AMOCO/USEPA POLLUTION PREVENTION PROJECT

Executive Summary

December, 1991
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Appendix C Project Documentation

Forward

This volume provides an executive summary of work completed during a voluntary, AMOCO/USEPA Pollution Prevention Project undertaken at Amoco Oil Company's Yorktown, Virginia Refinery. Overall goals of the Project were to (1) inventory releases of all pollutants to the environment from the Refinery; (2) develop, evaluate and rank process, maintenance and operating options that reduce these releases; and (3) identify barriers and incentives to implementing the alternatives identified.

Special thanks are due to the AMOCO/USEPA Workgroup who provided Project oversight and direction during this two-year, $2.3 million effort. In addition, more than 200 people, from 35 organizations participated at various times in this unique Project. Their enthusiasm and contributions are obvious from the wealth of ideas developed, considered and analyzed. Their assistance supports a central belief of this Project: that developing effective solutions to complex environmental management problems will take the best efforts of the many 'partners' in our society. We extend a personal thanks to all participants.

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Amoco/USEPA Pollution Prevention Project

ABSTRACT

In late 1989, Amoco Corporation and the United States Environmental Protection Agency began a voluntary, joint project to study pollution prevention opportunities at an industrial facility. The Amoco/EPA Workgroup, composed of EPA, Amoco and Commonwealth of Virginia staff, agreed to use Amoco Oil Company's refinery at Yorktown, Virginia, to conduct a multi-media assessment of releases to the environment, then to develop and evaluate options to reduce these releases. The Workgroup identified five tasks for this study:

1. Inventory refinery releases to the environment to define their chemical type, quantity, source, and medium of release.

2. Develop options to reduce selected releases identified.

3. Rank and prioritize the options based on a variety of criteria and perspectives.

4. Identify and evaluate factors such as technical, legislative, regulatory, institutional, permitting, and economic, that impede or encourage pollution prevention.

5. Enhance participants' knowledge of refinery and regulatory systems.

Project Organization, Staffing, and Budget

Workgroup: Monthly Workgroup meetings provided Project oversight, a forum for presentations on different Project components, and an opportunity for informal discussion of differing viewpoints about environmental management. Although attendance varied, each meeting included representatives from various EPA offices, the Commonwealth of Virginia, and Amoco.

Peer Review: At the Workgroup's request, EPA arranged for Resources for the Future to assemble a group of outside scientific and technical experts. This Peer Review Group provided evaluation and advice on the Project workplan, sampling, analysis results, and conclusions. Members of this group were paid a small honoraria for their participation.

Workshop: A special Workshop, held during March 24-27, 1991 in Williamsburg, Virginia, reviewed sampling data and identified reduction options and ranking criteria. More than 120 people from diverse backgrounds--EPA, Amoco, Virginia, academia and public interest groups--attended the Workshop.

Participants: More than 200 people, 35 organizations, and many disciplines were involved in this Project. This reflected a central belief of this Project that solving difficult environmental problems must draw on many of society's "partners."

Cost: Total cost for this Project was approximately $2.3 million. Amoco Oil Company provided 70 percent of the funding and EPA the remainder.

Lessons and Results

Refinery Release Inventory

A. Existing estimates of environmental releases were not adequate for making a chemical-specific, multi-media, facility-wide assessment of the Refinery.

B. A substantial portion of pollution generated at this refinery is not released to the environment.

C. The Toxic Release Inventory database does not adequately characterize releases from this Refinery.

D. Site specific features, determined during the facility-wide assessment, affect releases and release management options.

Reducing Releases

A. A workshop approach, drawing on a diverse group representing government, industry, academic, environmental, and public interests, developed a wide range of release reduction options in a multi-media context more quickly than either EPA or industry alone would do.

B. Pollutant release management frequently involves the transfer or conversion of pollutants from one form or medium to another.

C. Although the Refinery is highly efficient in handling materials (currently recovering 99.7 percent of its feedstock in products and fuel), four source reduction options identified show positive rates of return ranging from one to nineteen percent.

D. Source reduction is not necessarily practical for all release management options, despite its cost effectiveness. Effective release management requires a combination of source reduction, recycling; treatment and safe disposal.

Choosing Alternatives

A. Ranking the options showed that better environmental results can be obtained more cost-effectively. At this facility, about 97 percent of the release reductions that regulatory and statutory programs require can be achieved for about 25 percent of today's cost for these programs. Table 1.3 summarizes several management options.

These savings could be achieved if a facility-wide release reduction target existed, if statutes and regulations did not prescribe the methods to use, and if facility operators could determine the best approach to reach that target.

B. All participants agreed on which options were the most effective and which were least, regardless of their institutional viewpoints and preferred ranking criteria.

Obstacles and Incentives to Implementing Pollution Prevention

A. EPA does not have the policy goal and may not have the statutory authority to simply set an emissions reduction "target" without prescribing how this target should or could be met. Current administrative procedures discourage such an approach, including the analysis of tradeoffs in risks, benefits, and costs of managing residual pollutants in different media.

The Agency is required to implement media-specific legislation enacted by Congress. In addition, EPA does not have the technical and analytical skills to determine if multi-media, facility-wide reduction plans are meeting the requirements established in single medium-specific legislation. This would make compliance monitoring and enforcement more difficult than present approaches.

B. Many legislative and regulatory programs do not provide implementation schedules compatible with design, engineering, and construction timeframes. Consequently, short-term "fixes" which meet legal deadlines are used at the expense of more cost- and environmentally effective, long-term, solutions.

C. Well established problem-solving approaches are difficult to change. Congress, EPA, and much of industry are used to command-and-control, end-of-pipe treatment approaches based on twenty years of experience. Many of today's problems could benefit from a different approach.

D. Inadequate accounting for both the benefits and costs of environmental legislation and regulations is an obstacle to developing a more efficient environmental management system.

Responsibility for pollutant generation and accountability for environmental protection are difficult to quantify.

Recommendations

1. Explore Opportunities to Produce Better Environmental Results More Cost-effectively.

2. Improve Environmental Release Data Collection, Analysis and Management.

3. Provide Incentives for Conducting Facility-wide Assessments, and Developing multi-media Release Reduction Strategies. Such Strategies must Consider the Multi-Media Consequences of Environmental Management Decisions.

4. Encourage Additional Public/Private Partnerships on Environmental Management.

5. Conduct Research on the Potential Health and Ecological Effects of VOCs.

SUMMARY

1.1 Project Goals

In late 1989, Amoco Corporation (Amoco) and the United States Environmental Protection Agency (EPA) began a voluntary, joint project to study pollution prevention opportunities at an industrial facility. The Amoco/EPA workgroup (Workgroup), composed of EPA, Amoco, and Commonwealth of Virginia staff, agreed to use Amoco Oil Company's refinery at Yorktown, Virginia (the Refinery), to conduct a multi-media assessment of releases to the environment, then to develop and evaluate options to reduce these releases. The Workgroup identified five tasks for this study:

1. Inventory refinery releases to the environment to define their chemical type, quantity, source, and medium of release.

2. Develop options to reduce selected releases identified.

3. Rank and prioritize the options using a variety of criteria and perspectives.

4. Identify and evaluate factors such as technical, legislative, regulatory, institutional, permitting, and economic, that impede or invite pollution prevention.

5. Enhance participants' knowledge of refinery and regulatory systems.

Figure 3.1 shows a schematic diagram of the Refinery, potential release sources, and a number of pollution prevention options identified in this Project. Table 3.2 describes specific options to reduce releases. At the time this Project began, pollution prevention was a concept predicated on reducing or eliminating releases of materials into the environment rather than managing the releases later. The Workgroup adopted this general concept and agreed to consider all opportunities--source reduction, recycling, treatment, and environmentally sound disposal--as potential choices in pollution management. Since then, Congress, in the Pollution Prevention Act of 1990, and other organizations, have put greater emphasis on source reduction as the primary, if not the exclusive, means to accomplish pollution prevention.

A central goal of this Project was to identify criteria and develop a ranking system for prioritizing environmental management opportunities that recognized a variety of factors including release reduction, technical feasibility, cost, environmental impact, human health risk, and risk reduction potential. Due to the inherent uncertainties in risk assessments, the Project focused on relative changes in risk compared to current levels, rather than establishing absolute risk levels. Because of difficulties in quantifying changes in ecological impact from airborne emissions, changes in relative risk were based primarily on human health effects indicated by changes in exposure to benzene. The risk assessment did not include a quantitative analysis of VOCs due to limited information on their health effects.

This project focused on pollution and potential risks posed by normal operation of the Refinery and chronic exposure to its releases into the environment. Minimizing emergency and upset events is a top priority of Amoco's facility managers. Such events can have catastrophic results. However, they were not studied in this project because: (a) prevention and control of such events involves significantly different skills, technical resources, and analyses than controlling releases from day-to-day operations (AIChE, 1985); (b) the number, type, and frequency of incidents at Yorktown is very low; and (c) data regarding the type of release, and relevant meteorology during the release are not available for analysis. Appendix D describes potential emergency and upset events that might occur at a petroleum refinery and the general preventative measures used to minimize their severity and the likelihood of their occurrence.

1.2 Project Organization, Staffing and Budget

Project Content: The Pollution Prevention Project has many components. Each component defines and addresses an issue associated with pollution prevention and facility management choices. These include pollutant source identification, sampling, exposure modeling, risk assessment, etc. Table 1.1 provides a complete list of the components in this Project. The Project workplan outlined the purpose and content for most of these components (Amoco/EPA, 1990).

Exclusions/Limitations: A number of areas specifically excluded or limited in this Project are described in Appendix B. Some are listed below:

^G Limited sampling time and data provided a "snapshot" of releases rather than measured annual values.

^G Very few generally accepted methodologies exist for the sampling used to obtain a site-wide release inventory, particularly for measuring air emissions. Both EPA and Amoco concerns about specific sampling issues are highlighted in Appendix B and discussed in more detail in Air Quality Data, Volume II (Amoco/EPA, 1992 b).

^G The Project considered available technologies rather than exploring innovative techniques for reducing releases.

^G Chemical changes of airborne pollutants were not evaluated.

^G Data and analysis focused on the Yorktown Refinery. Site-specific features of this facility and its emissions may not apply to other refineries. Broader regional concerns were not evaluated.

^G The forthcoming human health risk assessment focuses on potential cancer risks associated with benzene exposure outside the facility fenceline.

Peer Review: At the Workgroup's request, Resources for the Future organized a group of outside scientific and technical experts. This Peer Review Group provided evaluation and advice on the Project workplan, sampling, analytical results, and conclusions. Members of this group were paid a small honoraria for their participation and reimbursed for travel expenses to Washington by EPA. A report summarizing their comments is included as part of the documentation for this Project. Appendix C lists all Project documentation.

Workgroup: Monthly Workgroup meetings provided Project oversight, a forum for presentations on different Project components, and an opportunity for informal discussion of differing viewpoints about environmental management. Although attendance varied, each meeting included representatives from various EPA offices, the Commonwealth of Virginia, and Amoco.

Workshop: A special Workshop, held during March 24-27, 1991, in Williamsburg, Virginia, reviewed sampling data and identified reduction options and ranking criteria. More than 120 people from diverse backgrounds--EPA, Amoco, Virginia, academia and public interest groups--attended the Workshop. The Workshop sessions resulted in suggestions that further refined and directed Project activities (Amoco/EPA, 1991a).

Participants: More than 200 people, 35 organizations, and many disciplines have been involved in this Project. Table 1.2 lists the various participating organizations.

Cost: Total cost for this Project was approximately $2.3 million. Amoco Oil Company provided 70 percent of the funding and EPA the remainder.

1.3 Lessons and Results

1.3.1 Refinery Release Inventory

A. Existing estimates of environmental releases were not adequate for making a chemical-specific, multi-media, facility-wide assessment.

The Yorktown Refinery had good information about the quantity of material released to the York River from NPDES Permit monitoring requirements, and for solid wastes as a result of internal programs and participation in recent American Petroleum Institute surveys (API, 1991b). These releases, however, made up only 11 percent of the total releases from the facility. Available data did not include adequate chemical-specific characterization of the water discharge or solid waste streams.

The Refinery (and other refineries as well) could not easily identify specific airborne hydrocarbon compounds released or the quantity released because:

(a) Refineries typically do not manufacture products with specific chemical compositions, and therefore do not routinely measure chemical compositions of their products or emissions. Rather, refinery products have specific properties such as octane, freeze point, and sulfur content. Crude oil, the raw material used to make these products, contains thousands of distinct chemicals that are never fully separated during the manufacturing processes. Airborne releases from this kind of facility are similarly complex.

(b) Most hydrocarbons are released through a large number of widely distributed sources (valves, flanges, pump seals and tank vents). Even a small refinery may have more than 10,000 potentially different sources. Direct measurement of each of these sources is not practical.

(c) The quantities released through any single source are extremely small--on the order of pounds per year--dilute and difficult to measure. In addition, some large sources that emit pollutants in the amount of tons per year are difficult to measure and quantify. Total hydrocarbons released from Yorktown Refinery from all sources were approximately 0.3 weight percent of the total crude oil processed. Therefore, they would not be detected through normal mass balances and materials accounting (NRC, 1990).

Thus, collecting detailed, chemical specific release information used to characterize the Refinery was expensive and time consuming. This Project developed a sampling and monitoring program that included about 1,000 samples (see Figure 2.2). Each sample was analyzed for 15-20 chemicals. The sampling program took about 12 months to complete at a cost of about $1 million. Even with this time and dollar commitment, only selected sources were sampled. The final release inventory was assembled using a combination of sampling, measurements, dispersion modeling, and estimates based on emission factors.

Because this sampling program was a first of its kind effort, its scope was intentionally broad. Subsequent analysis showed that not all of the information obtained was necessary to identify significant sources and potential reduction options. For the Yorktown Refinery (and the petroleum refining industry overall), more general information, such as source specific VOC emissions, is adequate to identify many of the pollution prevention projects developed in this study. Total VOC emissions are a good indicator of overall emissions and can be used for tracking emissions reduction progress.

B. A substantial portion of pollution generated at this refinery is not released to the environment.

The release inventory process allowed a comparison of pollutant generation, on-site management and ultimate releases to the environment. The Refinery generates about 27,500 tons/year of pollutants. As a result of site hydrogeology, on-site wastewater treatment, and solid waste recycling practices, about 12,000 tons are recovered, treated or recycled and do not leave the Refinery site. Of the remaining 15,500 tons about 90 percent are released to the air.

Figure 2.4 illustrates the transfers which take place between generation and ultimate release. Figure 2.5 characterizes pollutants released from the Refinery. This site-wide analysis of pollutant generation and release characteristics allowed the Workgroup to focus much of the remaining Project resources on the largest releases--airborne emissions.

Modeling studies indicated relatively little naturally occurring transfer of hydrocarbon emissions from air into other media (Cohen and Allen, 1991). Most hydrocarbons are not very water soluble, and so are not easily removed from the air by rainfall. Section 2.0 includes a more detailed discussion of the potential for transfer to other media. Although the fate of criteria airborne pollutants (like NOX and SO2) was not studied in this Project, they are known to be scavenged by rainfall and can contribute to nitrogen loads and pH changes in lakes and soil (See Appendix B). Measurements and modeling results showed small transfers from some surface water ponds to groundwater. Groundwater also enters the wastewater treatment system through the underground sewers, resulting in a net groundwater inflow.

Transfers of pollutants between media do occur, particularly as a result of pollution management activities. Over 370 tons/year of hydrocarbons initially present in wastewater streams are volatilized into air from the water collection system. More than 2,000 tons/year of biosolids are produced by treating wastewater in the Refinery's activated sludge system.

C. The TRI database does not adequately characterize releases from this Refinery.

Title III of SARA, Emergency Planning and Community Right-to-Know Act, created the Toxic Release Inventory (TRI) in 1986. Title III requires regulated facilities in SIC Code 20-39 to submit annual release data on more than 300 chemicals manufactured, produced or otherwise used in quantities exceeding certain threshold values. Releases to all media must be reported. The TRI is one way of focusing corporate attention on release reduction opportunities.

TRI reports are based on either emission estimates, direct measurements or a combination of both methods. Each facility is responsible for the accuracy of the data reported. Industrial facilities frequently file amendments to TRI reports to reflect improvements in the accuracy of the estimation and measurement techniques.

The TRI database has become the de facto national release inventory. The quality and utility of data reported can vary widely. At a plant that uses a single solvent to wash manufactured parts, and that purchases extra solvent every year to make up for evaporative losses, the quantity of solvent emissions is well known and tracked through monthly purchasing records. A TRI report which included this solvent and plant should be quite accurate. However, at the Refinery, the TRI does not report total facility emissions because:

^G The TRI is based on estimates rather than measurements. Estimating accuracy varies widely. During the measurement portion of this Project, several new sources were identified whose significance had been previously underestimated. One source was identified which had been overestimated. Figure 2.7 summarizes the results of this analysis.

^G The measurement phase of this Project revealed substantially higher TRI reportable emissions from the blowdown stacks than had been estimated previously. On the other hand, measurements revealed that emissions from wastewater sources had been overestimated. Amoco has filed an amendment to its past TRI reports for Yorktown to reflect new data. Figure 2.7 compares the starting TRI data with results obtained from the Project.

^G The TRI focuses on specific chemicals which account for only a portion of the total emissions. In the Refinery's case, the TRI report covers only 9 percent of the total hydrocarbons released, and only 2.4 percent of the total releases to all media. Criteria pollutants--CO, NOX, SO2, and PM-10--are not reportable in the TRI.

^G Some activities and emissions are excluded by EPA from record
keeping requirements, such as emissions from barge loading. At this facility, barge loading operations account for about 20 percent of the total benzene emissions (See Figure 3.4).

Finally, TRI provides an approximate inventory of selected materials released to the environment. TRI data by itself does not allow for meaningful risk evaluation or comparisons on a facility basis, because it does not define the facility's relationship to nearby populations and ecosystems.

D. Site specific features determined during the facility-wide assessment, affect releases and release management options.

National programs, by design, address overall problems in specific media. But these programs seldom consider site-specific differences in developing standards. Other refineries, and indeed other industrial facilities, can use the general sampling approach developed here to obtain the facility-wide release inventory. However, each site will exhibit unique geophysical and process characteristics. Each assessment plan must include these site-specific characteristics in its design and focus. As an example, the Yorktown Refinery does not have a hydrofluoric acid (HF) alkylation unit and HF was not measured. HF can pose a significant health risk if managed improperly, and may need to be tracked at facilities that use it.

Groundwater: As a result of a clay soil layer, unique hydrogeology, the placement of the underground drainage system relative to the water table, and local climate, groundwater movement at this site is minimal. In fact, the underground drainage system is acting as a groundwater collection unit, sending groundwater to the Refinery's wastewater treatment plant.

Thus, groundwater at this site is not leaving the property. Furthermore, sampling showed surprisingly low levels of groundwater contamination, compared to other refineries (LA Times, 1988).

Marine Loading Emissions: Yorktown Refinery uses marine transportation for receiving all crude oil and shipping more than 80 percent of its products. Estimated releases from product loading operations are 784 tons/year of VOCs. Computer modeling analysis showed this source had the greatest impact on exposure of nearby residences to Refinery hydrocarbon emissions. Therefore, it would be useful to include marine loading emissions in this facility's environmental management plans. Many other refineries rely more on pipeline, rail and truck shipments to handle crude and products, and would thus not expect to find the same potential impact from marine operations.

Airshed Status: As discussed in Appendix A, the Refinery is located in an airshed classified as an attainment area for all criteria pollutants including ozone. Therefore, relatively few hydrocarbon emission controls have been required or installed at this facility. The sampling program and release reduction options focused on hydrocarbon releases. Many other refineries in ozone non-attainment areas have already installed extensive hydrocarbon emission controls. Consequently, other facilities may have a significantly lower percentage of hydrocarbon emissions. Similarly, NOX, CO, PM-10 and SO2 emissions have been more tightly controlled in some other airsheds (such as the Los Angeles basin) which do not meet NAAQS for these pollutants.

1.3.2 Release Reduction Options

A. A workshop approach, drawing on a diverse group representing government, industry, academic, environmental and public interests developed a wide range of release reduction options

in a multi-media context more quickly than EPA or industry alone would do.

The release inventory described in 1.3.1 above, served as the basis for identifying ways to reduce releases. A 3-day brainstorming Workshop, held in Williamsburg, Virginia generated more than 50 potential release reduction options for the Refinery. These ranged from producing a single grade of gasoline to specific technical options for particular equipment or processes. Table 3.1 lists all options identified.

The Workgroup subsequently narrowed this list to 12 options for more careful, quantitative analysis. This winnowing process considered only those options that were technically feasible now, offered potentially large release reductions, addressed different environmental media, and posed no process or worker safety problems. Projects designed to comply with several current or anticipated regulations were also included. Table 3.2 lists engineering projects included for further analysis.

The Workshop also addressed screening criteria to help prioritize the options, potential barriers and incentives for implementation, and permitting concerns. The diverse viewpoints brought to all these discussions helped guide subsequent Project activities. These views reinforced the Workgroup's desire to consider broader issues such as multi-media release management consequences, future liability impacts, etc. The Workshop was able to consider these issues more comprehensively than either government or industry alone would normally do.

B. Release management frequently involves the transfer or conversion of pollutants from one form or medium to another.

It is not at all unusual for pollutants to be converted and transferred from one form or media to another as part of a pollution control practice. For example, scrubbers used to remove acidic pollutants from many electric utility stacks generate large volumes of calcium sulfate sludge (EPRI, 1983) which must also be managed. For options developed at the Yorktown Refinery:

^G Modifications of the underground drainage system and process water treatment plant (required under the Benzene Waste Operations NESHAP; Federal Register, 1990) will improve process water treatment and reduce air emissions, but produce more solid waste such as biosolids and fully spent activated carbon.

^G The Refinery has limited sludge processing capacity. Keeping soils out of sewers would reduce the amount of sludge in the API Separator and thus allow for more on-site management of other solid wastes, reducing offsite disposal.

^G Installing an electrostatic precipitator would reduce FCU particulate (PM-10) emissions (catalyst fines), but transfer the additional collected particulates to land disposal.

^G Burning hydrocarbons that cannot be economically recovered generates other criteria pollutants which may also need to be managed.

None of these transfers or transformations are bad, in and of themselves. The Project simply pointed out the need to recognize, plan, and manage these changes at an early stage of the release management cycle.

C. Source reduction options were more cost-effective than most treatment and disposal alternatives. Nevertheless, source reduction alone was not adequate to achieve all the desired or legally required release reductions.

The Workgroup agreed to consider the waste management hierarchy--source reduction, recycling, treatment, and safe disposal--as the basis for developing release reduction options. Technologies identified and analyzed fit into this hierarchy. Time and budget constraints limited technology choices to conventional, proven solutions rather than exploring innovative alternatives.

However, less than half the options identified qualified as "source reduction." Had the options been limited to only source reduction, the scope of potential opportunities for reducing releases and improving environmental quality would have been unnecessarily restricted.

If all source reduction options identified in this Project were implemented, benzene and total hydrocarbon emissions would be reduced by about 25 percent and 16 percent, respectively. The Workgroup concluded that a cost-effective strategy for the Refinery would have to include a mix of source reduction, recycling, treatment and disposal options.

Of the source reduction options considered, most appear to be significantly lower cost than recycling, treatment, and disposal. Source reduction options considered have had an average cost of $650/ton of pollutant recovered. The remaining seven options analyzed had an average cost of $3,200/ton, nearly 5 times higher. The cost-effectiveness of individual options varied form a low of $190/ton for secondary seals on gasoline storage tanks to a high of $128,000/ton for the treatment plant upgrade.

D. While release reductions do not always pay for themselves, some environmental improvements can be made at a net cost savings to the Refinery.

The Refinery is relatively efficient in managing materials. An ongoing weight-loss management program to capture lost material has been in place at all Amoco refineries for a number of years. Approximately 99.7 percent of the incoming crude is converted to useful products and refinery fuel. The hydrocarbon release reduction options identified in this Project dealt with the remaining 0.3 percent.

Despite the relative efficiency of the Refinery, two source reduction options--seals on gasoline tanks and a leak detection and repair program--have net cost savings and a positive rate of return. Amoco did not know this before this Project. On the other hand, some of the source reduction options and all treatment options were not economic investments for the Refinery.

For example, fitting all fixed roof storage tanks with secondary seals would result in much higher cost for relatively little additional reduction in hydrocarbon emissions compared to fitting only gasoline storage tanks. Treatment options generally require significant capital outlays with no return in the form of recaptured or improved product. Technology options with positive rates of return are shown in Figure 3.9. Options that have negative return are not shown.

1.3.3 Choosing Alternatives

A. Ranking the options showed that better environmental results can be obtained more cost-effectively.

Compliance with current and anticipated regulations requires controls for eight sources types, reducing airborne hydrocarbon releases by 7,300 tons/year at an average cost of $2,400/ton.

The Refinery could reduce about 7,100 tons of airborne hydrocarbons each year (or about 97 percent) by controlling six sources at about 25 percent of the cost. This cost-effectiveness comparison does not account for possible benefits to other media.

If allowed to address both hydrocarbons and listed hazardous waste, the Refinery could reduce about 7,500 tons per year at an average cost of about $500/ton using its choice of sources and techniques. Table 1.3 provides a more detailed comparison of different Release Management Strategies, results and costs.

These results are all the more significant because the options evaluated were neither selected nor developed ahead of time with a target reduction goal in mind. Nor did the selection process have a goal of meeting regulatory requirements in some alternative fashion. This suggests that even more impressive results might be achieved, if that were the focal point at the beginning.

B. All participants agreed on which options were the most effective and which were least, regardless of their ranking criteria or institutional viewpoints.

The Project used a multi-dimensional prioritizing process (the Analytical Hierarchy Process, AHP) in which weights were developed for all criteria used to rank alternatives. These criteria included cost, release reduction, timeliness and changes in benzene exposure, among others. The process allowed the Workgroup to assess the significance of and interactions between criteria--how changes in one criterion affect other criteria and total rankings.

All options were considered legally acceptable, and no specific regulatory requirements were imposed on the decision making process. Although different organizations brought different perspectives to the discussions, each organization reached the same conclusions about which options would be most effective and which were least. The driving forces in this prioritization were cost and relative risk reduction, as measured by benzene exposure. A variety of sensitivity studies confirmed this initial set of preferences.

Amoco ranked control of marine loading losses as the most effective--though not the lowest cost--option. A second tier of options included installing secondary seals on tanks, instituting a leak detection and repair program, and upgrading blowdown stacks. All four were also viewed as reasonably effective pollution prevention projects. In total these four projects would prevent or capture almost 6,900 tons of releases annually at a cost of about $510/ton. EPA and Virginia selected the same five options, in this hypothetical case with no specific regulatory requirements. See Items 4 and 5 in Table 1.3.

1.3.4 Obstacles and Incentives to Implementing Pollution Prevention

After identifying several alternative environmental management options, it is reasonable to ask why these options are not being implemented. What can be done to encourage their use? The following discussion summarizes the general findings based on an assessment of potential obstacles and incentives for implementing five highly ranked options. For more details, see Section 5.0.

A. EPA does not have an explicit policy goal and may not have the statutory authority to simply set a release reduction "target" without prescribing how this target should or could be met. When the target involves releases in multiple media, current administrative procedures discourage a coordinated approach, including evaluating risks, costs and benefits of managing residual pollutants in different media.

Requirements under many statutes and regulations prescribe how release reductions should be achieved, sometimes in terms of which technology should be used, often in terms of which specific sources should be controlled. For example, the Benzene Waste Operations NESHAP focuses on a specific emissions source to a single medium--benzene emissions from wastewater. The rule requires control of benzene emissions from this single source.

Data from this refinery indicated that wastewater is a small contributor to total benzene releases. Amoco and EPA disagree about some of the specific measurements and results. These are discussed in detail in Air Quality Data, Volume II (Amoco/EPA 1992b).

A number of pollution prevention approaches developed in this Project are more effective in controlling benzene emissions, and less costly to implement than the benzene NESHAP. Other refineries might find other sources that present more cost-effective control opportunities. Focusing on individual sources, rather than on desired overall "performance," limits the ability to achieve the most cost-effective control.

RCRA requires application of the Best Demonstrated Available Technology (BDAT) to a hazardous waste before it can be disposed.

BDAT standards are typically based on a destruction technology rather than on methods at the higher end of the pollution prevention hierarchy.

One proposal now before Congress (S. 1081) to reauthorize the Clean Water Act would amend 304(b) of the Act and require EPA to promulgate effluent guidelines which reflect the application of best available control technology (BAT) for all categories of pollutants. This Congressional proposal, which does not reflect the Administration's position, could limit the Agency's ability to set environmental protection priorities.

B. Legislative and regulatory programs do not provide implementation schedules compatible with design, engineering, and construction timeframes.

Most regulatory and statutory programs require compliance within six months to at most three years after promulgation of a final rule. In some cases, compliance requirements do not consider normal maintenance schedules and economic penalties associated with facility-wide shutdowns. Consequently, short-term "fixes" which can meet legal deadlines, are used at the expense of more cost- and environmentally effective, long-term solutions.

A typical refinery project for processing oil using established technology and design procedures, normally takes 2-3 years from initial design to startup, assuming there is agreement on what to build, no unusual equipment delivery problems, no additional safety considerations, and no prolonged startup difficulties. Many projects take longer when regulatory applicability, scope or design criteria are unclear, or new technologies are involved.

For example, the benzene NESHAP rule discussed above was promulgated in March 1990 (under the 1977 Clean Air Act Amendments). Statutory language required compliance with the regulations within two years. In this case, significant differences in interpretation between EPA and the regulated community took more than one year to resolve and to clarify the regulatory requirements. An acceptable understanding is a prerequisite to engineering and construction. It was physically impossible to design, engineer, procure, construct, and start up the required control within the remaining one year compliance time frame.

C. Congress, EPA and much of industry have become used to command-and-control, end-of-pipe treatment approaches based on twenty years of experience. These well established problem solving approaches are difficult to change.

In the 1970's, environmental regulations successfully helped reduce point source emissions to air and water. End of pipe treatment was successful partly because many industrial firms and permitting authorities had little experience dealing with these problems, and found the specification of technical solutions offered a "road-map" for how to proceed along an uncharted course. These requirements also provided a relatively "level playing field" for US industry. Many of today's problems are sufficiently different than those of the early 1970's that they can benefit from alternative approaches.

D. The short time taken by the Virginia Air Pollution Control

Board to issue or modify air permits is not a deterrent to installing technologies to reduce airborne emission at this site.

Most of the technical options would reduce air releases at the Refinery. However, obtaining permits to install most of these technologies would probably not be a problem since the Virginia Air Pollution Control Board is estimated to take about six months to issue a permit (Virginia is a delegated state for issuing air permits).

However, information generated through a facility-wide multi-media assessment is a necessary first step to not only developing a strategy to reduce these releases, but also to exploring such implementation options as integrated permits.

E. Inadequate accounting for both the benefits and costs of environmental regulations is an obstacle to developing a more efficient environmental management system. Responsibility for pollutant generation and accountability for environmental protection are difficult to quantify.

At many industrial plants, such as Amoco's, waste management costs are frequently charged to a central environmental management division rather than to the operating unit that generates the waste. Remediation costs for clean-up of contaminated soil, for example, are frequently charged against another cost center, rather than to the generator of the contamination. This separation between release generation and costs is a disincentive to manage releases more effectively.

Few EPA accounting systems measure direct benefits of the Agency's activities, such as improved ecological health, biodiversity, reduced risk to human populations, etc. Rather, accomplishments are usually measured in terms of activities such as permits written, amount of fines collected, or number of enforcement actions pursued. (GAO, 1991) The lack of direct connection between Agency activities and environmental results reduces accountability for program costs and benefits. Without adequate measurement systems, it is difficult to tell when environmental management practices actually improve the environment.

1.3.5. Education/Communications/Working Relationships

This Project enhanced knowledge of both government and industry, and generated information that EPA and Amoco can use.

The study provided an opportunity to educate individuals within EPA and Amoco. Based on plant visits and information exchanges, EPA personnel better understand how a refinery works, the complexities of the refining processes, and the difficulties in obtaining reliable environmental release data. This improved understanding will be useful as the Agency considers future data needs for regulatory development and permits.

Similarly, Amoco personnel better understand how EPA develops regulations, the type of information needed, and the Agency's operating constraints. This will be useful for Amoco in interacting with EPA and other government agencies.

The detailed release information developed in this Project could be useful to all three media offices: air, water, and solid waste.

^G The Office of Air and Radiation may be able to use air monitoring and modeling information for developing MACT standards and improving emission factors.

^G The Office of Solid Waste should be able to use sampling and monitoring information for characterizing RCRA Subtitle D wastes and management practices.

^G The Office of Water should be able to use wastewater sampling information to evaluate Petroleum Refining effluent guidelines, and the biomarkers research results in evaluating aquatic health measurement tools.

The working relationships between various EPA offices, State and Amoco personnel were quite fragile when the Project began. Individuals brought their institutional viewpoints to initial discussions. By agreeing at the beginning of the Project that we may not necessarily agree with all findings and conclusions, people showed a willingness to discuss issues and focus on data and factual information. Many of the perceived and real differences in views were more easily dealt with in a factual setting.

1.4 Recommendations

1.4.1 Explore Opportunities to Produce Better Environmental Results More Cost-effectively.

Data from this study show that the Refinery can meet a release reduction goal more cost-effectively than by meeting reductions prescribed by current regulatory or legislative requirements.

For example, the ranking analysis shows that given the opportunity the Refinery could remove about 97 percent of tons of airborne hydrocarbons at about 25 percent of the cost of reducing them under current and anticipated regulations. The cost-effectiveness of the flexible option is about $600/ton compared with the cost-effectiveness of $2,400/ton for regulatory requirements.

EPA might evaluate options for setting a goal or target for reducing multi-media releases from a facility, and then allow the facility to develop an alternative compliance strategy to meet the goal. This alternative strategy would allow the facility to meet the goal at a lower cost, include interim milestones, and be enforceable. This strategy would also make appropriate information available to ensure that the reduction targets will be met.

This strategy might also include commitments to other environmental improvements such as cogeneration, additional reductions in releases, wetlands restoration, wildlife habitat enhancement, creation of new wetlands, controls on nonpoint sources of pollution, improved environmental data collection and research. The cost savings realized from meeting requirements under a more flexible approach make it possible to realize additional environmental benefits which are presently foregone because of the high costs of many regulatory programs.

1.4.2 Improve Environmental Release Data Collection, Analysis and Management.

Data from this study show that an emissions inventory could be improved by measuring releases and developing new emission factors. For example, the emissions inventory at the beginning of the project did not account for all potential releases to the environment. Some releases were excluded because the Agency has excluded them from reporting (e.g., barge loading operations); some releases were not included because the sources and the amount were thought by Amoco to be insignificant (e.g., blowdown stacks); some emissions were overestimated (e.g., API Separator); and some releases were underestimated (e.g., coker pond). Jointly established sampling and analysis protocols could help improve data quality, so that reported values more accurately portray facility releases.

Data currently collected in response to regulatory or permitting requirements could be evaluated to determine how its utility and quality might be improved. For example, TRI data quality and utility could be improved by:

^G Providing more inclusive estimates of facility-wide releases to all media. The Project found the exclusion of marine loading operations from TRI reporting requirements conveyed an inaccurate picture of total facility releases.

^G Reporting groups of chemicals, rather than individual species, especially if these chemicals have similar structural, physical and toxicological properties.

Requiring reporting of all VOCs for refineries, rather than specific compounds like xylene (and its individual isomers), would provide a meaningful measure of refinery releases. That is because xylene poses approximately the same risks and has physical characteristics similar to the hundred of undifferentiated VOC compounds not covered in TRI. For a refinery, where a complex mixture of chemicals are released from most sources, tracking many separate chemicals does not make good use of technical, laboratory, and environmental management resources.

^G Reporting other selected chemicals of concern for demonstrated human health or ecological impact separately. At a refinery, chemicals such as butadiene, benzene, and nickel may be good indicators of risk/release potential and management practices. Other industrial sectors would need to track different specific chemicals.

^G Improving emission factors for estimating releases based upon information developed in this project, and additional work by EPA/industry task groups that could focus on the different data collection needs of discrete industry sectors.

The Project had great difficulty collecting and verifying environmental release data from the site. Emissions from these sources are complex and measurement techniques are rudimentary. Many emission measurements varied with time. For example, the Coker pond emissions varied by a factor of three within a few hours. Better sampling and analysis methods and statistical tools are needed to analyze variability. Research is also needed to develop methods that can verify release inventories within reasonable confidence limits, accounting for specific differences in emissions factors.

1.4.3 Provide Incentives for Conducting Facility-wide Assessments, and Developing multi-media Release Reduction Strategies. Such Strategies Should Consider Multi-Media Consequences of Environmental Management Decisions.

This Project demonstrates that more cost-effective environmental protection programs can be designed by allowing companies to consider site specific factors and focus on results.

A detailed facility-wide, multi-media assessment identified the most significant medium (air) and releases sources, both in terms of quantity and impact on the surrounding area. Specific technology options were then developed to deal with these sources. The significance of sources identified in this Project were not initially known or apparent to the participants.

Proposed solutions could not have been developed in the absence of data which identified their importance.

For example, hydrocarbon emissions from barge loading operations (784 tons annually) and blowdown stacks (5,200 tons annually) are significant. However, the Refinery did not know this prior to this Project, nor did the existing regulations require the collection of this data. Thus, it did not develop control options to reduce these emissions.

Several technologies considered for reducing releases, transfer pollutants from one medium to another or convert pollutants to different forms. Since human health and environmental consequences vary from one medium to another, viewing a release problem in the context of net environmental effects is essential to developing more sound solutions.

The current institutional framework and procedures for developing regulations do not include multi-media assessments and analysis. Current practices should be reviewed to determine how they could be modified to use information from such assessments. An integrated pollution prevention and management strategy would facilitate development of release management options that produce better environmental results. (EPA/SAB, 1990a; EPA/SAB, 1990b; OMB, 1991)

At present, industry has little incentive to conduct such assessments because it does not have an opportunity to implement their findings.

1.4.4 Encourage Additional Public/Private Partnerships on Environmental Management.

The Yorktown experience demonstrates the opportunities and pitfalls that can occur when government and industry work together. The opportunities are significant. The pitfalls are worth overcoming. All organizations--EPA, Virginia and Amoco--sought to develop and test innovative environmental management approaches that, unlike most traditional "command and control" approaches, consider risk reduction, address multi-media concerns, maximize environmental benefits, encourage efficient use of resources, and promote facility-specific implementation choices. While it will take time and patience to overcome decades of distrust, such joint government/industry efforts can result in more cost-effective environmental protection by providing the opportunity to share different viewpoints and skills.

In this study, for example, EPA brought expertise on the type of information needed to develop regulations, and their operating constraints, while Amoco brought an understanding of refinery operations and economics. By helping to educate each other and develop a mutual understanding of issues and technology, Amoco, EPA and the Commonwealth of Virginia together agreed on the most significant emissions from the Refinery and the most promising approaches to reducing them.

Public/Private partnerships could also be used to leverage Agency resources for providing improved data needed to develop regulations. This Project illustrates a possible approach to collecting data, assessing technologies and characterizing a facility within an industry that took less time and Agency resources but relied more on private support.

1.4.5 Conduct Research on the Potential Health and Ecological Effects of VOCs.

The Refinery is a major source of the area's VOC emissions. However, information on the potential adverse health effects of VOC emissions is rather limited (Graham, 1991). Research is needed to better characterize health and ecological effects of VOCs that can be used in conducting risk assessments. This study could also build on efforts currently underway at the American Petroleum Institute, and the Chemical Industry Institute of Toxicology (CIIT) and others.

EPA should also undertake research to develop indicators that measure impacts on the ecosystem of multi-media releases from industrial facilities. This Project looked at several biomarkers that show promise as indicators in aquatic environments. Limited information and methods for assessing ecological risk limits the ability to conduct comprehensive risk assessments, and measure changes in environmental quality.

1.5 References

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Table 1.1

Project Components

Biomarkers
Chemical Fate and Transport
Communications
Cost Estimation
Decision Making Methodology
Engineering
Environmental Impact
Exposure Modeling
Facilities Management
Group Dynamics
Meteorology
Public Perceptions
Regulatory/Legislative Policy
Risk Assessment
Sampling
Source Identification

Table 1.2

Participants in the AMOCO/EPA Pollution Prevention Project

U.S. Environmental Protection Agency

Office of Air and Radiation
Office of Solid Waste and Emergency Response
National Advisory Council on Environmental Policy
and Technology
Office of Research and Development
Office of Policy, Planning and Evaluation
Office of Water
Office of Pesticides and Toxic Substances
Office of Air Quality Planning and Standards
Region III

Amoco Corporation

Environmental Affairs and Safety
Public and Government Affairs
Art Services
Analytical Services
Groundwater Management Services

Amoco Oil Company

Refining and Transportation Engineering
Research and Development
Yorktown Refinery
Whiting Refinery

Commonwealth of Virginia

State Water Control Board
Department of Waste Management
Department of Air Pollution Control

Academic Institutions

Virginia Institute of Marine Science, College of William and Mary
University of California at Los Angeles
University of Michigan

Table 1.2 (Continued)

Consultants

ICF/Clement International
Research+able
ENSECO Laboratories
Radian Corporation
Linnhoff-March
York Laboratories
Murry/Trettel Consulting Meteorologists
Industrial Marine Service, Inc.
James R. Reed and Associates
Industrial Economics, Incorporated
Abt Associates
Resources for the Future

Peer Review Committee Members

Dr. Clifford S. Russell, Vanderbilt Institute for Public Policy Studies (Chair)
Ms. Jolene Chinchilli, Chesapeake Bay Foundation
Mr. A. Ray Dudley, Array Enterprises, Inc.
Dr. John R. Ehrenfeld, MIT Center for Technology, Policy and Industrial Development
Dr. John D. Graham, Harvard School of Public Health
Dr. Robert J. Huggett, Virginia Institute of Marine Science
Ms. Frances H. Irwin, Conservation Foundation
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Jim Lounsbury
Keith Mason
Richard Olin
Pat Pesacreta
Mahesh Podar
Alex Ross
Manik Roy
Marv Rubin
Dale Ruhter
Debora Sparks
Mary Spearman
Pat Woodson

Table 1.3

Comparison of Different Environmental Management Options for the Yorktown Refinery

Selection Criteria for Release Reduction Projects

No. of
Projects

Material
Released
(Note 1)

Total
Release
Reduction
Tons/Yr.

Capital
Cost
$MM

Annual
Cost
$MM

Benzene
Exposure
Reduction, %

Average
Cost
$/Ton

1. Current and Expected Regulatory Requirements
(Table 4.5) (Note 3)

7,300

17.5

2,400

2. Cost-Effective Release Reduction (Table 4.6)

VOC/HC
Listed HW

7,500

10.7

3.8

510

3. Cost-Effective Benzene Exposure Reduction (Table 4.7)

7,100

13.2

4. Multiple Criteria (Table 4.4) (Note 4)

4a. Work Group (Top 4)
4b. Amoco (Top 4)
4c. EPA/Virginia (Top 4)

4
4
4

VOC
VOC
VOC

Four options were consistently selected as most effective in different ranking exercises.

5. Most Favored--All Rankings, All Evaluators (Table 4.8)

6,900

10.2

3.5

510

Notes:

1. VOC = Volatile Organic Compounds
   HC = Liquid Hydrocarbons
   Listed HW = Solid, Hazardous Waste

2. Values are rounded. See tables 4.1 through 4.7 for details.

3. Regulatory and Statutory Programs considered include Benzene NESHAP, Ozone non-attainment, likely Clean Air Act requirements under MACT and HON rules.

4. Multiple criteria included release reduction potential, benzene exposure reduction potential, cost, impact on liability, transferability to other facilities, status in pollution prevention hierarchy, etc. See Section 4.0 for discussion.

Table 3.2

Selected Pollution Prevention Engineering Projects

The following projects were identified for further study as a result of the Pollution Prevention Workshop in Williamsburg and subsequent Workshop meetings.

1. Reroute Desalter Effluent: Hot desalter effluent water currently flows into the process water drainage system at Combination unit. This project would install a new line and route this stream directly to the API Separator. This reduces volatile losses from the sewer system by reducing process sewer temperature and oil content. Volatile losses at the API Separator increase slightly.

2. Improve Desalter System: Evaluate installation of adjunct technology (e.g., centrifuge, air flotation, or other technology) on desalter water stream prior to discharge into the underground process drainage system. This reduces oil and solids waste loads in the sewer system, affecting the waste water treatment plant and volatile losses from the drainage system.

3. Reduce FCU Catalyst Fines: Evaluate possible performance of more attrition resistant FCU catalyst to reduce fines production. (Subsequent review with catalyst vendors indicated the Refinery was already using the most attrition resistant catalyst available.) Two other fines reduction options were considered.

3a. Replace FCU Cyclones: Assess potential for reducing emissions of catalyst fines (PM10) by adding new cyclones in the regenerator.

3b. Install Electrostatic Precipitator at FCU: Assess potential of electrostatic precipitator in reducing catalyst fines (PM10) emissions.

4. Eliminate Coker Blowdown Pond: Change operating procedures for coke drum quench and cooldown so that an open pond is no longer needed. This reduces volatile losses from the hot blowdown water.

5. Install Seals on Storage Tanks: Double seals or secondary seals will reduce fugitive vapor losses. Recovery efficiency varies from tank to tank, depending on the hydrocarbon stored and construction details. Table 3.3 provides additional information.

5a. Secondary Seals on Gasoline Tanks: Secondary rim mounted seals on tanks containing gasoline.

5b. Secondary Seals on Gasoline and Distillate Tanks: Secondary rim mounted seals on tanks containing gasoline and distillate material.

5c. Secondary Seals on ALL Floating Roof Tanks: Secondary rim mounted seals on all floating roof tanks.

5d. Option 5c + Internal Floaters on Fixed Roof Tanks: Secondary rim mounted seals on floating roof tanks and the installation of a floating roof with a primary seal on all fixed roof tanks.

5e. Option 5d + Secondary Seals on Fixed Roof Tanks: Secondary rim mounted seal on all floating roof tanks and the installation of a floating roof with a primary and secondary seal on all fixed roof tanks.

6. Keep Soils out of Sewers: Use road sweeper to remove dirt from roadways and concrete areas which would otherwise blow or be washed into the drainage system. Develop and install new sewer boxes designed to reduce soil movement into sewer system, particularly from Tankfarm area. Estimate cost for installation on a Refinery wide basis. Both items reduce soil infiltration, in turn reducing hazardous solid waste generation.

7. The Benzene Waste Operations NESHAP requires control of benzene emissions from refinery wastewater sources. Three separate projects (7A, 7B, and 7C) were identified to meet these requirements. Specific design and construction features of these projects will provide for compliance with some future regulations, such as storm water permitting, RCRA remediation, the Primary Sludge rule and land disposal restrictions.

7A. Drainage System Upgrade: Install above-grade, pressurized sewers, segregating storm water and process water systems.

7B. Upgrade Process Water Treatment Plant: Replace the API Separator with a covered gravity separator and air floatation system. Capture hydrocarbon vapors from both units.

7C. Convert Blowdown Stacks: Replace existing atmospheric blowdown stacks with flares. This reduces untreated hydrocarbon losses to the atmosphere, but creates criteria pollutants.

8. Change Sampling Systems: Install flow-through sampling stations (speed loops) where required on a refinery-wide basis. These replace existing sampling stations and would reduce oil load in the sewer or drained to the deck.

9. Reduce Barge Loading Emissions: Estimate cost to install a marine vapor loss control system. Consider both vapor recovery and destruction in a flare.

10. Sour Water System Improvements: Sour water is the most likely source of Refinery odor problems. Followup on projects previously identified by Linnhoff-March engineering to reduce sour water production, improve sour water stripping.

11. Institute LDAR Program: Institute a leak detection and repair program for fugitive emissions from process equipment (valves, flanges, pump seals, etc.) and consider costs and benefits.

11a Annual LDAR Program with a 10,000 PPM hydrocarbon leak level

11b. Quarterly LDAR Program with a 10,000 PPM hydrocarbon leak level

11c. Quarterly LDAR Program with a 500 PPM hydrocarbon leak level

A

Appendix C
Project Documentation

Project Workplan (October, 1990)
Release Inventory Summary (Draft, March, 1991)
Solid Waste Data (May, 1991)
Groundwater and Soil Data (March, 1991)
Surface Water Data (August, 1991)
Pollution Prevention Workshop (September, 1991)
Project Summary (January, 1992)
Executive Summary (December, 1991)
Air Quality Data, Volume I (December, 1991)
Air Quality Data, Volume II (Draft, September, 1991)
Air Quality Data, Appendices B-J (5 Volumes, December, 1991)
Project Peer Review (November 1991)
Projects, Evaluation and Ranking (due July, 1992)
Ecological Impacts (due July, 1992)
Public Perceptions (January, 1992)
Risk Assessment Methodology and Results (due August, 1992)
Supplementary Information (due August, 1992)