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Comprehensive System-Level Noise Reduction Strategies

WA-RD 247.1

Final Report
September 1991



Washington State Department of Transportation
Washington State Transportation Commission

in cooperation with the
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Federal Highway Administration

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16. ABSTRACT A comprehensive review of the state-of-the-art in traffic noise abatement was conducted. Key literature was reviewed, and surveys conducted with state DOT noise analysts, and local environment noise control programs, and vehicle manufacturers. Areas of interest included abatement strategies, effective vehicle noise control, land use compatibility programs, and programmatic and administrative issues. Findings included: <ol style="list-style-type: none"> 1. the demand for noise abatement is increasing; 2. state DOTs need better sources of funds for retrofit ("Type II") noise barrier programs; 3. state and local noise control programs have suffered greatly since the end of the USEPA noise program in 1982; 4. truck manufacturers in the U.S. and Europe are successfully meeting the newly manufactured vehicle noise standards in their respective areas. Current Washington initiatives were also examined. WSDOT has included noise abatement as a priority area in its 1991 Transportation Policy Plan and the legislature developed a Growth Management Act and Growth Strategies Act that calls for comprehensive land use plan development by cities and counties. Recommendations to WSDOT included the need for expanded staff, a dedicated source of funds for a phased retrofit abatement program and active involvement in implementation of the two growth acts.			
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"Comprehensive System-Level Noise Reduction Strategies"

COMPREHENSIVE SYSTEM-LEVEL NOISE REDUCTION STRATEGIES

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COMPREHENSIVE SYSTEM-LEVEL NOISE REDUCTION STRATEGIES

SUMMARY

The purpose of this research was to assess the state-of-the-art in a wide variety of areas related to traffic noise control and to make recommendations to Washington State DOT (WSDOT) for its programs. The research was conducted in part because Washington citizens are becoming increasingly vocal about traffic noise and their state legislators are responding to their concerns.

Key findings from the literature and from surveys with state highway agencies (referred to as DOTs in this report), state and municipal noise control programs and vehicle manufacturers indicate:

1. Demand for traffic noise abatement by citizens is growing, even in some rural states.
2. This demand is especially strong along existing highways (a noise abatement project on an existing highway is called a "Type II" project by Federal Highway Administration (FHWA)).
3. State DOTs, in general, cannot meet this demand with the current funding mechanisms.
4. Our nation's state and local noise control programs, which are largely responsible for enforcing motor vehicle noise standards and encouraging/requiring noise compatible development, were decimated by the closing of the U.S. Environmental Protection Agency's (EPA) Office of Noise Abatement and Control and the EPA noise program in 1982.
5. Federal noise regulations for new trucks, motorcycles and motorcycle exhaust systems are still in effect, are not enforced, and are being complied with by manufacturers.
6. The federal regulation for in-use noise levels of motor carriers engaged in interstate commerce is still in effect; while FHWA is charged with compliance testing, virtually no testing has been done since the early 1980's, even though the maximum levels were reduced 3 dB for 1986 and newer trucks.
7. There is a need for more research, development, implementation and technology transfer to better understand the cost, benefits and trade-offs of various noise abatement strategies, to reduce abatement costs, and to improve analysis techniques.

Some other individual findings are of note. For example, the primary noise abatement measure used by state DOTs has been the noise barrier (over 720 miles of barriers at a cost exceeding \$635 million in 1989 dollars), yet work is needed on issues such as abatement cost and cost effectiveness, and analysis tools for special situations. State DOTs indicate a need to spend between \$130 - \$147 million per year over the next five years for barriers as part of new roadway construction or reconstruction.

Twelve states have indicated plans or a need to spend an average of \$75 million per year over the next five years for Type II barriers on existing highways (one-third of that in California alone). For several of those states, however, these plans are being de-emphasized or delayed because of difficult budgetary times.

California voters recently passed Proposition 111, which increased the state gas tax and also stipulated that \$150 million in new money be directed to its Type II program over the next 10 years. In most other states, however, traffic noise, while very serious, remains a lower priority issue. Its impacts can be severe, but probably do not affect a large enough population for a California-like initiative to succeed. Lacking such a voice, the impacted public must rely on the various branches and levels of government to protect and enhance the environment while carrying on the mission of providing safe and efficient transportation.

Use of other abatement strategies, such as sound insulation of public facilities, depressing the highway, shifting the alignment, is fairly common. Many states also indicate a willingness to allow privately funded or locally funded barriers erected on the state right-of-way, but are reluctant to obtain easements to place their barriers off the right-of-way, where in certain situations they would be more effective. States are also generally reluctant to soundproof private facilities or reduce speeds on roads to reduce noise. There is much interest in "quiet pavement" research, but little implementation yet. Noise control at the receiving land use is largely beyond the jurisdiction of the state DOTs, yet effective land use compatibility planning, zoning control and physical noise mitigation techniques could prevent many future noise problems from arising.

The legal issues involving traffic noise have varied from lawsuits over decisions to not install barriers to justification of analysis techniques. Seeking of damages with and without partial taking of the property has occurred in a number of cases, although noise damages are generally not compensable unless "severe damage" is demonstrated. Staffing concerns include the difficulty in keeping properly trained personnel and having insufficient staff to handle increasing demands regarding noise as well as other environmental matters.

Washington State is fortunate in many ways compared to other states in the sense that environmental protection has maintained a high profile and priority among the public, the legislature, and the administration. The state legislature has shown its concern over growth and, to some degree, the resultant environmental impact, with the passage of the Growth Management Act of 1990 and the Growth Strategies Act of 1991. WSDOT has demonstrated leadership by defining a Transportation Policy Plan that gives top priority to environmental protection and delineates action strategies to minimize noise impacts from transportation systems and facilities. However, noise abatement must compete with other important areas of environmental protection and other departmental priorities. Without adequate resources, laws and policies are of little use.

The emphasis on noise control through land use planning is important, and ties in with the Growth Management and Strategies Acts. The Acts require cities and counties experiencing rapid growth to develop comprehensive land use plans that include environmental protection as an important goal. While noise mitigation is not specifically required to be addressed in the plans, noise control is certainly a key item that should be made part of the plans. Many of the legislated aspects of the plans offer opportunities for WSDOT to play a role in mitigating existing noise or avoiding future noise impacts. Additionally, the department can be expected to be called upon by the Department of Community Development to assist in providing technical assistance to the cities and counties in development of the plans and subsequent regulations.

Given the Transportation Policy Plan, the Growth Management and Strategies Acts, and even the new National Aviation Noise Policy, the duties, responsibilities and work load of the noise specialists in the main office and the districts will increase if the state wants to successfully mitigate transportation noise on a system-wide basis. Additionally, WSDOT has taken an active role in the last several years in defining and conducting a traffic noise research program and will easily become a leader in traffic noise research in this country with its current and proposed levels of effort. Research must be continued in the areas of noise mitigation and improved noise analysis techniques.

Based on staffing in other state DOTs, one or two new main office staff positions would be needed to carry out the full potential work load, especially if WSDOT implements a comprehensive Type II noise abatement retrofit program for existing highways. A six to eight year retrofit program, funded at a level of \$3-\$4 million per year (in current dollars) is on the order of magnitude needed to solve Washington State's existing highway noise problems. WSDOT may wish to consider adding a new category of funding for highway improvements, called Environmental Mitigation Enhancement Improvements, and seek to fund its Type II noise barrier program through this category, possibly through a dedicated percent of the state gasoline tax. It should also investigate other funding opportunities through the provisions in the Growth Management and Strategies Acts.

Washington State has put forth a policy to abate transportation noise. More legislation is needed and more administrative support within WSDOT is required, in terms of staff and funds, to succeed.

CONCLUSIONS AND RECOMMENDATIONS

There are nine key conclusions that can be drawn from this research:

1. There is a large unmet and increasing demand by citizens for traffic noise abatement in Washington and many other states.
2. There is a need for a dedicated source of funding for Type II noise abatement (the addition of noise barriers to existing highways in Washington and many other states).
3. There is a need for more research, implementation, and technology transfer for traffic noise abatement, especially regarding costs and effectiveness of abatement strategies.
4. There is a need to reestablish a program in EPA headquarters to provide technical and financial assistance to state and local noise control programs.
5. There is a need to evaluate the current degree of compliance with the noise regulations for motor carriers engaged in interstate commerce.
6. There is a need to consider the need for national noise emission standards for automobiles, buses and tires.
7. WSDOT views noise abatement as a high-priority policy issue, but it realizes that noise abatement must compete with other high priority environmental issues.
8. The Washington State Growth Management and Strategies Acts offer a significant opportunity to attack the transportation noise problem from the point of view of land use compatibility; implementation of the Acts should put demands on the WSDOT staff even if WSDOT chooses not to actively pursue the compatibility approach.
9. Staffing and funding, however, are inadequate for WSDOT to succeed with the State's Policy Plan "action strategies" on noise mitigation or to meet the opportunities possible through the Growth Management and Strategies Acts.

These and other more specific conclusions related to them will be amplified below. The first six conclusions on the state-of-the-art assessment and the last three conclusions dealing with WSDOT are described in more detail in the chapter called DISCUSSION.

STATE DOT TRAFFIC NOISE PROGRAMS

There is a willingness on the part of state DOTs to try new noise abatement measures, but there has not been a great deal of actual use of most alternative measures. Agencies need more information on the costs and benefits of all noise abatement measures, as well as the consequences and legal aspects of several abatement measures, such as locating state barriers off the right-of-way (ROW), locating private barriers on

the right-of-way, and insulating private facilities. More information needs to be gathered on design, implementation, and construction experiences.

Many conclusions can be drawn on specific abatement strategies. First, not all sound-absorbing barrier systems currently being used seem to be designed for the highway environment. More study of the degradation in insertion loss between parallel barriers is needed. Tilting noise barriers is a feasible alternative, but more field data on the effectiveness of this strategy other than at controlled test sites, and data for in-situ traffic situations is needed. The use of transparent noise barriers is generally not a good idea along roadside edge, except perhaps for areas with winter shadow problems in states where snow is a problem. Transparent barriers seem to be a good alternative when the barrier location is near the ROW line. More experience on maintenance durability and ultraviolet yellowing is needed. "Planted" noise barrier systems offer good aesthetic treatment but the costs are much higher than conventional barriers. Recycled chopped-up tire "crumb" may prove to be an acceptable noise barrier material, although more testing and development is needed.

Using private funding to assist or pay for noise barriers on the state ROW can be a very workable strategy. However, these barriers should be designed to state standards, both physically and acoustically. State DOTs should be involved in all aspects of project development, from review and approval to construction supervision. The state should assume liability for the wall after installation and be responsible for maintenance. States unwilling to consider placing their noise barriers off of the state ROW may be missing a good opportunity for cost effective noise abatement. The use of barriers on limited access facilities should be considered where curb cuts are few; there may be a need to extend the barriers down the side streets and to carefully consider sight distance.

A state DOT should be willing to be innovative as a situation demands. The use of depressed highways and shifting of highway alignment should be considered where feasible. The use of buffer zones, while attractive, is limited because of the cost of land. The installation of a decked facility, although extremely expensive, may be justified where concerns such as community cohesion and environmental enhancement are important. Concrete pavement grooving or tine spacing can cause serious noise problems, but can be successfully mitigated with proper attention to the grooving or spacing details. More effort should also be focused on reduction of overall traffic noise levels through the use of quiet pavements.

The insulation of public facilities is a good solution, as illustrated by the California school noise abatement program. The insulation of private facilities has its place, for non-residential buildings (churches and private schools), and may be a low-cost strategy for isolated residential impacts. The legal issues are solvable through state legislation; an excellent model could be the soundproofing experiences with airports. Traffic management schemes should only be considered for noise abatement in selected situations. The banning of trucks has merit if alternative truck routes are available. Reduced speed limits for noise purposes will only offer marginal benefits.

There is a significant need in the country for noise barriers for planned new highways and reconstruction of existing highways ("Type I" barriers). There is also an extremely large demand for Type II (retrofit) noise barriers. Having a good prioritization system for Type II projects is essential, as is a state funding source. Policies matching funds from local governments or affected homeowners are needed. Useful models may be the Wisconsin idea of a local match for barrier costs exceeding its criteria, and the local pay-back provision in the California program. State DOTs should insist on some type of action from local government in support of Type II projects.

Good communications with the public are essential. The views of the directly impacted residents must be considered. Effective visual aids are also important. More use should be made of computer technology to present views of the proposed project to the citizens. One-on-one project meetings with small groups of homeowners can be extremely effective. The Colorado urban design committee idea is an excellent prototype for involvement of the DOT, the local government and the affected citizens.

In terms of legal decisions, careful analysis and proper documentation of methodologies is important. Potential legal issues should be identified early in a project's development, and state DOT counsel should be involved in the process.

Research for traffic noise analysis and abatement needs increased emphasis in the future. The pooled-fund concept allows states to make more efficient use of limited resources. WSDOT should play an active role as FHWA shapes its environmental research agenda for the next five years. Important topics include vehicle emission, multiple reflection effects, CAD for traffic noise analysis, evaluation of in-place noise barriers, source heights used in the prediction models, and tire/pavement noise reduction using open graded asphalt.

State DOTs need to do more to coordinate with local governments to prevent future noise problems from developing along existing highways. The "noise element" of the California local government has led to effective compatible development and mitigation along California highways. DOTs should play active roles in technology transfer and assistance for locals.

A DOT needs a well-trained staff for noise analysis and noise barrier design. Noise abatement policy and philosophy are as important as technical skills. Main office staff should provide a strong support role to district office personnel. Consultants must be well qualified for noise analysis and noise barrier design. Nationwide, there is too much variability in the interpretation of the FHWA noise standards in terms of "substantial" increases in noise levels, noise barrier design goals and interpretation of the noise abatement criteria. In some cases, the FHWA noise standards are being interpreted incorrectly.

LOCAL AND NON-DOT STATE NOISE CONTROL PROGRAMS

Elimination of the EPA noise program has had a serious, and often fatal, effect on state and local noise control programs in this country. The infrastructure of experience at all levels of government has largely been lost. Nonetheless, noise control remains an important issue. Local programs need financial assistance from state and/or federal programs, and state programs need federal assistance. EPA should reestablish its Office of Noise Abatement and Control and investigate the extent of this nation's transportation noise problem and the effectiveness of its current regulations. Programs in California, Colorado and Canada offer good models for land use compatibility programs, especially regarding requirements on developers.

CONTROL OF VEHICLE NOISE AT THE SOURCE

The major American and European manufacturers have excellent noise control programs. They have proven that through a careful analysis of individual noise source components vehicle noise levels can be reduced. It appears that some further reduction over current levels is still possible as more sophisticated computer analysis techniques are used. Noise control is a key design element in overall vehicle design. The European strategy of a joint government/industry initiative to reduce vehicle noise seems to be effective, much like the efforts in the United States in the early 1970s.

While a need for additional reduction in truck emission levels has not been proven at this time, several state DOT survey respondents identified such a need, including lowering of exhaust stacks, as a key issue. Additional noise reduction will be costly and difficult, but should not be ruled out pending a more comprehensive assessment of the national noise impact. The problem may be due more to the older trucks being in the population rather than those that are newly manufactured.

As the heavy truck noise levels are reduced, their dominance over the total traffic stream will become less significant. Emission level data collected by state DOTs indicate that the automobile levels are increasing, probably due to the great number of light trucks being included in this class. Finally, vehicle exterior noise reduction efforts should place more attention on minimizing tire noise contributions.

WASHINGTON STATE DOT NOISE PROGRAM

Many individual recommendations have resulted from this research regarding the WSDOT noise program, as detailed in the final technical report. Key among these are the following:

1. WSDOT should study a variety of issues on individual noise abatement strategies including investigating innovative materials, developing specifications, considering use of barriers off the state-right-of-way, accepting private fund contributions toward the construction of Type II barriers, investigating legal issues regarding noise insulation of private dwellings, considering a noise insulation program for schools near highways, and continuing its research on the noise properties of open-graded asphalt;
2. WSDOT should have an active involvement in the implementation of the Growth Management and Strategies Acts, especially related to providing technical assistance to cities and counties in the development of their comprehensive land use plans and subsequent development regulations. The department should take a lead role in the development of noise barrier design specifications for residential developers and in the testing and approval of proposed barrier materials and systems;
3. WSDOT should support the revival of a noise program in the US Environmental Protection Agency, related to both land use compatibility and source control, and expanded programs for noise control within the appropriate state agencies.
4. WSDOT should carefully examine its level of staffing to be able to adequately deal with the action strategies for noise abatement in the 1991 State Transportation Policy Plan and to be proactive in responding to the interest generated in cities and counties during the debate over the Growth Management and Growth Strategies Acts; expansion of activities beyond the current level of effort will require additional staff.
5. WSDOT should move to include departmental noise experts in the regional transportation planning process, much along the lines of what is done with air quality;
6. WSDOT should continue with its progressive policy in transportation noise research and should continue to move toward a leadership role within NCHRP and TRB;

7. The Noise Unit should continue to pursue the latest technology in video and computer-aided design in the preparation of information for communicating with the public, legislators, and upper management;
8. The WSDOT legal staff should investigate issues such as obtaining easements to construct noise barriers off the state right-of-way, the sound insulation of private facilities including schools, churches and residences, allowing privately contributed funds to move a Type II barrier up on the state's priority list, the use of impact fees, development fees, state real estate excise taxes, and the newly proposed growth management financing accounts for use in noise mitigation by cities and counties;
9. WSDOT should consider adding a new category of funding for highway improvements called Environmental Mitigation and Enhancement Improvements from which noise mitigation along existing state or federal-aid roads could be financed;
10. WSDOT should seek additional funding for the Type II program; a funding level of \$3-\$4 million per year (in current dollars) would allow the retrofit program to be completed in six to eight years;
11. WSDOT should be prepared to provide funding to increase the noise specialists on staff, both in the main office and those districts with large needs for both Type I and Type II noise analysis and design; as an example, a major effort in Type II abatement would seriously impact workloads in Districts 1, 2 and 5; WSDOT should provide adequate funding for noise related duties in the architecture, design standards and local programs offices;
12. The Noise Unit should reconsider its prioritization method for Type II projects to include all areas exceeding 55 dB in its definition of impact; and
13. The Noise Unit should raise its cost per residence from \$8,000 to \$20,000-\$25,000 for accessing the reasonableness of noise abatement features in project studies.

INTRODUCTION

RESEARCH OBJECTIVES

The first project objective was to review and evaluate the state-of-the-art for:

1. noise abatement strategies at the source, along the path, and at the receiver;
2. successful state and local traffic noise laws, ordinances, codes and regulations with emphasis on emission level enforcement and land use compatibility;
3. traffic noise research results, including modeling and abatement;
4. successful techniques for communication with various audiences, such as the public, agency executives, legislators and technical personnel in cooperating agencies;
5. traffic noise legal decisions, especially as related to state DOTs;
6. state DOT administrative and programmatic issues, including prioritizing and funding for noise abatement on existing highways, funding for research, and staffing for noise analysis.

The second objective was to make recommendations to WSDOT, based on the state-of-the-art evaluation, for its traffic noise analysis and abatement programs. These recommendations focus on both needed implementation efforts and future research needs. The third objective was to package this information for possible input to the state legislative transportation committee. Collectively, an interim report, a final report and a final detailed technical report serve the third objective.

THE PROBLEM

As noted by the Honorable Dick Nelson of the Thirty-Second District of the State House of Representatives in a 1990 letter to WSDOT:

"Traffic noise will grow as a transportation problem as the level of use of our older freeways and state highways in the Seattle area and other urban areas continues to grow. Citizens will increasingly demand that the current noise problem be fixed before we address the need for the greater utilization of the existing roadways or additional roadway capacity."

While much work has been done in traffic noise control, there has been a need for viewing this body of work in a comprehensive manner to gain a perspective on the state-of-the-art and a recommended course for future action.

BACKGROUND

The fields of traffic noise analysis and control grew in the late 1960s and early 1970s in response to environmental and highway legislation and regulations. There were three areas of focus: source control, path control and receiver control. Source control on a national level aimed at emission level regulations for newly manufactured vehicles and for trucks and buses engaged in interstate commerce. State and local source control focused on enforcement of the federal in-operation regulations, state and local "nuisance" and "muffler" ordinances. Path control efforts consisted mainly of the construction of traffic noise barriers. Federally sponsored research projects since the mid-1960s developed and refined or revised mathematical models to predict traffic noise levels and to design noise barriers. Receiver control was divided into administrative strategies, such as zoning, building codes, and subdivision laws, and physical methods, such as site planning and acoustical construction. Most of these activities fell under the jurisdiction of local government, although some state DOTs have insulated public buildings.

Much of the above research, development and technology transfer was done in the 1970s when federal emphasis was strong. In the 1980s, the EPA program was phased out and its Office of Noise Abatement and Control closed. Also, FHWA emphasis shifted to more of a "maintenance" effort as administration priorities shifted. Some new research was funded but there was little implementation or dissemination of the results.

However, interest in noise control remained high within many state DOTs, often spurred by citizen demands. Several state DOTs have had active programs in providing noise control along existing highways, and all DOTs must abide by federal regulations when building or rebuilding federal-aid roads. Some new research and development has been funded or conducted by state agencies, but a need remains to assess source, path, and receiver control and where Washington should focus its future efforts. As other states have seen, Representative Nelson described exactly the problem that Washington will face in the coming years: citizens recognize that traffic noise can and should be controlled and that their voices can be heard by their legislators over the roar of traffic.

PROCEDURES

The work on this study consisted of six major tasks: (1) information gathering; (2) information analysis; (3) interim report preparation and briefing; (4) response to WSDOT comments; (5) preparation of recommendations; and, (6) final report preparation and briefing. These tasks involved reviewing the relevant literature, and contacting state DOT noise analysts, non-DOT state and local agencies known to have noise control programs, and U.S. vehicle manufacturers.

Information gathering first focused on the formal literature, government reports and articles, noise control conference proceedings, and transportation and noise control journals.

Then, a survey was sent (with subsequent follow-up) to each state DOT plus Puerto Rico and Ontario (the most active Canadian province in traffic noise control). Questions dealt with abatement measures, abatement expenditures, communication techniques, legal decisions, research, land use and local coordination issues, staffing, analysis tools, and issues and problems.

Also, a survey on source control and land use control was done for non-DOT state and local environmental noise programs. Contact came from an EPA report on the effects of its program in the early 1980s. Interesting programs were identified and follow-up was done.

Finally, a questionnaire was distributed to major truck and automobile manufacturers. The Motor Vehicle Manufacturers Association and Society of Automotive Engineers (SAE) provided lists of the appropriate professional committees. Questions focused on facilities, programs, problems, and challenges. As with the other questionnaires, follow-up by telephone was done.

After the information gathering and analysis, a detailed draft "technical report" and an "interim report" were prepared for review by WSDOT. A briefing for WSDOT and state legislative representatives was held to inform them of the results and to seek comments.

The researchers then responded to WSDOT comments, completed some needed additional analysis, and developed recommendations for the WSDOT program. This final report and a final detailed technical report serve as updates to the earlier reports.

DISCUSSION

Quite a few findings have resulted from this comprehensive survey of the state-of-the-art in traffic noise abatement. This chapter will present those findings, focusing first on the state DOTs, second on the non-DOT state and local programs and third on vehicle manufacturers. Findings specific to Washington State will be described in the next chapter on APPLICATIONS AND IMPLEMENTATION.

STATE DOT NOISE PROGRAMS

Noise Abatement Measures

By the end of 1989, over 720 miles of noise barriers had been constructed by 39 states and Puerto Rico at a cost of over \$635 million (in 1989 dollars) (1). Seventy-five percent of those barriers were constructed in just ten states, with one-third of all barrier length constructed by California. A 1987 estimate for the completion of the U.S. Interstate Highway System showed a need for approximately \$142 million for noise barriers on that system (2). Ontario, Canada, has also constructed many miles of barriers.

Most of the noise abatement measures used by state DOTs have involved sound-reflecting walls owned by the agency and located on state right-of-way (ROW). The survey of state DOT practices conducted by this study focused on strategies other than this category. The state DOTs were presented with a list of twenty noise abatement measures and were asked to comment on their use. Table 1 lists these abatement measures with the numbers of states in each category. FHWA has also compiled a list of projects featuring "unusual" noise barriers and other non-barrier abatement measures (through 1988) (3).

The most commonly used of these other abatement strategies are: depressing the highway, shifting the highway alignment, insulating public facilities, using sound-absorbing barriers, and prohibiting heavy trucks from a facility. The relatively high use of the last three measures was surprising, given their sometimes controversial nature. In addition, quite a few states have installed noise barriers of either the reflecting or absorbing type on non-limited access facilities (barriers are often dismissed in these situations because it is assumed that curb cuts are needed, which is not always true).

The data showed that while 13 states have been very active in their use of these alternative measures, 20 of the states have used none or only one of these measures. Despite that finding, 60 percent of all

Table 1. Number of State DOTs* That Have Used, Would Consider Using or Will Not Use Various Noise Abatement Measures

<u>Abatement Measure</u>	<u>Have Used</u>	<u>Would Consider Using</u>	<u>Will Not Use</u>
Sound-absorbing barriers	15	32	4
Tilted barriers	5	33	11
Translucent/transparent barriers	4	23	21
Other innovative or low cost materials or designs	7	31	0
Barriers off state ROW	6	18	24
Privately-funded barrier on state ROW	6	32	9
Barrier on non-limited access facility	16	22	12
Deck (lid) over highway	6	9	30
Depressed highway	24	24	4
Shifted highway alignment	17	32	0
Provided buffer zones	4	30	10
Chose alternative corridor/mode	6	30	8
Canceled highway project	2	11	27
Pavement surface treatment	4	30	13
Noise insulation:			
1. Public facility	18	22	9
2. Private facility	7	13	27
Traffic management:			
1. Prohibit heavy trucks	10	24	14
2. Prohibit all trucks	2	21	24
3. Reduce truck hours	1	29	17
4. Reduce speed limit	2	27	18

*Puerto Rico and Ontario are also included.

respondents said that they would consider using sound-absorbing barriers, innovative or low-cost materials, buffer zones, shifting the highway alignment, choosing alternative corridors or modes, using pavement surface treatments, and allowing privately-funded barriers to be constructed on state ROW. However, the willingness to try various alternative abatement measures has not fully been matched by actual implementation. Also, there was a general unwillingness to install barriers off the ROW, and to deck over highways, insulate private facilities, and ban all trucks from facilities.

A number of findings were made on the individual abatement measures and are summarized in the following paragraphs. First, fourteen states have tried to solve sound reflections problems, but some have found certain sound-absorbing barrier installations to be very expensive, and certain others to have maintenance problems after installation (metal, plastic, and concrete). Four states have used tilted barriers as an alternative to sound-absorbing measures in parallel barrier situations. The use of transparent barriers seems to have a role in certain situations, but problems with two of the few current installations have occurred in Maryland and Massachusetts. Ontario is conducting research on weathering and visibility degradation (4).

In terms of new or innovative products, a composite material panel called Soundzero has been used as a lightweight alternative on bridges in Pennsylvania and Connecticut. The Evergreen "planted" wall appears to have potential where the appearance of an earth berm is desired but ROW is not available, but the initial U.S. installation in Pennsylvania was very expensive. Several states are interested in using recycled plastic for noise barriers and Ontario is pursuing the use of recycled tire "crumb" as a panel material.

It was found that homeowners have been willing to cooperate and share the cost of installing noise barriers off the state right-of-way in a number of instances in Arizona, Wisconsin, California, Georgia, Utah and Oregon. The use of privately funded barriers on state ROW had raised concerns in several states, but has been a workable solution in California, Ohio, Illinois, Michigan and Washington. There have been no major problems with installing barriers on non-limited access facilities if curb cuts are few, but attention to sight distance is needed. Arizona, Colorado, Florida, Pennsylvania and North Carolina reported such projects.

Decking over highways as future noise abatement is extremely expensive and has seen limited application, with examples in Pennsylvania, Michigan, New Jersey, Arizona and Washington State. The use of depressed highways for noise reduction is common. Good examples included a section of I-78 in

works well if feasible. The provision of buffer zones, however, is not common, being noted by only Alaska, New York and Oklahoma.

Minnesota and Oregon developed specifications for reducing the noise caused by the tine spacing used to put a finish on fresh concrete pavement. The use of open-graded asphalt to reduce tire/pavement noise shows promise from the field data in Maryland and several European countries, but questions remain on long-term benefits. Ongoing research in Washington is inconclusive about the relative benefit of open-graded asphalt for roadside receivers. Pennsylvania is using open-graded mix on I-676.

Insulation of public buildings, especially schools, along highways is common, and usually involves air conditioning (or ventilation) and some glazing of windows. California has had a major school noise abatement program, with 116 schools treated at a cost of \$23 million, and nine more yet to be done at a projected cost of \$3-4 million (5). Insulation of private facilities is not popular, especially for residential property, but has been done in several instances for properties such as churches and private schools. Michigan has conducted a major residential insulation program on its I-696 project. Sixty residences were treated through 1988, with as many as 70 more to be treated, at a low cost of \$3,500-\$4,500 per residence. Some states have legal problems with this strategy because it involves working off the ROW without any taking of land.

In terms of traffic management schemes, banning trucks has led to reduced noise barrier heights on limited access facilities in Florida, Minnesota and Maryland. However, reduced speeds provide marginal benefit. Only Minnesota, Illinois and Alaska reported use of reduced speeds.

Planned Noise Barrier Expenditures

Thirty-seven states have indicated needs or plans to install Type I (new highway construction or reconstruction) barriers over the next five years. Fourteen plan to install Type II (retrofit) barriers on existing highways over the same time period. The projected annual expenditures of the responding states for Type I barriers were in the range of \$130-\$147 million per year (plus \$4 million (Canadian) per year in Ontario). This amount excludes eight states that did not provide estimates (three of which, Colorado, Pennsylvania and Arizona, have been active in the past). Fourteen states indicated that no expenditures were planned. Seven plan to spend less than \$1 million, while fifteen indicate between \$1-5 million. Six states plan to spend over \$5 million per year (CA, CO, NJ, OH, TX, VA). By far, the states with the largest planned annual funding for Type I projects were California (\$30-\$40 million), New Jersey (\$20 million), and Texas (\$30 million).

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The Type II annual expenditures needed or planned by the responding states totaled \$75 million per year, and also varied considerably by state. Thirty-six indicated no planned Type II barriers. Two plan to spend under \$1 million, while six plan between \$1-5 million. Four states plan to spend over \$5 million. However, for three of those four states (California excepted), spending is in jeopardy due to funding constraints. As an example, New Jersey has indicated a need of over \$100 million. It is listed in the "over \$5 million" group above because even though no funding is available currently, the state is looking to start a \$15 million per year program soon. Ontario also indicated plans to spend \$30 million (Canadian) per year in its program. More details on Type II programs are in the next section.

Type II Noise Barrier Programs

More and more states are concerned about the need for Type II programs, as citizen demands for noise abatement increase. Several states have been developing policies, priority listings, and state legislation for Type II programs over the last few years (6),(7),(8),(9). The new National Transportation Policy calls for flexibility in the use of federal-aid funds, which could lead to a funding mechanism for Type II barriers. In June of 1990, California voters approved a five cents per gallon gasoline tax increase under Proposition 111, which stipulated that the Type II noise abatement program shall receive an additional \$150 million over the next ten years. Coupled with existing funding, the California Type II program will exceed \$20 million per year.

There were mixed responses on the seeking of funds from local governments or affected citizens by a DOT for noise abatement. Wisconsin will seek funds if the cost per residence for the barrier exceeds \$30,000 per dwelling unit. California will allow a barrier to move up on its Type II priority list if the local government pays for the barrier, with provisions to reimburse the local government when that project is reached on the normal Type II priority list for funding. Different states require different actions of support by local government when barriers are planned, such as seeking concurrence with the project or requiring land use compatibility plans for undeveloped lands. Colorado meets with its cities and counties on an annual basis to select the Type II barrier priorities.

A number of prioritization systems for Type II projects have been developed over the years, generally considering factors such as cost, dwellings affected, noise level, and achievable reduction. Two new methods by Wisconsin and New Jersey have a degree of complexity not seen previously.

Communication Techniques

By far the most commonly cited method of communication with the public is through public meetings. Several different presentation methods are employed. For example, on one Virginia project an audio tape of existing noise (without the project) and noise after construction (both with and without a barrier) was used. Construction of a barrier was going to require donation of some land by the residents. The residents decided that the 5-7 dB reduction was not sufficient to donate their land. Colorado has used computer imaging to show views of a planned expansion project where changes to existing noise barriers were required. The computer images done by a consultant showed the noise barrier, any traffic that could be seen above it and the Denver skyline. Other techniques include slide presentations and slide shows, artist's renderings (including noise barrier overlays on existing photos), posters of noise contours on aerial photos, pamphlets on highway traffic noise and questionnaires.

Several states have held individual meetings with affected homeowners, often in the field. On one Florida project, the number of planned barriers was reduced from thirteen to three with substantial cost savings (based on \$15-24/ft²). The cost in time was 3-4 weeks for 3-4 people. Other techniques include organizing adjacent property owners through their local city or county representatives, notifying all residents within a certain distance of a proposed Type II project of the date and location of public meetings, distributing information to the first row houses along a project and illustrating the proposed height of noise walls in the field by raising a rod to the wall elevation. Use of videos was reported by Florida, Kentucky, New Jersey, Pennsylvania.

For communication with executives or other staff within the DOT, most states rely on personal contact, and one-on-one briefings. In Massachusetts, all bureau and district office heads, as well as the MPOs, reviewed and commented on its Type II noise policy. Florida provides its staff with field/computer training and Washington has given classes to contractors on construction noise abatement. Maryland uses large scale status boards to keep the staff informed.

Most of the states involve their legislators by inviting them to public meetings and providing them with correspondence, literature and reports, often in response to a request for information or action. Officials

from other agencies are kept informed through public meetings, scoping meetings, briefings, reports and field visits. Colorado uses an urban design committee approach, which is a group of representatives from the city, county, neighborhood, DOT main office and district, and the state legislator, directed by a local planning firm.

Legal Decisions

Fourteen states reported on legal decisions that had some consequence on their noise analysis or abatement program. Issues have involved the seeking of damages for noise impacts on partial takes of property, and payment of damages when there is no taking.

Florida courts have held that traffic noise on individual projects has generally not caused "severe damage" relative to other traffic noise situations, and therefore has not been compensable (10). However, severance damages have been allowed in Florida for partial takes, representing the "cost-to-cure" to restore the remaining property to its original use and value.

In California, a landowner sought severance damages on a partial take of his yet-undeveloped property mainly due to an alleged increase in noise from a state-built truck inspection station. The jury's verdict was for the state. Kentucky reported two highway widening cases involving out of court settlements, one for damages with a recording studio (approximately \$40,000), and one for condemnation for an apartment complex (approximately \$400,000). Texas reports a settlement of \$31 million regarding impacts on a school in Houston for a proposed highway construction.

In Michigan, a class action suit alleged that as a result of the taking of certain properties for highway purposes, the remaining properties were damaged without payment of just compensation. Integral to their case was a neighborhood restrictive covenant stating that the properties be used for residential purposes only. No outcome was reported. In New Jersey, however, the appellate court has ruled that noise is a compensable item in ROW negotiations.

Delaware noted a 1976 court decision that required the installation of a barrier along I-95 to protect a school building. Connecticut has developed a lengthy, comprehensive process when requests are made to remove or alter proposed barrier systems.

In Utah, the attorney general's office has given several opinions regarding the protection of second-story receivers (necessary if there is exterior use, such as a deck), rented dwellers (must be considered on an equal basis with non-rental residential land use), and redeveloped sites (do not qualify for abatement). FHWA

has indicated to the state that it cannot extend the project limits to include noise abatement for impacted sites outside of the construction limits. Washington reports that a condemnation case caused the state to defend FHWA's use of L_{eq} . The plaintiff argued that the impact was actually caused by increased incidences of peak noise and intensity. The court allowed the jury to consider this argument. The degree to which the jury was influenced by it is unknown. However, an award was made to the plaintiff.

Research

Over half the state DOTs have either done research on noise in the last ten years or plan to do work in the next five years. However, for about half of those respondents, some or all of their research activity has been their involvement in a national pooled-fund study on parallel barrier effectiveness (11). The past and future research focuses on improved prediction modeling, evaluating barrier performance, and studying tire/pavement noise. Several states have revised or are revising noise prediction vehicle emission levels, generally finding that heavy truck levels are lower than the national averages in the computer models.(12),(13),(14) Florida has also found that the source heights used for medium and heavy trucks in the noise prediction model may be higher than in reality, which could have major consequences on barrier design (15).

There is much interest in the subject of multiple reflections between parallel barriers. Recent field results tend to support previous findings that degradations in barrier insertion loss tend to increase as the ratio of barrier height to width increases. However, the actual field sites tested have had low barriers and wide separations, resulting in small degradations (16),(17),(18).

Other studies of single barrier noise reduction have found generally good comparison between predicted and measured levels (19),(20),(21). The use of open-graded asphalt pavement appears to offer noise reduction capabilities, but more data is needed on long-term performance (22). There is a great deal of research on this subject in Europe.

State DOTs have a long list of over 50 items of needed noise research (23) and will be active through TRB in helping FHWA set its environmental research agenda.

Land Use Compatibility and Local Agency Coordination

The control of traffic noise impacts through land use compatibility is an important part of an overall noise abatement strategy. Land use compatibility is generally the responsibility of local agencies, although

states such as California and Florida, as well as the province of Ontario, require residential developers to consider noise as an element in their developments. California and Ontario have noise level standards that developers must meet, leading to many miles of developer-built noise barriers along their roads. Several other states have assisted in review of subdivision plans. Virginia has developed a policy requiring the local government to pay 50 percent of the abatement costs for non-federal aid projects and to have a noise ordinance for abatement by developers adjacent to roads. Many states, however, do little more than provide the local governments with the predicted future noise levels near a project and information on the strategies for land use compatibility.

Some states report successes from coordination efforts with local government. Noise mitigation or distance setbacks have been required by several municipalities for new residential developments. Additionally, Indiana and Mississippi reported that some of communities have been making zoning changes from residential to commercial near busy roads. Several other states have seen some noise ordinances be developed by local governments. However, the number of land use compatibility programs throughout the country is very small compared to the extent of the problem and the potential success from proper action.

Administrative Issues

State DOT staffing for noise analysis and abatement varies considerably. All of the states had at least one person who, at a minimum, works part-time on noise. Approximately two-thirds of the states have centralized project development, while one-third rely on their district offices. Eight of the centralized states have less than one "full-time equivalent" (FTE) person and 13 more had less than two FTE staff. Eleven centralized DOTs have three or more FTE staff for noise work. The decentralized states have small main office staffs consisting of one or two FTE people. Five of the 14 decentralized states have five or more FTE staff in their districts, with California reporting a total of 48 registered engineers and technicians involved in noise studies and measurements in its district offices. Connecticut notes a need for 10 additional staff to fully carry out its needed Type II abatement program.

The level of training and educational background of noise staff also varies considerably. While most states have at least one staff member with a four-year degree, the major fields range from civil engineering to physics, business administration and forestry. Twelve states have one or more staff with graduate degrees in fields such as planning, environmental science and engineering.

The main sources of training for noise staff are FHWA training courses and workshops and in-house or privately-run short courses. In several states, the analysts simply have to learn on the job. Twenty of the states rarely or never use consultants in their noise analysis and research while the remainder report frequent use. Six states use consultants over half the time on their projects. The types of work upon which consultants are used varies from EIS-level analysis to preliminary engineering or final noise barrier design.

Most of the states use the FHWA STAMINA 2.0/OPTIMA computer programs in their work. Thirty states do part or all of their work on microcomputers, while twelve use only mainframe systems. A few states are using digitizing systems and graphics for file creation and display. Noise measurement equipment ranges from simple sound level meters to sophisticated sound level analyzers.

Issues, Problems and Challenges

By far the biggest problem or challenge reported by the DOTs is funding. Eight states listed funding as a primary problem within their noise programs, with four mentioning specifically Type II project funding. Other key problems include: inadequate training and staffing, responding to public and legislative demands, lack of legislation on land use compatibility (coupled with difficulties in getting local governments to consider noise in future development) and in-house resistance.

A major source control issue among the state DOTs was the need for quieter heavy trucks, including the lowering of truck exhaust stack heights. Some states called for better legislation regulating vehicle noise emissions, rejuvenating the EPA noise abatement office, providing more federal support for manufacturer's noise control efforts, and improving both federal and local enforcement of vehicle noise laws. Noise barrier issues included the need for Type II funding, the need to improve barrier cost effectiveness, and concern over barrier maintenance. For noise control at the receiver, land use compatibility planning was the key issue.

The overall sense one gets from reading many of the state DOT responses is that of frustration. The public demand for abatement is increasing in many states while the resources--funds, staff, executive management support, legislation, regulations and technical tools--are inadequate or need improvement. The exception is in a number of the more rural states, which do not perceive themselves as having a "noise problem." However, two such states, Maine and Montana, expressed concerns about noise becoming a problem for them as the public becomes more aware of traffic noise as a serious problem.

Source control is generally beyond the jurisdiction of state DOTs, yet the EPA programs on source control and technical assistance to local government have been virtually nonexistent since funding was cut in the early 1980s. Control at the receiving land use is also largely beyond the jurisdiction of the state DOTs, yet effective land use compatibility planning, zoning control and physical noise mitigation techniques could prevent many future noise problems from arising.

Other Information

In addition to the survey, documents reviewed on state DOT noise abatement programs and/or FHWA policy provided interesting insights. Key among these was the wide variation by states and the interpretation of the Noise Abatement Criteria in the FHWA Noise Standards (24). The criteria are still interpreted by some states as desirable noise levels or design goals, rather than indicators of impact severe enough to warrant abatement. Additionally, FHWA found that states need to pay more attention to the views of the impacted residents in the decision to implement noise abatement on new construction projects and to the "will and desires" of the general public in dealing with traffic noise, particularly in implementing Type II abatement.

The states were also found to have a wide range of interpretations of items such as definition of impact, eligibility for Type I projects, insertion loss goals, and cost per residence criteria (25),(26). The most common criterion for a "substantial increase" in levels is 10 or more dB. The most commonly used cut-off date for new developments to qualify for Type I treatment is location approval of the proposed project. While many states try to achieve 7 or more dB insertion loss during barrier design, the most commonly cited range was 5-10 dB, with two states reporting 3-5 dB. Cost per residence criteria ranged from \$8,000 to \$37,000 per dwelling unit.

LOCAL AND NON-DOT STATE NOISE CONTROL PROGRAMS

The control of transportation noise by local governments and non-DOT state agencies falls generally into two categories: enforcement of motor vehicle emission level standards and development and implementation of land use compatibility programs. The major finding in this area of investigation is that the closing of the EPA Office of Noise Abatement and Control (ONAC) and the phase-out of the EPA noise program had a very major impact on state and local programs. These impacts were not anticipated by EPA when the decision to end the program was made. Only about 35 percent of the approximately 200 local noise

control programs that were active during the 1970's remain active today, largely attributed to the loss in EPA funding and technical assistance. Only eight of the 20 state agencies with programs in the 1970's are still active. Few individuals remain heavily involved in the field at the state and local level. Over half of the municipalities with active programs felt that reinstating federal program would be of help while one-fourth did not think so. A study for the EPA of the impacts of ending its noise program concluded that the state and local programs were unable to remain strong after the discontinuation (27). That study calls for a new federal program to provide technical assistance and technology transfer to these agencies.

These conclusions were corroborated by a General Accounting Office (GAO) investigation (28). The GAO concluded that the federal government needed to strongly consider expanding its efforts in several possible areas, including enforcement of current standards (although revision first is preferable) and the provision of technical assistance to local governments for land use control.

EPA had a thriving program in noise control in the 1970's in response to the Noise Control Act of 1972. Major functions included identifying "major sources of noise" and developing regulations for newly manufactured products of these major noise sources. EPA also had a very active state/local assistance program. Since the ending of its program in 1982, EPA now has only a few people in the noise area, mostly to review environmental impact statements, as required by federal law. EPA is also not enforcing its standards on newly manufactured medium and heavy trucks, (29) and motorcycles and motorcycle exhaust kits. The EPA new product regulations for medium and heavy duty trucks had included a 3 dB reduction in maximum allowable levels (to 80 dB at 50 feet per an SAE acceleration test) that was supposed to go into effect in 1982, but finally became effective in 1988.

EPA had also promulgated in-use motor carrier noise regulations that applied to trucks and buses engaged in interstate commerce (30). Enforcement of these regulations, delegated to FHWA, is not being done currently because of previously determined high compliance rates and other priorities. However, the maximum allowable noise levels were reduced 3 dB for 1986 and later model years (as part of the original regulations), and no compliance testing has occurred since that reduction. Recently collected independent data suggests compliance may be an issue (31). Three test conditions are specified -- stationary, 35 mph or less, and over 35 mph -- with respective levels at 50 feet of 85, 83 and 87 dB for 1986 or later year models (the pre-1986 levels are each 3 dB higher).

A key issue in source control is federal preemption. State and local agencies can promulgate their own regulations for newly manufactured medium and heavy trucks and in-use interstate buses and trucks, but their standards must be identical to the federal ones. Several states and municipalities have passed such regulations, but only Oregon, Florida and California require certification letters from manufacturers. Automobile and light truck noise is not regulated by EPA, and as a result, a number of states and cities have standards for these vehicles (typically, a value of 80 dB at 50 feet per an SAE acceleration test).

As part of this research, those state and local agencies that had reported to EPA that they still had a noise program in place were surveyed. Six states and 35 municipalities responded. All of the state programs began in the early 1970's by acts of their state legislatures. Annual operating costs range from \$48,000 to \$270,000, with no federal assistance. The full-time equivalent (FTE) staff in the state programs range from 1 to 8.5 people (Hawaii). Four of the six state programs specifically exempt motor vehicles from their regulations (the exceptions being Hawaii and California). Hawaii seems to have had the most success in surviving the EPA program's demise. While most of the state respondents wanted to see an EPA program reestablished, Illinois opposed such an action because it felt federal preemption led to lax standards.

There was a wide diversity of program size and scope among the responding municipalities. Over half of the programs were started in the mid-1970's. Annual operating costs range from \$130 to \$214,000, with FTE staff ranging from 0.01 to 7 employees. Most of the respondents had less than one FTE person. Local agencies in California and Colorado seemed to be the most active. Five respondents--two in California, two in Colorado, and one in Washington, D.C.--have annual operating budgets exceeding \$100,000.

Twelve of the thirty-five municipal respondents note motor vehicle noise being a regulated source. Most ordinances deal with source emission levels and properly functioning mufflers. Others deal with land-use planning (avoiding noise-sensitive development in high noise areas or requiring noise mitigation). Most of the respondents indicated the ability to provide some service other than ordinance enforcement, although services are limited by the small staff.

Follow-up investigations identified a number of successful efforts in California, Colorado and Canada. Key to the California success is the existence of a "noise element" that must be part of all city and county general plans. The noise element sets maximum sound levels by land use category and has led to the

construction by residential developers of many noise barriers near transportation noise sources. In Boulder, Colorado, most of the current focus is on motor vehicle noise emission enforcement. The Colorado Springs program has four full-time employees, regulates individual vehicles and has land development responsibilities.

In Canada, Calgary has had a strong program since the early 1980s, and has a noise level standard that developers must meet near roadways. Calgary uses a classification method to determine potential traffic impact zones to assist in its program. Other Canadian cities, such as Saskatoon, also have traffic noise policies with residential level standards for developers. The province of Ontario also has had a very active program of developer-provided noise abatement since the mid-1970s.

In summary, it was found that while there are a number of examples of good state and local noise control programs, they are few and far between. The closing of the EPA Office of Noise Abatement and Control has hurt the state and local noise control efforts significantly.

CONTROL OF VEHICLE NOISE AT THE SOURCE

The third aspect of the three-part approach to controlling transportation noise is source control. It was found that significant efforts have occurred in controlling motor vehicle noise, especially heavy trucks, since the 1970s. These efforts were driven by regulation, both in the United States and in the European community. The EPA regulations on medium and heavy trucks, motorcycles and motorcycle replacement exhaust systems are still in effect, even though the EPA program has been abolished. Likewise, the EPA in-use noise regulations for motor carriers engaged in interstate commerce remain in place, but are not being enforced. Regulated levels on newly manufactured motorcycles range from 70 dB for mopeds to 82 dB for off-road motorcycles with engines over 170 cc.

European noise control efforts begin in the early 1970s. The allowable levels have been reduced in a staged fashion over the last 20 years. Effective October 1990, all new heavy trucks exceeding 3.5 tons with "engine power not less than 150 kW" must meet a standard of 84 dBA at 25 feet per a European acceleration test procedure (32). This 84 dB standard is roughly equivalent to 80 dB U.S. standard at 50 feet.

Many European researchers are working actively on controlling truck noise (33),(34),(35),(36). The main sources of engine noise are mechanical or combustion-related. Noise level reductions are obtained by optimizing the combustion process, improving the structural response

of the engine block, reducing the vibration of engine panels such as the oil pan and the valve cover and using properly designed engine shields or covers (35). Data are also available based on a design criterion of 95 dBA at 1 meter, a level that would result in the European 7.5 meter standard being met (37). Engine/drivetrain encapsulation with a cover is very effective acoustically but requires careful consideration of cooling, and poses concerns about weight, space and maintenance (34). Most European researchers believe that the new standards can be met without having to go to engine covers.

In summary, U.S. and European vehicle manufacturers have invested heavily in control measures to successfully reduce engine and exhaust noise in both light and heavy vehicles. While gains in these areas will be made in the future, the incremental gains will be smaller and at much greater cost. As a result of engine and exhaust improvements, tire noise has become a more dominant source of vehicle exterior noise than ever before, especially at highway speeds.

APPLICATIONS AND IMPLEMENTATION

The earlier sections of this report examined the state-of-the-art in traffic noise analysis and control. This section focuses on the state of Washington. How the previously reviewed material should be viewed by WSDOT will be examined in the context of WSDOT's policies, programs and structure. Recommendations are then made for the WSDOT noise mitigation programs.

There are three key factors that must be in place if a state wishes to successfully mitigate its transportation noise problems:

1. the public must demand traffic noise mitigation;
2. the legislature must respond with laws conducive to noise mitigation; and
3. the administration must be committed to implementing the laws.

Washington State has seen a demand for traffic noise mitigation from the public. Concerns over growth have led the governor to create a Growth Strategies Commission and the state legislature to pass a Growth Management Act (37) and Growth Strategies Act (38) that call for the development of comprehensive land use plans by cities and counties experiencing rapid growth. WSDOT has also responded by making environmental protection, including transportation noise mitigation, one of its top priorities in the 1991 State Transportation Policy Plan (39). WSDOT has also embarked on a process called Choices in Transportation for Washington's Environment.(40)

Even given a demand by the public for noise abatement, action by the legislature to lead to noise control, and a choice and policy of the WSDOT administration to abate transportation noise, two key factors must be kept in mind:

1. noise abatement must compete with other areas of environmental protection that the public, the legislature and the administration sometimes choose to be more important; and
2. demands, laws, choices and policies are useless without the resources to bring about action.

More legislation is needed and more administrative support is required in terms of staff and funds, or else the efforts will not succeed. This section begins with an examination of the 1991 State Transportation Policy Plan, the Choices process and the Growth Management and Strategies Acts, and their implications to the Noise Unit of WSDOT. Also discussed are the State Growth Strategies Commission final report issued after passage of the Growth Management Act and the resultant Growth Strategies Bill (41) later amended

to become the final Growth Strategies Act. Noise unit responsibilities and duties are examined in the context of the organizational structure of WSDOT. Also, existing WSDOT noise policies, procedures and methods are reviewed. Then, with the material in the earlier parts of this report as a basis, recommendations are made for the control of transportation noise in Washington State, with focus on WSDOT.

The actions and focus of the Noise Unit will be driven by the Transportation Policy Plan for Washington State. Two of the three key policy areas are Transportation Programming and Transportation Finance; the third area is Environmental Protection and Energy Conservation. The Plan groups the environmental issues into eight areas, one of which is noise abatement. Additionally, the consequences of other environmental actions on noise need to be considered. Also, the Noise Unit must be sensitive to the implications on its work contained in the other two broad policy areas of Programming and Finance.

The 1991 Policy Plan delineates four action strategies regarding noise impacts: (1) minimize noise impacts of new transportation system facilities; (2) require local land use plans to identify noise impacts and needed mitigation measures, and avoid future impacts through land uses and building code actions; (3) develop a program to mitigate noise impacts identified in local land use plans; and (4) support research on quiet alternative transportation modes.

The first strategy goes beyond normal federal-aid project requirements and includes projects without federal funding. The second strategy contains several essential items for a comprehensive, integrated noise abatement approach. The requirement that local and regional land use plans identify excessive noise impacts and the establishment of a pattern of land uses and building codes to minimize noise exposure are critical. A funding policy must be established, a funding program phased over several years must be developed, and finally, legislative or administrative action must be taken to make available the funds to abate the noise.

The third strategy provides a tangible incentive to those local governments, but must have a funding mechanism that allows abatement of problems in a timely, dependable manner. The fourth strategy is aimed toward the noise consequences or benefits from other policy initiatives such as the improvement of air quality, the use of alternative fuels and the reduction of traffic congestion.

The second major policy area in the 1991 Policy Plan, Transportation Programming, calls for a continued, strong regional transportation planning process. The Noise Unit needs to be involved in this planning process in the various metropolitan planning organizations (MPOs) across the state to ensure

coordination between the Noise Unit's action strategy to minimize the noise/land use conflict in the development of region-wide transportation systems and the city and county comprehensive plan activities. Noise impact and noise mitigation could become important factors in assessing components of the regional transportation system plans. Noise impact and noise mitigation could be established as part of the criteria for the identification of regionally significant projects. Region-wide noise mitigation or impact minimization could be adopted as one type of performance standard, and noise monitoring could become a component of a performance monitoring program for regional system development.

The third policy emphasis area in the 1991 Policy Plan is Transportation Finance. The Plan identified ten key financial needs. None of them dealt specifically with noise abatement, although a general statement was made that financial needs must be met while protecting the environment. However, if the Noise Unit is going to be successful in responding to its own charge in the 1991 Policy Plan, then provision of funds for mitigation of existing noise problems is essential. Without explicit priority for noise abatement funding, mitigation of existing noise impacts may fall victim to limited resources in the face of higher priorities, despite noise abatement being a high priority of Washington State citizens.

The 1991 Policy Plan also delineates ongoing policy planning activities and new policy research initiatives. One such activity is the Freight Mobility and Economic Opportunity Subcommittee which deals with Urban Congestion and Freight Mobility. The Noise Unit should investigate the preliminary policy recommendations of this subcommittee for implications on noise impact, such as the possible restrictions on trucks during peak periods and the potential forcing of trucks to make deliveries during the noise-sensitive nighttime periods. Another initiative deals with privatization and joint development. The potential investment in privately funded toll roads implies the use of toll plazas and the potential for noise impact from accelerating and decelerating vehicles. The Environmental Branch should have input into the policy on privatization.

In summary, the 1991 Transportation Policy Plan Report to the State Legislature contains many items that impact on the Noise Unit's program and workload, either explicitly or implicitly. To be able to act on its explicit noise abatement action strategies, the Noise Unit must see that it plays an active role in other emphasis areas that could have noise consequences, such as land use planning, other environmental impact mitigation areas, and consideration of alternative transportation modes or management strategies.

Additionally, the Noise Unit must get noise abatement funding put on the agenda of either the WSDOT or the state legislature if it hopes to make any significant progress in mitigating existing noise impacts along WSDOT transportation facilities.

The Choices process focuses on five major areas. Consideration of transportation noise is a part of the discussion on land use and transportation planning. WSDOT indicates that it will encourage local agencies to adopt noise compatible land use plans for undeveloped areas near highways, and will continue to install noise barriers to protect noise sensitive land uses along existing highways. The Noise Unit in WSDOT must be in a position to respond to these policy initiatives. Additionally, the Noise Unit must be prepared to address the consequences and/or benefits on the noise environment from the other policy initiatives being considered, such as congestion management, transit usage, air quality control, alternative fuels usage, and visual quality.

Of special importance to WSDOT are the Growth Management Act of 1990 and the Growth Strategies Act of 1991. Among the planning goals in the Acts are protection of the environment. The Acts call for comprehensive land use plans to be developed by counties experiencing rapid growth. Noise mitigation is not mentioned specifically in either act. However, the initial Growth Strategies Bill that had been introduced in the legislature (which was modified for the final Growth Strategies Act) had called for the Land Use element of the plans to "incorporate noise exposure standards as defined by the Department of Ecology, identification of sources, including those from transportation facilities, and noise mitigation measures." Also, the Bill called for the Transportation element of the plans to include a Facilities and Services Needs subelement that would include "identification of noise mitigation measures needed for existing or planned transportation facilities as defined in the Land Use element."

Despite the deletion of these items (and many others) from the final Growth Strategies Act, both Acts still provide an opportunity for long-term control of traffic noise through land use management and control. The Noise Unit should work with the Department of Ecology on developing the transportation facilities noise exposure standards. The Noise Unit also needs to be prepared to provide ongoing technical assistance to cities and counties during plan development and implementation. Specifically, the Noise Unit can serve as a technical resource to developers and as a reviewer of noise mitigation plans. This role is essential to ensure

integration of developer-funded noise mitigation measures and state DOT noise control measures from points of view such as acoustical performance and integrity, and aesthetic quality.

WSDOT must try to influence, or provide for some consistency in, developer-installed noise mitigation measures along transportation facilities. The recent example of Toronto, Canada, needs to be noted carefully. Many miles of developer-built noise barriers were installed on private property along transportation facilities using an inferior concrete panel product. Within one to two years after installation, the concrete panels began to crumble and the responsibility may fall onto the Ontario government to replace these barriers at its cost. The WSDOT must take the lead in developing minimum materials or systems standards for privately built noise barriers if the state legislature is requiring cities and counties to include noise mitigation as part of their comprehensive plans. Indeed, WSDOT should develop the capability to test and approve such systems.

Other sections of the Growth Management and Strategies Acts also need attention by the Noise Unit, namely those on new, fully contained communities, master planned resort projects, impact fees, pilot projects on the environmental review process, real estate excise taxes, natural resources of state-wide significance, and technical assistance to the cities and counties. WSDOT needs to seek an amendment or ruling that impact fees may be imposed and used for noise mitigation purposes. Lacking such an ability, some means of placing the financial burden for provision of these measures onto the developers must be established. The problem is that noise mitigation measures such as barriers or berms are not specifically defined as "public facilities" for which impact fees may be used ("open space" is specifically mentioned as a public facility, implying that open space as a noise mitigation measure in terms of buffer zones would be able to be funded through impact fees).

Revenues from real estate excise tax may be used for local capital improvements that are identified in the Capital Facilities Plan element of the comprehensive plan. Again, noise mitigation measures are not specifically included in the definition of capital facilities. Nonetheless, the real estate excise tax could be an excellent funding mechanism for noise mitigation.

WSDOT is not designated as a member of the newly established temporary Committee on Natural Resources of statewide Significance, despite the fact that transportation facilities can have major impacts (such as noise) on these natural resources. The FHWA Noise Abatement Criteria are too high for natural resources of "statewide significance." The committee's report to the legislature is due at the end of 1991.

The Department of Community Development is designated lead agency for implementing the Acts, but is directed to utilize staff of other state agencies for technical assistance, which may include "model land use ordinances, regional education and training programs, and information for local and regional inventories." WSDOT should take the initiative, especially in light of the noise "action strategies" in the State Transportation Policy Plan, to make noise compatible planning part of the comprehensive plans.

However, lack of specific discussion of noise in the Acts could result in noise mitigation being given a lesser priority, either by design or necessity, in times of tight funding. Nonetheless, WSDOT needs to be adequately staffed so that it can be diligent in seeing that the goals of both the Growth Management and Strategies Acts and the Transportation Policy Plan are achieved.

The Growth Management Act asked the State Growth Strategies Commission, which was created by the governor in 1989 by executive order, to address how state government could ensure that local governments comply with the Act's goals and coordinate their planning, and how state agencies could comply with the Act and do a better job of planning and managing growth statewide. In its final report on its work (42), the commission called for more explicit strategies for protecting the environment than had been delineated in the Growth Management Act. For example, the commission recommended that an Environmental Management element be added to the comprehensive plans.

The commission specifically recommended that "all local governments must protect environmentally sensitive areas and address identified environmental problems." It also recommended that "a process must be developed by which all communities within a region fairly share the burden of public facilities." While the commission did not specifically mention roads as one such type of public facility, one could easily extend their recommendations to include the noise impacts created by new roads, and the need for the communities in a region to share the burden of mitigating the noise problems.

The commission noted that the Environmental Management element should "ensure that cumulative impacts and standards are considered and that best practice development standards and mitigation efforts are incorporated into land use, economic development, and infrastructure planning." The goal was to protect and, where needed, enhance environmental quality. Specifically, the comprehensive plans "should minimize development and growth impacts. . ." Also, the commission recommended "lack of attainment in the state and

federal environmental standards should be addressed by instituting stricter development standards, which if not adhered to, may be cause for limiting or precluding new developments."

The commission also called for regional plans for transportation to "contribute to an improved environment" and to be consistent with state or other regional environmental plans. It recommended that if local governments desire to undertake cooperative environmental planning efforts through regional processes the state should support such efforts. The commission also recommended all new infrastructure and off-site impacts from master planned communities should be fully considered and paid for by the developer. It called for the appointment of a permanent Growth Strategies Advisory Council that would include representatives from the appropriate state agencies, such as transportation.

The initial version of the Growth Strategies Bill contained sections amending the legislative code on Priority Programming for State Highways and on Project Criteria for the Allocation of Funds from the Transportation Improvement Account, and had a new section on a statewide Transportation System Plan. While all three sections were deleted from the final Act, they provided some ideas for a systems approach to noise mitigation. First, WSDOT may wish to consider establishing a new category of highway improvement, namely "Environmental Mitigation and Enhancement Improvements." In principle and philosophy, such a category is precisely in line with the 1991 Transportation Policy Plan for Washington State, the 1989 FHWA Environmental Policy Statement, and the National Transportation Policy. Establishment of such a category would be an action by WSDOT that indicates its serious concern and commitment for environmental mitigation and enhancement. A noise barrier retrofit program for existing highways could be funded from monies in this category. A second idea is that it is entirely appropriate, given the high priority assigned to environmental protection in 1991 Transportation Policy Plan, that environmental mitigation and enhancement be added to the list of criteria to be considered for funding for specific transportation projects from the Transportation Improvement Account.

In summary, Washington State has taken strong steps toward managing growth while preserving environmental quality. The Growth Management Act of 1990 mandated a comprehensive land use planning process with environmental protection as a goal. It also expanded the MPO process beyond urbanized areas and required that regional transportation plans conform with land use plans. The Act permitted real estate excise taxes and impact fees to be imposed to help fund capital facilities improvements. It also called for state

agencies to provide technical assistance and grants to the cities and counties for the development of their plans and subsequent implementation regulations. Important steps were made toward managing growth, but not enough was mandated explicitly on the subject of environmental protection.

The work of the Washington State Growth Strategies Commission extended, refined, and further defined the provisions in the Growth Management Act of 1990. The commission was much more proactive in its call for an Environmental Management element to be a part of each comprehensive plan so that the goal of protecting the environment and quality of life would be incorporated into the process.

The resultant Growth Strategies Bill was a significant proposal with respect to environmental quality as it related to the development and implementation of the comprehensive plans by cities and counties. Control of noise from existing and planned transportation facilities was specifically mentioned as a component of these plans with the likely use of the WSDOT for assistance with transportation noise mitigation.

The final Growth Strategies Act of 1991 was significantly different from the Bill and did not fully implement the recommendations of the Growth Strategies Commission, especially towards incorporating environmental management as part of the comprehensive land use planning process. Also, by deleting the requirement for consideration of noise mitigation in the Land Use element of the comprehensive plan, the Growth Strategies Act has neglected probably the best long-term measure to ensure that the management of growth within the State of Washington would be done in a way to minimize noise impacts both on that growth and due to that growth.

Despite its final form, the Act does not prevent or preclude WSDOT from encouraging noise mitigation as part of the Land Use element. The provisions on technical assistance and planning grants call for action by the Department of Community Development and other state agencies; WSDOT can and should take a leadership role by seeing that one focus of the technical assistance includes noise mitigation through land use strategies. While the Act opens some opportunities, WSDOT should continue to work through the legislature to see that an Environmental Management element and noise mitigation strategies are made part of the comprehensive land use planning process through amendments to the Growth Management Act and/or the Growth Strategies Act.

Any comprehensive system-wide noise mitigation strategy for Washington State must be considered in the context of the organization of the WSDOT. The Noise Unit (which currently consists of one noise

specialist) is in the Environmental Branch of the Design Office within the Program Development Division. Other offices that should interact with the Noise Unit include Architecture, Bridges and Structures, Real Estate Services, Design Standards and the Local Programs Division. The latter could play a major role in the implementation of the Growth Management and Strategies Acts. Additionally, the Planning, Research and Public Transportation Division could have an important role in the city/county comprehensive plan implementation process in all three areas in its title.

(Also, the Aeronautics Division is responsible for supporting the state's airports and heliports through planning and financial assistance. Aviation noise impacts have been described by the Federal Aviation Administration (FAA) as the single, largest problem affecting the operation, capacity and growth potential of our nation's airports. Departmental expertise in aviation noise is important, especially because of the National Aviation Noise Abatement Policy passed by Congress in 1990 and the recent FAA rules implementing the Policy.)

The Noise Unit provides numerous functions to the department such as: (1) development of noise analysis and mitigation policies, rules, procedures and methods, (2) district noise specialist training, (3) district noise analysis review and advice, and (4) research project planning and monitoring. The Noise Unit represents the department in dealing with the public, the legislature and other state and local agencies, and plays a liaison role within the department beyond its division in dealing with Offices such as operations, public transportation, aeronautics, research, transportation planning, local programs (especially technology transfer) and legal affairs.

The role that the main office Noise Unit will play with each of the district offices will vary from district to district. Factors such as the number of projects requiring noise analysis, the number of available people to do this work, and the experience and expertise of the staff will affect the nature and extent of interaction with each district. For example, District 1 has three full-time noise specialists, which allows delegation of many of the main office functions noted in the previous paragraph. If not already done, a meeting of the noise specialists from each district and the main office staff should be held at least annually.

Thus, while the noise specialist function is located organizationally within the Design Office, the Noise Unit must provide technical support across organizational lines within its own division, across other main office divisions, and in the districts. Knowledge that a noise specialist exists within the Design Office of the

Program Development Division neither requires nor guarantees that the specialist will be consulted on issues that need an expertise in noise for proper input to decision-making.

While formal organizational changes may not be warranted, some consideration is needed. With the Transportation Policy Plan, the Growth Management and Strategies Acts and even the new National Aviation Noise Policy, the duties, responsibilities and workload of the Noise Unit, other main office groups and the district offices will increase if the state wants to be successful in mitigating transportation noise on a system-wide basis.

As part of this study, four WSDOT documents on traffic noise policies and procedures were reviewed. The first document defined four criteria for accomplishing noise attenuation in construction programs and gave responsibility to the district offices to establish and maintain a list of priorities. The second document presented a Type II noise barrier priority listing of 28 projects. This directive gave a procedure for inventorying and prioritizing the noise abatement sites. The procedure used the philosophy of only listing those areas exceeding an L_{eq} of 67 dB. A second philosophy is to prioritize down below the 67 dB level (to a value of 55 dB, for example). This ranking establishes impacts without regard to feasibility of abatement. The advantage is that many more sites are listed, providing visible evidence as to why certain sites are unlikely to receive abatement. Once this ranking of impacts is available, the consideration of feasibility, effectiveness and cost of abatement can be introduced to produce the barrier construction priority list.

The third document, on WSDOT's Noise Abatement Program, is built upon the previous procedures. Seventy-seven sites were listed in the priority ranking for noise abatement. The document acknowledged the Department's concern for traffic noise impact but also described the funding reality. In fact, noise mitigation receives a low priority relative to other departmental needs such as maintaining and improving the existing highway system. Of the 77 priority sites, only two projects were funded and built between 1986 and January, 1989. At that rate it would take over 100 years to complete the projects on the priority list.

Clearly, if the state of Washington wants to be able to succeed with its policy statements to abate traffic noise, funding must be made a priority. With an accumulated need of nearly \$15 million dollars (in 1985 dollars) for only these 77 sites, a Type II funding level of \$3-4 million dollars a year would seem appropriate. With that level, WSDOT could probably complete its noise barrier retrofit program in six to

eight years. With proper staffing (or use of consultants), such an abatement schedule is feasible and certainly much more realistic than the current situation.

One other note: WSDOT uses a value of \$8,000 per residence protected as a measure for determining cost-effectiveness of a barrier. This value appears to be quite low relative to those used by other states, but it does consider more than first row residences, which some other states do not. A value on the order of \$20,000-25,000 per residence is suggested.

The fourth document was a partial draft of a proposed new directive on noise abatement. The development of this directive is an excellent idea and its periodic review and update would be appropriate. The document quantifies some of the qualitative terminology in the FHWA Noise Standards defining noise impact. The draft uses a 2 dB value to define "approaching" the FHWA noise abatement criteria, and a 10 dB value as defining a "substantial increase over the existing noise level," both of which are consistent with other states. Taken together, the reviewed documents show that WSDOT is approaching its noise control program in a proper manner, with some areas worthy of some additional consideration.

One may conclude this study by noting that Washington State has declared as policy the mitigation of traffic noise. The state legislature has provided legislation for comprehensive land use plan development by cities and counties experiencing high growth. The legislation presents an opportunity for achieving the policy goal, but will require WSDOT to take the initiative since noise is not specifically mentioned in the legislation. WSDOT traffic noise analysis and abatement procedures are sound, but staffing seems inadequate to successfully meet the policy goal. Funding is clearly inadequate to meet that goal.

The findings of this research, both in terms of the state-of-the-art review and the reviewed Washington State legislation, regulation and policy, have led to a series of recommendations addressing these various areas of interest. These recommendations are summarized in the Chapter on CONCLUSIONS AND RECOMMENDATIONS and presented in detail in the Final Technical Report.

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