J O I N T C E N T E R
AEI-BROOKINGS JOINT CENTER FOR REGULATORY STUDIES

Regulation Decrease Health Risks?

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Regulatory Analysis 99-3

August 1999

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J O I N T   C E N T E R

In response to growing concerns about understanding the impact of regulation on consumers, business, and government, the American Enterprise Institute and the Brookings Institution have established the new AEI-Brookings Joint Center for Regulatory Studies. The primary purpose of the center is to hold lawmakers and regulators more accountable by providing thoughtful, objective analysis of existing regulatory programs and new regulatory proposals. The Joint Center will build on AEI's and Brookings's impressive body of work over the past three decades that has evaluated the economic impact of regulation and offered constructive suggestions for implementing reforms to enhance productivity and consumer welfare. The views in Joint Center publications are those of the authors and do not necessarily reflect the views of the staff, council of academic advisers, or fellows.

Executive Summary

The EPA's new regulation to protect ground water, the *Pesticides and Ground Water Management Plan* rule, will not significantly decrease health risks. Existing evidence suggests that the risk from ground water contamination is low and states have effective ground water protection programs. It is therefore unlikely that extensive federal involvement is necessary to protect ground water.

The EPA has indicated it will use the new regulation to require states to expand their programs. The EPA did not, however, estimate the benefits of expanding ground water protection in the proposed rule, consider the risk of alternative pesticides, or show that the actual level of risk is potentially greater than existing data suggest.

In this paper, I illustrate an approach for estimating the benefits and costs of ground water protection based on a case study of ground water contamination in California's San Joaquin Valley. The study shows that the health risk from ground water contamination is low, the costs of reducing contamination are high, and California is effectively protecting ground water. The study also shows that better analysis of the benefits and costs of ground water protection in each state can help the EPA determine the appropriate level of federal involvement in state ground water protection activities.

Pesticides in Ground Water: Will the EPA's New Regulation Decrease Health Risks?

Petrea Moyle

I. Introduction

Left unchecked, ground water contamination from pesticide use presents risks to human health and the environment. A high level of ground water contamination, for example, increases the risk of cancer from drinking water in rural areas and adversely impacts ecosystems.[1] The EPA proposed the *Pesticides and Ground Water Management Plan* (PMP) rule in 1996 to address this potential risk, and plans to finalize it by the end of 1999. The EPA designed the rule to prevent risks from ground water contamination resulting from the use of alachlor, atrazine, cyanazine, metolachlor, and simazine. In this paper, I show that the EPA could provide better estimates of the benefits and costs of protecting ground water than it provided in the proposed rule. I support this finding with a case study of simazine contamination in California's San Joaquin Valley. I further argue that better analysis of the benefits and costs of ground water protection could help the EPA determine the appropriate level of federal involvement in state ground water protection activities.

The EPA's PMP rule is only the most recent action in a series of actions related to its ground water protection program.[2] The EPA first addressed concerns about widespread ground water contamination in the early 1980s, and outlined its plan for the future in the agency's 1991 *Pesticides and Ground Water Strategy*.[3] The five PMP herbicides are the most heavily used herbicides in the nation. Once the rule is final, each state must submit a plan for each herbicide to the EPA within two years, subject to

[1] The primary benefit of ground water contamination reduction is a decrease in the risk of cancer and non-cancer risks to human health from drinking water. Ground water contamination also could adversely impact ecosystems because ground water is often connected to lakes, streams, or other surface water bodies. Ground water also has "existence value," which is the value to society of knowing that the nation's ground water sources are, and will remain, relatively pristine. Protection of microorganisms living in ground water is also cited as a potential benefit, although it is probably very small.

[2] The PMP rule applies to both states and tribal lands, in addition to the six U.S. territories. I refer to "state" plans throughout the paper.

[3] USEPA (1991).

approval by the EPA's regional offices. The EPA could ban the use of the PMP herbicides in any state that does not submit a plan the EPA approves.

Existing monitoring data suggest that the PMP herbicides generally are not found in ground water at levels that exceed the EPA's safety standards. A forthcoming study by the United States Geological Survey (USGS) synthesizes information on nationwide ground water monitoring results for the PMP herbicides since 1991. The USGS found only two wells with concentrations of a PMP pesticide that exceeded the EPA's safety standards.[4,5] A study conducted by Abt Associates, Inc., commissioned by the EPA, shows that the nationwide ground water contamination from all pesticides used on corn crops is associated with between .4 and 5 cancer cases per year.[6] Atrazine contamination is responsible for nearly all the estimated cancer cases, although the study includes all five PMP pesticides and twenty additional pesticides used on corn crops. The study also concludes that non-cancer risks are very low.

Data on PMP herbicide use shows that the level of use was relatively consistent from 1990 to 1995, so it is unlikely the risk from ground water contamination will increase above existing levels in the future. Atrazine, alachlor, cyanazine, and metolachlor are used primarily on field crops, while simazine is used primarily on fruit and nut crops. The amount of atrazine used on field crops has declined from 45 million pounds in 1990 to 39 million pounds in 1995.[7] Alachlor use during that period declined from 41 million pounds to 11 million pounds, cyanazine use has increased slightly from

[4] The Safe Drinking Water Act requires the EPA to set a Maximum Contaminant Level (MCL) for each contaminant it determines may present a public health concern. The MCL is based on studies of the effect of the herbicide on laboratory animals, and the results are extrapolated to humans. Safe Drinking Water Act, 42 USC § 300(g)–1 (b)(4)) (1996).

[5] USGS (forthcoming). Personal communication with Jack Barbash, primary author of the forthcoming study, January 1999.

[6] Abt Associates, Inc. (1994). The study is important because the risk of ground water contamination resulting from PMP herbicide use on corn crops was one of the motivating factors behind the PMP rule. The estimate of cancer cases is based on the results of a model that simulated the expected concentration of pesticides in ground water over twenty years. The concentration estimates are within the range of concentration found in published field studies, and are based on information about the level of use, soil characteristics, weather, level of irrigation, planting and harvesting, application practices, and the chemical characteristics of the pesticides. The study assumes a three meter depth to ground water for the low estimate of cancer cases and a one meter depth to ground water for the high estimate. It uses the EPA's risk assessment guidelines to calculate the cancer risk, and makes conservative assumptions about population exposure.

[7] USDA (1997).

22 million pounds to 24 million pounds, and metolachlor has held steady at around 37 million pounds.

The EPA has indicated it will require states to expand their ground water protection programs, despite evidence of low risks from ground water contamination. The EPA also has not shown that the actual level of risk is greater than existing data suggest. The EPA could, for example, answer the following questions: What is the maximum level of existing risk? How much will the risk increase in the future? What are the costs of reducing uncertainty about risk? These are important questions because the answers will help the EPA determine the appropriate level of additional ground water protection, if the EPA believes existing data is not adequate to estimate risk. In this paper, I evaluate existing data and recommend ways to improve the EPA's approach to protecting ground water based on the resulting analysis.

In Section II, I discuss the need for federal involvement in state efforts to protect ground water from PMP herbicide contamination. In Section III, I evaluate the EPA's economic analysis of the proposed rule. In Section IV, I present a study of the benefits and costs of ground water contamination from simazine in California's San Joaquin Valley to illustrate a way to collect more information on the benefits and costs of contamination reduction. In Section V, I recommend ways in which the EPA can help states improve their ground water protection programs at low cost.

II. Should the Federal Government Help States Protect Ground Water?

The need for government involvement in ground water protection efforts is the source of an ongoing debate between environmental interests and farmers. Environmental interests argue that the extent and severity of ground water contamination is poorly understood, despite nationwide monitoring efforts. Farmers argue their ability to maintain a steady income, as well as the supply of cheap and fresh produce in the market, depends on the continued use of low-cost pesticides. They further argue that these economic and health benefits outweigh the low health risks that pesticide use presents. The extent of government involvement in efforts to clean up ground water depends on some resolution of this debate.

Government involvement in ground water protection efforts could have an economic rationale if there is evidence of a market failure.[8] The primary market failures associated with ground water contamination are the externality resulting from ground water contamination that moves off the original site of application, and insufficient provision of information about risks. An externality can exist if a pesticide moves off a farmer's fields through ground water and contaminates the drinking water wells of neighboring farmers or otherwise causes harm to third parties.[9] The Safe Drinking Water Act requires constant monitoring and evaluation of water quality in wells that regularly serve at least 25 people. The only potential externalities that the federal government does not already regulate are therefore from contamination in wells that serve under 25 people, typically in rural areas, and to the environment if the ground water contamination spreads to surface water. It is unlikely, however, that pesticides often move off the original site of application. In the San Joaquin Valley, for example, the sedimentary architecture and the amount of irrigation result in maximum rates of movement on the order of 100 meters per year.[10] Since the PMP pesticides generally break down to harmless compounds in less than three months, the pesticides probably do not move off the original site of application in the San Joaquin Valley. In other states, however, different soil types or levels of irrigation could increase the rate at which pesticides move off the original site.

Second, the market may not provide sufficient information about risks.[11] Residents in an area susceptible to contamination benefit from the provision of additional information about risk because they can then take action to prevent the risk and because it reduces "dread" of the risk.[12] The high cost of ground water monitoring, however, gives each farmer the incentive to let neighboring farmers incur the costs of monitoring while he/she reaps the benefits of that information. Individual farmers have the incentive to monitor on their own property, assuming they are cognizant of the potential risk, but not

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[8]For more information on the justification for government involvement when market failures exist, see the Office of Management and Budget's 1996 "Economic Analysis of Federal Regulations Under Executive www.whitehouse.gov/WH/EOP/OMB/html/miscdoc/riaguide.html.

[9] An externality exists when the welfare of an individual depends directly on his or her activities in addition to activities under the control of some other individual. Tietenberg (1992).

[10] Personal communication, Stuart Rojstaczer, Professor of Hydrology, Duke University, June 1999.

[11] Ground water monitoring data is a public good, and is efficiently provided if the provision of an additional increment of data can not make one person better off without making another person worse off. Rosen (1995).

to contribute to the establishment of a comprehensive ground water monitoring program for their agricultural region.

In states with high levels of pesticide use, state agencies are already taking action to protect ground water and to reduce uncertainty about the level of risk.[13] California, Wisconsin, and Florida, for example, have ground water protection programs that started in the 1980s. California passed the Pesticide Prevention and Control Act in 1986 and Wisconsin passed the Ground Water Law in 1983.[14] Also in 1983, Florida passed the Florida Water Quality Assurance Act, which established a ground water quality monitoring network. Comprehensive ground water protection programs followed passage of these laws. As a result of these programs, state representatives assert that ground water contamination resulting from pesticide use has declined. These states, in addition to many others, worry about the impact of the PMP rule. States with low levels of PMP herbicide use, for example, fear the EPA will require them to expand their monitoring programs at high cost, regardless of existing levels of risk.[15] States with high levels of PMP herbicide use also fear that the EPA will require extensive ground water monitoring, regardless of ongoing efforts to protect ground water or resource constraints.[16]

In the rest of this paper, I explore how to determine the extent of EPA involvement in state ground water protection activities, given low levels of risk, uncertainty associated with estimates of risk, and the success of ongoing state ground water protection programs.[17]

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[12] Public perception of risk and its influence on agency priorities has been extensively discussed in the literature. See, for example, Slovak et al. (1985), Viscusi and Magat (1987), and Sunstein (1996).

[13] The information is based on personal communication with state and federal government representatives, environmental interests, and agricultural interests. The information in this section is presented only to provide examples of ongoing state efforts, and is not representative of all states.

[14] California's Pesticide Prevention and Control Act was passed in part because of the detection of high concentrations of popular pesticides in well water and in part because 80% of California's small drinking water systems, primarily in agricultural regions, rely on ground water. Pease et al. (1995).

[15] Personal communication with Barry Patterson, Director of Agricultural and Environmental Services, New Mexico Department of Agriculture, August 1996 and with John Smith, Program Administrator, North Carolina Department of Agriculture, July 1996.

[16] Personal communication with Dr. Marion Fuller, Florida Department of Agriculture. August 1996.

[17] If one assumes that most of the people drinking from wells serving under 25 people are the same farmers that applied the pesticides that contaminate the ground water, and that the pesticides do not move off-site into other people's wells, there is no externality. While this is an interesting point, I do not pursue it in this paper because the complexity of hydrologic systems prevents me from making the assumption that

III. Evaluation of the EPA's Economic Analysis of the Proposed Rule

The EPA conducted an economic impact analysis of the PMP rule, as required by President Clinton's Executive Order 12866. While the EPA arguably complied superficially with the economic analysis requirements in the executive order, the EPA did not provide defensible estimates of the benefits and costs of its proposed strategy or consider a reasonable range of alternatives.

The EPA provided no estimate of the benefits of contamination reduction in the proposed rule. In place of a benefits estimation, the agency simply stated that "Due to the preventative nature of [Pesticide] Management Plans and general methodological difficulties inherent in quantifying the value of ground-water resources, the potential benefits of [P]MPs were not monetized."[18] The courts have interpreted language in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which gives the EPA jurisdiction for the PMP rule, to mean that the EPA should balance the costs and benefits of a regulation designed to prevent unreasonable adverse effects[19,20] In addition, President Clinton's Executive Order 12866 requires agencies to show that the benefits of economically significant regulations justify the costs.[21] Although the EPA is expected to expand on its estimation of the benefits in the final PMP rule, it is doubtful it will provide state-specific analyses of the benefits of reducing PMP herbicide contamination.

Although the EPA did not estimate the benefits of the rule, it reviewed six existing studies of contamination. The EPA only presents a range for the ground water concentration of each pesticide in each study, rather than a mean concentration, so it is impossible to know whether the risk is high or low without looking more closely at the studies. The EPA reports, for example, that the concentration of simazine in California

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pesticides do not move off-site in all areas of the U.S. and because I cannot assume that the states have perfect information about levels of contamination.

[18] USEPA (1996).

[19] According to the EPA, the two provisions of FIFRA that support the use of pesticide management plans as a condition of initial registration are the restricted use provisions and the cancellation provision (EPA, 1993). Federal Insecticide, Fungicide, and Rodenticide Act, 7 USC §136a and § 136d (1972).

[20] The regulatory objective of the EPA's PMP rule is to prevent unreasonable adverse effects of pesticide use, as defined by FIFRA, and to protect the environmental integrity of ground water in the United States. Unreasonable adverse effects is defined as "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of any pesticide. Federal Insecticide, Fungicide, and Rodenticide Act, 7 USC § 136(2)(bb) (1972).

ground water ranges from .1 to 2.4 parts per billion (ppb), based on the California Well Inventory Database. Later in this paper, I use the same California data to calculate the mean concentration of simazine in California. The mean concentration is .3 ppb with an upper bound of .35 ppb and a lower bound of .28 ppb, according to data from 1986 to 1995. The concentration ranged from .05 to 19 ppb, however. During this period, simazine was only detected four times at a concentration that exceeded the EPA's safety standard for simazine of 4 ppb.

The EPA also did not fully estimate the costs of the rule. The EPA found that lost productivity and higher pesticide prices resulting from a switch to alternative pesticides could cost farmers and consumers between $242 to $254 million annually.[22] It also found that the rule could cost pesticide manufacturers between $36 million and $46 million annually in lost sales and ground water monitoring expenditures. The most controversial cost estimate, however, is the estimate of state program costs because the EPA did not define the criteria it will use to approve state plans. The EPA states that "An acceptable Plan must, to the satisfaction of the Administrator, demonstrate that monitoring activities (including ground-water monitoring) performed pursuant to the Plan are appropriate for the purposes of the Plan, with assurances that the activities will be carried out adequately"[23] Without more information about what the EPA may consider "appropriate" or "adequate," it is difficult for states to know what the EPA expects, and therefore how much the PMP rule will cost. The EPA further states that "most states will find it necessary to expand their ground water monitoring programs to meet additional criteria established in the plans."[24] The EPA does not, however, estimate how many more ground water samples per year the states should collect, or how many new wells states should construct.

Since the EPA did not define the criteria is will use to approve state plans, it did not use state-specific data to aggregate the potential costs of state plans. The EPA instead based its estimate on the annual costs of Wisconsin's ongoing ground water protection

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[21] According to Executive Order 12866, an "economically significant" rule is generally one that has an annual effect on the economy of $100 million or more.

[22] The agency did not specify the year dollars for all the estimates mentioned in this section, although the estimates are probably in 1992 or 1993 dollars. All the numbers in this section are taken directly from the *Federal Register* notice and the economic analysis of the proposed rule.

[23] See USEPA (1996a), p. 33297.

[24] USEPA (1996b), p. IV-21.

program. The costs of ground water monitoring can vary dramatically by state, however, depending on the level of pesticide use, depth of aquifers, and other factors. Based on an estimate of $500,000 per year per pesticide management plan, the EPA estimates that the PMP program will cost states approximately $60 million annually for the first ten years of the program. While the EPA appears to think that Wisconsin is representative of the higher end of costs to a state of a pesticide management plan, the EPA could require states to expand their ground water monitoring beyond the scope of Wisconsin's program.[25]

The EPA states in the preamble to the proposed rule that it "believes the proposed action is the most cost-effective and least burdensome alternative to the alternatives considered in the development of the *Pesticides and Ground-Water Strategy*, developed as the groundwork for today's proposed rule."[26] The EPA considered only four alternatives: federal mandated restrictions (such as national standards or label changes), outright cancellations, the "do nothing" alternative, and the PMP rule. The EPA asserts that the PMP rule is better than the other alternatives, although it provided very little information about the benefits and costs of each alternative. For example, the EPA states in the preamble that it did not analyze the "do nothing" alternative, which would leave pesticides and ground water management to the states. According to the EPA, "this alternative was not analyzed because it clearly failed to meet the regulatory objective. Such an option that freely permits contamination would entail no direct regulatory costs, but the far larger reduction in the value of the resource must be compared to the more conventional economic impacts."[27] Given that the EPA provided no analytical foundation for its belief in a "far larger reduction" and extensive state efforts to protect ground water,

[25]Furthermore, the economic analysis of the proposed rule indicates that the EPA does not have current information on the level of ground water monitoring. The EPA uses national data on ground water sampling from 1971 to 1991, for example, to provide the reader with some idea of sampling efforts in each state and therefore the potential costs of sampling. Evidence suggests, however, that these numbers underestimate current levels of sampling. In California, for example, there were 4,908 simazine samples between 1986 and 1995, while the EPA estimates that there were 2,931 simazine samples in California between 1971 and 1991. California Well Inventory Database, 1986-1995 and USEPA (1996b).

[26] USEPA (1996a), p. 33295. The Unfunded Mandates Reform Act requires agencies to identify alternatives to a proposed action, and select the least burdensome alternative that achieves the desired social objective, or explain why it did not choose the least burdensome alternative. Unfunded Mandates Reform Act, 2 USC § 1535 (1995).

[27] USEPA (1996a), p. 33295.

the EPA should evaluate the "do nothing" alternative to determine the extent of justifiable federal involvement.

The EPA also did not consider variations of the PMP rule as alternatives. The EPA could have, for example, built in flexible reporting and implementation requirements for those states that historically do not have problems with the PMP herbicides. It could have specified the level of ground water monitoring that states must conduct to meet the EPA's approval, based on the level of pesticide use and the vulnerability of ground water to contamination. It could have built further flexibility into the process by allowing states to submit plans for the top five pesticides with potential to contaminate ground water in each state. Instead, the EPA picked five pesticides that nationwide are used on average more than other pesticides. Without a discussion of such alternatives, the EPA cannot claim that it chose the least burdensome alternative.

The EPA could improve its analysis of the benefits and costs of protecting ground water by first gathering more information about the benefits of reducing contamination in different states, and then using that information to estimate the risk to human health and environment. As demonstrated in the next section with an example of ground water contamination in California, it is possible to unearth more information on the benefits of contamination reduction than the EPA cites in the proposed rule. Furthermore, a good analysis of the benefits and costs of the EPA's policy should include a comparison of the risk from ground water contamination to other risks to human health and the environment. It should also include an evaluation of risks of alternative pesticides or other risks that could increase as a result of efforts to reduce ground water contamination.

IV. The Benefits and Costs of Reducing Simazine Contamination in California's San Joaquin Valley

I demonstrate an approach to estimate the costs and benefits of protecting ground water in this section, based on a study of simazine contamination in California's San Joaquin Valley.[28] First, I provide some background information on the history of

[28] The analysis in this section is tailored to pesticides and ground water management, but the principles on which it is based are widely recognized components of policy analysis. See, for example, Stokey and Zeckhauser (1978).

simazine use and contamination in California. Second, I estimate the benefits of ground water contamination reduction in the Valley. Third, I discuss the costs of banning the PMP herbicides in California and the costs of ground water monitoring.

The California Department of Pesticide Regulation, responsible for developing a management plan if the PMP rule is finalized, contends that existing data show little risk to human health from ground water contamination resulting from PMP herbicide use. The Department further asserts that California's existing ground water protection program is sufficient to prevent and control ground water contamination. The EPA, on the other hand, asserts that the Department does not have enough data to assess the extent and severity of ground water contamination in California, and therefore additional monitoring and ground water protection measures are necessary to learn more about the risk.[29] Both agencies are correct, because although California operates an effective ground water contamination prevention program, California cannot claim it knows the actual level of risk from ground water contamination. It is unlikely, however, that gathering additional information will show that the risk is greater than existing data suggest because California monitors frequently in areas of high simazine use.

Simazine is the most heavily used of all the PMP herbicides in California. Simazine is used in California on fruit, vegetable, and nut crops, and over 70% of California's simazine use is in the San Joaquin Valley.[30] Over 40% of simazine use is in two of the Valley's eight counties, Fresno and Tulare. California supplies over 50% of the total value of the nation's fruits and nuts, the majority of which are grown in the San Joaquin Valley.[31] As a result of the high simazine use, California has focused its simazine monitoring efforts in the San Joaquin Valley. Almost two-thirds of all samples for simazine collected in California over a ten-year period were in the San Joaquin Valley.[32]

I used ground water monitoring data from the Well Inventory Database, a collection of monitoring results from all California agencies dating back to 1986, to calculate the mean concentration of simazine in ground water in every county in the San Joaquin Valley, in every year for which data were available. Assuming that only wells

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[29] The opinions of the CDPR and the EPA in this section are the result of conversations with Pat Dunn of the CDPR and Jan Baxter of the EPA, both of whom were involved with the PMP process in 1997.
[30] Author's calculation based on California pesticide use data. See Moyle (1997).
[31] USEPA (1996b).
[32] Moyle (1997).

not covered by the Safe Drinking Water Act are potentially contaminated by pesticides, I used 1990 U.S. Census data to calculate the number of small wells serving less than 25 people in each county in the San Joaquin Valley.[33] I assumed that each of these wells served between eight and sixteen people.[34] I then used the EPA's standard risk assessment guidelines and assumptions to calculate the number of cancer cases averted if simazine is eliminated from San Joaquin Valley ground water.[35]

While simazine is detected frequently in San Joaquin Valley ground water, especially in Fresno and Tulare counties, it is not detected in concentrations that pose a risk to human health. The mean concentration of simazine in San Joaquin Valley ground water ranges in different counties between 0 to .76 ppb, well below the Maximum Contaminant Level (MCL) of 4 ppb set by the EPA with an adequate margin of safety.[36] The table below presents my estimates of the mean concentration, which excludes wells in which no simazine was detected. The upper and lower bounds of the mean concentration calculation are based on a 95% confidence interval. The table shows that simazine is detected frequently in the ground water of Fresno and Tulare counties, but the concentration of simazine has exceeded the EPA's MCL only once in over ten years.

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[33] See Moyle (1997). The U.S. Census defines a "small" well as one that is not connected to a public water system, and that provides water for four or fewer houses, apartments, or mobile homes. I calculated the number of small wells in each county for the years 1997 to 2006, the timeframe for my analysis. I therefore adjusted the 1990 data by applying population growth estimates calculated by the state of California.

[34] I assumed between eight and sixteen people drink from each well for two reasons. First, the U.S. Census question defines an individual well as one that serves four or fewer houses. I therefore multiplied four houses by two people per household and four people per household to arrive at my estimate of eight to sixteen people per well. According to the EPA, the national average per household is 2.64 people (USEPA, 1996a, p. 33290).

[35] Cancer risk is the easiest of all benefits from ground water contamination reduction to quantify using EPA risk assessment techniques. It is much more difficult to quantify existence value or similar benefits of ground water protection. Boyle et al. (1994) summarize existing studies that attempt to estimate the value protecting ground water from nitrates and other unspecified pollutants. They conclude that significant differences exist between ground water values, but that additional studies are necessary before valuation results will have policy relevance.

[36] The mean concentration in Stanislaus county is high because one detect in 1988, out of 28 detects over ten years, measured 6.60 ppb.

Mean Concentration of Simazine in San Joaquin Valley Counties, 1982-1995 (parts per billion)

	Mean	Upper Bound	Lower Bound	Total Samples	Total Detects	Detects MCL
Fresno	0.23	0.24	0.21	842	334	0
Kern	0.16	0.39	0	176	4	0
Kings	0.11	0.11	0.11	80	1	0
Madera	0	0	0	85	0	0
Merced	0.36	0.84	0	160	6	0
San Joaquin	0	0	0	170	0	0
Stanislaus	0.76	1.23	0.29	194	28	1
Tulare	0.32	0.34	0.29	1376	629	0

The number of cancer cases averted if simazine is eliminated from San Joaquin Valley ground water ranges from 2 to 23 over a ten-year period, or .3 to 2.3 per year, using the EPA's risk assessment guidelines and conservative assumptions about the number of people exposed to each potentially vulnerable drinking water well.[37] In addition, the annual risk to human health from drinking water from a contaminated well does not exceed one in a million for any county in the San Joaquin Valley. This risk is less than the risk incurred by travelling 150 miles by car, living 2 months with a cigarette smoker, and flying 1,000 miles by jet.[38] All of these activities carry an annual risk of one in a million.

I tested a number of different scenarios to reflect the uncertainty associated with the population exposure estimates and the number of contaminated wells. The range of cancer cases averted is based on the assumption that the concentration of simazine in each contaminated well is the mean concentration. The low end of the range assumes eight people drink from each well and that only a percentage of small wells are contaminated. The high end of the range assumes that sixteen people drink from each well and all small wells are contaminated. I used the percentage of total wells sampled

[37] I built conservative assumptions into my analysis to reflect the uncertainty about the level of risk that stems from a lack of information about some of the factors that contribute to ground water contamination, discussed in the first section of this paper. For a more detailed description of my assumptions and the risk assessment methodology, see Moyle (1997).

[38] Viscusi (1996).

with contamination from the Well Inventory Database as an estimate of the percentage of small, contaminated wells for the low-end scenario.

The costs of the PMP rule in California are difficult to estimate because the EPA did not define its criteria for approving state management plans. The EPA states in the proposed PMP rule that it will probably require states to increase their ground water monitoring, however, although it did not provide reliable estimates of the costs of additional ground water monitoring. It also states that it will ban the PMP herbicides if the state does not develop a plan the EPA will approve, but does not estimate the costs of a ban.[39] While estimating the potential costs of increased ground water monitoring was beyond the scope of this analysis, I compared an estimate of the costs of a ban in California to my estimate of the benefits of a ban.

Hueth and Cohen estimated the total costs of a ban of the five herbicides in California.[40] Using data from 1993, Hueth and Cohen estimated that the direct costs of a ban on all five herbicides to consumers and producers in California is between $20 million to $35 million dollars per year.[41] These cost estimates are based on the increase in the cost of production when farmers switch to more expensive alternatives to the PMP herbicides. Hueth and Cohen also surveyed California farmers to determine whether they would change their production practices if forced to switch to alternatives, and whether they expected yields to drop as a result of the switch. The farmers decisively responded that crop yields are not expected to drop because of a switch to an alternative herbicide, because although more expensive, the alternatives are equally effective. In addition, the farmers did not expect to change their production practices. As a result, the increase in the price of alternative pesticide relative to the PMP herbicides is the only cost Hueth and Cohen considered. They did not include the administrative and enforcement costs associated with a ban.

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[39]The EPA indicates in the economic analysis of the proposed rule that farmers will switch to more expensive alternative pesticides if the EPA bans the PMP pesticides, but does not calculate the aggregate costs of a ban. The EPA lists the major alternatives to the PMP herbicides, the main crops on which they are used, the percentage of acreage to which each PMP herbicide and its alternatives is applied, and provides a simple cost comparison between the PMP herbicides and the alternatives.

[40] Hueth And Cohen (1996).

[41] Hueth and Cohen (1996). The estimate is in 1993 dollars. Hueth and Cohen calculated the costs of a ban using equations to estimate the short-run changes in marginal production costs for a single crop developed by Lichtenberg et al. (1993) and Sunding (1996). Hueth and Cohen picked 11 of the main crops in

As discussed earlier, eliminating simazine contamination of ground water in the San Joaquin Valley would save .3 to 2.3 lives per year, and a ban on all the PMP herbicides will cost California between $20 and $35 million per year. Assuming a value of life between $3 million and $8 million per life saved, the benefits from cancer cases averted from simazine contamination reduction in the San Joaquin Valley is between $1 and $18 million per year.[42] Several adjustments are necessary to compare these benefits to the cost of a ban, some of which increase the risk estimate and some of which decrease the estimate.

Including atrazine in the analysis of the benefits would at most double the estimate of the benefits of a ban.[43] From 1986 to 1995, atrazine was detected 209 times and simazine was detected 563 times in California ground water. The mean concentration of atrazine in California ground water during that time was .36 ppb, with an upper bound of .44 ppb and a lower bound of .28 ppb. The EPA's MCL for atrazine is 3 ppb. The benefits from a ban on metolachlor, alachlor, or cyanazine are insignificant. Alachlor was detected twice from 1986 to 1995, and cyanazine and metolachlor were never detected.[44] Including the rest of the state in the analysis will also increase the benefits, although not by a significant amount because approximately 70% of California simazine use is in the San Joaquin Valley. Furthermore, the mean concentration of simazine in the rest of California is only .37 ppb, with an upper bound of .53 ppb and a lower bound of .22 ppb. The estimate of the benefits also does not include the benefits from reducing "dread" of the risk of contamination.

The analysis also significantly overestimates the benefits of a ban. It does not consider that many individuals drinking water from small wells sometimes monitor their own wells, filter their own water, or drink bottled water. Pesticide manufacturers could

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California on which PMP herbicides are used and applied the Lichtenberg/Sunding method to calculate the total welfare loss from a total ban on the use of the herbicides on each crop.

[42] The value of life is established in the economics literature, based on studies of willingness-to-pay for an increase in risk in labor markets. See Viscusi (1993). The estimates are adjusted to 1993 dollars using the Consumer Price Index (CEA, 1999). Alternatively, Van Houtven and Cropper have estimated the EPA's implicit value of a life at $60 million per cancer case avoided (adjusted to 1993 dollars), based on a study of the EPA's actions on cancer-causing pesticides from 1975 to 1989. The ban is therefore possibly consistent with past EPA actions. It is unclear, however, whether members of society agree with this valuation of life so I did not use it in my analysis. See Van Houtven and Cropper (1996).

[43] Other benefits could include those from non-cancer risks and ecological risks, although given the low levels of contamination it is unlikely these benefits are large.

[44] Moyle (1997)

also develop replacements to the PMP herbicides that could off set the risk reduction, even if the replacements are less harmful than the PMP herbicides.[45] Most importantly, a ban on the PMP herbicides will result in an increase in the use of existing alternative herbicides. Hueth and Cohen found that farmers would substitute bromicil or a combination of oxyfluorfen and diuron for simazine.[46] Bromicil and diuron are already detected frequently in California ground water, although more research is necessary to determine the risk of these herbicides relative to simazine. From 1986 to 1995, for example, bromicil was detected in California ground water 190 times, diuron was detected 362 times, and simazine was detected 563 times.[47]

A switch to alternative herbicides could require changes in application practices that could increase the risk to pesticide applicators, a risk widely recognized by the EPA and the regulatory community as a significant public policy issue.[48] Another potential increase in risk, although difficult to quantify, is the change in fruit and vegetable consumption from an increase in the price of production related to higher substitute pesticide prices.[49] Consideration of these factors could further reduce the already low estimates of the benefits of the PMP rule.

Since the EPA proposed the PMP rule as an alternative to a ban on the five pesticides, the agency apparently recognizes the high costs of a ban relative to the benefits. The EPA has indicated that a primary component of the state management plans is increased ground water monitoring.[50] The purpose of increased ground water monitoring is primarily to reduce uncertainty about the level of risk, although ground water monitoring data also provides information about the success of various measures to reduce ground water contamination. Concern about uncertainty is justified because the

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[45] Novartis is replacing alachlor with acetochlor. Ciba-Geigy has developed a substitute for metolachlor that they have not yet released for sale. Personal communication with Bob Fugitt, Chemist, Dupont Chemical Company, June 1996.

[46] Hueth and Cohen further report that farmers will switch from cyanazine to oxyfluorfen or prometryn.

[47] Moyle (1997).

[48] Goldman (1996). For a discussion of the tradeoffs between economic benefits and worker health safety, see Harper and Zilberman (1992).

[49] There is a strong science base indicating that consumption of fruits and vegetables reduce the risk of many diseases. See Liebman (1996).

[50] Personal communication with Jan Baxter, EPA Region IX, Barry Patterson, New Mexico Department of Agriculture, John Smith, North Carolina Department of Agriculture, and Marion Fuller, Florida Department of Agriculture. Summer 1996. The EPA writes in the *Federal Register* notice that "present levels of ground water monitoring are inadequate to gauge the levels of overall ground water contamination with confidence." USEPA (1996a). EPA guidance documents also emphasize ground water monitoring.

process through which pesticides reach ground water, and travel through ground water, depends on complex hydrogeologic processes that vary by region, if not by acre.[51] In addition, the properties of individual pesticides determine the extent to which they contaminate ground water.[52] Ground water monitoring is costly, however. The EPA must therefore carefully compare the benefits of additional ground water monitoring to the costs.

Although the EPA does not provide very much information on the costs of ground water monitoring in its analysis of the proposed PMP rule, the EPA provided such information elsewhere.[53] The cost of a ground water monitoring program depends on the number of wells that the state must construct for monitoring purposes (related in turn to the number of existing wells suitable for monitoring), the number of times per year a well is sampled, travel time, the costs of field measurement and sample analysis, the costs of equipment and well maintenance, the costs of sample analysis, and the costs of staff time.[54]

In its analysis of the PMP rule, the EPA finds that the cost of constructing a ground water monitoring well is about $1,690 for a well with a depth of 30 feet.[55] To determine the extent of contamination in one spot, it is generally necessary to build 3 to 5 monitoring wells.[56] Depending on the complexity of the area's hydrogeology, many sampling sites could be necessary to obtain a clear picture of the extent of contamination. According to the EPA, it takes an average of 3.5 hours to take field measurements and

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[51] For a complete discussion of the process through which pesticides reach ground water, see Moyle (1997).

[52] These properties include the rate that a pesticide dissolves in water and its ability to sorb to soil. The composition of the soil, the level of irrigation, and the level of precipitation also could effect the risk of ground water contamination in some areas. For more information, see Barbash (1996).

[53] The EPA provided ongoing and initial compliance costs for two types of ground water monitoring programs in an evaluation of the estimated costs of programs under the Resource, Conservation, and Recovery Act. USEPA (1997).

[54] A typical monitoring program, according to the EPA, is composed of the following tasks: development of work plan, field investigation, report of results, design of monitoring system, installation of ground water monitoring wells (if necessary), maintenance of wells, calculation of ground water flow rate and direction, presampling activities, field measurement and sample collection, sample analysis, and evaluation of data quality. USEPA (1997).

[55] See USEPA (1996b). The cost of well construction varies from state to state. The cost depends on the depth of the well, the type of soil, and other factors.

[56] While existing drinking water wells could be used for monitoring instead of building new wells, monitoring wells are generally preferred because drinking water wells are typically deep and open to a number of aquifers below the surface to capture the maximum amount of water possible. Samples from these wells do not represent contamination in a particular aquifer because of dilution, which makes it difficult to determine the source of contamination.

collect samples from monitoring wells, excluding travel time. Staff time can range anywhere from $50 to $100 per hour.[57] Laboratory analyses of samples range from $176 to $328 per sample.[58] As is clear from this simple description of potential costs, increased ground water monitoring can rapidly use up available resources.

In California, the benefits of additional ground water monitoring are probably low. First, existing data indicates that the risk from ground water contamination resulting from PMP herbicide use is low. Second, current ground water monitoring efforts are focused in areas of high simazine use. Existing data is therefore sufficient to estimate risk, and perhaps overestimates the risk. Approximately 40% of California's simazine use is in Fresno and Tulare counties, for example, and 45% of all California ground water samples for simazine were collected in Fresno and Tulare between 1986 and 1995.[59] Even if simazine use increases in the future, it is unlikely that contamination will increase enough to pose significant risks to human health and the environment.

V. Recommendations for Improving the PMP Rule

Each state should balance the benefits and costs of taking additional action beyond current efforts to protect ground water, similar to the California analysis presented in the previous section. If these analyses support my findings that the risk from PMP contamination is low and existing ground water protection programs are working, it is unlikely that extensive federal involvement in state ground water protection activities is necessary.

Although extensive federal involvement is not necessary, the EPA could use the PMP process to continue to help states improve their ground water protection programs at low cost. The EPA could develop a clearinghouse of information about ground water protection strategies. It could provide information on best management techniques to reduce pesticide use and give advice on ground water monitoring techniques. It could further help states assess the vulnerability of soil to ground water contamination, and provide information on how to clean up ground water contamination resulting from accidental spills or illegal dumping of large quantities of pesticides. The EPA could

[57] USEPA (1997).
[58] USEPA (1997).
[59] Moyle (1997).

survey the ongoing activities of states and share success efforts with states developing or improving their ground water protection programs. The EPA could further help states access and use ground water databases, such as that of the National Pesticide Survey conducted by the United State Geological Survey.

The EPA could also mount an information campaign aimed at educating residents of vulnerable areas about the need to regularly monitor drinking water wells for pesticide residues, assuming that some residents are unaware of the potential risk.[60] The EPA could further provide assistance to residents who monitor their own wells with monitoring kits available through mail-order catalogs.

Finally, the EPA could look more closely at policies that encourage states to reduce pesticide use at the source, rather than specifically targeting ground water contamination. Such policies include the use of precision technologies to improve pesticide application, cropping, and irrigation techniques. These improvements could also reduce important risks from other sources, such as worker exposure, and could further prevent soil erosion and contamination of surface water.

VI. Conclusion

The EPA's new regulation to protect ground water will probably not significantly decrease health risks. Existing evidence suggests that the risk from ground water contamination is low and states have effective ground water protection programs. The EPA should therefore carefully evaluate whether to require states to undertake additional ground water monitoring or other ground water protection activities. Such requirements could consume resources that states might otherwise use to reduce more significant risks to human health and the environment.

[60] Smith et al. (1990) evaluated how different types of informational materials explaining the risks from radon influenced people's perception of these risks. They find that risk communication policies can be effective in modifying risk perception. See also Smith et al. (1995).

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