UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

INSERT DATE

EPA-SAB-12-xxx

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: SAB Review of EPA's *Retrospective Cost Study of the Costs of EPA Regulations: An Interim Report of Five Case Studies (March 2012)*

Dear Administrator Jackson:

EPA's Science Advisory Board (SAB) was asked to review and comment on the *Retrospective Cost Study of the Costs of EPA Regulations: An Interim Report of Five Case Studies (March 2012, RCS)*. The RCS is comprised of five case studies developed by EPA's National Center for Environmental Economics (NCEE) to investigate how well EPA has predicted the costs of regulatory compliance. The RCS sought to compare cost estimates ex post (after the regulation) to EPA's ex ante (before the regulation) predictions. EPA asked the SAB a series of questions on the case study approach applied in the RCS and specifically on appropriate methodologies to be applied in these and future case studies.

The SAB applauds EPA's efforts to evaluate the ex post costs of regulations, to examine systematic differences between the ex post and ex ante estimates, and to identify ways in which to improve future ex ante cost analysis. Accurate assessment of ex ante costs of regulation is critical for designing cost-effective regulations. The SAB finds the case studies are useful in showing that there are often significant divergences in assumptions underlying the ex ante analysis and ex post outcomes regarding methods of compliance, timing of compliance, and impact of compliance on production and market parameters. A comprehensive assessment of the ex post costs of regulations is, however, limited by available data. In addition, there is significant heterogeneity across regulations in terms of the pollution medium, industry structure and size, timelines, variety of compliance methods and rates of technological change. EPA's case studies generally showed more evidence of overestimation of ex ante costs than underestimation although the results cannot be generalized given the small sample size of cases considered and paucity of data. Based on these case studies, the SAB agrees with the Agency's conclusion that it is not possible to draw meaningful conclusions regarding general tendencies to under- or over-estimate costs in ex ante evaluations.

The SAB strongly urges the Agency to invest the resources needed to do a proper evaluation. EPA's sample size will need to extend far beyond the 5 case studies completed and 5 case studies planned. The Agency does not typically collect information on costs of compliance ex post. As a result, EPA was limited to publicly available data and collaboration with industry experts. If the Agency is to draw meaningful lessons for future ex ante cost estimates as well as for the direction and extent to which ex post cost estimates diverge from ex ante estimates, it must go beyond the existing data sources and pursue a primary data collection approach using surveys, focus groups and broad based expert opinions as well as consult with the outside research community. The SAB also recommends that EPA consider ways of building in a routine ex post data collection effort either within the Agency or in collaboration with other agencies.

The attached SAB report offers specific suggestions for how EPA's methodology might be improved. The SAB recommends development of a conceptual framework as well as a focus on the drivers of compliance costs. Rather than simply focusing on the question of whether EPA generally overestimates or underestimates costs, the SAB recommends a focus on the drivers of costs so that insights can be gained for future analyses.

We appreciate the opportunity to provide advice on this important subject and look forward to the Agency's response.

Sincerely,

Enclosure

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This report has been written as part of the activities of the EPA Science Advisory Board (SAB), a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The SAB is structured to provide balanced, expert assessment of scientific matters related to problems facing the agency. This report has not been reviewed for approval by the agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names of commercial products constitute a recommendation for use. Reports of the SAB are posted on the EPA website at http://www.epa.gov/sab.

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Acronyms and Abbreviations

AF&PA – American Forests and Paper Association
CAAA – Clean Air Act Amendments
CUE – Critical Use Exemption
MACT – Maximum Available Control Technology
MBr – Methyl Bromide
MBTOC – Methyl Bromide Technical Options Committee
NCASI – National Council for Air and Stream Improvement
NCEE – National Center for Environmental Economics
PACE – Pollution Abatement Costs and Expenditures
PM – Particulate Matter
RCS – Retrospective Cost Study
RIA – Regulatory Impact Analysis
SAB – Science Advisory Board
SEC – Securities and Exchange Commission

1. EXECUTIVE SUMMARY

EPA routinely performs benefit-cost analysis on major environmental regulations. Historically, the benefits portion of these analyses has received the most attention given the need to put monetary values on unpriced goods and services like clean air or clean water. There is a large literature in environmental economics devoted to "nonmarket valuation" or the monetization of unpriced environmental goods. There is also a large literature examining the cost-effectiveness and environmental effects of market-based regulations relative to command-and-control or technology-based regulations. However, there are relatively few studies that estimate the realized costs of existing regulations, largely due to lack of easily accessible data. Yet, it is important to have the most accurate possible estimates of the costs of specific regulations in order to assess the impact of regulations on the regulated community and design cost-effective regulations in the future. Toward that end, EPA's National Center for Environmental Economics (NCEE) has developed a White Paper comparing its own ex ante (before the regulations) cost analyses to an ex post (after the regulation) evaluation. In its *Retrospective Cost Study of the Costs of EPA Regulations: An Interim Report of Five Case Studies (March 2012, RCS),* EPA used a case study approach to address the question of whether ex ante and ex post estimates differ by a substantial degree. When a substantial difference exists, EPA sought to identify any systematic reasons for the differences in order to improve future ex ante cost modeling. The SAB was asked to review this interim report, provide technical advice and make recommendations on how to improve the methodologies for cost analysis.

Evaluating the Retrospective Cost Study Methodology (Charge Questions 1 – 3)

The RCS begins with a review of existing studies that examine the accuracy of ex ante cost estimates. As described in the RCS, these studies find that costs are more often overestimated than underestimated and identify some of the major reasons for the divergence of ex post and ex ante costs. The potential reasons ex ante and ex post estimates differ are described in the RCS but these factors are not analyzed in a systematic taxonomy that could provide a consistent structure throughout the study. Some factors will affect ex ante estimates differently from others. Strategic misreporting by firms, for example, would tend to raise ex ante estimates whereas induced innovation tends to lower actual (ex post) costs. The SAB recommends that EPA develop a conceptual framework that can be used consistently throughout the case studies. This conceptual framework would set out the various reasons that could lead to differences between ex post and ex ante costs, and would incorporate the various drivers of costs, providing a foundation for the literature review and the case studies that follow. The framework could be used to identify the key components of compliance costs relevant to a regulation and the factors likely to lead to each of those components being larger or smaller in the ex post assessment. For each regulation, the EPA should categorize the ex ante expectations about compliance costs (compliance methods, key factors affecting compliance costs for each method, and distribution of methods across the industry), and identify any ex post deviations from those expectations. This approach can then be used to undertake a systematic assessment of whether each of the components turned out to be larger or smaller than the ex ante estimate and the characteristics of the regulation that could influence the divergence between ex ante and ex post costs. Having a similar framework for all case studies would enhance comparability of outcomes across different cases.

Interestingly, the RCS recognized possible incentives for regulators to understate costs, but there may also be an incentive to overstate costs when benefits are extremely high. In fact, as acknowledged in one case study, EPA overestimated costs "in order to avoid preparing estimates that were too low and could be challenged" (RCS, p. 53). Rather than tailoring a cost estimate to satisfy other objectives, costs estimates should be based on the best possible science with assumptions and uncertainties clearly stated. If EPA has the discretion to choose a regulation based on net benefits, less accurate cost estimates will lead to sub-optimal regulations. Ex ante cost estimates that are too low can lead to regulations that are too stringent. Ex ante estimates that are too large can lead to regulations that are insufficiently protective.

Evaluating the Case Study Approach (Charge Questions 4 – 6)

EPA selected ten rules for inclusion in the RCS, the first five of which are profiled in "Phase 1" of the RCS. EPA limited its study to publicly available information; however for four of the five case studies in Phase 1, there was insufficient information in the public domain to estimate ex post costs. Thus EPA had to rely on industry experts, some of whom participated in the ex ante cost analysis. For the next five case studies, EPA plans to go beyond publicly available data, conducting site visits and exploring the possibility of comprehensive surveys of the affected industries. These efforts can provide better quantitative measures of ex post costs, but to improve comparability of results across rules, the studies should also include a coordinated qualitative approach with a systematic description of the ex ante expected compliance techniques and costs along with any deviations observed ex post.

In the long run, developing an extensive and authoritative set of studies comparing ex ante and ex post analysis will require additional time and resources and involvement with the outside research community. One major contribution towards conducting better ex post analysis would be the resumption of the Pollution Abatement Costs and Expenditures (PACE) survey conducted by the Census Bureau, which can contribute to both qualitative and quantitative analysis. When conducting future ex ante cost analyses, EPA should consider ways to build a routine effort to organize ex post data collection, either within the Agency or in collaboration with other agencies. One source of ex post information could be regulatory staff (from both EPA and state agencies) involved in monitoring and enforcing compliance with specific regulations. In addition to the PACE survey, the Agency should explore the possibility of working with data-collecting agencies to add questions related to costs of compliance to existing surveys (e.g., the surveys of costs of agricultural enterprises taken by the National Agricultural Statistics Service). The SAB strongly urges the Agency to allocate the additional resources needed to support ex post analyses.

The SAB generally agrees with the conclusions offered in the five case studies. The five case studies illustrate enormous heterogeneity in regulations --- in terms of the pollution medium, industry structure and size, timelines, variety and availability of compliance methods, rates of technological change and the role of prices. This, of course, made it difficult to render a meaningful judgment about whether ex ante costs are generally higher or lower than ex post costs. All case studies were bedeviled by a paucity of data on ex post costs, thus EPA utilized a variety of sources to construct ex post costs and made reasonable judgments in the face of severe data limitations.

In the arsenic case study of the effects of EPA's Maximum Contaminant Level (MCL) for arsenic in drinking water, the Agency concluded that it is not possible to render a judgment about how EPA's ex ante cost estimates compare to ex post realizations. For study of the effects of EPA's restrictions on the use of Methyl Bromide (MBr) in agriculture, EPA concluded that its ex ante estimate of the cost of the MBr phase-out exceeded ex post estimates by more than 25% for the 2006 – 2010 growing season. For the Maximum Available Control Technology (MACT) II rule enacted to control toxic air emissions from pulp and paper mills, EPA found that it overestimated the cost of capital investment by roughly 25% and overestimated annual costs by nearly 5 times. For its 1998 rule mandating emissions reductions in locomotives, EPA found that the total costs of bringing switch locomotives into compliance was likely lower than anticipated while its ex post assessment of the costs of bringing line-haul locomotives into compliance was inconclusive. In each of these case studies, EPA needed more data, time and resources.

For the Cluster rule designed to reduce chlorine emissions to water bodies from pulp and paper mills, EPA found that it over-estimated the capital cost by 30% to 100% depending on the choice of baseline year. One analytic issue that arose with this rule is the choice of a timeline for estimating the cost of compliance. EPA chose not to include industry's voluntary spending that occurred prior to the promulgation of the regulation; however, there is evidence of large expenditures by the pulp and paper industry to eliminate dioxin from air and water emissions prior to the official promulgation of the Cluster rule. The SAB believes this pre-regulatory, voluntary spending should be counted in EPA's cost estimates, both ex ante and ex post if there is clear evidence that it was undertaken in response to impending regulations.

Moving Forward (Charge Questions 7 – 10)

The SAB did not consider it possible to establish a weight of evidence determination on the direction of ex post costs compared to ex ante costs based on the lack of data and small number of case studies examined. Focusing only on regulations for which data is available instead of a randomly selected representative sample of regulations will make it problematic to reach generalizable conclusions about the extent to which ex ante costs are over-estimates or under-estimates of ex post costs. To advance the RCS and draw lessons learned for future ex ante analyses, EPA needs a larger sample size to identify patterns in the data. The SAB suggests that EPA do more, but shorter qualitative analyses of regulations. The goal would be to improve ex ante analyses by identifying and categorizing any deviations observed ex post from the expected components of compliance costs. After doing a substantial number of these qualitative studies, the deviations from ex ante expectations could be examined to look for patterns in the types of deviations observed across different settings (by pollution medium, by industry size, by the time lag until implementation, by the key factors affecting costs, by the amount of resources devoted to the analysis). If certain types of deviations are very common (e.g., always underestimating the rate of technological change in regulations with a long time lag), future ex ante analyses could take that into account. Trying to rely on the relatively detailed quantitative analyses conducted in Phase 1 and anticipated for Phase 2 seems less likely to yield generalizable results. A focus on the drivers or factors that influence the accuracy of ex ante cost estimates should help improve the usefulness of this RCS for future analyses. EPA should seek to understand which factors could have been anticipated and what, if any, adjustments to ex ante cost approaches should be made to provide better predictions of actual costs of compliance.

To summarize, the SAB offers these recommendations for the RCS:

- Develop a conceptual framework that can be used consistently throughout the case studies.
- Focus on the drivers or factors that influence the accuracy of ex ante cost estimates.
- Expand the sample size with qualitative analyses of more regulations.
- Consider ways to collect ex post cost information routinely, either within the Agency or in collaboration with other agencies to facilitate detailed quantitative comparisons of ex post and ex ante costs in the future.

2. INTRODUCTION

The U.S. Environmental Protection Agency's National Center for Environmental Economics (NCEE) has launched an effort to evaluate the accuracy of EPA's ex ante estimates of the costs of environmental regulation as part of its mission to provide the Agency with guidance on analyzing the benefits, costs, and economic impacts of regulations and policies. In its draft *Retrospective Study of the Costs of EPA Regulations: An Interim Report of Five Case Studies (RCS, March 2012)*, EPA sought to determine whether a "weight of evidence" determination could be made about whether EPA's ex ante costs are higher or lower than ex post costs. EPA used a case study approach to identify differences between ex post and ex ante compliance cost estimates. The RCS summarizes EPA's initial findings from a small set of pilot case studies that attempt to evaluate the costs of EPA's regulations. The initial set of case studies rely on a variety of methods for collecting ex post information and aim to examine key drivers of compliance costs to see if informed judgments (weight-of-evidence) can be made about whether ex post costs are generally higher or lower than the estimates of ex ante costs.

The SAB was asked to review this interim report and provide advice on the methodology applied in the case studies and offer potential improvements for future case studies. The Agency sought the SAB's advice on potential improvements in the way in which cost analyses are done. The SAB's Environmental Economics Advisory Committee discussed the RCS in a series of teleconferences (April 19 – 20, 2012, July 12, 2012 and September 7, 2012). This Advisory responds to the Agency's charge questions found in Appendix A. Highlights of the SAB advice are provided in the Executive Summary and detailed responses to the individual charge questions are provided in the body of the report.

3. RESPONSES TO EPA's CHARGE QUESTIONS

3.1. Evaluating the Methodology

3.1.1. Literature Review

Charge Question 1: Section 2 of the report summarizes existing retrospective cost studies. Has EPA adequately summarized the existing literature or mischaracterized it in some way? Is the SAB aware of any additional studies not captured in the interim report? Have we captured key take away messages offered by this literature? How can this discussion be improved?

Section 2 of the RCS summarizes the existing literature and main results showing that regulatory compliance costs are more often overestimated than underestimated. Section 2 also presents studies that actually show that the ex ante costs are higher than the ex post costs. The emphasis on studies of Title IV of the 1990 Clean Air Act Amendments (CAAA) was especially appropriate because it identified the main forces that affect the adjustment to regulations and the causes of deviation from ex ante to ex post. The study by Popp (2003) is especially insightful and an excellent reference.

The SAB recommends that EPA take a broader perspective on this question and begin with a conceptual framework. In principle, ex ante studies estimate something that will happen in the future and as such, an ex ante estimate is the sum of biases reflecting uncertainty about the future (timing bias) plus a random measurement error term. If the ex post estimate is the sum of the true cost plus a random measurement error, then we can divide the difference between the ex ante and ex post estimates to estimate a timing bias plus an error term. Then, the literature review can be used to understand any systematic biases and random effects that may be causing the difference. Such understandings could lead to improvements in future cost studies.

A richer analysis would be achieved by first forming a hypothesis regarding the differences between ex ante and ex post, then reviewing the literature in this light. As discussed in the RCS and in the next section, there are several hypotheses about the causes of differences between ex ante and ex post estimates. One such hypothesis is strategic behavior by regulated agents. Since regulated agents provide information that is used to estimate the ex ante costs, the regulated agents may report higher than expected costs in order to influence the regulator's decision. The other hypothesized cause is technological change, a phenomenon that is frequently underestimated, especially in response to regulation. Other issues that may result in bias are related to issues of enforcement and compliance and better understanding of the structure of the problem. Exploring these hypotheses before surveying the literature can guide the analysis.

One study that is quite insightful from Europe that wasn't mentioned is by Bailey et al. (2002). This study raises the issue of strategic behavior as well as adjustment in terms of technology, innovation and implementation that can drive a wedge between ex ante and ex post costs.

In sum, the RCS provides a good literature review but more insight could be gained by starting with a conceptual analysis of factors that may affect the gap. A survey of the literature is best guided by some basic hypotheses deriving from a conceptual analysis.

3.1.2. Potential Reasons Ex Ante and Ex Post Cost Estimates Differ

Charge Question 2: Section 3 of the report briefly describes potential reasons ex ante and ex post estimates might differ. Has EPA accurately described the various hypotheses? If not, how can this discussion be improved? Are there other hypotheses that should be included or considered?

The RCS does a good job amassing and explaining the variety of reasons for discrepancies between ex ante and ex post cost estimates. It lists such factors as industry incentives to overstate their costs in order to influence policy in their favor, induced innovation after implementation of regulations, changing market conditions over time such as the reduction in costs of transporting low sulfur coal in SO_2 regulation, etc. The RCS describes possible regulator incentives to understate costs but it should also acknowledge that regulators may face incentives to overstate costs when benefits are extremely high. A high ratio of benefits to costs can reduce the regulators' incentive to precisely estimate compliance costs given that the economic feasibility of the rule is ensured. As EPA moves forward in its next phases of the RCS, it will be important to uncover and state incentives faced by the regulator. Interestingly, EPA acknowledges its own data manipulation in one case study: "EPA was "conservative in its cost estimates, in order to avoid preparing estimates that were too low and could be challenged."[1] Economic analysis should not be manipulated to satisfy other objectives.

While the RCS describes the factors that can cause wedges between ex ante and ex post estimates, it did not attempt to group or classify these factors, nor did it suggest how these factors can bias the estimates. For some factors, the direction of the ex ante and ex post differences can go both ways, but for others, there is strong theoretical (and sometimes empirical) argument for the differences to go one direction only. It might be easier to "correct for" some differences but not for others. An alternative classification scheme to highlight these features is suggested below.

- Ex ante and ex post differences due to inherent uncertainties. Fundamentally, ex post costs are dependent on realizations of states of nature, while ex ante estimates represent the best effort to estimate the distribution of states of nature. As such, differences, even large differences, are genuine features of imperfect information and are hard to correct. This kind of difference can go both ways, but if the ex ante distribution is skewed, the ex post realizations are asymmetrically distributed around the ex ante mean, leading to a higher probability of the ex post realization above or below the mean depending on the direction of the skewness.
- Differences arising from asymmetric information and strategic (mis-)reporting. Since the EPA often relies on the regulated industries for cost information, these industries might have incentive to strategically misreport their private information. Misreporting predominantly takes the form of over-reporting the compliance costs rather than under-reporting, especially at the aggregate level. Over-reporting is more likely and of a higher magnitude when (i) more is at stake for the industries, (ii) the firms are more effectively organized and are more homogeneous, (iii) the degree of information asymmetry is high (e.g., lack of correlated information from objective third parties), and (iv) opposing groups (such as consumer groups) are more pronounced in voicing their opinions. (Note that the four kinds of factors provide, at least theoretically, guidelines about the drivers for misreporting and possible ways of correction such as utilizing results from the mechanism design literature.)

[1] / RCS. p. 53.

- Differences due to firm responses to regulation. This includes induced innovation as well as other gradual responses such as substitution toward different inputs. The endogenous firm responses will make ex post costs lower than ex ante estimates.
- Differences due to exogenous shocks. They include exogenous changes in market conditions, in (related but separate) regulations, and in natural conditions after the implementation of the regulation. Ex ante and ex post differences can go either way. Although efforts can be made to better assess future changes, such shocks are difficult to capture fully in ex ante cost estimation.
- Differences due to inconsistent baseline between the ex ante and ex post estimates. It is important to have a consistent timeline for considering the costs of implementation of the regulation.

3.1.3. Case Study Methodology

Charge Question 3: One goal of the EPA study is to demonstrate the use of different methodologies for obtaining ex post information on key drivers of compliance cost. While the level of coverage and detail does not match what is typically used in an ex ante analysis in support of a rule, the purpose is to gather enough evidence on key drivers to establish a weight of evidence determination on the direction of ex post costs compared to ex ante costs. These approaches are briefly described in section 4 of the report. Are some approaches more defensible than others? If so, which ones and why? Which of the methodologies are more likely to yield reliable results and why? Or are the merits of each method dependent upon characteristics of the case study to which they are being applied? If some methodologies are more applicable under specific contexts or rule settings, please identify and describe. Are there other methodologies that should be considered for ex post cost analyses?

In some cases, it may be possible to find a dataset containing sufficient information for an ex post statistical analysis that would identify the costs of a new regulation, but this usually will not be possible. Two major obstacles are the reluctance of firms to provide detailed data on production costs and the likelihood that other factors besides the regulation have changed. In the locomotive case study, firms were reluctant to cooperate by providing data on costs, and there were major changes in industry demand and diesel fuel prices.

It's important for an ex post analysis of regulatory costs to take a systematic approach to the process. Start with a "story" about the ways in which the industry was expected to achieve compliance (based on information from the ex ante regulatory analysis), and connect this story to the various components that went into the ex ante cost calculations. This provides a "bottom up" calculation for total industry costs. Then identify ways in which the actual industry experience was similar to or different from the ex ante expectations, including an assessment of how much of an impact (positive or negative) each difference would have had on compliance costs. This could include a discussion of the heterogeneity of responses among the firms in the industry, and factors other than regulation that affected the industry's level of activity. The end result would be at least a qualitative idea of whether actual compliance costs were significantly lower than expected, higher than expected, or similar - and why. Perhaps more importantly, it provides information that could be used to modify the methodology for future ex ante estimates - or at least a healthy degree of skepticism about how much can be known in advance.

The methodology section of the RCS includes an overview of how the rules to be analyzed were selected, a description of the decision rule used to identify substantial differences between ex ante and

ex post cost estimates and a discussion of different potential sources of data for the ex post cost estimates and ways to gather pertinent information about compliance activities as well as what would have happened in the absence of regulation. The discussion in this section is largely focused on the last issue regarding identifying sources of cost data and approaches to gathering other information necessary to understand compliance activities. We discuss each of these sections in turn.

Selection of rules for study: The process used to identify the rules has the virtue of starting from a fairly comprehensive list of regulations issued in the past 17 years. The rules for eliminating regulations from the list (small regulations, etc) seem reasonable. EPA economists used EPA's Rules and Policy Information Development System (RAPIDS) to identify candidate rules for analysis. They focused on economically significant rules (those with costs over $100 million) and recent regulations (issued since 1995) that were deemed easier to evaluate. Older rules were deemed less appropriate because they pre-dated recent advances in benefit cost analysis. This process yielded a list of 111 entries from which various rules were discarded, e.g., rules that were not yet implemented, remanded by the courts, represented minor amendments to existing rules or had costs below the $100 million cost threshold or rules deemed too difficult to analyze. This winnowing of the set resulted in a list of 42 regulations that was vetted internally at EPA to make sure no major rules were missing. Notably over half of the rules on the list of 42 are air regulations. The RAPIDS database does not include regulations applied to chemicals, including pesticides, so one rule in this category was selected through a separate process. It would be helpful to know the process by which that rule was selected and how many pesticide (and chemical) regulations might be included if these rules had been treated similarly to the waste, effluent and air emissions rules included in the larger sample.

Ultimately EPA selected 10 rules for the RCS study. The five rules include in Phase 1 were chosen to illustrate the use of different data gathering methodologies and a range of regulations (different media and regulatory forms). For Phase 2 the regulations were selected using a randomized stratified approach (three air regulations and two other). Randomization is important for, as Simpson (2011) points out, most of the rules that have been included in prior studies comparing ex ante and ex post analyses have not been randomly selected, but selected because there is data or, in some cases, to make a point about particular forms of regulation (such as incentive based regulations, or regulations of energy efficiency standards for appliances). As a result, it may be difficult to generalize the findings of the prior studies. The main goal in rule selection should be to identify a random sample of rules as well as to cover a range of different EPA regulations - not just focus on air quality regulations where estimated health benefits can be very high, providing little incentive to estimate costs precisely.

The small number of rules that EPA has chosen for study in the RCS also limits the generalizability of its findings. One way to supplement the set of case studies currently planned would be to do more qualitative studies of a larger sample of rules to identify the most important factors that affect differences between ex post and ex ante cost estimates across the different rules. Such studies could provide important lessons regarding the relative importance of different cost drivers and how those drivers differ across regulations.

Discerning Real Cost Differences: In the draft RCS study, EPA uses a +/– 25% cost difference threshold to define discernible differences between ex ante and ex post costs. There is precedent in the literature for using this threshold (Harrington et al. 2000; OMB 2005) and it seems to be a reasonable one as it avoids the assumption of too much precision in either cost estimate. Nonetheless, it is

important to understand the reasons for cost differences even if these differences fall below the 25% threshold.

Sources of Cost Data and Related Information: Ideally, to facilitate replicability and independence, the RCS would use only publicly available data and not rely on sources of ex post cost data from sources that had a vested interest in the findings of the ex ante analysis of compliance costs (the RIAs). In the absence of existing data, EPA could use an industry wide survey to gather relevant information from all regulated firms, but such surveys are costly to conduct, difficult to implement and subject to strategic misreporting.

Historically, data on environmental compliance costs were collected in the Pollution Abatement Costs and Expenditures (PACE) Survey formerly conducted annually by the Census Bureau (and in some years funded by EPA). Regulated establishments were required by law to answer this survey so non-response was less severe. However, these data have not been collected since 2005 and not on an annual basis for almost 20 years. Also, the PACE Survey historically did not break out regulatory costs by particular regulations (only by media and category of cost), so discerning the costs of complying with particular regulations would likely require additional information to be collected should the survey be reinitiated in the future. Nonetheless, it would be very useful to resume annual administration of the PACE survey and data collection based on the survey. Conducted annually by the Census Bureau from 1973-1994, these data have been the basis for many studies of regulatory costs over the years. A redesigned version was launched in 2005, but was only collected for one year. The PACE survey, if collected annually, would provide baseline measures of pollution abatement expenditures from years before a regulation is adopted (or even proposed), and would permit comparison with similarly-measured abatement costs after the regulation is implemented. By contrast, acquiring the same data with regulation-specific surveys is likely to be difficult or impossible, given the time lags inherent in survey approval and the uncertainties in developing comparable measures of pre-regulation costs. In addition, the 2005 PACE included questions about specific water and solid waste pollution abatement techniques in use at the facility, along with usage of a detailed list of air pollution control devices, distinguishing between newly installed devices and those previously in use. Thus the PACE data could assist with both quantitative statistical analysis of changes in pollution abatement costs following the implementation of a new regulation and a detailed qualitative analysis about the techniques being used to comply with that regulation. The major limitation of the PACE survey is that it covers only manufacturing facilities, so alternative data sources would be needed for regulations covering other sectors.

For four of the five rules included in Phase 1 of the study, there was insufficient information in the public domain to estimate ex post costs. Thus for those rules (cluster, MACT II, Arsenic and Locomotive rules) EPA had to rely on industry experts, many of whom provided information and expertise to the development of ex ante costs used in the RIAs. An extensive process was used to identify experts and develop a questionnaire relevant to each case study. Given the reliance on experts for information, it would be useful for the EPA staff to consult the literature on expert elicitation to see if there are any particular statistical issues or techniques that they should be aware of when using this approach.

The draft report indicates that more detailed information gathering (including a site visit to a regulated facility) will be incorporated in Phase 2. An important part of that process will be the selection of the

rules under which the site visit will be conducted and identification of the site to be visited. The timing of the site visit could also be important to the extent that it provides lessons that might be useful in conducting the ex post cost evaluations of other rules.

Methodology for Comparing Rules: An important omission from the methodology section is the specification of a framework to make the studies of the different regulations more comparable to one another and provide consistent documentation of the different factors that contribute to differences (or similarities) between ex ante and ex post cost estimates. Understanding the underlying factors that contribute to differences in cost is important to drawing conclusions about which factors could have been anticipated and to the ultimate goal of this study which is to understand what, if any, adjustments to ex ante cost estimation approaches should be made to provide better predictions of actual costs of compliance. Understanding these factors does require consultation with industry experts including experts within EPA or consultants about what firms and farms did to comply with regulation and comparing those outcomes to what was expected in the RIAs. Publicly available sources of data will generally not be sufficient for getting this type of information (unless a prior ex post study has been conducted). Public data sources may be particularly deficient when there are multiple avenues for compliance and considerable heterogeneity among the regulated firms.

One approach to enhancing comparability across the case studies that might be generalizable is illustrated in the locomotive rule case study where each of the underlying components of the ex ante cost calculation is identified and the difference between each ex ante assumptions and post regulatory realizations for each component is evaluated to understand its contribution to differences in ultimate cost estimates. This approach helps to clarify the sources of differences and similarities and could help to illustrate what factors might be common across regulations and what factors are idiosyncratic to particular regulations.

While the focus of the RCS is to do a retrospective cost calculation, in order to understand why ex post estimates differ from ex ante, it would be useful to know more about the underlying assumptions about technological change, input and output prices and other key inputs in the ex ante study. Instead of comparing a single ex ante estimate with a single ex post estimate it might be better to generate a range of estimates under alternative assumptions for these key inputs and see if the resulting range or distribution of ex ante and ex post estimates overlap. By starting with the ex ante distribution of cost estimates and the underlying assumptions, one could examine which assumptions might explain the gap between ex ante and ex post estimates.

3.2. Evaluating the Case Study Approach

3.2.1. Data Challenges

Charge Question 4: Each case study encountered a number of data-related challenges. Comprehensive, detailed data on compliance costs simply was not available for any of the case studies. In some cases, the EPA obtained detailed data on compliance costs for a small segment of the affected industry. In others, the Agency obtained aggregate level data for a larger proportion of the industry.

a. Under what conditions are different sources of ex post data useful/not useful for assessing ex post costs? In responding, please consider each of the following sources of data: aggregate information from states, data from demonstration projects, detailed data for a small portion of a heterogeneous industry, detailed data on what technologies have been adopted but unit costs for a "typical" entity, expert opinion on costs without external validation, cost estimates from contractors that worked on the original rule.

By design, the RCS used only publicly available data, most of which is highly aggregated. Survey data would have strengthened all the case studies, but failing that, it is appropriate to use aggregate information from states, data from demonstration projects, detailed data from small portions of industry, unit costs for "typical" entities, expert opinions and cost estimates from contractors. All of these data can be intelligently interpreted with proper qualifications to broaden the scope of the ex post analysis. In particular, if available quantitative and qualitative data suggest the same conclusion, then it is appropriate to note that. Aggregate information does not reveal what really caused the differences in ex ante and ex post costs but supporting stories on what caused the differences underlying the data can help improve understanding. The approach of using unit costs for a "typical" entity is useful. Like a "price and quantity" approach, prices (unit cost) can be multiplied by quantity (number of units) to get an estimate but the more heterogeneous the industry, the more sampling would be needed to get unit costs for each technology. When using expert opinions, it is helpful to have corroborating information.

b. Is there anything more we could do with the data we have for these case studies that would yield meaningful conclusions?

In general, improvements to the case studies depend upon getting more data but a systematic approach across case studies would at least improve the readability of the case studies and it may improve the analysis. The locomotive case study did a nice job in following a systematic approach as exemplified by their presentation slide which outlined 11 distinct components of compliance costs, the available sources of ex post data for each component, and an assessment of whether that component had turned out to be larger or smaller than the ex ante estimate.. One suggestion for the locomotive case study would be to identify cases where the industry behaved differently than expected and use that information to look back at the Agency's original assumptions about costs. The locomotive case study assumed a fairly high fixed cost to develop and certify a new engine model, leading to the conclusion that few new models would be developed. In fact, many new models were developed, which could have raised the question of whether the fixed costs of model development may have been lower than expected.

c. Do you have ideas on ways we can collect better ex post information for these case studies given limited resources? Are there data sources we have not considered that we could use?

In the longer run, for future ex ante cost analyses, EPA might consider ways of building in a routine ex post data collection effort either within the Agency or in collaboration with other agencies. One source of ex post information could be regulatory staff (from both EPA and state agencies) involved in monitoring and enforcing compliance with specific regulations. The Agency might also explore the possibility of working with statistical agencies to insert questions related to costs of compliance into regularly conducted surveys (e.g., the surveys of costs of agricultural enterprises taken by the National Agricultural Statistics Service).

3.2.2. Analytic Challenges

Charge Question 5: When conducting these ex post cost analyses, EPA also struggled with a number of analytic challenges including establishing a clear counterfactual and disentangling costs incurred in response to a regulation from costs associated with other activities pursued simultaneously (e.g., system upgrades, product redesigns).

a. Do you have suggestions on ways to better meet these challenges?

EPA was appropriately cautious about data that might have included other kinds of capital spending, such as upgrades to expand water treatment facilities or paper mills. A related analytic issue is the construction of a baseline. For the Cluster Rule case study, the construction of industry's baseline spending should be revisited. The public comments provided by the National Council for Air and Stream Improvement (NCASI) and American Forest and Paper Association (AF&PA) provided strong evidence of voluntary, pre-emptive spending before the promulgation of the Cluster Rule in 1998. It is worth revisiting the choice of a "starting point" for the construction of a baseline. For the Cluster Rule, it appears that voluntary capital expenditures were clearly made to remove dioxin from air and water emissions in anticipation of the regulation that was ultimately promulgated in 1998. The SAB believes this pre-regulatory, voluntary spending should be counted in EPA's cost estimates, both ex ante and ex post, if there is clear evidence that it was directly driven by impending regulations.

b. Do you have any thoughts or recommendations on how EPA can estimate or better apportion costs across activities pursued by industry and differentiate between the regulatory driven and non-regulatory driven changes?

More detailed survey data are needed across the board. One opportunity to separate regulatory driven and non-regulatory changes is presented in the MBr case study in which it might be possible to take advantage of heterogeneity in regulation at the state and local level. As noted in the study, the rules on fumigant use vary considerably between states and even between townships within a state. Survey data collected from farmers could take advantage of that variation to separate regulatory effects from other changes in the industry.

c. What should the EPA do in cases where there is a real paucity of data that limits the analytic options? Are some methods of estimation more or less useful in these cases (e.g., expert opinion,

maintaining consistency with ex ante; a rough estimate based on assumptions and publicly available data)?

The ex post analysis used available data in reasonable and creative ways, combining expert opinion, engineering estimates, publicly available data, aggregate data from states, etc. Given that the appropriate method of estimation is extremely context-dependent, it does not seem wise to generalize about particular methods.

3.2.3. Weight of Evidence Conclusions

Charge Question 6: Given the various data and analytic challenges, is it appropriate to draw "weight of evidence" conclusions on compliance costs based on the examination of key drivers of cost?

Given the data challenges for assessing the ex post costs for the five case studies, it may only be reasonable to reach conclusions about the key drivers of costs and the likely direction of the divergence between ex ante and ex post costs. To draw "weight of evidence" conclusions based on the limited data available to the EPA as described in the RCS would be a stretch in most cases.

a. Are thre cases where drawing conclusions is less or more defensible?

When multiple methods corroborate each other, a particular conclusion is more defensible.

b. Some previous retrospective exercises have used hard metrics for evaluating whether costs are over or underestimated (e.g., Harrington et al. used +/- 25 percent). This same metric was applied in the case studies presented in the Interim Report. Should the EPA continue to use this metric? What are the drawbacks, if any, to applying a consistent metric across the case studies given their differences in data quality?

The SAB is less in favor of drawing a hard line than reporting actual numbers, e.g., 15% underestimate or 90% overestimate or even a range.

3.3. Moving Forward

3.3.1. Using Ex Post Cost Comparisons to Inform the Agency

Charge Question 7: It is difficult to make general statements about the accuracy of ex ante estimates of the costs of a regulation because the promulgation of every regulation is a unique event. Different considerations of timing, technology, industry structure, and a host of other factors go into the estimation of ex ante costs and determine the accuracy of those ex ante estimates relative to ex post experience. With this in mind, how can the EPA meaningfully make generalizations concerning ex ante cost estimates based on ex post comparisons? How can ex post cost comparisons be used to inform how the Agency estimates costs ex ante for future rules?

In order to make meaningful generalizations, one needs a sufficiently large sample size to identify patterns in the data. The SAB suggests modifying the research strategy to do more, but shorter, qualitative analyses of regulations in Phase 2. These analyses would examine selected ex ante studies to identify three components of prediction: (1) the expected compliance method(s); (2) the key factors expected to affect the compliance cost for firms using each method; and (3) the expected distribution of the compliance methods and costs across the regulated entities. This approach provides a "bottom-up" analysis, breaking down total compliance costs along these three components. The goal would be to improve ex ante analyses by identifying and categorizing any deviations observed ex post from the expected components of compliance costs. Was there an unanticipated compliance method? Did surprisingly rapid technological change or unexpected shifts in factor prices affect compliance costs for a given compliance method? Did market forces change overall industry size or composition, affecting the mix of compliance methods used?

Note that these deviations wouldn't necessarily cause prediction errors in total compliance costs, because there could be multiple deviations, for example, a failure to foresee a cheaper compliance method could be offset by an underestimate of the industry size. Getting "the right answer for the wrong reasons" isn't a good result. On the other hand, a well-conducted ex ante study could identify the correct compliance method and understand the drivers of compliance costs perfectly, but underestimate actual costs because of an unexpected rise in fuel prices.

At least some of the ex ante studies chosen for analysis should be selected in some predetermined probabilistic manner and the number of studies should be large enough (perhaps 25 to 30 in all, including the 10 already identified in Phase 1 and 2) for the sample to be representative. This will allow for generalization of results. The shorter nature of the analyses should allow for a larger sample than currently planned. There should also be fewer worries about data availability, since the qualitative approach is less demanding. The SAB also suggest that the probabilistic-based selection process be a stratified random sample where regulation size, pollution type, and even political salience of the regulations is considered in sampling, but that is an issue EPA will need to sort out given its particular needs.

After doing a substantial number of these qualitative studies, the deviations from ex ante expectations could be examined to look for patterns in the types of deviations observed across different settings (by pollution medium, by industry size, by the time lag until implementation, by the key factors affecting costs, by the amount of resources devoted to the analysis). If certain types of deviations are very

common (e.g., always underestimating the rate of technological change in regulations with a long time lag), future ex ante analyses could take that into account in their calculations. Perhaps more important, this could encourage ex ante analyses to more explicitly deal with uncertainty along the lines where errors are common in the ex ante studies. If fuel prices play a major role in compliance costs, the ex ante analysis could highlight that assumption, e.g., "we assume that diesel fuel will cost $2 per gallon and predict $150 million in total compliance costs, but if the price of diesel rises to $4, we predict $200 million in total compliance costs."

Note that the SAB is suggesting "qualitative" analyses in the sense that they do not yield bottom-line total cost estimates, completeness across all cost categories, or flesh out details on each cost component. Instead, they leave the analyst with the flexibility to discover and present well-formed and documented 'stories' that identify the large drivers of differences between ex ante and ex post results. Some regulations will require more depth than others. Most analyses would likely have a quantitative aspect but with much less detail than one would find in full replication of the ex ante study or what has been done thus far in Phase 1. For example, ex post unit cost estimates for different compliance strategies would be obvious quantitative data points of interest.

The relatively detailed quantitative analyses conducted in Phase 1 and anticipated for Phase 2 seem much less likely to yield generalizable results. First, the sample size is too small - only 10 regulations studied, spread across a variety of pollution media and other differences (as noted in the charge question itself). Second, the Phase 1 studies show that it is rare to find sufficient ex post data to construct complete quantitative measures of compliance costs, which raises concerns about selectivity. If the Agency only looks at regulations that happen "under the lamppost" of available data, its conclusions will not reflect the full spectrum of regulations. . Third, as Phase 1 demonstrates, the differences in data quality across the regulations, and the differences in resources available for doing ex ante and ex post studies, make it problematic to treat a set of "ex ante - ex post" quantitative calculations as "homogenous" observations for the purposes of statistical (or regression) analysis.

Instead, the SAB suggest concentrating primarily on qualitative ex post analysis. The existing Phase 1 and Phase 2 studies provide a set of 10 regulations. For each regulation, categorize the ex ante expectations about compliance costs (compliance methods, key factors affecting compliance costs for each method, and distribution of methods across the industry), and identify any ex post deviations from those expectations. Develop a systematic approach to categorizing the expectations and deviations, as well as the characteristics of the regulations. This will make it easier to analyze the results of the qualitative studies for patterns, and to present those results in a way that facilitates comparisons across regulations. The necessary qualitative information about deviations from expectations may be available from industry experts within or outside EPA; some information (such as the actual compliance methods being used) may also be available from federal or state inspectors responsible for enforcing the regulation.

More complete quantitative analyses could be carried out for one or two of the Phase 2 regulations where data are available. The broader (and more randomly selected) set of additional qualitative analyses, in addition to providing more generalizable results, will also provide a framework for interpreting the detailed compliance cost comparisons in the quantitative analyses.

3.3.2. General Statements on the Bias of Ex Ante Estimates

Charge Question 8: Previous studies in the literature have focused on the relative proportions of over- and underestimates of costs or the average ratio of ex ante to ex post cost estimates. In section 3, EPA suggested reasons for which these indicators might not reveal a bias in ex ante cost estimates, and have suggested a regression-based procedure for making such a determination.

a. Is it possible to make general statements as to the accuracy of ex ante cost estimates? If so, what might be the best way to evaluate their accuracy?

It is not possible to make general statements as to the accuracy of ex ante cost estimates. The best way to evaluate their accuracy is to identify systematic errors in procedures, methods and data used in previous ex ante analyses and to uncover the key factors or driving forces that cause the differences between ex ante and ex post cost estimates. However, it may be difficult to determine if there are procedural or methodological errors that generate bias because there is only one analysis per regulation. Given the uncertainty that accompanies both ex ante and ex post estimates and the variability in uncertainty over time, the probability that ex ante and ex post estimates are identical should be small, and a finding that ex ante generally over or under-estimates ex post costs is not a finding of procedural error. An over/under estimate can occur every time, especially with few repeating analyses, without any underlying procedural bias.

Given the above, quantitative assessments of ex ante cost estimate accuracy are not likely to be very informative as supported by the analysis of Simpson (2011). However, qualitative assessments of process and choice factors that appear to have been important in a random sample of cases may help refine best practices. The goal should be a consistent set of best-practice rules that are followed, and those rules should be updated frequently as lessons are learned from ex post analyses.

b. Is it appropriate to concentrate on the bias of ex ante cost estimates, or might other statistical measures be more revealing?

Ex ante estimates of the effects of an environmental regulation, by definition, are based on information available before the policy is undertaken. Because of uncertainties about technological progress and other factors affecting the compliance costs, it is likely that ex ante estimates will differ from the ex post costs. The larger the uncertainties, the smaller the probability that the ex ante estimates will equal the ex post estimates. Under such circumstance, an appropriate ex ante analysis would provide an estimate of the range of the expected compliance costs. Let $f(C)$ denote the probability distribution function of the ex ante estimate of the compliance cost of an environmental regulation, with $C \in [C_{\min}, C_{\max}]$. The best ex ante estimate of the compliance cost based on the information available equals the mean of the distribution, denoted by $\bar{C}$. The probability that the difference between the best ex ante estimate and the ex post cost is greater than ΔC equals

$$\text{Prob}(\text{difference} > \Delta C) = \int_{C_{\min}}^{\bar{C}-\Delta C} f(C)dC + \int_{\bar{C}+\Delta C}^{C_{\max}} f(C)dC .$$

This suggests that the larger the uncertainties about technological progress and other factors affecting the compliance costs, the larger the probability that the ex ante estimate will be different from the actual

ex post compliance cost by a large amount. In this sense, the term "the bias of ex ante cost estimates" is an invalid concept, unless the procedures, methods or data used to conduct the ex ante analysis are invalid or inappropriate.

Given this, the SAB again suggests that it is useful to concentrate on the "bias" of ex ante cost estimates only if the objective is to uncover the systematic errors in procedures and methods used to collect and analyze data used in previous ex ante analyses and/or in reporting of results. Such examinations are useful for future ex ante analyses as well as for policy reforms. If the ex ante estimates of compliance costs are too small, the regulation might be too stringent; if the ex ante estimates are too high, the regulation might be too lenient.

3.3.3. Rules for Evaluation

Charge Question 9: The rules addressed in the Interim Report were selected so as to cover a range of media. Rules identified for Phase 2 of the project were randomly selected using stratified sampling. For both Phase 1and Phase 2 rules, EPA has encountered (and continues to encounter) data challenges that make it difficult to draw conclusions regarding realized compliance costs. If EPA continues with this project, is there a way to credibly identify rules that would lead to informative ex post cost studies from which conclusions can be drawn?

As noted above in the overall comments, discussion of ex ante versus ex post costs has emphasized whether a "weight of evidence" determination can be made on whether ex ante costs are higher or lower than ex post costs. Too narrow a focus on this goal naturally leads to a focus on information-rich rules. Too much focus on information-rich rules may lead to bias that undermines the credibility of the effort. Of particular concern is the possibility that more complete cost information may be confounded with analyst or stakeholder concern that ex ante estimates are more likely to be off the mark for those rules. Perhaps less cost information is associated with those rules for which ex ante estimates are more trusted. This would imply data rich rules are not representative of the population of relevant rules.

The SAB recommends an alternative approach to randomly select rules, determine what classes/sets of compliance costs associated with the rule are reasonably measurable, and then conduct analysis based on available information. This may lead to partial analyses that do not provide insight into a "weight of evidence" determination on the relationship between ex ante and ex post costs. However, these partial analyses may be quite useful in helping "identify systematic differences between ex post and ex ante cost compliance estimation, and ultimately allow for improvements in the way in which ex ante analyses are done" (RCS, p. 7). Qualitative information should be used to identify the important drivers of potential differences between ex ante and ex post cost estimates. For some rules, cost information is so scarce that no insights are possible. However there should be at least partial information for most rules that could provide insights regarding this second goal. Using random rule selection and examining those compliance cost drivers turns the unit of observation into randomly selected drivers. The focus on the drivers or factors that influence the accuracy of ex ante cost estimates should also help to improve the usefulness of this analysis for future ex ante compliance cost assessments in regulatory impact analyses conducted by the EPA.

a. What should our priorities be with regard to how we select the sample of rules for evaluation? Should we compromise the random selection of rules in favor of selecting rules with more readily available data? If so, on what types of rules should we focus? What types of rules could we defensibly leave out? What kind of selection biases would we introduce under different sampling methods? For instance, if we exclude rules where the industry is particularly heterogeneous or data are difficult to identify, can we still draw conclusions that would be generally applicable?

A significant portion of the rules selected for analysis should be drawn randomly from the candidate rules. In addition, EPA should try to identify a few of the most important rules. Note the recommendation is not to select rules according to how much information is available, but rather to make sure some consideration is given to the most high profile rules. Since the initial screening process eliminated rules with very low costs, candidate rules may have already been selected on account of their significance. For most of the rules selected for study, random selection should not be compromised. At the rule selection stage, there is no scientifically plausible defense for a priori leaving out rules simply because they do not have complete information.

It is difficult to predict the direction of bias from studying only information-rich rules or rules that affect homogeneous firms. Suppose that information is generated in response to a belief that ex ante and ex post costs are more likely to diverge. In that situation, concentrating all analytical effort on information-rich rules would likely provide a biased view on the precision of ex ante estimates.

b. How do we balance pragmatism vs. the purity of our sampling method, given our experiences (e.g., the challenges/limitations we have faced due to lack of participation by industry, an inability to identify industry compliance experts, potential contractor bias, and data limitations)? Should our choice of methodology inform the way we select the sample of rules or vice versa?

With respect to the first question, the balance between pragmatism and purity of the sampling method is fundamentally dependent on the analytical methods used. If, as discussed in Section 3 of the RCS, a regression-based procedure is adopted to analyze the differences between the ex ante and ex post cost estimates, then the statistical properties of the data are crucial to the validity of the inferences that are drawn. In this case, the "purity" of the sampling method is very important.

However, the SAB agrees with EPA that there is limited value in using econometric tools in the absence of sufficient ex post cost data. Incomplete data, variability in the quality of the available data, and incomplete specification of possible drivers and their measurement preclude specification of an appropriate statistical methodology and sampling strategy. Even if all rules in Table 1.1 were included, the sample is still too small (n=42) to permit robust inferences about multiple drivers, even disregarding the obvious data issues (sample selection bias, measurement errors, missing variables, etc.). As described elsewhere, the SAB favors a pragmatic qualitative review of a larger number of rules followed by detailed quantitative analysis of a smaller number of rules, focused on analyzing drivers for systematic differences between ex ante and ex post estimates.

For the second question, the methodology should drive the sampling method. In following the recommended "qualitative followed by quantitative" approach, the Agency might consider stratifying rules. Proper stratification along the dimensions of pollutants (air, water, etc.), nature of regulated entities (public vs. private), timing of regulation, and heterogeneity of responses, among others, enables identification and understanding of the drivers and their impacts on the ex ante and ex post differences. The analysis thus focuses on the drivers rather than cost differences themselves. In following this approach, there is no need to balance pragmatism and purity because there is no tradeoff.

3.3.4. Building a Database

Charge Question 10: What additional suggestions does the SAB have on how best to build a database of ex ante versus ex post cost comparisons of regulation given the difficulties the Agency has faced thus far?

Although the RCS is focused specifically on EPA regulations, many of the issues of concern are not unique to the United States, or even to environmental policy. As a result, it may be possible to expand the database of ex post studies by surveying environmental regulatory agencies in Europe and elsewhere that may have carried out similar exercises. In the long run, that would help EPA establish guidelines for ex post analysis that would draw on international best practices. Similarly, it may be possible to expand the database through inter-agency collaboration as other federal or state agencies may have carried out ex post analyses that could be included in the database.

In the long run, building an extensive and authoritative literature comparing ex ante and ex post analysis will require deep and continuing involvement with the outside research community. To facilitate the development of that literature, it would be very valuable to establish a long-term program on ex post analysis that could provide research grants and funding for conferences and workshops.

Building a good base of knowledge for ex ante vs. ex post assessment of regulatory impacts is a major challenge that will take time and resources. EPA and the outside research community need to establish a base of evidence that will be sufficiently large to allow statistical inference of differences between ex ante and ex cost estimates under alternative circumstances. The time required to improve this understanding can be shortened if, as noted above, EPA takes advantage of economies of scale and increases the evidence considered to include cases related to regulations outside the United States and in individual states. But increasing the evidence base may lead to a tradeoff between quantity and quality and incorporation of extra evidence will require additional care. The understanding of the causes of ex ante vs. ex post differences will be enhanced if it will become a major subject of academic research, and that can be affected by financial and other incentives.

Differences between ex ante and ex post estimates of regulatory costs are not limited to environmental regulation and occur in other fields. The SAB recommends that EPA make a concerted and ongoing effort to learn from experiences in other regulatory fields. The Agency may be able gain additional data for ex ante studies if it works with statistical agencies to insert questions related to costs of compliance for regulatory requirements in various surveys and studies taken by these agencies (for example the surveys of costs of agricultural enterprises taken by the National Agricultural Statistical Survey (NASS). Care should be taken in the design of questions to account for strategic behavior by respondents.

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APPENDIX A: CHARGE QUESTIONS

MEMORANDUM

To: Holly Stallworth, Designated Federal Officer
Science Advisory Board Staff Office

From: Nathalie B. Simon, Associate Director
National Center for Environmental Economics

Date: March 30, 2012

Subject: Charge Questions for SAB-EEAC Advisory on the "Retrospective Study of the Costs of EPA Regulations: An Interim Report of Five Case Studies," April 19-20, 2012

The purpose of this memorandum is to transmit charge questions for consideration by the Science Advisory Board's Environmental Economics Advisory Committee (SAB-EEAC) during the upcoming Advisory meeting scheduled for April 19 and 20th on the "Retrospective Study of the Costs of EPA Regulations: An Interim Report of Five Case Studies."

Benefit-cost analyses are often conducted to inform decision-making at the Environmental Protection Agency (EPA). While the EPA strives to use the best available science and engineering when conducting its economic analyses, they are by their very nature uncertain, relying on forecasted information. While new science and the need to quantify more, previously unquantified benefits has driven benefits analysis, comparatively less work has been done retroactively examining how well EPA estimates the costs (or benefits) of regulation. The ex post cost studies that are available in the literature are often based on limited data and overlap in coverage – many of the same regulations appear in multiple publications. And, while the literature posits a number of hypotheses for why one might expect ex ante and ex post cost estimates to differ, ex post analyses are too few in number to be able to credibly accept or reject these hypotheses.

The National Center for Environmental Economics (NCEE) has launched an effort to evaluate the feasibility of augmenting the existing literature with additional ex post evaluations of costs. Using a case study approach, we attempt to determine if sufficient information can be gathered on individual rules to make a "weight of evidence" determination about whether ex ante costs are higher or lower than ex post costs. If the case study approach is successful, there is much that can be learned from this effort. A careful assessment of ex post costs could help identify systematic differences between ex post and ex ante compliance cost estimation and, ultimately, allow for improvements in the way in which ex ante analyses are done. For instance, if unanticipated changes in market conditions, energy prices, or available technologies regularly result in an over or underestimate of costs, the EPA can invest in improving methods that better capture these effects on costs ex ante.

"Retrospective Study of the Costs of EPA Regulations: An Interim Report of Five Case Studies" (March 2012) summarizes the initial findings from a small set of pilot case studies that attempt to evaluate the costs of EPA regulatory and other policy actions ex post. The initial set of case studies rely on a variety of methods for collecting ex post information – some mainly rely on publically available

data and literature and are conducted internally, while others rely on industry experts or third-party data collected by a contractor.

The five case studies presented in the interim report are:

- Integrated NESHAP and Effluent Guidelines for Pulp and Paper (1998)
- NESHAP: Chemical Recovery Combustion Sources at Kraft, Soda, Sulfite and Stand-Alone Semichemical Pulp Mills (2001)
- Methyl Bromide Critical Use Nomination for Preplant Soil Use for Strawberries Grown for Fruit in Open Fields on Plastic Tarps (2004-2008)
- National Primary Drinking Water Regulation for Arsenic (2001)
- Locomotive Emission Standards (1998)

To be clear, the case studies in this report do not aim to estimate ex post costs of these EPA actions. Rather, they examine key drivers of compliance costs to see if informed *judgments* (weighing the evidence) can be made about whether ex post costs are higher or lower than the estimates of ex ante costs.

While a number of these case studies are suggestive of overestimation of costs ex ante, EPA could not cost-effectively gather sufficient information in other case studies to form judgments. As a group they expand our understanding of how and why ex ante costs may differ, but they are not conclusive. First, they only represent a small subset of regulatory and other policy actions taken by the EPA. Second, conducting ex post analysis has proven more challenging than anticipated. With regard to data, these challenges have included the inability to identify qualified industry experts that did not also work on the rule and limited access to industry data. Analytic challenges have included how to evaluate a highly heterogeneous industry with a limited set of information, how to form a reasonable counterfactual, and disentangling the costs of compliance from other factors, to name a few.

Before proceeding with additional work in this area, NCEE is seeking advice from the SAB-EEAC on the case study approach applied in the paper and specifically on appropriate methodologies to be applied in these and future case studies. As such, the findings presented in the report should be considered preliminary and are subject to change.

Please contact me if you have any questions about the attached charge.

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Part I: Evaluating the Retrospective Cost Study Methodology

(1) Section 2 of the report summarizes existing retrospective cost studies. Have we adequately summarized the existing literature or have we mischaracterized it in some way? Are you aware of any studies we have missed? Have we captured key take away messages offered by this literature? How can this discussion be improved?

(2) Section 3 of the report briefly describes potential reasons ex ante and ex post estimates might differ. Have we accurately described the various hypotheses? If not, how can this discussion be improved? Are there other hypotheses that should be included or considered?

(3) One goal of this study is to demonstrate the use of different methodologies for obtaining ex post information on key drivers of compliance cost. While the level of coverage and detail does not match what is typically used in an ex ante analysis in support of a rule, the purpose is to gather enough evidence on key drivers to establish a weight of evidence determination on the direction of ex post costs compared to ex ante costs. These approaches are briefly described in section 4 of the report. Are some approaches more defensible than others? If so, which ones and why? Which of the methodologies are more likely to yield reliable results and why? Or are the merits of each method dependent upon characteristics of the case study to which they are being applied? If some methodologies are more applicable under specific contexts or rule settings, please identify and describe. Are there other methodologies that should be considered for ex post cost analyses?

Part II: Evaluating the Case Study Approach

Conducting ex post cost analyses for the selected rules proved to be more difficult than expected. We encountered a number of challenges, both data-related and analytical in the process. Please answer questions 4 through 6 **for each case study**.

(4) Each case study encountered a number of data-related challenges. Comprehensive, detailed data on compliance costs simply was not available for any of the case studies. In some cases, we obtained detailed data on compliance costs for a small segment of the affected industry. In others, we obtained aggregate level data for a larger proportion of the industry.

a. Under what conditions are different sources of ex post data useful/not useful for assessing ex post costs? In responding, please consider each of the following sources of data:

- aggregate information from states,
- data from demonstration projects,
- detailed data for a small portion of a heterogeneous industry,
- detailed data on what technologies have been adopted but unit costs for a "typical" entity,
- expert opinion on costs without external validation,
- cost estimates from contractors that worked on the original rule

b. Is there anything more we could do with the data we have for these case studies that would yield meaningful conclusions?
c. Do you have ideas on ways we can collect better ex post information for these case studies given limited resources? Are there data sources we have not considered that we could use?

(5) When conducting these ex post cost analyses, we also struggled with a number of analytic challenges including establishing a clear counterfactual and disentangling costs incurred in response to a regulation from costs associated with other activities pursued simultaneously (e.g., system upgrades, product redesigns).
   a. Do you have suggestions on ways to better meet these challenges?
   b. Do you have any thoughts or recommendations on how EPA can estimate or better apportion costs across activities pursued by industry and differentiate between the regulatory driven and non-regulatory driven changes?
   c. What should we do in cases where there is a real paucity of data that limits our analytic options? Are some methods of estimation more or less useful in these cases (e.g. expert opinion, maintain consistency with ex ante; a rough estimate based on assumptions and publically available data)?

(6) Given the various data and analytic challenges, is it appropriate to draw "weight of evidence" conclusions on compliance costs based on the examination of key drivers of cost?
   a. Are there cases where drawing conclusions is less or more defensible?
   b. Some previous retrospective exercises have used hard metrics for evaluating whether costs are over or underestimated (e.g., Harrington et al. used +/- 25 percent). This same metric was applied in the case studies presented in the Interim Report. Should we continue to use this metric? What are the drawbacks, if any, to applying a consistent metric across the case studies given their differences in data quality?

Part III: Moving Forward

(7) It is difficult to make general statements about the accuracy of ex ante estimates of the costs of a regulation because the promulgation of every regulation is a unique event. Different considerations of timing, technology, industry structure, and a host of other factors go into the estimation of ex ante costs and determine the accuracy of those ex ante estimates relative to ex post experience. With this in mind, how can we meaningfully make generalizations concerning ex ante cost estimates based on ex post comparisons? How can ex post cost comparisons be used to inform how the Agency estimates costs ex ante for future rules?

(8) Previous studies in the literature have focused on the relative proportions of over- and underestimates of costs or the average ratio of ex ante to ex post cost estimates. In section 3, we have suggested reasons for which these indicators might not reveal a bias in ex ante cost estimates, and have suggested a regression-based procedure for making such a determination.
   a. Is it possible to make general statements as to the accuracy of *ex ante* cost estimates? If so, what might be the best way to evaluate their accuracy?
   b. Is it appropriate to concentrate on the bias of ex ante cost estimates, or might other statistical measures be more revealing?

(9) The rules addressed in the Interim Report were selected so as to cover a range of media. Rules identified for Phase 2 of the project were randomly selected using stratified sampling. For both Phase 1 and Phase 2 rules, we have encountered (and continue to encounter) data challenges that make it difficult to draw conclusions regarding realized compliance costs. If we continue with this project, is there a way to credibly identify rules that would lead to informative ex post cost studies from which we can draw conclusions? Specifically,

   a. What should our priorities be with regard to how we select the sample of rules for evaluation? Should we compromise the random selection of rules in favor of selecting rules with more readily available data? If so, on what types of rules should we focus? What types of rules could we defensibly leave out? What kind of selection biases would we introduce under different sampling methods? For instance, if we exclude rules where the industry is particularly heterogeneous or data are difficult to identify, can we still draw conclusions that would be generally applicable?

   b. How do we balance pragmatism vs. the purity of our sampling method, given our experiences (e.g., the challenges/limitations we have faced due to lack of participation by industry, an inability to identify industry compliance experts, potential contractor bias, and data limitations)? Should our choice of methodology inform the way we select the sample of rules or vice versa?

(10) What additional suggestions do you have on how best to build a database of ex ante versus ex post cost comparisons of regulation given the difficulties we have faced thus far?