance standards when they are applied to nonpoint sources of pollution.

Regulators suffer from compliance uncertainty due to unobservable effluent, incomplete knowledge on their behalf with respect to understanding the fate and transport of effluent from nonpoint sources and its stochastic characteristics, and because farmers can behave opportunistically due to asymmetric information between many actors and the regulator, resulting in moral hazard. Farmers themselves suffer from uncertainty with respect to whether their actions or effort will be deemed sufficient for compliance, and they are also uncertain as what other farmers are doing.

For an ambient compliance measure, the actions of other farmers may also affect whether the farm is deemed compliant. These transaction costs resulting from compliance uncertainty affect the benefits that farmers receive through induced innovation, and thus affect the likelihood that an innovation will occur. As highlighted in Chapter 6, in their desire to minimize costs, both the regulator and farmer will prefer to reduce their total expected costs resulting from compliance uncertainty.

This study examined the effect of uncertainty and its resulting transaction costs on the cost-effectiveness of flexible environmental performance standards to curb nonpoint source pollution. This examination was guided by an *ex ante* analysis of the implementation of total maximum daily loads by Michigan regulators to control phosphorus and the compliance response by dairy farmers. The following two key research questions were examined to give insight into the differential incidence of farmer's costs under different compliance measures:

1. ***How might compliance uncertainty affect the effort level of Michigan livestock farmers, their costs, and their benefits from induced innovation?***

2. ***Can flexible environmental performance standards ensure induced innovation in the context of compliance uncertainty, and what are the implications for the Porter Hypothesis?***

The graphical models used in this paper show that differing levels of cost-savings due to innovation result from various levels of compliance uncertainty with a flexible performance standard. In the model, the TMDL process is implemented alternatively as an ambient standard, an effluent standard, and a design standard to investigate the abatement efforts and costs under each approach. The regulator ensures compliance through monitoring and enforcement efforts and levying a penalty on those who do not comply. As predicted, this analysis of the total maximum daily load process reveals that transaction costs due to compliance uncertainty affect the effort level of farmers, their costs, and their benefits from induced innovation. Essentially, the greater the compliance uncertainty with higher resulting transaction costs, coupled with a high expected marginal penalty, the greater is the control effort by the farmer, and the greater are his costs to comply with the TMDL process.

The analysis reveals three main lessons: 1) compliance uncertainty coupled with high penalties provides farmers important additional incentives to innovate by allowing them to adjust their level of effort, thereby reducing their expected penalty costs, 2) both the regulator and farmer prefer the flexible effluent performance standard to the flexible ambient performance standard because compliance uncertainty is reduced[60] – the regulator has more information about farmers' actions with flexible effluent standards, reducing moral hazard – resulting in a lower expected marginal penalty, and lower total expected costs for the regulated farmer, and 3) the uncertainty-reduction effect from an innovation that decreases compliance uncertainty – shifting down or rotating the farmer's expected marginal penalty curve – results in lower effort and lower total expected costs for the farmer, so farmers will choose those alternatives that will affect compliance uncertainty since their costs are lower.

What are the implications for the Porter Hypothesis which predicts that flexible environmental performance standards will provide incentives to regulated firms to innovate thereby reducing their compliance costs? In the case of farms, characterized as nonpoint sources of pollution, compliance uncertainty can exacerbate the possibility of lawsuits. That is, in such a situation, farmers may face liability issues that are not due to their own management efforts. The focus groups showed that farmers want to avoid lawsuits since they expose personal assets to loss. Consequently, farmers may prefer to not invest in research and development efforts to reduce their compliance costs – that is, they may not innovate – but would prefer to shift liability costs to the regulator by demanding that the regulator implement design standards. If this were the case, then the Porter Hypothesis would not hold since innovation is precluded when farmers follow a design standards as discussed in 6.5.

[60] Additionally, the flexible effluent performance standard may be perceived as being more fair and equitable, and therefore more acceptable.

8.2 Policy implications

The total maximum daily load process poses a challenge to both regulators and farmers because they have not been implemented before. Regulators in Michigan – and throughout the country – have little experience in terms of technical expertise, model building, data gathering, and monitoring and enforcement. Farmers too have faced few environmental regulations historically, while smaller farms, which were the subject of this study, have by and large never been subjected to consistent water quality regulations. As such, they do not have a great degree of technical skills to deal with any agro-environmental policy, let alone a TMDL process.

If regulators implement a TMDL process in the short-run with a technical sheet, they will reduce their institutional demands; in fact, by examining practices as opposed to examining actual environmental outcomes, little institutional change will be necessary. The Michigan Department of Environmental Quality (MDEQ) has essentially been conducting design-inspections for the past 30 years in its efforts to monitor point sources that have National Pollutant Discharge Elimination System permits. Thus, an approved list of practices requires few institutional changes by the MDEQ. Moreover, although state regulators have limited budgets for developing a list of approved technical practices, Michigan's Generally Accepted Agricultural Management Practices (GAAMPs) can be adapted as required, thereby reducing regulators' program development costs.

The use of this list, however, precludes any induced innovation from occurring. Nevertheless, the technical sheet can allow some degree of innovation if updates with farmers' and researchers practices are allowed, after these practices have been validated.

Regulators will have to continue working with researchers to better understand the link between management practices and environmental outcomes.

Regulators can encourage dynamism – by incorporating flexibility within a TMDL process – through an adaptive approach. This approach is consistent with NRC's recommendation that TMDL plans be employed in an adaptive manner (NRC 2001). Regulators may begin implementing the total maximum daily load process in the short run by providing a technical sheet to farmers. But as they develop expertise in implementing TMDL standards, regulators should work towards a flexible standard to allow for induced innovations and possible innovation offsets. The high degree of compliance uncertainty and resulting transaction costs coupled with farmers' equity concerns make a flexible ambient standard unattractive, leaving flexible effluent standards as the remaining option.

The regulator will have to invest in reliable modeling, data gathering from farm sites, and monitoring efforts to implement a flexible effluent standard. The regulator must invest in research and extension activities to assist farmers in better understanding the link between their practices and environmental outcomes. The trade-off is that the greater flexibility exposes farmers to lawsuits, where their personal assets are exposed to potential loss. Understandably, this situation ensures farmers' personal attention. But if the regulator invests in modeling efforts and gathers high quality data from farm sites, then this possibility can be reduced. With flexibility and assistance, the regulator can provide farmers with the incentive to undertake efforts that result in induced innovation and, perhaps, in innovation offsets. Consequently, over time, with the right regulatory measures, the Porter Hypothesis may hold in nonpoint source pollution control.

Essentially, farmers will choose those incentives that will allow them to reduce their expected marginal penalty. With a flexible standard, if farmers believe that their innovation will reduce the probability of them being penalized, say by having a significant positive effect on the quality the impaired body of water, or if the regulator responds to induced innovations by reducing the penalty, then they will prefer flexible performance standards, and will innovate, possibly resulting in innovation offsets. This preference, however, depends upon the degree to which they believe the marginal penalty will shift. For example, if the regulator invests resources in actively monitoring the effluent and responds to innovations by reducing penalties and informs the farmer of this reduction, then this incentive will increase the probability of induced innovations and innovation offsets, improving the relevance of the Porter Hypothesis.

Regulatory actions like enforcement depend upon political leadership, and this changes over time. If state regulators do not provide the correct incentives to farmers, then resources will not be allocated cost-effectively, neither by the regulator nor the farmer. In fact, this model shows that with a high degree of uncertainty coupled with a high marginal penalty, farmers over-invest relative to the case of perfect informaiton, and may do so just to avoid lawsuits. Without consistent regulatory action, such as monitoring and enforcing the total maximum daily load process, third-party citizen groups will continue to be the *de facto* enforcer of the federal Clean Water Act, forcing farmers to remain focused on efforts to improve water quality, but at a cost that is greater than necessary.

8.3 Caveat for research

There are two main caveats to this research. The first caveat is that this analysis is an *ex ante* analysis. It does not analyze actual compliance measures that have been implemented by Michigan nor responses by farmers. Nevertheless, it does provide some information to both regulators and farmers as to what considerations are pertinent in their decision-making process. At the time that this study was undertaken, there was little information exchange between the state regulator and the farming community.

A second caveat is the data from the focus groups. These data were not statistically representative of all dairy farmers in the state, so only qualitative results could be presented. Yet, these results can provide a guide to a more quantitative analysis once total maximum daily load process has been in effect in the state and data can be collected from farmers.

8.4 Future research

The findings from this research suggest a number of areas for future research, such as the role of liability, the need for a dynamic analysis, and *ex post* studies. The overwhelming concern with respect to legal liability is an area to be explored both as a motivator – indeed as a substitute for regulatory actions – and as a risk to be minimized. With little real information, even from extension agents, regarding the requirements needed to avoid lawsuits for violations of the Clean Water Act, farmers fear being put out of business by lawsuits. The model in this paper finds that high penalties and their concern of being put out of business by lawsuits may cause farmers to over-invest in abatement efforts.

The economic literature needs to be more aware of the role played by imperfect information that leads to compliance uncertainty when advocating flexible ambient performance standards. Flexible performance standards may be more appropriate for some point sources of pollution, where the pollutant level is observable and easily quantified. This ease of measurement eliminates most uncertainty as to whether point sources are in compliance with the environmental regulation. But with nonpoint sources of pollution, compliance uncertainty and its resulting transaction costs indicate a need for additional economic research into uncertainty relating to the implementation of flexible environmental performance standards to control nonpoint sources.

Clearly if the total maximum daily load process is to achieve its objective, considerable research needs to be undertaken to investigate ways in which the transaction costs resulting from compliance uncertainty can be reduced, for both the regulator and farmers in Michigan. For instance, regulators and dairy farmers need to be able to link practices with resultant water quality outcomes in a cost-effective and equitable manner. Currently there is insufficient information and knowledge to target enforcement on the major sources of pollution, including farms, and to tailor solutions to their needs. Monitoring of water bodies and enforcement by regulators must be undertaken; research may help to reduce these *ex post* transaction costs for regulators. Additionally, research to improve fate and transport models of nonpoint source is needed by both regulators and farmers. Research efforts can help fill these knowledge gaps to ensure that the benefits of flexible environmental performance standards, such as total maximum daily loads, are realized, thereby ensuring continual water quality improvements in Michigan.

Data from these research efforts can lead to a richer analysis that incorporates the strategic actions of regulators and regulated firms when information is imperfect due to asymmetries and poor scientific, technical knowledge, and imperfect monitoring and enforcement. A dynamic model that accounts for all these characteristics may be able to more fully answer the question: Can flexible environmental performance standards improve environmental outcomes?

APPENDIX A

Survey with Regulators

Issues for Regulators

1) Implementation of TMDL

   a) When will they be implemented here in MI?
   b) How is the threshold being specified?
   c) What will compliance mean?
   d) How will compliance be determined?
      - E.g. +/- 10% 80% of the time?
      - How flexible will they be?
      - How will they know who is in compliance?
      - How will they be able to detect if the threshold is not being met?
      - How will monitoring be carried out? Agency personnel, or say if there is a complaint?
      - Will farmers be given a suite of technologies, and what practices/behavior is considered to be "in compliance"
      - Will discharges be measured from fields?
      - Will farmers be given permits?
   e) How strong will enforcement be?
      - What's the probability of being caught? Of being penalized?
   f) If the TMDL is not being met, what is the consequence?
      - Mandated technologies? If so what?
      - Do they know what the costs will be?
      - How do they follow-up? Monitor?
   g) What are EPA requirements?
   h) Does everyone have to be in compliance?
      - Dividing TMDL evenly by all the people? or?
   i) Are they following a model from elsewhere (e.g. Oregon?)
   j) Do they have an idea of how farmers will respond?
   k) What do farmers think of TMDLs?
      - Have any been involved in the public comment phase?
   l) What incentives are they providing to farmers to meet the TMDL?
   m) Cost-sharing for adoption of abatement technologies to meet TMDL?

2) Third Generation BMPs

   a) What are they? Where will they come from?
   b) What are the costs of implementing these BMPs?
   c) How much P does each BMP reduce? %, quantity ?

3) Legal issues

   d) Who can sue whom?
   e) What is the connection between CWA and Michigan Right to Farm Guidelines?
   f) Does liability insurance exist? Are farmers using it?

APPENDIX B

Materials for Farmer Focus Groups

Environmental Performance Standard Script

Presented by Lorie Srivastava
Graduate Student, Dept. of Agricultural Economics

Introduction

Welcome. I would like to thank all of you for participating today. I know this is an extremely busy time of the year, so I really do appreciate you taking the time to come. Let me first introduce myself and explain the purpose of this discussion. My name is Lorie Srivastava, and I will serve as the facilitator for this meeting. I am a Ph.D. student in the Department of Agricultural Economics at Michigan State University. I would also like to introduce Corey Risch. Corey is a Masters student in the Dept. of Agricultural Economics. She is from a dairy farm in Ingham county. They milk 175 cows. Corey will be making notes of what is said during this meeting, so that we can see keep track of our discussion. In a moment I will describe my role in more detail, but first I would just like to say a few words about why we invited you here.

Purpose

Today's meeting is part of my Ph.D. research. As part of my research, I am looking at how Michigan dairy farmers might be affected by federal water quality regulations that are being implemented in Michigan under the Clean Water Act, and how important issues like third-party lawsuits, and pollution insurance affect farmers. I will be holding 6 discussions like this in the 6 largest milk producing counties in Michigan to gather the concerns and opinions of dairy farmers. I will be speaking with farmers from a variety of farm sizes – small, medium, and large, people who intend to stay in dairy for the next 15-20 years, and people who will be retiring soon. I want to talk to a variety of dairy producers because the industry is made up of different kinds of operators, who are making different kinds of decisions.

The intent of today's roundtable discussion is to ensure that **your** knowledge and concerns are incorporated into my research. Does this mean that what is said here will be written up and forgotten in the library at MSU? No! After all the roundtable discussions are held, I will summarize what you tell me and disseminate the information to various policy makers so that they can be informed of dairy farmers' perspectives when they implement water quality regulations in Michigan.

I should mention that I do **not** work for MDA, DEQ or the EPA, and have no plans to do so. As I said before, this work is for my Ph.D. research. I want to admit right up front that I am not an expert in dairy, which is why I am asking you for your help with my research. My research is funded by the Great Lakes Protection Fund, which provides funds for a variety of research issues pertaining to the Great Lakes. I would also like to mention that this has nothing to do with the Michigan Agricultural Environmental Assurance Program (or MAEAP), in case any of you were involved in those focus groups.

Lorie: keep in mind the policy makers are MDA, DEQ – and they can in turn inform EPA

I want let you know that I am not doing this research because I think water regulations for agriculture are a good or a bad thing, or that mandatory water quality regulations are needed for agriculture. Rather, I believe that there has been a lot of research on voluntary environmental programs, but less on potentially mandatory environmental programs like those that we will discuss today. And, as far as I know, there has been almost no research done that directly asks dairy farmers what **they** think about possible mandatory water quality programs, what **they** think the costs will be, how **they** think their operation will be affected, how **their** production decisions might change, and what **they** think the benefits are. The water quality regulations that are discussed in the LSJ article have not been implemented in Michigan yet because it is still being designed and debated, so this is an opportunity for farmers to let their concerns be known, which I think is important.

I am here to facilitate this discussion and to listen to you – I am not here to judge you in any way. I just want to hear directly from **you** what concerns you about upcoming water quality legislation, lawsuits, and how you believe these will affect you. Let me give you some background.

Background

It looks like farmers – particularly livestock farmers – are faced with increasing regulatory pressures because of agricultural contributions to water pollution, and that such pressures will become stronger with time. The regulatory pressure is in response to the declining acceptance by the general public of many current farming practices because of perceived water pollution from agriculture. The cover story in the Aug. 20th issue of the Lansing State Journal talks about agriculture's contribution to water pollution, and how new legislation will change it. The implication is that runoff from agriculture **has** to stop because runoff, along with other sources, is causing Michigan waters to be unsafe.

Lorie: hold up newspaper

An example of this public concern recently happened here in Michigan. As you may know, on July 25th of this year, the Sierra Club gave notice that it is suing four

Michigan dairies under the Clean Water Act.[61] The Sierra Club contends that these dairies have repeatedly discharged manure into Michigan's waterways, which is a violation of the federal Clean Water Act[62].

In Michigan, it is commonly thought that using the Generally Accepted Agricultural Management Practices (GAAMPs) specified under the Right to Farm Act (RTFA) protects farmers from environmental complaints and from too many inspections from state regulators. It is, however, possible that a farmer using GAAMPs could have a discharge of wastes into surface waters, and if so, they could be penalized. So, RTFA does not actually protect farmers from violations of the Clean Water Act.

So where does that leave us? What will future water quality regulation for agriculture look like? This is a big unknown right now. It is likely that in the future, at least those farmers with significant potential for pollution discharges will increasingly be asked to change management practices so as to further protect water quality for drinking water, fish habitat, and to reduce sediment runoff. Water quality regulations may continue as in the past with voluntary programs with incentives to get farmers to participate, or instead it might be composed of mandatory requirements with required management practices. A third possibility is that agriculture may be governed by what policy makers call ***environmental performance standards***.

Lorie: hold up visual – a flow diagram

So, what are environmental performance standards? It is a standard that sets a limit on how much of a certain pollutant can enter a surface body of water, by surface

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[61] In case it is asked, the 4 dairies are: are Bruinsma Farms, River Ridge Farms, Walnutdale Farms, and Bradford Dairy Farms – Kent county, Ottawa County, others??

[62] Lorie: Sierra Club is just making the point to explain the need for federal enforcement

body I mean a lake, or a stream, or creek, something on the surface, as opposed to groundwater. Let me illustrate with a hypothetical case of phosphorus in a lake. An environmental performance standard would set a pre-determined amount of phosphorus that can legally exist in the lake. If a state regulator (such as MDA/DEQ) were to check the phosphorus level, and they found that the amount of phosphorus in the lake was ***below*** the allowed standard, then no further action is taken. If, however, the regulator tests the water and finds that there is ***more*** than the allowed level, then there would have to be a cutback in the amount of phosphorus entering the lake. I am using phosphorus as an example because it promotes rapid algae growth, and when the algae dies and decays, the oxygen in the water is used up, causing fish kills and other creatures to die. It is the main concern from agricultural runoff, along with sediments. Any questions?

One type of environmental performance standard is a total maximum daily load process, or so called TMDLs (some people pronounce it *timdls*, others TMDLs, I will say TMDLs). How many of you have heard of total maximum daily loads, or TMDLs?

In order to direct the discussion, I would like to focus on total maximum daily loads since it is the only example of an environmental performance standard in agriculture. Also rules are being developed for it, so I am interested in how farmers may react to it, if it is implemented. First, let me explain a total maximum daily load. A total maximum daily load is a process that is specified under the federal Clean Water Act. The current total maximum daily load process calls for each state to set an environmental performance standard for every surface water body within its jurisdiction (this has already been completed in Michigan). Different water quality standards are set for waters that are used for different purposes, such as drinking water source, recreation, fishery, etc. The EPA is letting states decide whether to use mandatory or voluntary approaches to implement any clean up plan. They have 10 years to do so. I should add that government authorities expect all sectors of the economy to be regulated with TMDLs, not just agriculture.

Lorie: Go through the visual

The total maximum daily load process calls for the state to regularly check each water body and see if it meets its environmental performance standard. As an example, can you look at the handout of the lake that I have passed around? There are two lakes, which are surrounded only by farms – no waste water facilities, or urban golf courses, nor anything else, are near the lakes. The smaller lake meets its designated water quality standard, and so does not exceed its allowable level of phosphorus. Hence Farm E does not have to change any management practices. The larger lake, however, does **not** meet its water quality standard. There is too much phosphorus in this lake – so as you can see in this example, Farm A has to cut back its phosphorus by 15%, farm B and C by 40%, and Farm D does not have to change any practices. These amounts would be determined by a regulator, along with a timeline for when the changes must be completed. Questions?

Since total maximum daily loads have not been implemented in Michigan yet, how it will be specified is not known. There are a few options: 1) they may be implemented so that only major polluters have to reduce their pollution, not everyone. In this case, only those farms that are a major source of water pollution will have to reduce their runoff, not all farms; 2) farmers may be given a lot of flexibility to meet a needed reduction. So it may be up to the farmer to find a cost-effective way to bring the farm into compliance – for example, the farmer can change hauling practices, build additional storage, etc. 3) **Or** total maximum daily loads can be implemented so that farmers have to follow specified practices – they can not choose their practices.

In July of this year, the EPA issued a final rule on how to implement the TMDL process. Since August 1999, the EPA has considered over 34,000 comments on changes that it proposed to the TMDL process. Here in Michigan, the DEQ and the EPA are going back and forth on how TMDLs will be implemented, with no resolution. A major bone of contention is the issue of discharge permits. The EPA is pushing DEQ to issue discharge permits to agricultural operations, as called for in the Clean Water Act[63]. But the DEQ does not grant discharge permits to agriculture, since technically agricultural enterprises are not allowed to discharge into Michigan waterways at all. So the DEQ is arguing with the EPA about discharge permits.

What do TMDLs have to do with lawsuits like the ones being filed by the Sierra Club? Third-party lawsuits against firms (such as farms and processors) are used to put pressure on regulating agencies like the EPA and DEQ to implement sections of the Clean Water Act that have been ignored until now, like total maximum daily loads.

I would like to now begin the questions, but want to point out that there are no right or wrong answers to the questions that we will be discussing today. I just want to know what you believe are the important issues for your farm with regard to water pollution.

If you are wondering why you are here – you have been selected from a nomination list submitted by extension dairy agents. I'm not trying to pick on you or

[63] this is for confined operations of over 700 mature dairy cows

anything! Finally, I know I can not fully compensate you for your time, I do want to recognize your contribution, so you will be paid $100 for your time today.

Procedure

Before we begin our discussion, I would like to explain a few things.

There are several things that I need you to do to help improve my research:

1. I would like to hear from everyone, since I expect that there are a variety of opinions in this room, some in disagreement, some in agreement. All your opinions are valid –they're just based on different experiences – so I am genuinely interested in hearing what all of you have to say. Please don't worry about offending me. You won't! Although a roundtable discussion format allows us to have an open discussion, and a chance to bounce ideas off each other, we have a limited amount of time to get through a full list of questions. So there may be times when I ask you to summarize or shorten your remarks to make sure that everyone has a chance to give their input. If I change the subject, it's not because I'm not interested in what you have to say. It just means that we have to move forward in order to be done by noon.

2. I hope that you will feel comfortable enough to share your honest opinions. Your identities will remain confidential, through the following 3 means:

    - no names will be used in the analysis
    - though I will be taping our conversation so that I can have an accurate record of what is expressed, I will remove all references to peoples' names and replace them with number codes when I transcribe the tape
    - I am asking that you treat comments made today by other participants as confidential as well

- I would ask that you be honest in your answers. I will take every precaution to ensure the confidentiality of what is said here today. No one will be able to trace back any comments that you make to you. I will not be recording your names in my dissertation. I only need your names so that the accounting folks at MSU can issue you a check.

3. I hope that you will feel comfortable enough to share your honest opinions. Your identities will remain confidential, through the following 3 means:
4. I would ask that everyone try to speak up and speak clearly so that the tape can pick up your comments.
5. At the end of our discussion, I would ask that you complete and leave a short questionnaire that should only take about 10 minutes.
6. Does anyone have any questions before we begin?

Focus Group Questions[64]

Attitudes towards water quality issues

1. What kinds of production decisions are influenced by water quality considerations, e.g. day to day decisions, planning for the season, or when planning an expansion?

    a) **Probe** one individual or groups of individuals: If so, in what way?

    b) **Probe** one individual or groups of individuals if none: If not, why not? What comes to mind first?

2. In a good financial year, how high a priority would improving your manure handling system be? Top 3, top 5?

    a) What affects how high a priority it is for you?

3. In general, do you feel that serious water quality problems stem from dairy farms in Michigan? Why or why not?

Concerns about water quality regulations

Lorie: Hold up TMDL visual

4. Thinking of your farm, if you were to make an investment that reduced runoff (such as equipment/facilities and additional training for you and your employees), would there be any advantages for making these investments and being in complete "compliance" or even "over-compliance" with a TMDL? If so, what would be the main advantage?

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[64] Due to time constraints, not every focus group answered every question.

5. Now I am going to present you with a hypothetical scenario. Suppose that a state regulator determines that a water body in your watershed is being polluted above an acceptable standard that is set by the state. Suppose there is evidence that there is animal manure and other dairy farm wastes runoff entering this water body. Assume your farm is contributing to this pollution, like farm A. Would you be more worried about being sued by a third party (like a neighbor or an citizen group), or being fined by the government, or would neither be a concern?
    a) If so, which is the bigger concern? Why?
6. Actually, before we move on, have any of you heard of fines by DEQ and/or the EPA being assessed against dairy operations here in Michigan? Were they large fines? I know I can look it up, but does anyone know?

Lorie: hold up TMDL visual again

7. What do you think of TMDLs?
    a) What is your biggest concern regarding a water quality performance standard for agriculture, such as a TMDL process?
    b) Do you think TMDLs are appropriate for reducing runoff?

Lorie: Show TMDL 2 visual:

    c) If there is a TMDL process, should an agency assign responsibility to exceeding a water body's TMDL limit to an individual farm?

8. A discharge permit specifies the steps that farms have to take to minimize water pollution. As long as you follow the permit requirements, you are protected to some extent against law suits. Do you think it is appropriate for the state of

Michigan to issue discharge permits to dairy operations. If so, which farms and why?

9. If the TMDL process is implemented next month, and you are told by the state regulating agency that you have to reduce phosphorus loadings by 10%. Say you decide to follow the TMDL process as closely as possible, which of the following would you do?

    a) Would you evaluate your operation and devise new practices on your own to comply with the TMDL and cutback phosphorus by 10%?

    b) Say DEQ/MDA/NRCS develops a list of approved practices where you could use those that are best suited for your farm and cutback phosphorus by 10%. If you use the practices on this list, you would be protected from lawsuits to some degree. Would you like to be given this list of approved practices and apply those that are suitable to your farm?

    c) Now suppose, that you come up with a way that can significantly reduce the runoff from your farm, so that you meet the allowed phosphorus limit in a TMDL, but MDA and NRCS are unfamiliar with it, and it is not on their list of approved practices. And let's say that your practice is cheaper to use than those on the approved list – would you use yours or the more expensive approved practices? Why?

Pat said that I may need to clarify that a performance standard specifies an outcome (i.e. control of P), and not which practices are used – since farmers are used to NRCS and FSA checking practices

d) Would you rather hire a consultant? Why?

e) **Probe**: If you would hire a consultant, how much would you pay to ensure that you are in compliance with the law?

10. I explained earlier that things are in flux with regard to water quality laws both federally and here in Michigan at the state level. Laws change, different people are elected into office, who knows where exactly it will all end up. Imagine you are Farm A, do you think you would: 1) do something immediately, 2) wait for things to settle down to do something, or 3) ignore it.

    a) **Probe** those who say will wait: What are you waiting for and why?

How will regulations affect your farm

11. Now let's assume that an environmental performance standard such as a TMDL process which I talked about earlier were implemented next month, and assume your farm is assigned the responsibility of reducing, say phosphorus, any way you can.

12. If the TMDL process is implemented next month, and you are told by the state regulating agency that you have to reduce phosphorus loadings by 10%.

    a) What would you do to comply with the TMDL process? In terms of: management changes, new investments, seek out information?

    b) Where would you seek assistance?

    c) Would your efforts to comply with the TMDL process be different if it is enforced by an honor system like now where you are not checked unless there is a complaint, where there would be little monitoring by state regulators, vs. a system that is enforced with periodic inspections? Which do you prefer?

d) Would it matter who did the enforcing, DEQ or MDA? Why and who do you prefer?

Concerns about lawsuit uncertainty

13. Let's return to the situation of the Sierra Club giving notice to sue those four farms in Michigan. Do you worry about such lawsuits being filed against you? Why or Why not?

    a) If so, what actions, if any, have you, or might you undertake to reduce the likelihood of a lawsuit against you?

14. Do you think regulations like total maximum daily loads will have any effect on lawsuits being filed? How?

15. Do you think there will be more lawsuits like this one in the future – do you see this as a trend?

    a) **Probe** those who say yes: If you think there is a trend towards more lawsuits, do you think you will change how you farm? How?

16. How many of you have special provisions in your insurance against a pollution event such as a lagoon breaking that leads to a fish kill?

    a) Why did you get it?

    b) Do you think it is adequate for environmental pollution events?

c) Do you believe your special insurance will provide you with some financial protection against environmental lawsuits?

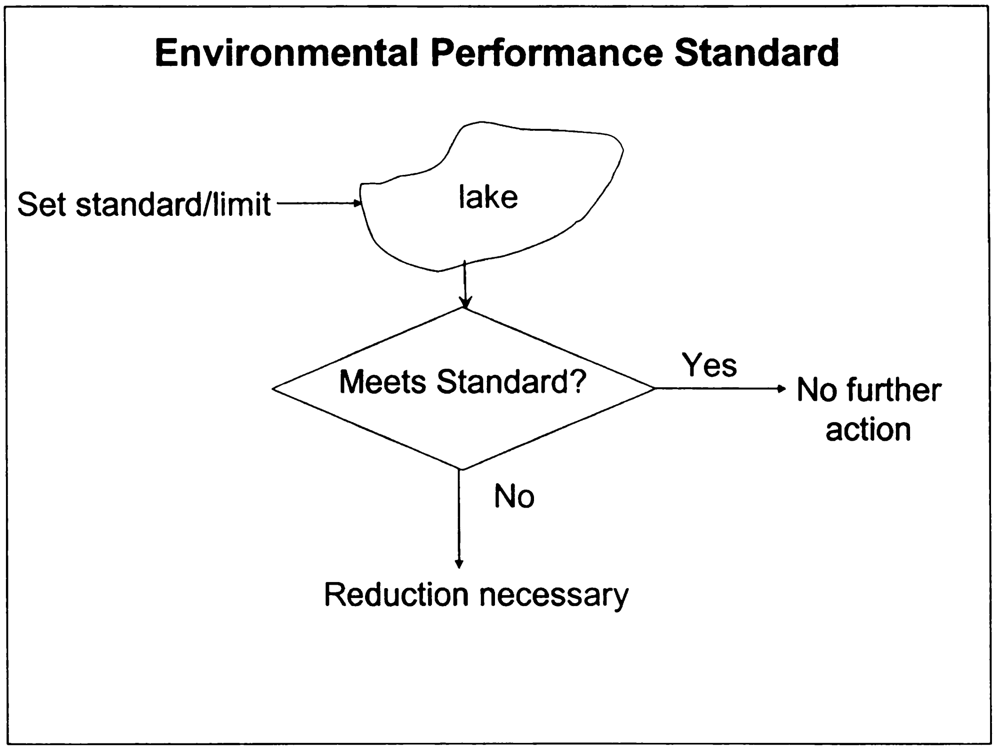
17. Do you have any further thoughts on the Sierra Club lawsuit that are relevant to today's discussion?

18. Finally, is there anything else you would like to tell me today?

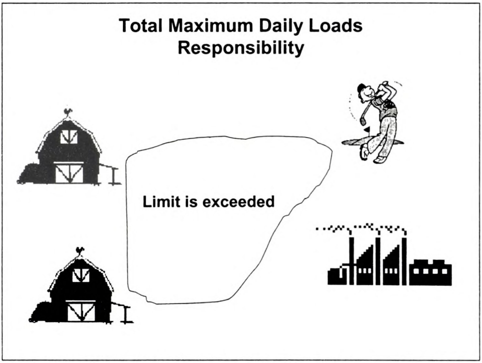
Wrap-up

This completes our discussion today. Thank you very much for participating. Before you leave, there is a brief questionnaire that I need you to complete. PLEASE DO NOT PUT YOUR NAMES on it. We want your answers – like your comments here today – to remain anonymous. I would like to thank you all for sharing your thoughts on these questions.

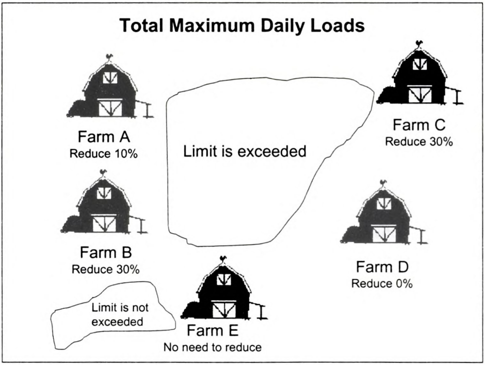
Visual 1: What is an Environmental Performance Standard?



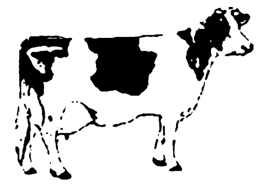
Visual 2: Who is Responsible?



Visual 3: Allocating TMDL Amongst Farms



Water Quality
Producer Opinion
Exit Survey



Your concerns

1. How serious do you believe surface water (e.g. lake, river, creek) quality problems are:

	not at all serious	somewhat serious	serious	very serious
in the nation as a whole	1	2	3	4
in Michigan	1	2	3	4
in your county	1	2	3	4
from your farm	1	2	3	4

2. In your opinion, which of the following entities are the top three (3) contributors to surface water quality problems in **your county**? Please choose and rank the top three (3) only, with number 1 being the most responsible.

Responsible Entity	Rank
Urban residents (e.g. lawn maintenance, golf courses)	______
Sewer overflow (from urban areas, into rivers during storms)	______
State of Michigan (e.g. highway maintenance)	______
Waste water treatment facilities	______
Industry/manufacturing facilities	______
Row crop farmers	______
Swine farmers	______
Poultry farmers	______
Small dairy farmers (100 milking cows or less)	______
Medium dairy farmers (101-300 milking cows or less)	______
Large dairy farmers (301 milking cows or more)	______
Beef cattle farmers	______
Other livestock enterprises (e.g. sheep, horses)	______
Other: ______	______

3. How concerned are you about the following issues on **your dairy farm**?

Issue	not at all concerned	somewhat concerned	concerned	very concerned
Creating/maintaining good wildlife habitat on my property, or property adjoining my property	1	2	3	4
Controlling water and manure run-off	1	2	3	4
Storage and disposal of animal waste	1	2	3	4
Soil erosion control	1	2	3	4
Protection of groundwater	1	2	3	4
Protection of surface waters	1	2	3	4

4. If you **had** to **strictly** comply with a **mandatory** TMDL process, to what extent do you agree with the following motivations as reasons for you to comply with the TMDL?

	Motivation	strongly agree	agree	disagree	strongly disagree
a)	I will do whatever the law requires	1	2	3	4
b)	I care about my neighbors' opinions of my management style	1	2	3	4
c)	I want to avoid penalties and fines	1	2	3	4
d)	I want to avoid lawsuits	1	2	3	4
e)	I need to have access to pollution insurance	1	2	3	4
f)	I need lower insurance premiums because I can't afford higher premiums	1	2	3	4
g)	I need to protect our water resources for future generations	1	2	3	4
h)	I want to reduce the chances of being caught out of compliance	1	2	3	4
i)	I want to follow a list of approved practices (approved by state and federal regulators), even if the list is not mandatory	1	2	3	4
j)	I need to have access to consultants because I need access to their knowledge and technological expertise	1	2	3	4

5. From the list of reasons above, pick the ***one*** that represents the ***most important*** reason you would comply with a mandatory TMDL process: Letter: ___________

6. Suppose a **mandatory** TMDL process is implemented and you are expected to comply with it, to what extent would you agree with the following motivations as reasons why you would **not** comply:

Motivation	**Strongly agree**	**Agree**	**Disagree**	**Strongly Disagree**
a) I have to carefully consider the costs of suitable water protecting practices	1	2	3	4
b) I have many other things to take care of that take priority over water quality	1	2	3	4
c) Current milk prices affect the water-quality related practices that I can undertake	1	2	3	4
d) I have to consider the costs of a consultant because of financial constraints	1	2	3	4
e) I want to wait until everything is finalized before making any necessary management changes or investments	1	2	3	4

7. Do you think the state should issue discharge permits to dairy farms in Michigan?

❍ Yes ❍ No ❍ Don't know

Information about your operation

8. What is the size of your dairy operation?

No. of milking cows: ______ No. of heifers (birth to 1st calving): ______

No. of acres of tillable land for manure application: ________

9. In what counties do you farm? ____

10. In what county do you live?

____

11. What is the ownership arrangement for your farm?

❍ Sole proprietorship
❍ Family partnership
❍ Partnership with non-family member
❍ Corporation - family
❍ Corporation – non-family
❍ Other ____________________

12. How many non-farming households (unrelated to those living on the farm) are located within 0.5 miles of your milking parlors?

Milking parlor 1:	0 to 4 households ❍	5 to 10 households ❍	More than 10 households ❍
Milking parlor 2:	0 to 4 households ❍	5 to 10 households ❍	More than 10 households ❍
Milking parlor 3:	0 to 4 households ❍	5 to 10 households ❍	More than 10 households ❍

13. In the last three years, how many times have you received a formal nuisance complaint in which you have been contacted by MDA?

Never ❍	1 to 3 times ❍	More than 3 times ❍

14. What manure storage method(s) do you use? (Choose **all** that are applicable)

Daily scrape and haul ❍	Concrete storage ❍	Outdoor earthen storage ❍	Other (please specify) ______________

15. If you have storage, how many months do you have? ____________ month(s)

16. What type of application method(s) do you use? (Choose **all** that are applicable)

Surface application ❍	Injection ❍	Irrigation ❍	Other (please specify) ______________

17. How often do you test the soil on which manure is applied? (please mark only one circle)

Never ❍	Once each 5 years ❍	Once each 3 years ❍	Every other year ❍	Annually ❍

18. In which watershed is your primary dairy operation located (i.e. what is the name of the closest river or creek to your property)?

19. Do not know: ❍ or Name: ______________________________________

20. Do you have a creek or river that runs through your farm property or borders it?

❍ Yes ❍ No

If you answered NO, how far is the nearest lake, river, or creek from your farm?
___________ miles

21. What type of slope does the majority of your land have?

0-1% (flat)	2-5%	more than 5%
❍	❍	❍

22. Do your cattle utilize:

rotational grazing pastures	confined feeding facility	both
❍	❍	❍

23. Have you made any investments in the last 10 years in manure handling practices?

❍ Yes ❍ No

If you answered YES, how much has it cost you (approximately)? $ ___________

24. Have you made **any** investments in the last 10 years in improving neighbor relations?

❍ Yes ❍ No

If you answered YES, how much has it cost you (approximately)? $ ___________
What kinds of things have you done?

____

____

25. Which of the following water quality related management practices do you follow?

(check all that apply)

❍ filter strips

❍ animals are confined all the time

Do you have a stream/creek/river adjoining your property? ❍ Yes ❍ No

If yes, do you fence off the stream/creek/river from your cattle? ❍ Yes ❍ No

❍ control barn runoff (How? ___________________________________)

❍ Other(s) ___________________________________

26. Will you be retiring within the next 5 years? ❍ Yes ❍ No

If you answered YES, are you considering any of the following?

❍ pass farm onto family/relative who will keep it in agriculture

❍ pass farm onto family/relative who will keep it in dairy

❍ sell land to someone for non-agricultural purposes

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