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ECONOMIC IMPACT OF PROPOSED AIRPORT NOISE REGULATIONS, R77-4

VOLUME IV: ECONOMIC ANALYSIS OF O'HARE AND MIDWAY AIRPORTS

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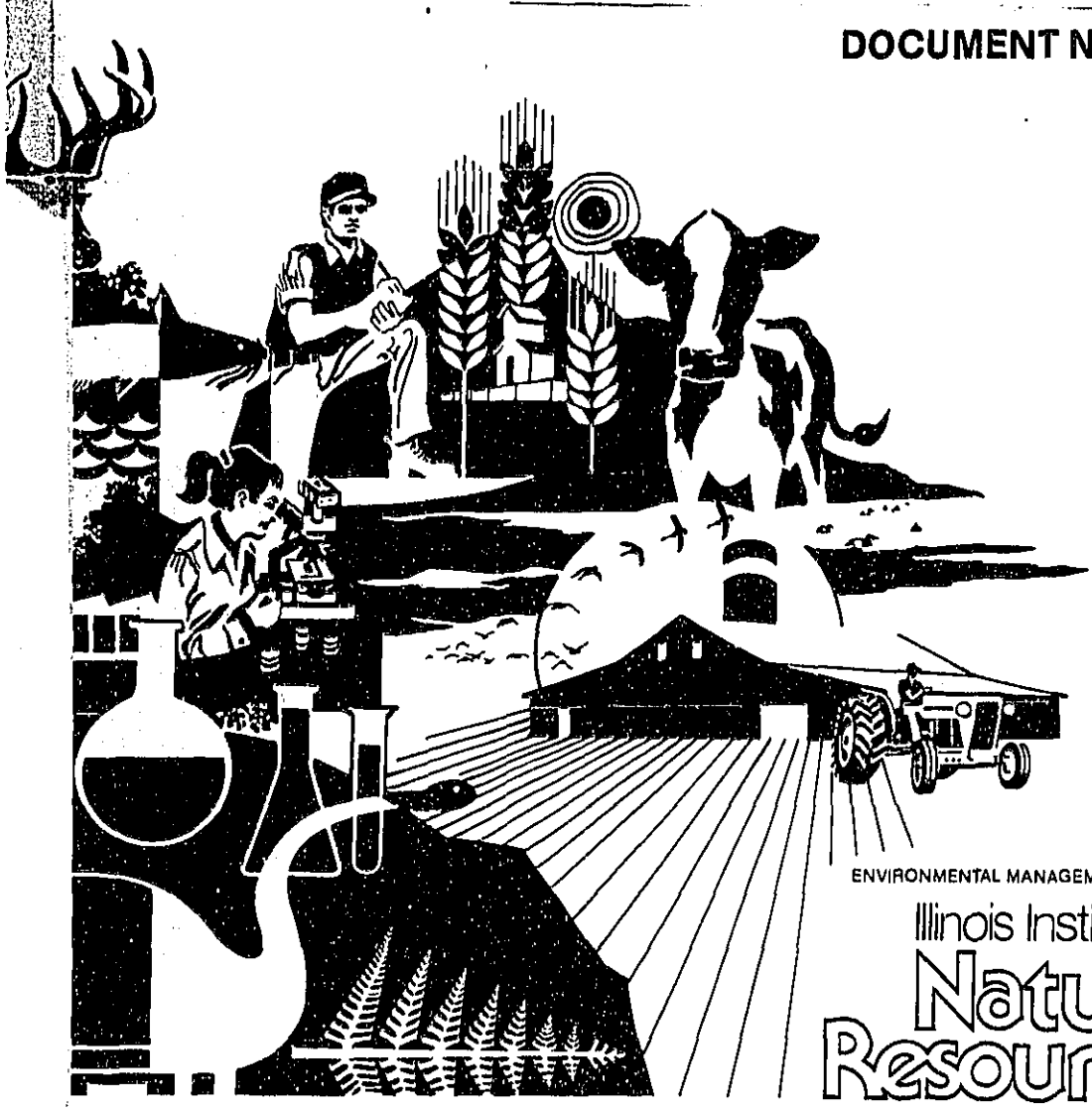

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Illinois Institute of Natural Resources

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ECONOMIC IMPACT STUDY OF

PROPOSED AIRPORT NOISE REGULATIONS, R77-4

VOLUME IV: Economic Analysis of O'Hare and Midway Airports

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NOTE

This report has been reviewed by the Institute of Natural Resources and approved for publication. With the exception of the Opinion of the Institute's Economic Technical Advisory Committee, views expressed are those of the contractor and do not necessarily reflect the position of the IINR.

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Opinion of the Economic Technical Advisory
Committee of the Illinois Institute of Natural Resources

The Economic Technical Advisory Committee (ETAC) has reviewed and approved Volume IV of the four-part study entitled: The Economic Impact of the Proposed Airport Noise Regulations, R77-4. The submission of this volume to the Illinois Pollution Control Board (IPCB) fulfills the requirement of Section 4 of P.A. 80-1218 on IPCB Docket R77-4. The study has been reviewed by the Institute's project management staff and approved for publication.

The INR and ETAC unanimously concur that Volume IV is a truly outstanding example of an economic impact study that fulfills both the letter and intent of P.A. 80-1218. The costs and benefits of alternative strategies to deal with the airport noise problem are accurate and well documented. Where data constraints impinge on projecting dollar values for benefits and costs, the author is frank and impartial by inserting appropriate caveats.

Without question, the four-volume study is the largest economic impact analysis ever conducted by the Institute. Likewise, the 36 technical hearings which generated over 7,000 pages of testimony undoubtedly qualifies Docket R77-4 as one of the largest proceedings ever before the Board.

The INR and ETAC submit the following comments on the proposed regulations and the relationship R77-4 has to other ongoing research work on the auspices of the Noise Management and Economic Impact Analysis Programs.

Illinois has one of the strongest state economies in the nation today. Illinois is blessed with a unique blend of agricultural and

industrial sectors. The growth of the state economy as a whole is inextricably linked to a highly developed transportation infrastructure. The recognition of the economic significance of a viable transportation network in Illinois cannot be understated: nearly one-third of our nation's gross national product (GNP) is produced within a 300-mile radius of Chicago.[1] Illinois industries and airline passengers depend heavily on a viable air transportation network.

The record in these proceedings suggests that unrestricted use of a major airport is a significant factor in industry decisions to locate new plants and expand existing operations. Thus, the importance of O'Hare is not confined to Illinois alone. Indeed, over 50,000,000 domestic and international passengers used the facility in 1980.

It is apparent that enforcement of the regulation to achieve compliance with the prescribed noise limits would involve the implementation of curfews and operations cutbacks. Within this context, the noise limits in the regulation are acknowledged to be unenforcable in the absence of these measures in tandem with the use of the IPCB's variance process. With regard to the former, Section 2 of Volume IV provides an accurate description of the economic impacts of the use of a night curfew (Section G) and operations cuts (Section H) on O'Hare. The economic implications of these actions are summarized below.

The use of a curfew at O'Hare would affect up to 65,400 aircraft operations between 10:00 p.m. and 7:00 a.m. per annum. The implications would not be limited to aircraft operations alone. More specifically, enforcement of this scheme would eliminate 3,685,000 night coach fares. Ancillary effects of a curfew include passenger inconvenience, reduced efficiency of airline operations, cancellation and elimination of flights

and a severe adverse economic impact on air cargo transport.

The economic impacts of imposing operations cuts as a means of reducing noise is discussed in Section H (page 80). The economic effects of an operations cutback would, as the author notes, " . . . lead to decreases in direct employment, payrolls and expenditures for local goods and services by airport tennants, resulting in, ultimately, a variety of indirect and induced changes throughout the Chicago area economy." In this regard, the record in these proceedings indicates that compliance with the L_{dn} noise limit would result in a direct employment decrease of over 11,600 with a commensurate payroll reduction of $220,000,000. The latter would induce indirect effects on employment and payroll in the Chicago area by more than 35,168, with a payroll of $345,000,000. Furthermore, the decrease in airport related expenditures of $194,000,000 translates into an indirect and induced decrease of $538.3 million.

Although the foregoing discussion eludes to differential cost and benefits projections, the economic impacts of operations cuts as a means to achieve compliance with the proposed regulations is substantial and readily quantifiable: a reduction in aircraft operations of 45 percent to achieve the $80L_{dn}$ noise limit would, according to an estimate contained in Volume IV, reduce employment in the Chicago area economy by a total of 49,000 jobs with a negative economic consequence of approximately $2,000,000,000 on the regional economy.

By comparing the various noise abatement strategies, the modified take-off and night-time procedures at O'Hare are shown to be cost-beneficial by a wide margin. The modified take-off procedure would remove 54,000 housing units from within the $65L_{dn}$ contour, while housing units remaining within the contour would enjoy a noise reduction.

Finally, as the study author points out, the regulation as proposed does

not come to grips with the longer-run problem of land use control and related preventative measures. In this regard, Volume IV concludes:

> "Vacant land approximate to the airport is subject to future development, just as current residential patterns reflect past development trends . . . to cope with this problem, consideration might be given to measures to adapt land uses to noise compatible purposes."

It is within this context that the IINR and ETAC provide the following information for the Board's consideration.

Since its creation, the Institute has been in the unique position to advise the Board on contemporary pollution control, environmental and natural resource problems. Section 25 of the Illinois Environmental Protection Act (as amended January 1, 1979), states that "the Board shall secure the cooperation of the Illinois Institute of Natural Resources (formerly the Institute for Environmental Quality) in determining the categories of noise emission and the technological and economic feasibility of such noise level limits." Pursuant to this mandate, the Institute has completed a white paper on the airport noise problem in the state entitled: Issues Related to Airport Noise in Illinois, (IINR Document No. 81/16). A second ongoing research effort in the Noise Management Program, namely, The Airport Noise Demonstration Project, will provide essential information for the Board's consideration.

The Institute commissioned the white paper to examine the legal, economic and technical factors affecting noise abatement at Illinois airports, thus providing Illinois' citizens and the IPCB with a complete description of the airport noise problem and possible long range solutions. The white paper came to two important conclusions. The first of these is that:

> "Illinois and other states should play a larger role in airport noise abatement because the states

> have unique authority which the federal and local governments do not, but which is essential to an effective solution to the problem. State action should be directed at using this unique authority to complement federal and local efforts by filling gaps and correcting weaknesses in the current program."

The second and most important conclusion is that:

> "The State of Illinois needs to consider some means for discouraging or preventing land use decisions by local governments which allow noise sensitive uses in existing or potential high noise areas surrounding airports. No program for dealing with the airport noise problem can succeed without this preventative aspect and the State is the only authority that can bring it about."

It is also apparent that Illinois should consider the approaches to this problem adopted by Minnesota and Maryland, as well as the proposal of the Illinois Public Airports Association in their suggested amendment to the Illinois Airport Zoning Act. We note that Volume I of the economic analysis showed the strong likelihood of a multi-fold increase in noise impact if land use and related controls were not instituted in the areas surrounding the airports outside of Chicago.

As previously discussed, the Institute is also conducting a four-part airport mitigation project. That research effort has as its goal the development of a comprehensive set of noise mitigation procedures to be used by Illinois' public airports. Phases I through III of the project shows that land use and related controls would play an important role in the harmonious development of communities around the airport along with the growth in aviation at the airports.

In view of the foregoing, the obvious question becomes: What combination of legal, economic and administrative changes are needed to solve the airport noise problem? With the Airport Noise Demonstration Project entering its final stages (Phases III and IV), the INR is in the process of

establishing a statewide airport noise prevention program for Illinois. The Statewide Airport Control Task Force will be organized and consist or representatives from a cross-section of Illinois' airport communities with existing and potential noise problems. Municipal and county officials, state officials, airport proprietors and representatives of public and special interest groups and others will be included in the task force. The objective of the group will be to develop a comprehensive statewide program for airport noise control at publicly owned airports in Illinois. Staff support and a professional consultant will be provided by the Institute.

In summary, this approach may offer a viable alternative and a possible long range solution to the airport noise problem. The task force will eventually formulate specific recommendations for possible legislative or regulatory action. Required state and federal actions will be identified. Draft legislation may be prepared if it is deemed appropriate. In this way, a comprehensive solution to the airport noise problem may be realistically attainable.

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[1] Commission for Economic Development, Report and Recommendations to Governor James R. Thompson and the 82nd General Assembly, January, 1981, p. 6.

PREFACE

The Illinois Attorney General has proposed to the Illinois Pollution Control Board noise control regulations applicable to all publicly owned airports in the state. The regulations would establish limits on cumulative aircraft noise received at residential and other noise-sensitive properties near the airports. An airport producing noise in excess of the limits would require a variance to continue operations. To get a variance the airport proprietor would have to prepare and implement a noise control plan.

Under Illinois law, before the Pollution Control Board can act on the proposed regulations, it must receive from the Illinois Institute of Natural Resources an economic impact analysis of the proposal. The present study, being done under contract with the Institute, is intended to satisfy that requirement. The report consists of four major parts:

I. A technical study of public airports outside Chicago.

This study contains a detailed analysis of aircraft operations, land uses, and resulting noise impacts in the vicinity of each of twenty-one airports outside Chicago.

II. An economic analysis of noise abatement measures at the non-Chicago airports. This volume examines the economic costs and benefits of implementing various noise abatement measures at the 13 airports that currently violate the proposed 1985 noise limit of 65 L_{dn}. As the data show, such benefits and costs can vary substantially according to the individual circumstances of an airport.

III. A technical study of Chicago's O'Hare and Midway airports. The format of this volume is similar to that of part I, except that the numbers and types of aircraft operations and the intensity of nearby land development make analysis more complex than for downstate airports.

IV. An economic analysis of noise abatement measures at O'Hare and Midway airports. The format of this volume is similar to that of Volume II. But the analysis differs from the earlier volume in many of its basic features, as well as in its details.

Professors Roger W. Findley (law), Marvin Frankel (economics), and Paul D. Schomer (engineering), all of the University of Illinois, have cooperated in the overall design of the study. Particular individuals are responsible for the preparation of the separate reports: Professor Schomer for Volumes I and III, and Professor Frankel for Volumes II and IV.

The preparation of this volume (V. IV) has benefitted from the cooperation and advice of many individuals and groups, not all of whom can be acknowledged here. They include officers and staff of the Illinois Public Airports Association, the Air Transport Association, the Division of Aeronautics of the Illinois Department of Transportation, the Federal Aviation Administration, the Port of Seattle, the Minneapolis-St. Paul Metropolitan Airports Commission and the Minnesota Pollution Control Agency, Orange County Airport and the County of Orange, California, the Los Angeles Department of Airports, and Northwest Orient Airlines. We also have enjoyed the assistance and cooperation of the City of Chicago's Department of Aviation and its consultants, Landrum and Brown, of personnel at airports throughout Illinois, and of colleagues at the University of Illinois. The Illinois Institute of Natural Resources, through Frank Beal*, its Director, Peter Loquercio, Manager of the Division of Environmental Management, and

*Mr. Beal resigned as Director of the Institute effective November 6, 1981.

Neils Herlevsen, Project Manager, has provided continuing support to the project. Mr. Herlevsen has followed the study closely as it evolved and has offered continuing assistance and encouragement. Ms. Lise Zwisler has given able and extensive assistance throughout, including the preparation of drafts for the sections on curfews, operations cutbacks, secondary and indirect impacts, and the health and related effects of noise. The listed authors bear final responsibility for the contents of the volume, including any errors, omissions or other deficiencies that it may contain.

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EXECUTIVE SUMMARY

The Illinois Attorney General has proposed that aircraft-generated noise at Illinois' public airports be limited to progressively lower levels over time, with a maximum of 65 L_{dn} in 1985. This study, building upon a variety of sources, including an earlier Technical Study, examines the effects of the Attorney General's proposal for O'Hare and Midway Airports.

The main body of the study deals with O'Hare Airport. Several alternative abatement strategies are considered and, to the extent possible, their costs are estimated. The benefits from abatement also are reviewed and, on the basis of information relating to the effects of noise on property values, estimates are made of their magnitude. The implications of the proposed regulation for Midway Airport are considered in a supplemental section. The analysis follows the same general pattern as is used for O'Hare Airport. The treatment is, however, comparatively brief, both because there are fewer noise-mitigation options to consider in the case of Midway and because the discussion does not repeat relevant matters and material previously considered in the analysis of O'Hare.

O'Hare Airport is the busiest airport in the world. It supports over 800,000 aircraft operations per year, of which about 12% occur at night. Over 75% of these operations are by large air carrier-type aircraft, and over 95% of them are by jet aircraft. Estimates of the airport s current noise impacts vary somewhat, depending upon certain assumptions made about the present activity levels and pattern and also about the various kinds of operating procedures employed by aircraft. A modified Master Plan scenario presented in the Technical Study (Volume III of this series) indicates that about 45,000 acres of land, exclusive of the airport, have noise levels in excess of 65 L_{dn}. The re-engining of some aircraft, the retrofitting of others, and changes in the fleet mix that are expected to occur by 1985, will reduce this exposed land area to about 39,000 acres. Of this total, approximately 44% will be used for residential purposes. This land is estimated to contain about 101,500 housing units, of which 98,800 are in the 65-75 L_{dn} range and the remainder are at noise levels above 75 L_{dn}. These numbers could be reduced by each of several abatement strategies.

The first of the abatement strategies considered consists of 1) a modified takeoff procedure involving quick flap retraction and, for some aircraft, a deep-thrust cutback, and 2) modified nighttime procedures, entailing changes in takeoff and landing runways and in the approach path for landing. This strategy would reduce the number of dwellings located above 65 L_{dn} by close to 60%. The first of its two components would give rise to a small increase in fuel consumption for departing aircraft. The aggregate cost of this increase

on an annual basis, would be about $450,000. The second would require the extension of runway 27R and the associated taxiway, and the relocation of the ILS system and of the approach lighting. These changes would cost a total of about $6.3 million. The modified nighttime procedures would, however, bring about a net reduction in taxi time for aircraft, with consequent fuel savings. These savings are estimated at $3.1 million per year. This annual saving is more than sufficient to offset the capital costs associated with runway extension and the nominal increase in fuel costs arising from the modified takeoff procedure.

The insulation of homes represents a second approach to abatement, and it is assumed to be applied to the dwellings remaining above 65 L_{dn} after the implementation of the modified takeoff and nighttime procedures. Costs are estimated on two alternative bases. The first assumes that dwellings are insulated in 1 dB increments, to an extent dependent on their prevailing noise levels. Thus, a dwelling at 71 L_{dn} would receive insulation for 6 dB of quieting, another at 77 L_{dn} would receive 12 dB of quieting, etc. The second assumes that insulation takes place in 5 dB increments, so that those dwellings in the 65-70 L_{dn} range would each receive insulation for 5 dB of quieting, those in the 70-75 L_{dn} range would receive insulation for 10 dB of quieting, etc. Approximately 42,000 dwellings would be candidates for insulation. The aggregate insulation cost for these dwellings, estimated on the first basis, is $210 million. Of this total, about $60 million would be spent for the 2800 dwellings with noise levels above 75 L_{dn}. The estimated total cost on the alternate, or 5 dB increment, basis is put at about $341 million, with $74 million of this sum devoted to dwellings above 75 L_{dn}. These estimates should be regarded as gross figures, since a substantial fraction of insulation costs can reasonably be expected to be recovered within five to fifteen years through reduced heating and air conditioning costs. While data with regard to this point are lacking, it is a plausible surmise that the true economic costs of insulation would be perhaps one-half of the figures cited.

Besides residential dwellings, some 65 schools are located within the 65 L_{dn} contour. These schools experience adverse effects from aircraft noise through disruption in classroom communication, student distraction and a consequent lowering of teacher efficiency. The cost of insulating classrooms is put at $191,000 per school, and the estimated total cost for all affected schools is $12.4 million.

The acquisition of noise emission rights, or easements, rather than the actual reduction of noise, constitutes a third approach to the problem. Limited data, based mainly on litigation experience for Los Angeles International Airport, suggest that the purchase of easements might cost 2.5% of property value for dwellings at 65-70 L_{dn}, with the cost rising to 17% of property value for dwellings at 75-80 L_{dn}. The (1979) cost of an easement for an average dwelling, or housing unit, in the vicinity of O'Hare would be about $2700, and the aggregate cost of

easements for all dwellings remaining above 65 L_{dn} after implementation of the modified takeoff and nighttime procedures would be around $113 million. Thus, this approach, though it would not provide physical relief from noise, appears to be considerably less costly than an insulation approach.

A fourth approach to the problem of aircraft noise is to acquire impacted residential properties and demolish them, with or without redevelopment of the land for alternative uses. It is not possible to generalize as to redevelopment possibilities, for they depend upon the presence of a number of facilitating factors. Suitable opportunities are likely to exist for selected sites. But such opportunities may be comparatively limited within the context of the kind of program considered here, in which hundreds or thousands of residential acres are to be acquired. In the absence of such opportunities, the acquisition strategy is expensive, since it involves the payment of full market value for properties, plus added sums to cover relocation costs for occupants and administrative expenses. The estimated cost of purchasing and demolishing the 42,000 housing units within the 65 L_{dn} contour is $2.7 billion, of which $181 million would be for properties located above 75 L_{dn}. These estimates make no allowance for possible additional costs to purchase schools, hotels, churches and hospitals. An acquisition program could, of course, be applied much more selectively--for example, to only those properties having both high noise impaction and a promising potential for redevelopment. This restricted approach would limit cost, but would also limit the gains in noise relief. From an economic vantage point, in the absence of redevelopment opportunities, the purchase and demolition of residential dwellings is not advantageous, since it reduces the community's wealth by an amount in excess of the benefits from noise reduction.

Two additional noise-reducing strategies for O'Hare, curfews and operations cutbacks, are examined. A full curfew, if undertaken, might be presumed to follow the use of modified takeoff and nighttime procedures. It would eliminate all operations between 10 p.m. and 7 a.m., representing between 10% and 12% of total operations. Such an action would cause a substantial drop in the noise impacted residential acreage. The number of dwellings over 65 L_{dn} would fall by around 40%, with the major part of the decline occurring in the 65-75 L_{dn} range. The amount of noise-affected commercial and industrial acreage also would fall, though generally by lesser amounts. A major fraction of night operations at the airport involve cargo movements. A curfew would have adverse impacts on several main entities and activities: the airlines and their passengers, the cargo carriers, users of cargo service, the movement of mail, and bank-clearing and related operations. The airlines would experience difficulties in aircraft scheduling and routing, in positioning aircraft, and in meeting maintenance schedules. Passengers would face a reduction in choice of departure times, inconvenience and delay in making connections, and a loss of the reduced-rate, night coach fares. Shippers would lose the advantages of overnight and rapid delivery on high-value cargo, and cargo carriers would find

their schedules compressed into daytime hours while idle capacity existed at night. Between 200 and 250 thousand pounds of mail are shipped each night at the airport. A curfew would bring delivery delays, including a reduction in next-day delivery, and cause diversion of some mail to alternate means of transport. Chicago area banks would also encounter problems from a curfew, since they rely on night air transportation in the processing of drafts, receivables and deposits, and to facilitate the check clearing process. The burdens and difficulties a curfew would impose constitute its costs. However, because of the complexities of the problem, it has not been possible to measure these costs in simple, dollar terms.

Operations cutbacks, if used to reduce noise, would presumably be implemented following the imposition of a curfew. In order to achieve a maximum of 80 L_{dn} at the nearest residential property, a 33% reduction in 1979 daytime operations, and a 46% reduction in overall operations would be required. (To achieve 65 L_{dn} at the nearest property, overall operations would have to be cut by about 95%.) The kinds of problems and difficulties operations cuts would bring are not unlike those resulting from a curfew. Passengers departing from O'Hare would confront reduced schedules. There would be a loss of connecting service to passengers originating at other airports and using O'Hare as a transfer point. Cargo capacity would fall from levels already substantially reduced by a curfew. Special burdens could occur for the users of short-haul services, since those services would be likely candidates for elimination. More generally, many users of air services would be obliged to accept alternative, less efficient solutions to their transportation problems.

Another vantage point from which to consider the effects of cuts and curfews is in terms of their direct, indirect and induced effects. Operations reductions impact adversely on the activities of airport tenants; on the activities of the suppliers of goods and services to those tenants, and of the hotels and restaurants serving passengers; and via a multiplier process, on employment and expenditures in the economy at large. A reduction in aircraft operations of 45% to achieve 80 L_{dn} would, according to one estimate, serve via these separate channels to reduce employment in the Chicago area economy by a total of approximately 49,000 and aggregate expenditures by about $2 billion.

The costs of enforcing the proposed regulation would, in the first instance, fall upon three entities: the airport authority, the Illinois EPA, and the Illinois PCB. The largest share of these costs would be borne by the airport authority, and the largest component in the total would be the cost of acquiring and operating a noise-monitoring system. Aggregate ten-year enforcement costs for O'Hare are estimated at about $1.1 million. (The corresponding estimate for Midway Airport, for which no monitoring system is assumed, is $133 thousand.) In light of the uncertainties as to the manner in which the enforcement mechanism might operate, these estimates are subject to a substantial margin of error.

The benefits from aircraft noise abatement can be evaluated in different but complementary ways. Noise is capable of producing a variety of adverse physical effects, including health effects. The effects commonly experienced by large numbers of people living near O'Hare, particularly those living in the higher noise zones, are speech interference, sleep interference, and annoyance. Classroom communication in nearby schools also is subject to occasional and sometimes frequent disruption. The presence of all of these effects was affirmed in testimony by persons, including school personnel, living or working near O'Hare. The effects are also readily inferable from available technical information--on the noise levels at which the various indicated effects occur and the noise produced by aircraft overflights. At the same time, it does not appear that noise levels in the vicinity of the airport are sufficiently high and sustained to cause permanent damage to the hearing of nearby residents or other lasting impairments of a physiological nature.

The use of differential property value data permits estimates in dollar terms of the benefits from various abatement strategies. Two sources of property value data are used: published econometric or regression studies of the effects of noise pollution levels on residential property values and damage recoveries and settlements in inverse condemnation litigation based on airport noise. The litigation-based method yields higher estimates where the affected properties are exposed to higher noise levels--above 70 L_{dn}.

Comparison of noise abatement benefits, calculated by the foregoing methods, with the dollar costs of such measures, indicates that the modified takeoff and nighttime procedures at O'Hare are cost-beneficial by a wide margin. The modified takeoff procedure would remove about 54,000 housing units from within the 65 L_{dn} contour, while housing units remaining within the contour would enjoy a noise reduction. The dollar benefits from this action are estimated at about $104 million on the regression basis (or R-basis) and $120 million on the litigation basis (or L-basis). By contrast, the cost of the action, arising from additional fuel use, would be about $0.5 million. The modified nighttime procedures would remove an additional 6200 housing units from the 65 L_{dn} contour, while also benefitting the housing units remaining within the contour. Benefits from these procedures are estimated at $14 million on the R-basis and $20 million on the L-basis. The procedures would entail no net costs, but rather would produce fuel savings from reductions in taxi time.

Some 42,000 dwellings would remain above 65 L_{dn} after the application of modified takeoff and nighttime procedures. The insulation of these dwellings, if undertaken in 1 dB increments, would generate estimated benefits of about $58 million on the R-basis and $113 million on the L-basis. These benefit figures are overstated since insulation is a partial measure that leaves outdoor noise levels unaffected. Corresponding costs for insulation are $210 million. This figure is also overstated since it makes no allowance for energy savings. If insulation were undertaken in 5 dB increments, the R-based benefits would rise

about 50%, to $88 million. (L-based benefits would not change.) Costs, however, would rise more sharply, to $341 million, and costs would exceed benefits, however measured, (even after allowance for energy savings). Benefits from insulating the 65 schools within O'Hare's 65 L_{dn} contour are estimated on the basis of classroom time lost (teaching resources wasted) because of interruptions from aircraft noise. The resulting benefit figure is $43 million. The estimated cost of insulation, at about $12 million, is less than 30% of the benefit figure.

The purchase of noise easements produces benefits that just match their costs, since the gain to property owners from this procedure is just equal to their costs.

Under a large scale property acquisition program, the displaced owners and tenants (42,000 households) would presumably relocate to quieter surroundings. Were they to relocate to a 65 L_{dn} environment, the estimated R-based benefits would be $58 million and the L-based benefits $113 million. The estimated costs of $2.7 billion are far in excess of this figure. If only those properties above 75 L_{dn} (numbering about 2800) were acquired, benefits on the R- and L-bases would be, respectively, $12 million and $28 million. But cost would be far above these figures, at $181 million. Property acquisition will generally not be cost-beneficial, unless it is undertaken on a selective basis in situations offering favorable opportunities for land redevelopment.

With a night curfew, some 12,000 dwellings would be removed from the 65 L_{dn} contour, and those remaining within the contour would also enjoy a degree of noise reduction. Dollar benefits from the curfew are estimated at $35 million on the R-basis and $43 million on the L-basis. To assess these figures in the absence of an estimate of curfew costs, it is useful to adjust them to a "per airport day" and "per operation eliminated" basis. Using an average of the two figures, together with a ten-year time horizon or amortization period, yields a benefit figure of $10,700 per airport day. That is, a curfew would produce daily benefits to nearby households of this magnitude. This figure should be judged against the collection of daily benefits--to carriers, passengers, shippers and the community--that night flights currently bring and that would be lost if they were eliminated. Looking at the matter in a slightly different way, the daily benefit of $10,700 amounts to about $75 per operation curfewed. In a cost-benefit context, the question to be asked is whether the net gain from a typical night passenger or cargo operation at O'Hare is equal to or greater than $75. It is a reasonable inference from the data relating to night operations and to the purposes those operations serve that their benefits outweigh their costs, as indicated by the above pair of figures, by an appreciable margin.

Operations cuts are essentially an extension of the curfew-type of action. They would augment benefits to nearby households, though at a much diminished rate because of the lower weighting of day flights in L_{dn} measurement, while also increasing the losses, or costs to users. Benefits and costs would both rise, but with the losses from cutbacks remaining in excess of the gains to households.

Whatever may be done to reduce noise for the dwellings near O'Hare with present noise levels above 65 L_{dn}, a potential longer-run problem will remain. Vacant land proximate to the airport is subject to future residential development, just as the current residential pattern reflects past development trends. Apart from such future development, projected air traffic growth would, by itself, cause a substantial increase in the amount of residential acreage above 65 L_{dn}. This growth would, of course, also serve to attenuate the favorable effects from any abatement actions that might henceforth be taken. To cope with this problem, consideration might be given to measures to adapt land-uses to noise compatible purposes. For already-developed land, selective rezoning, intended to bring about conversion over the long-term, could be employed. For undeveloped land, direct zoning to compatible uses could be considered. Such measures might be supported by legislation at state or local levels or achieved through cooperative efforts. They might be aided by the publication of noise maps, for use by various parties: Agencies and groups concerned with land-use planning; developers contemplating the prospective uses of particular tracts; and the parties involved in the transfers of residential and other properties.

Opportunities for noise abatement at Midway Airport are limited by its size, its geography, and its current pattern of operations. Residential properties abut the airport to the west and south, and unevenly but still closely to the north and east. Because of this residential pattern and restrictions arising from runway length, there is little opportunity for noise abatement through the kinds of operational changes considered for O'Hare. Moreover, since there is little current nighttime activity at the airport, there is no opportunity for noise relief through a modification or reduction in such activity. A complicating factor for impact analysis is the uncertainty of future activity levels at the airport. Within the constraint of these limitations, it is possible to assess several of the same quieting options for Midway as were considered for O'Hare.

Insulation costs for the 8000 dwelling units with noise levels above 65 L_{dn} are estimated in the manner previously described. Aggregate costs are $71 million under the 1 dB increment procedure, with insulation as needed to bring interior noise levels to 65 L_{dn}, and $102 million under the 5 dB increment procedure. Of these totals, over half would be allocated to the 2000 dwellings above 75 L_{dn}. The dollar figures are gross amounts. Allowance for cost recovery through energy savings might reduce them by perhaps half. The estimated benefits from insulation are, on the R-basis, about $17 million and on the L-basis about $27 million. But as explained above in the discussion of O'Hare, these figures are overstated. With or without the overstatement, the benefit estimates fall below the energy-adjusted cost totals.

Besides residential dwellings, a half-dozen schools are adversely affected by aircraft noise. Analysis indicates that the insulation of these structures would bring an excess of benefits over costs, though by a considerably smaller margin than obtained for schools in the vicinity of O'Hare.

Estimates of easement costs at Midway were developed following the same procedures as for O'Hare. The average cost per dwelling would be about $3350 and the aggregate cost for all dwellings above 65 L_{dn} around $27 million. Dwellings with noise levels above 75 L_{dn} would claim about 60% of this total. The easement approach would not, of course, give physical relief from noise, but it would yield benefits to property-owner recipients equal to the program's costs.

The acquisition (and demolition) of all residential dwellings at Midway above 65 L_{dn} is estimated to cost approximately $423 million. This estimate makes no allowance for possible offsets through the redevelopment of properties for alternative uses (though in the context of a large scale acquisition program, such opportunities are likely to be limited). But the figure far exceeds the benefits from acquisition, depending on the basis of estimation, of $13 to $27 million. Acquisition on a more limited basis, say for the 2000 dwellings above 75 L_{dn}, would carry more nominal costs of $77 million, but the estimated benefits would still remain well below this sum. For this approach, the situations at O'Hare and Midway are similar, and the conclusion in each case is the same: Acquisition should be reserved for special, localized situations, preferably those where significant redevelopment opportunities exist.

To achieve 65 L_{dn} at Midway through operations cuts would entail substantial flight reductions, with the magnitude of the reductions dependent on their pattern - that is, on the mix of jet and non-jet flights that are eliminated. One scenario indicates requisite cuts in operations of about 97% from projected 1985 activity levels, or about 94% from current levels. These cuts would leave the airport with but 20 daily general aviation flights, including but a few jet operations. Commercial jet service would be effectively eliminated. Under this scenario, the number of permissible flights would not suffice to justify continuation of the airport. An alternate scenario suggests that much of the current non-jet activity could be preserved provided all jet operations (commercial and business) were eliminated. Under this arrangement, the airport would be constrained to serving propeller-driven commuter and general aviation aircraft. Plans for the expansion of commercial and other operations would be shelved.

The benefits to households and schools from operations cuts sufficient to achieve 65 L_{dn} are estimated at about $28 million (on a capitalized basis). However, we lack a dollar measure of the costs of operations cuts with which to compare this figure. In these circumstances, it is helpful to note that the benefit figure, adjusted to a "per airport day basis", amounts to about $7700. That is, this represents (on one set of assumptions) the aggregate daily benefit to households from achieving 65 L_{dn}. This figure should be judged against the collection of daily benefits to the users of Midway - commercial carriers and their passengers, business aircraft and others - that would be foregone through operations cuts.

I. INTRODUCTION

This report is Volume IV of four volumes dealing with the impact of proposed airport noise regulations in Illinois (R77-4). It discusses and evaluates the economic impact of proposed airport noise regulations for O'Hare and Midway Airports. In developing data and presenting its analysis, the report draws upon information provided in the Technical Study (Volume III of the series), upon the content of extensive hearings by the Pollution Control Board, upon data provided by Landrum and Brown for the City of Chicago's Department of Aviation, and upon a variety of other pertinent sources, as referenced in the report.

The sections that follow consider several possible methods for dealing with the airport noise problem. Certain of these methods are directly responsive to the proposed regulation, while others, though not recognized by the regulation, represent meaningful economic alternatives. The chief criterion for consideration of a particular method is whether it gives promise of providing substantial remedy for the noise problem at O'Hare and at the limit, of achieving compliance with the proposed regulations. A secondary criterion is whether a method has commanded attention at other airports as offering a meaningful prospect for noise relief. O'Hare is a complex airport, and it has not been possible to examine all abatement scenarios of potential interest. It is hoped that the analytic and information backdrop provided in this report will facilitate the evaluation of any methods neglected here that may be thought worthy of review.

The methods considered for O'Hare Airport include the following:

1. A modified takeoff procedure entailing quick flap retraction and thrust cutback;

2. Runway changes for night takeoffs and landings, together with associated flight track changes;
3. The insulation of noise-impacted dwellings;
4. The purchase of noise easements;
5. Property acquisition, with demolition or conversion;
6. A purchase-guarantee program;
7. A curfew on night operations;
8. Cutbacks in operations.

Four of these methods are considered also for Midway Airport. Of the remainder, three - modified takeoff procedures, runway shifts, and a curfew - are not applicable to the Midway case. Discussion of the purchase-guarantee idea is omitted to avoid repetition.

The analysis for O'Hare Airport is contained in Chapters II and III. The first of the two chapters offers a description of each abatement option and develops, where possible, an estimate of its cost, or cost range. The second of the chapters reviews the benefits of each option. The review of Midway Airport is contained in Chapter IV. Both the costs and the benefits of each quieting option are considered jointly in the several separate subsections of the chapter.

Benefits are assessed in terms of (1) the number of residential dwellings enjoying reduced noise levels; (2) the health-related advantages of quieter surroundings; and (3) the effects on property values of lower noise levels. Differential property value data are used to develop estimates of the dollar magnitude of the benefits of various abatement options. To the extent possible benefits and costs are compared, permitting some judgements to be made about the worth and relative efficiency of each option.

II. THE COSTS OF NOISE REDUCTION AT O'HARE AIRPORT

A. The Current Noise Status of the Airport

O'Hare Airport ranks as the busiest airport in the world. Its current activity levels are approximately described in Table II-1 below, taken from the 1978 Master Plan for the airport. The data, broken down by aircraft type, show operations for a typical day in August. The Technical Study has, with two modifications, used these data to generate noise contours describing the impact of aircraft operations on the surrounding community. One modification serves to adjust the fleet mix from that shown in Table II-1 to that used by the Air Transport Association in its hearings testimony.[1] This adjustment has only a small effect on the resulting noise contours. The other modification restricts the analysis to commercial jet aircraft activity, eliminating general aviation aircraft from consideration. This omission causes the generated noise contours to be slightly low, by perhaps 0.2 - 0.3 dB.[2] However, since the same procedure is consistently used to generate contours for successive cases, the resulting differences from case to case are little affected.

Use of the data in Table II-1, with the modifications indicated, and along with information on the relative frequencies of runway utilization, results in the 65 and 75 L_{dn} contours shown in Figure II-1 (which reproduces Figure 4-7 of the Technical Study). The figure reflects the so-called new ATA takeoff and reduced flap landings and, as such, it indicates the approximate noise impact from current activity at the airport. The impacted

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[1] See the discussion of this point in the Technical Study, pp. 25-27.

[2] General aviation jets account for about 14% of jet traffic at O'Hare, but because of their performance characteristics, their noise impact is lower than would be that of an equivalent number of commercial passenger jets.

TABLE II-1

O'Hare Operational Volume by Aircraft Type

Aircraft Type	Day		Night	
	Arrivals	Departures	Arrivals	Departures
DC-9-32	61	62	2	2
DC-9-15	37	37	2	3
B-737-100/200	54	62	2	1
B-727-200	71	66	1	1
B-727-100	132	132	5	8
B-707-320B/C	70	85	6	5
B-707-120B	45	19	8	5
DC-8-55	20	29	10	6
DC-8-61/63	21	23	4	7
B-707-120/320	3			
DC-10-10	32	27	4	9
L-1011	36	40	12	7
DC-10-30	20	25	3	2
B-747-200	10	9	5	6
B-747-100	6	5	3	3
DC-9 w/SAM	25	26	4	1
B-737 w/SAM	7	6	1	
727 w/RFN	72	68	2	3
SABREliner	50	53	7	4
Twin Engine Turbo	60	59	12	12
Light Single Engine Piston	22	20	18	16
Medium Twin Engine Piston	81	85	21	21
Heavy Turbo Fan	54	59	12	12
Total Daily	989	997	144	134

Source: "Discussion Outline, O'Hare International and Midway Airports Master Plan Information Workshops," Department of Aviation, City of Chicago, May 16 and 17, 1977, Table 3.

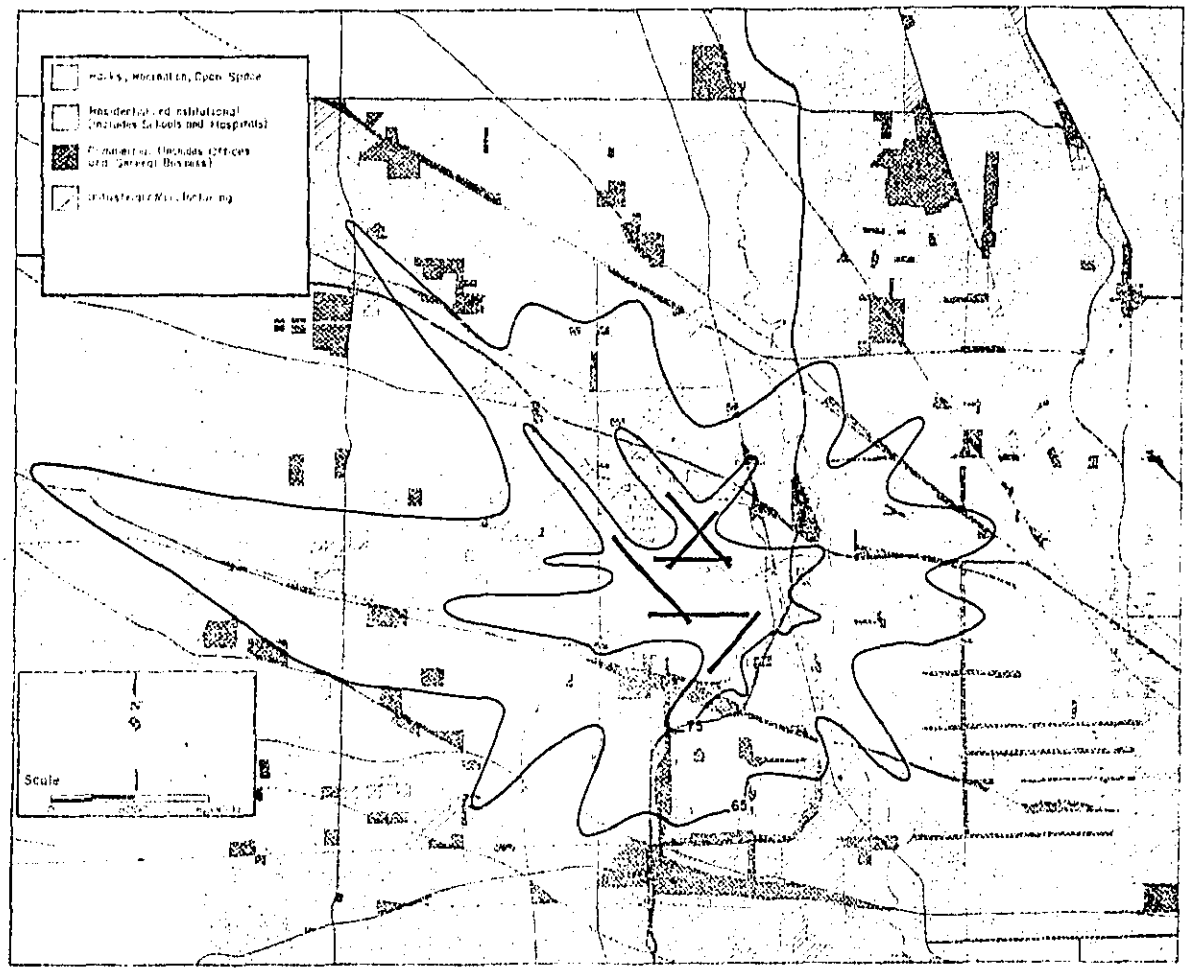

Figure II-1. L_{dn} contours for O'Hare Airport, Reflecting 1977 Activity Levels, New ATA Takeoff Procedures and Reduced Flap Landings (Figure 4-7 of Vol. III).

land area, classified by major use, is shown in the first two columns of Table II-2. A total of 45,335 acres (excluding airport property) have noise levels in excess of 65 L_{dn}. Of this total, about 45% is used for residential housing, 6.4% for commercial purposes and 12% for industrial activities. Open space occupies about 36% of the total acreage. The residential acreage contains both single- and multi-family dwellings, with the former representing approximately 70% of all households and the latter about 30%.[1] The total number of housing units may be estimated at 117,400.[2]

From the present to 1985 the aircraft fleet is expected to be brought into compliance with the noise limitation provisions of FAR Part 36. Compliance is expected to be achieved by the elimination of some JT-8 powered DC-8 and Boeing 707 aircraft and the re-engining of others, by the retrofitting of current-model DC-9, Boeing 727 and 737 aircraft, and by a shift in the composition of the fleet toward the newer and quieter DC-10 and Boeing 747 vehicles.[3] By 1985, therefore, in the absence of significant traffic growth or other changes not now foreseen, and apart from any actions to control airport noise by the State of Illinois, noise impaction in the neighborhood of O'Hare can be expected to decline somewhat. The contours shown in Figure II-2, which incorporate fleet mix changes and retrofit, reflect this decline. This figure is the same as Figure 4-8 of the Technical Study. The last two columns of Table II-2 show the affected acreage for the major land uses. A comparison of the two pairs of columns indicates a decline between

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[1] The breakdown is derived from information supplied by the Northeastern Illinois Planning Commission. It is based on data on utility meter counts for the several municipalities surrounding O'Hare Airport.

[2] A housing unit is either a single family dwelling or an apartment, flat or similar self-contained unit within a multi-family structure. Thus, a structure containing six flats represents six housing units. The method of estimating numbers of housing units is indicated in footnote 3 of Table II-2.

[3] Table 3-3, p. 30, of the Technical Study shows the anticipated fleet mix changes.

TABLE II-2

Land Area by Major Land Use and L_{dn} Zone, 1978 and 1985 Base Cases

Land Use	1978[1]		1985[2]	
	65-75	75 up	65-75	75 up
Housing (acres)	19,669	853	16,544	639
Housing Units (number)[3]	117,424	5,092	98,768	3,815
Commercial (acres)	2,631	279	2,365	220
Industrial (acres)	4,484	955	4,481	838
Open Space (acres)	15,582	882	13,635	558
Airport (acres)	1,676	5,557	1,866	5,363
Total, excluding Airport (acres)	42,366	2,969	37,025	2,255

Source: Technical Study (Part III), Table 4-3, p. 63.

[1]The figures, except housing units and totals, are from Table 4-3, Revised Base Case (4-7). The data reflect the new ATA takeoff procedures and reduced flap landings.

[2]The figures, except housing units and totals, are from Table 4-3, 1985 Aircraft Mix Base Case (4-8). The data reflect the new ATA takeoff procedures, reduced flap landings, retrofit and expected fleet mix changes.

[3]Number of housing units has been estimated using data relating to Exhibit 34 in the Testimony of the City of Chicago Before the Illinois Pollution Control Board, June 16-20, 1980. The number of housing units reported for the 65 L_{dn} contour was adjusted to the slightly smaller gross area (exclusive of the airport) contained in Case 4-7, p. 63, of the Technical Study. The resulting figure was then divided by the amount of acreage devoted to housing, as shown for Case 4-7, to get the average number of housing units per acre. The latter figure was in turn used to estimate the number of housing units contained in various acreages.

1978 and 1985 for all uses. Total acreage exposed to more than 65 L_{dn} is down by about 13%, with a reduction of 25% for housing above 75 L_{dn} and 16% for housing in the 65-75 L_{dn} range. Commercial and industrial acreage is down also, but by lesser amounts.

The impacted acreage and number of housing units shown in columns 3 and 4 will be treated henceforth as a base or reference case, with the anticipated effects of the proposed regulation measured against it.

While this case is dated 1985, it reflects 1977-79 activity levels. Its logic as a base case is that it displays the situation that might be expected to obtain in the absence of any further special steps that might be taken, whether pursuant to the proposed noise regulation or otherwise, to reduce noise. Use of the case for comparison purposes thus permits an assessment of fresh abatement initiatives, such as the modified takeoff and nighttime procedures described below.

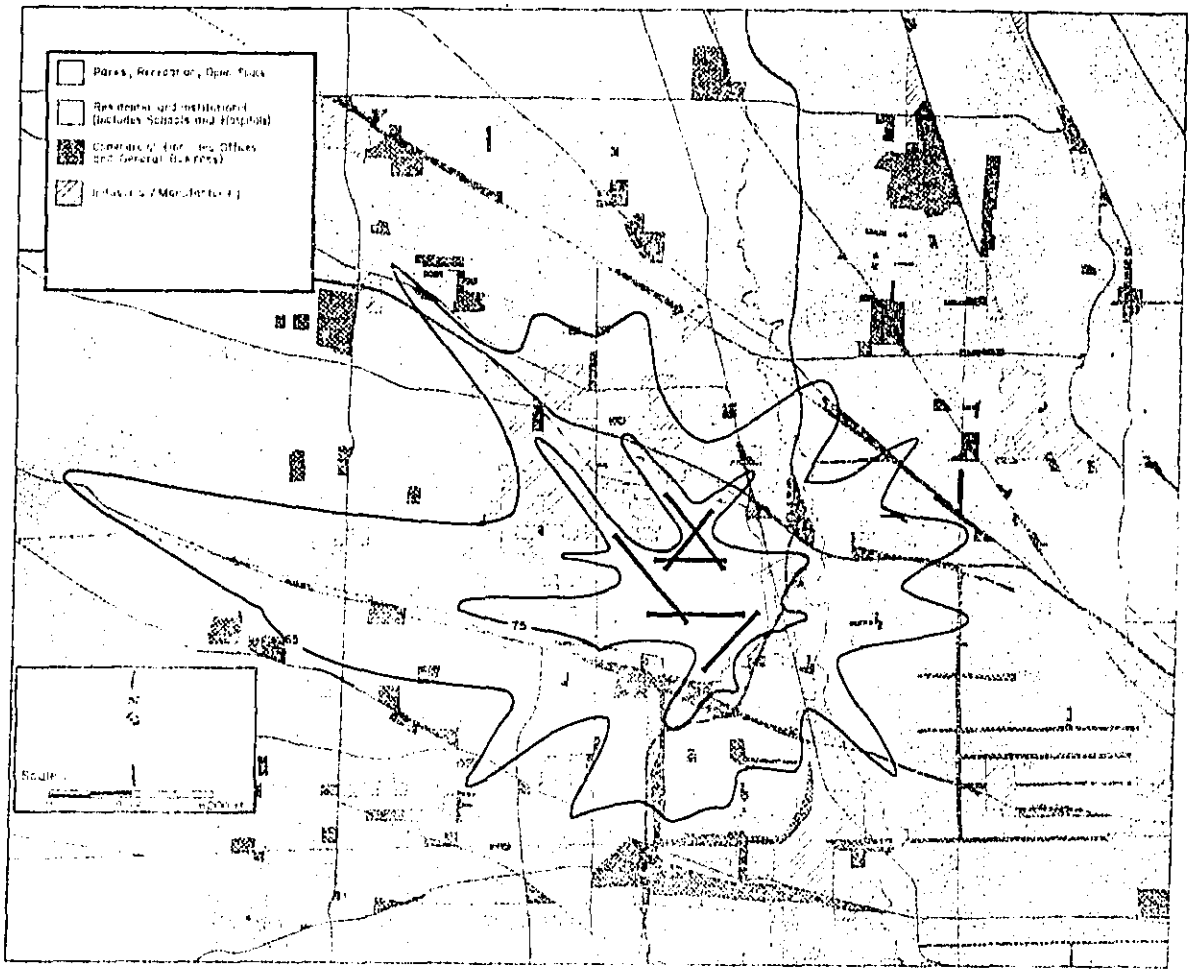

Figure II-2. L_{dn} Contours for O'Hare Airport, Reflecting Fleet Mix Changes and Retrofit (Figure 4-8 of Vol. III).

B. Abatement through Selected Changes in Operating Procedures

The Technical Study evaluates a number of changes in operating procedures intended to reduce the amount of noise-impacted residential acreage. One such change is a modification of the new, or current, ATA takeoff procedures to incorporate quick-flap retraction and deep-thrust cutback for JT-8 powered aircraft, and lesser cutbacks for aircraft with engines of higher bypass ratio. The procedure is described in the Technical Study (p. 33) as follows:

> (F)laps on all aircraft are retracted as quickly as possible upon attaining an altitude of 1000 feet AFL. Velocity is increased so that V_{ZF} is reached just when flap retraction is complete. Thrust is rapidly reduced upon attaining V_{ZF}, with thrust being gradually reapplied upon attaining an altitude of 3000 feet AFL. At this point the aircraft is gradually accelerated to a speed of 250 knots, which is maintained until an altitude of 10,000 feet is realized . . . On JT-8 powered aircraft the thrust cut-back is maximum. This has the effect of greatly reducing noise while extending the duration of the flight maintained at lower altitudes. On other aircraft, the thrust reduction is minimum.

This modification contributes to noise reduction when communities are located relatively far from the runway, as at O'Hare.

The effect of the procedure on the 65 L_{dn} and 75 L_{dn} contours is described by Figure II-3, which reproduces Figure 4-1 of the Technical Study. The resulting noise-impacted acreage and housing units are shown in the last two columns of Table II-3. The first two columns of the table repeat for reference purposes the base case (1985) data from Table II-2. The figures indicate a pronounced reduction in impacted acreage in the 65-75 L_{dn} zone for all non-airport uses, with the total of such acreage declining by over 50%. The number of housing units in the 65-75 L_{dn} range shows a decline of 55%. There is a much more modest decline of around 6% for units at 75 L_{dn} and above.

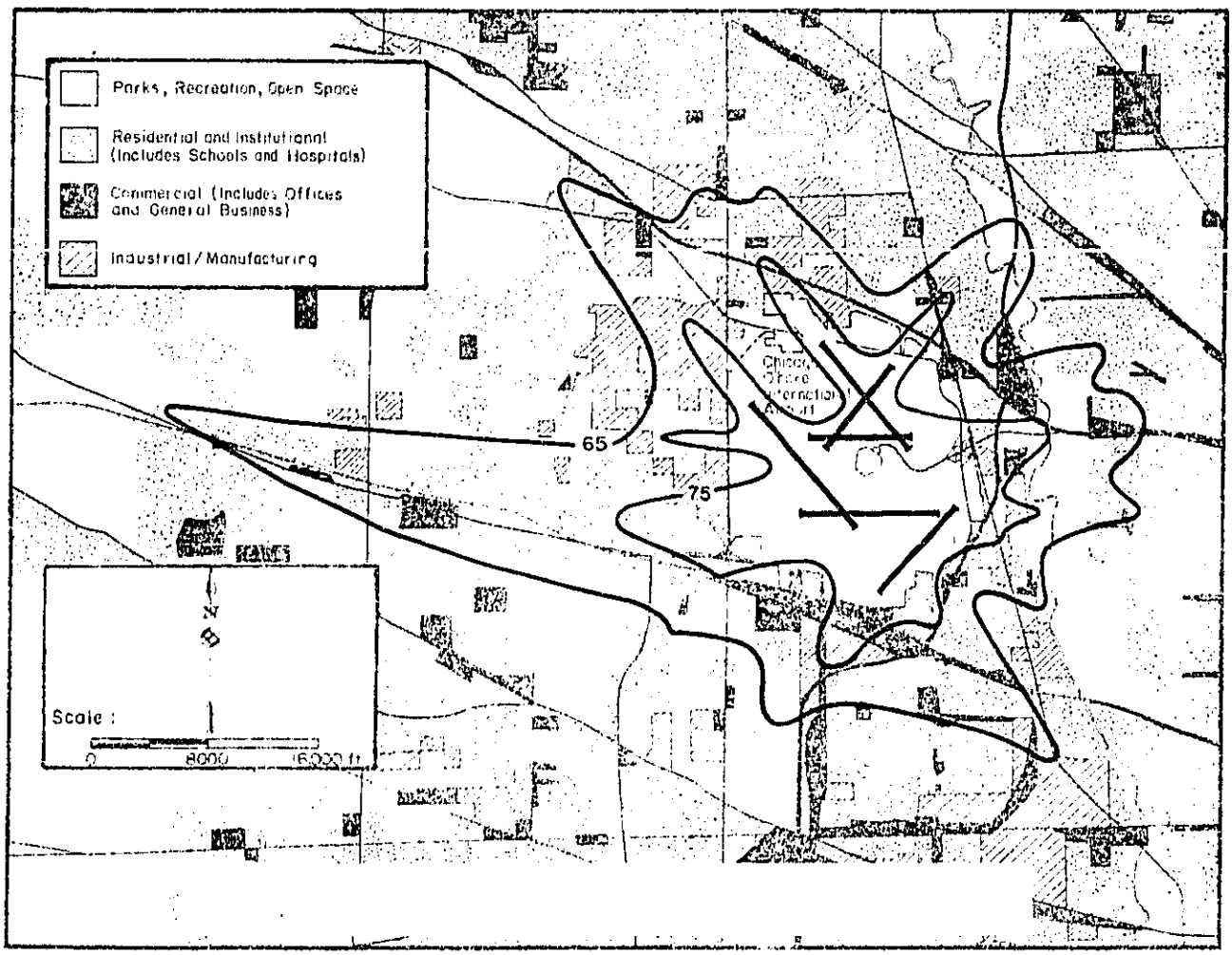

Figure II-3. 1985 O'Hare L_{dn} Contours, Including Quick-Flap Retraction Takeoffs, Reduced-Flap Landings, Retrofit, and New Technology Aircraft (Figure 4-1 of Vol. III).

Table II-3

Effects of Modified Takeoff Procedure on Impacted Acreage and Housing

Land Use	1985 Base Case		Modified Takeoff Procedure[1]	
	65-75	75 up	65-75	75 up
Housing (acres)	16,544	639	7,453	603
Housing Units (number)	98,768	3,815	44,494	3,600
Commercial (acres)	2,365	220	1,558	294
Industrial (acres)	4,481	838	3,102	720
Open Space (acres)	13,635	558	5,821	617
Airport (acres)	1,866	5,363	1,588	5,645
Total, excluding Airport (acres)	37,025	2,255	17,934	2,234

Source: Technical Study (Part III), Table 4-3

[1]The figures are for Quieted Case 1-1985 (4-1)

The modified takeoff procedure, with the resumption of climb power at 3000 feet, does not alter trip time. Fuel consumption is slightly higher, as compared with the new ATA procedure - by around 10-12 pounds for the B-727, 18-20 pounds for the DC-10, and 25-26 pounds for the B-747.[1] Taken over all flights, on an annual basis, the increase in fuel costs would be around $450,000.

In the procedure to which these data apply, normal climb thrust is resumed at an altitude of 3000 feet. This has the effect of increasing the noise levels somewhat, above what they otherwise would be, for the properties downrange beyond the 65 L_{dn} boundary. This increase can be avoided if the reduced thrust setting is maintained until the aircraft reaches an altitude of 4000 feet. However, if this is done, there will be some added seconds of trip time or, if the time is to be made up, a further nominal increase in fuel consumption. No effort is made here to formally estimate these contingent costs which, in any event, would not significantly affect the analysis.

A second category of change in operating procedure that promises noise reduction, though of significantly lesser amount than the previous case, entail shifts in the runways used for night takeoffs and landings and a change in one of the approach tracks for night landings. More specifically, the Technical Study (p. 51), on the basis of current land-use patterns in the vicinity of the airport, suggests that the following adjustments would be advantageous:

1. Shift night takeoffs from runway 27L, which presently handles the great majority of such departures, to 27R.

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[1] These estimates are based on information supplied by Captain J. T. Fredrickson of Northwest Orient Airlines. As compared to the old ATA takeoff procedure, the modified takeoff procedure saves around 100 lbs. of fuel for a B-727 type aircraft. There also is a slight reduction in engine wear.

2. Shift night landings from runway 32L, which currently handles about 40% of such landings, to 4R, which is now little used for night arrivals.

3. In conjunction with the change immediately above from 32L to 4R, have aircraft make their approach from the south over the Tri-State Tollway, turning right approximately where the tollway turns for the approach to 4R.

Figure II-4 below (which reproduces Figure 4-4 of the Technical Study) incorporates these three changes, and shows the resulting 65 and 75 L_{dn} contours. The figure otherwise reflects the same factors, including the quick-flap retraction-reduced thrust procedure, as Figure II-3. Table II-4, in the last two columns, summarizes the outcome in terms of the acreage devoted to the various land used. Use of the modified nighttime procedures serve to extend modestly the benefits to residential land obtained from using the modified takeoff procedure. The number of housing units in the 65-75 L_{dn} zone declines by about 12%, and the number at 75 L_{dn} and above falls by 22%. The outcome for commercial and industrial land uses, by contrast, is not consistently favorable. In particular, the acreage at 75 L_{dn} and more for these uses shows an increase. However, non-residential land uses are not covered by the regulation.

The combined effects on impacted housing of both the modified takeoff prodedure and the modified nighttime procedures are substantial. Dwellings in the 65-75 L_{dn} range decline by about 60% from the number contained in the 1985 Base Case, while the number at 75 L_{dn} and up falls by roughly 26%. The overall decline for dwellings over 65 L_{dn} is about 59%.

It should be noted that the Chicago Master Plan study projects around

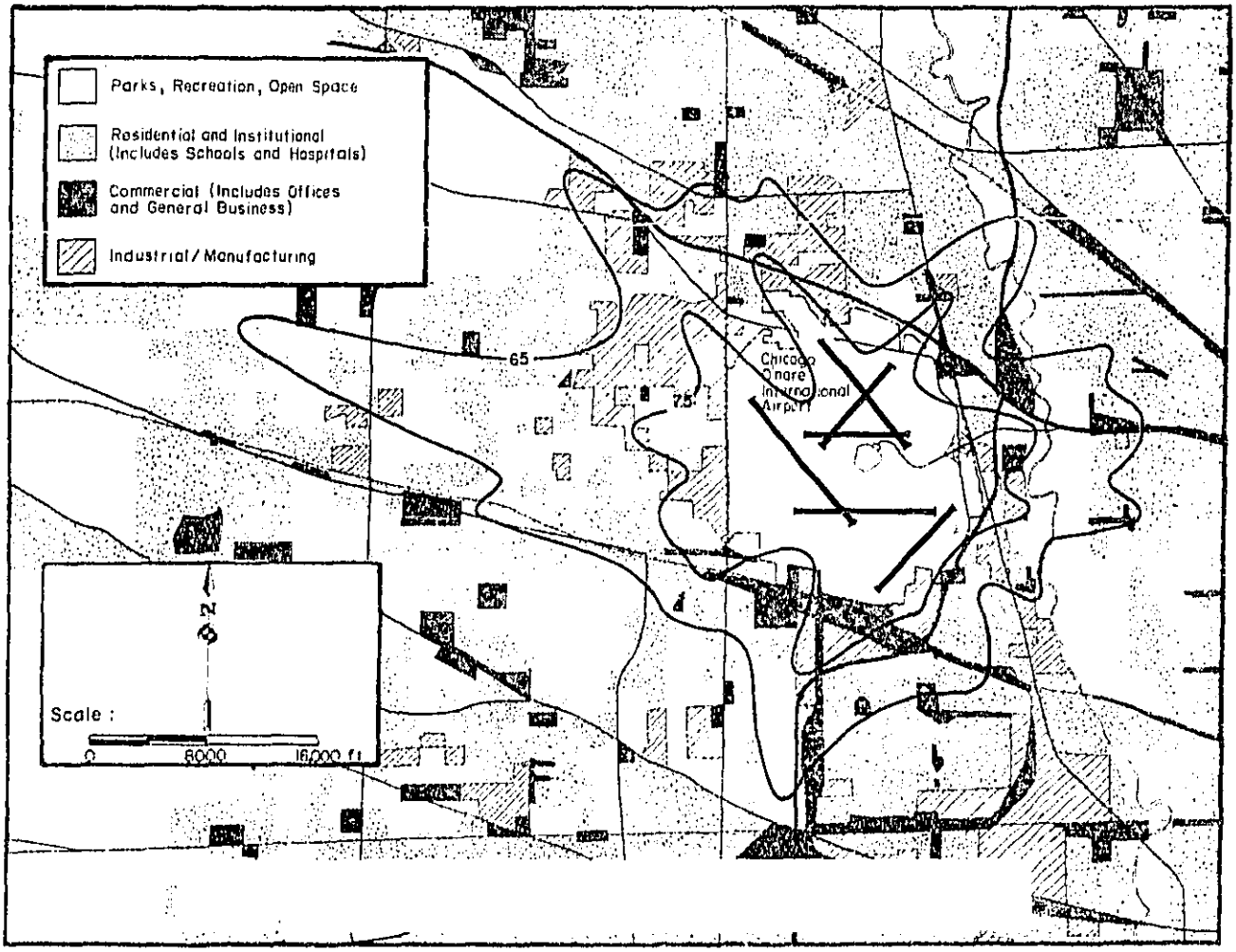

Figure II-4. 1985 O'Hare L_{dn} Contours, Including the Basic Reductions of Figure II-3 and the Nighttime Modifications (Figure 4-4 of Vol. III).

Table II-4

Effects of Modified Nighttime Procedures on Impacted Acreage and Housing

Land Use	Modified Takeoff Procedure[1]		Addition of Modified Nighttime Procedures[2]	
	65-75	75 up	65-75	75 up
Housing (acres)	7,453	603	6,556	470
Housing Units (number)	44,494	3,600	39,139	2,806
Commercial (acres)	1,558	294	1,485	353
Industrial (acres)	3,102	720	3,072	1,073
Open Space (acres)	5,821	617	6,600	706
Airport (acres)	1,588	5,645	809	6,424
Total, excluding Airport (acres)	17,934	2,234	17,713	2,602

Source: Technical Study (Part III), Table 4-3

[1]The figures are for Quieted Case 1-1985 (4-1)

[2]The figures are for Quieted Case 2-1985 (4-4)

a 35% increase in operations for 1995 over the level utilized for the 1985 Base Case. Such growth, if it occurs, will reduce the benefits otherwise obtained from the two sets of procedural changes just described. The decline for dwellings in the 65-75 L_{dn} zone would be approximately 34%, rather than 60%, and dwellings at 75 L_{dn} or more would rise by more than 100%, rather than fall. For all dwellings over 65 L_{dn}, the decline from the 1985 Base Case would be 28%, rather than the 59% that would occur without traffic growth.

Two types of costs would arise from the suggested modifications in nighttime procedures. First, runway 27R, to which takeoffs would be shifted, would have to be lengthened to the west. It is presently 7400 feet long. To accommodate aircraft in the same gross weight range as runway 27L, which presently is used for night takeoffs, it would have to be extended by perhaps 2600 feet. A similar extension of taxiway would be required, and runway and taxi edge lighting would have to be added. The approach lights, threshold bar, and instrument landing system for runway 9L would require relocation. The estimated costs of these changes are as follows:[1]

Runway and taxiway extensions	$5.4 million
Runway and taxi edge lighting, plus threshold bar	0.6 million
Relocation of the ILS system and approach lights for 9L and the localizer for 27R	0.3 million
Total	$6.3 million

[1]The estimates are based on information supplied by Professor Ernest J. Barenberg of the Civil Engineering Department, University of Illinois (Urbana-Champaign), by the Department of Aviation of the City of Chicago, and by the FAA.

The second type of cost arises from altered taxi distances. The change in night landings from 32L to 4R and in night takeoffs from 27L to 27R alters taxi distances and times. Because of the location of cargo ground facilities proximate to the far end of 4R, the shift in landing runways reduces taxi distances somewhat for cargo carriers, while for passenger carriers there is little change. For cargo carriers, the decrease in taxi time would average about 4.5 minutes. The shift in takeoff runways increases taxi distances for cargo carriers, while, as before, causing little change for passenger aircraft. The increase in taxi time would average about 2.5 minutes. Thus, for night cargo operations, the overall effect is a net decrease in taxi time averaging perhaps 2.0 minutes per operation.

Roughly 85% of all night flights are cargo operations.[1] Based on the data in Table II-1, and neglecting general aviation flights, this represents about 122 nightly operations. The aircraft involved are of different types - DC-9, B-737, B-727, DC-10, B-747. Their total costs of operation during taxi vary widely - about $21 per minute for a B-727, for example, and $49 per minute for a DC-10. A composite average figure, based on the expected fleet composition for 1985[2] might be around $35 per minute. Applying this figure to a full year's operations, at 2.0 minutes per operation, results in an annual saving of $3.1 million.

This annual saving more than offsets the annual extra fuel costs of $450,000 per year arising from the modified takeoff procedure and the $6.3 million of capital cost associated with the extension of runway 27R

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[1]The estimate is from O'Hare Tower personnel.

[2]Technical Study, Part III, Table 3-3, p. 30.

(for the modified nighttime procedure). The joint application of the modified takeoff and nighttime procedures serves to reduce the number of housing units above 65 L_{dn} from about 102,600 to 41,900 and the number above 75 L_{dn} from 3800 to 2800.

The foregoing analysis assumes that runway 4R, with an approach over the Tri-State Tollway, will uniformly be used in place of runway 32L. Weather conditions will at times prevent this. This factor will reduce somewhat the benefits attributed above to the modified nighttime procedures and will reduce also the estimated savings in taxi time and costs.

C. Noise Reduction through the Insulation of Dwellings[1]

An important way of reducing noise exposure for the dwellings remaining above 65 L_{dn} after the modifications just described (though not one recognized in the proposed regulation) is through the use of acoustical insulation. This procedure cannot, of course, affect the outdoor noise level, to which the proposed 65 L_{dn} standard refers. But it can reduce interior levels substantially. Even during the summer months, most individuals do not, on the great majority of days, spend more than an hour or two on their properties, out of doors. Hence a reduction in interior levels, insofar as those levels are presently excessive, would be expected to contribute significantly to an improvement in the noise environment of a dwelling's occupants.

There is an appreciable transmission loss when noise penetrates a dwelling from without. The loss or reduction varies with the characteristics of the noise and of the dwelling's structure, but averages around 20 dB. Thus outdoor L_{dn} levels of 75 and 70 would produce indoor levels, respectively of 55 and 50. Both of the latter figures are above the 45 L_{dn} level estimated by the federal E.P.A. as a threshold for indoor activity interference and annoyance.[2] Through insulation of exposed dwellings, the gap between both figures and the threshold could be reduced or eliminated. Were an airport authority to bear or share the cost of insulating a group of dwellings, it might expect, as an adjunct, to secure an avigation easement allowing continuation of the pre-existing noise level.

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[1] This section, along with a number of subsequent sections, draws freely from Section II-C of the volume, Economic Analysis of Public Airports Outside Chicago, which is Part II of this four-part study.

[2] U.S.E.P.A., Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, 550/9-74-004(Washington, D.C., Government Printing Office, March 1974), pp. 3, 29 and C-18.

The data available on insulation costs, while somewhat thin and uneven, appear sufficient to permit rough estimates of the cost of quieting dwellings around Illinois airports. For our purposes, the most useful study of such costs is one based on experience at Los Angeles International Airport and prepared by Wyle Laboratories. The study utilized data from a 1969 pilot program for the soundproofing of 20 homes.[1] The results of this study were subsequently updated to 1975, adjusted for regional differences in construction costs, and extended to three other cities - Atlanta, Minneapolis and Seattle. Cost figures intended to represent a U. S. national average also were developed.[2]

The U. S. national average figures, further updated to 1979 by the present authors, are shown in Table II-5. The figures indicate the per square foot costs for four levels of interior noise reduction - 5 dB(A), 10 dB(A), 15 dB(A), and 20 dB(A). These cost data when plotted on a graph and joined by a smooth curve, permit rough estimates of insulation costs for queting in 1 dB increments; these estimated costs are listed in Table II-6.[3] The Wyle study further reports that a house of 1500 square feet is typical for a household size of 3.2 persons.[4] Since the latter figure

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[1] Wyle Laboratories, Home Soundproofing Pilot Project for the Los Angeles Department of Airports, Report No. WCR 70-1, March 1970.

[2] H. G. Meindl et al., Costs and National Noise Impact of Feasible Solution Sets for Reduction of Airport Noise, Wyle Research Report WR 75-9, prepared for the U.S.E.P.A., February 1976, pp. 3-7 to 3-10 and Appendix B.

[3] The underlying curve, based on 1978 data, is shown in Figure II-3 of Volume II. Extrapolation of the curve below 5 dB, to the 1-3 dB range, may, through the neglect of fixed costs in an insulation program, introduce a downward bias to the cost estimates.

[4] Meindl et al., op cit., p. 3-7.

Table II-5

Noise Reducing Insulation Costs for Residential Dwellings (1979)[1]

Amount of Noise Reduction	Cost Per Square Foot
5 dB(A)	$ 3.78
10 dB(A)	10.85
15 dB(A)	19.72
20 dB(A)	28.92

Source: See text.

[1]The figures provided in the Wyle Laboratories study for 1975 have been updated to 1979 through use of the Bureau of Labor Statistics Home Ownership Cost Index, and the Department of Commerce Composite Construction Cost Index.

Table II-6

Noise-Reducing Insulation Costs
in 1 dB Increments (1979)

Amount of Reduction (dB)	Cost per Sq. Foot ($)
1	.57
2	1.14
3	1.93
4	2.84
5	3.78
6	5.00
7	6.25
8	7.61
9	9.09
10	10.85
11	12.61
12	14.20
13	16.02
14	17.84
15	19.72
16	21.58
17	23.52
18	25.33
19	27.04
20	28.92

Source: Figure II-3 in Volume II, Economic Analysis of Public Airports Outside Chicago. The data above have been updated to 1979.

is very close to the Illinois average of 3.3 persons per single family dwelling,[1] the 1500 square foot figure will be used in the analysis that follows.

It was noted in the preceding section that about 30% of housing units in the neighborhood of O'Hare Airport are multifamily units. These units are smaller in size, with an average of 3.7 rooms, than single-family dwellings with an average of 5.3 rooms.[2] Data on the square footage of multi-family units is not available, but consultation with real estate specialists suggests an average size of 800 square feet. Insulating costs will, on this account, be lower for multi-family units. Moreover, because such a unit is attached to other units or embedded with them in a common structure, it is less exposed acoustically, and this circumstance conduces to a further reduction in insulation costs. Multi-family units come in a variety of configurations, from duplexes in which the individual units have one common wall, to structures of two or more stories in which the units share a common roof and may have only one or two exposed walls. Considerations bearing on the relation between the amount of exposed wall and roof area and the square footage of living space indicate a wide range of insulation costs, depending on type of structure. Somewhat arbitrarily, for purposes of estimation here, we shall assume that insulation costs per square foot are 60% of the corresponding costs for a single family dwelling shown in Table II-6.

The information given in the preceding two paragraphs is used in

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[1] U.S. Department of Commerce, 1970 Census of Housing: General Housing Characteristics, Illinois (1971), Table 2. In a communication from Robert Hankin on the hearings testimony by the City of Chicago, the number of persons per housing unit is put at 3.24.

[2] U. S. Department of Commerce, Statistical Abstract of the United States, 1977, p. 787, No. 1384.

estimating the cost of insulating the 41,945 housing units remaining above 65 L_{dn} after the operational modifications previously described. It is assumed that dwellings are distributed with uniform density across each noise zone. However, since noise contours represent power functions, each decibel interval represents a specified percentage of area. Table 8-9 of the Technical Study (Part I, p. 109) suggests that a 1 dB increase in sound corresponds to about an 18% reduction in land area. Table II-7 below gives the percentage of land area - and, pursuant to the uniform density assumption, the percentage of total houses - per decibel in 10 dB and 5 dB contour zones. It is assumed also that dwellings are insulated in 1 dB increments, according to need. Dwellings in the 65-66 L_{dn} range would receive 1 dB of insulation, dwellings in the 66-67 L_{dn} range would receive 2 dB of insulation, etc., up to 85 L_{dn}.[1] Thus, each dwelling would be insulated so as to achieve an interior noise level equal to what would be attained if the exterior level were in compliance with the proposed regulation.

Table II-7

Distribution of Land Area per Decibel

dB	% of Land in a 10 dB Zone	% of Land in a 5 dB zone
x to x + 1	20.9	28.6
x + 1 to x + 2	17.1	23.5
x + 2 to x + 3	14.0	19.3
x + 3 to x + 4	11.5	15.7
x + 4 to x + 5	9.4	12.9
x + 5 to x + 6	7.7	
x + 6 to x + 7	6.4	
x + 7 to x + 8	5.2	
x + 8 to x + 9	4.3	
x + 9 to x + 10	3.5	

Source: See text.

[1] Table II-4 reports the number of dwellings with the 65-75 L_{dn} interval and the number at 75 L_{dn} and up. For the purpose of estimating insulation costs, dwellings in the latter group are assumed to lie in a 75-85 L_{dn} range.

The resulting estimated insulation costs are reported in Table II-8. The total is about $210 million, with about $60 million of this sum attributable to the relatively small number of dwellings (2800) subject to more than 75 L_{dn}.

Table II-8

Cost of Insulating Dwellings at O'Hare Airport[1,2]

(in $ millions)

Dwelling Type	Noise Zone 65-75 L_{dn}	75-85 L_{dn}	Total
Single-family	$132.3 (27,397)	$52.6 (1,964)	$184.9 (29,361)
Multi-family	18.1 (11,742)	7.2 (842)	25.3 (12,584)
Total	$150.4 (39,139)	$59.8 (2,806)	$210.2 (41,945)

Source: See text.

[1]After instituting modified takeoff procedure and modified nighttime procedures. Insulation is in 1 dB increments.

[2]Figures in parentheses show number of housing units.

Although methods of financing such costs are beyond the scope of this study, it may help to give perspective if the costs are translated into aircraft landing charges or additions to passenger ticket prices. Daily aircraft arrivals at O'Hare number about 1000. Suppose the insulation cost of $210 million were to be recovered over a 10 year period through additions to current landing charges. Then the average additional charge (neglecting any interest costs) per arriving aircraft would be about $58.

If instead it were recovered through an add-on to ticket prices for departing passengers, the requisite addition per ticket would be about $1.02.[1] The respective figures would be only 28 to 30% as large if insulation were limited to the dwellings located above 75 L_{dn}.

It is possible that the insulation of dwellings in 1 dB increments will not prove consistent with the practical needs of an insulation program. One potential difficulty is that in any such large scale program, it may be both impractical and costly to attempt to apply insulation in so tailored a way to a housing stock whose units vary in their designs, structures and materials. A second difficulty is that insulation to achieve but one, two or even three dB of quieting would not, for many households, bring an improvement above their thresholds of perception. Finally, the noise contours are subject to an error of perhaps two dB. Such considerations might lead to a program in which dwellings were insulated in, say, 5 dB increments. That is, dwellings in the 65-70 L_{dn} range would receive 5 dB of insulation, those in the 70-75 L_{dn} range would receive 10 dB of insulation, etc. Were this to occur, the insulation cost for dwellings in the 65-75 L_{dn} range would rise from $150.4 million to $266.2 million, and total insulation costs would increase by about 60%, to $340.6 million.

The types of insulation employed to reduce the levels of internal noise from external sources are, to a significant extent, the same as those needed to protect dwellings from outdoor cold and heat: attic and wall insulation, storm doors and windows (or double-glazed windows), caulking

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[1] Enplaned passengers at O'Hare number 20-21 million per year. See Exhibit 9 of the exhibits presented at the Hearings by the City of Chicago.

and weatherstripping.[1] Accordingly, a substantial fraction of insulation costs are likely to be recovered within a period of five to fifteen years through energy savings. The cost figures cited above for sound insulation should therefore be regarded as gross figures. We surmise that the net or true economic costs would be perhaps one-half or less of those figures.

The Technical Study considers at some length the impact of aircraft noise on schools and on activities in the classrooom. (See Part III of this study.) It identifies several adverse effects. Communication is disrupted, students are distracted, teaching effectiveness is diminished, and teacher morale suffers. It is possible also that there are adverse long term effects on the learning achievement levels of some students. It is appropriate, therefore, that schools as well as residences be considered in any program to use insulation as a means of protecting against noise.

No count is available of the number of schools contained within the 65 L_{dn} contour, as defined subsequent to the employment of noise-reducing takeoff procedures and nighttime operational changes. We can, however, roughly approximate the number by reference to earlier data. The 1971 "Metropolitan Aircraft Noise Abatement Policy Study, O'Hare International Airport"[2] reports 162 primary and secondary schools within the 65-75 L_{dn} zone and 19 schools above 75 L_{dn}. This study also reports 19,491 acres of residential land within these zones which, we presume, contains or is served

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[1] Pacific Gas & Electric Company's Application No. 59537 before the California Public Utilities Commission, dated March 25, 1980, proposes to implement a systemwide weatherization plan for energy conservation, using these techniques. PG&E would loan each homeowner all funds necessary to pay for the weatherization improvements; the loan would be repayable, without any interest, only when the residence was sold.

[2] Northeastern Illinois Planning Commission, p. 52.

by these schools. This compares with a total of 7026 acres of residential land remaining above 65 L_{dn} after implementation of the modified takeoff and nighttime adjustments. Adjusting the number of schools by the ratio of the latter to the former acreage figure yields 65 schools within our 1985 65 L_{dn} post-adjustment contour. This procedure assumed, of course, the same school-residential acres ratio as prevailed in 1971.

The costs of insulating schools are discussed in the Technical Study (pp. 149-52), which reviews two reports on the subject. The more pertinent of these is an FAA study in which two categories of modifications to schools are considered. The first category would reduce interior noise levels by about 10 dB, at a cost (in 1977 dollars) of $5,025 per room. The second category would reduce interior noise levels by 20 dB, at a cost of $5,765 per room. For our purposes, the two categories of insulation might be applied respectively to schools in the 65-75 L_{dn} range and the 75 L_{dn} and over range. Neglecting the 15% differential between the two categories, the cost per school comes to about $150,000. (There would, of course, be considerable variation among individual schools of differing size.) Updating this figure to 1979 gives a revised total of $191,000[2]

Extending this figure over the 65 schools within the 65 L_{dn} contour yields a total cost for school insulation of $12,400,000. Adding this cost to the cost of insulating residential dwellings gives a grand total of $222.6 million. If the insulation of residential dwellings were in 5 dB increments rather than 1 dB increments, the grand total would rise to

[1] "Study - The Feasibility, Practicability and Cost of the Soundproofing of Schools, Hospitals, and Public Health Facilities Located Near Airports." A Report to Congress, U. S. Department of Transportation, Federal Aviation Administration, FAA-EQ-78-14, July 1977.

[2] The Department of Commerce's Composite Construction Cost Index, as reported in the Survey of Current Business, Current Business Statistics Section, was used for updating.

$353.0 million. It is expected that a substantial fraction of insulation costs, as noted earlier, would be recovered through fuel savings within 5 to 15 years.

D. The Purchase of Noise Easements

An alternative to the reduction of excessive noise emissions or their impacts is the direct compensation of the receivers of noise for the disadvantage they suffer. Consider an individual who is subjected to noise at a level that he regards as undesirable. Suppose he has a choice between reduction of the noise to an acceptable level, and, alternatively, compensation for the discomfort he bears. Typically there will exist some minimum dollar payment that he will just prefer to noise abatement. By implication, such a payment, freely chosen, would leave him better off than would the noise reduction. It follows that, for the receiver, compensation offers a valid solution to the problem of excessive noise.

Imagine a situation in which those who generate excessive noise freely negotiate with the receivers of that noise for compensatory payment (with the alternative of noise abatement available to the receivers). Agreements would be reached and payments made, with the receivers fairly compensated and generators of noise thereby acquiring easements - that is, rights or privileges in the land of another, distinct from the occupation and enjoyment of the land itself - relieving them of further obligation so long as the noise is not increased. In practice, however, easements are not ordinarily transacted through open and unfettered exchange. Rather they are negotiated under constraints or agreed upon through court proceedings. Consequently, the sums paid for them may at times under- or overcompensate the receivers of noise.

How much might an Illinois airport operator actually have to pay for easements that would permit a continuation of the noise emissions remaining after the reductions prescribed by Level 1 methods? The evidence available

is limited and uneven. In a 1969 study, McClure reviewed the experience with aviation easements in five cities - Columbus (Ohio), Denver, DesMoines, Seattle and Jacksonville (Florida).[1] In some instances, easements were obtained through negotiation of the airport authority with property owners. In other instances, litigation was involved. In certain cases, properties were purchased at fair market values, easements attached, and the properties resold. In these cases, the difference between the purchase and resale prices represented the cost or worth of the easement. The mean easement cost varied from a low of 6.6% of the property value to a high of 19.8%, with an overall mean of 14.3%. The author suggests that the typical dwelling in the study might be exposed to a noise level of 100 PNdB, but supporting data are not given.

A report on experience at Tampa International Airport, covering 39 properties,[2] indicates easement costs ranging between 20% and 26% of property values. These figures are gross of appraisal and legal fees and court costs. Net of such costs, the range would be more like 12% to 15%.

A 1974 Arthur Little report on airport noise contains a brief discussion of easements.[3] The report notes, on the basis of selected sources, that easements often are expensive to purchase, frequently amounting to 20% or

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[1] McClure, Paul T., "Indicators of the Effect of Jet Noise on the Value of Real Estate," RAND Paper p. 4117, July, 1969, pp. 24-29 and p. 34.

[2] Doyle, Robert H. and Orman, J. C., "A Comparison of Costs Associated with Local Actions to Reduce Aircraft Noise Impacts," prepared for the March 2, 1978 AOCI Economic/Environmental Specialty Conference, pp. 26-28.

[3] Arthur D. Little Inc., Analysis of Methodology for the Economic Impact of Airport Noise Pollution Control Regulations, Report to the Environmental Protection Agency, No. 76874, April 1974, pp. II 10-11.

more of the value of the property.

Experience relating to Los Angeles International Airport provides a fifth source of pertinent information. In inverse condemnation actions for damages to residential properties, where the properties were subject to noise levels of 75-80 CNEL,[1] judges and juries have found the damages to be 16% to 18% of property values; out of court settlements have run in a similar range. For properties somewhat more remote from the airport, in the 70-75 CNEL range, recoveries have run from 8% to 10% of property value. The situation for noise zones of 65-70 CNEL is more problematic. Only about one-fourth of plaintiffs have been successful in winning judgements or settlements, with the recoveries running up to 10% of property values. A standard by-product of all such judgements and settlements is provision to the airport proprietor of a noise easement in the plaintiff's land, allowing the land to be subjected permanently to aircraft noise at least up to the level prevailing at the time the easement is created.[2]

Any attempt on the basis of the above information to relate variations in easement costs to variations in the noise levels of properties is necessarily somewhat speculative. Moreover, outcomes for like properties, in like circumstances, might vary from one legal jurisdiction to another. Bearing in mind these qualifications, use of the Los Angeles data, which are roughly consistent with the more limited data for other areas, as a

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[1] The CNEL measure resembles the L_{dn} measure in that it incorporates a 10 dB penalty for noise generated during the hours of 10 p.m. to 7 a.m. It differs from the L_{dn} measure in that it also includes a 5 dB penalty for noise generated during the hours of 7 p.m. to 10 p.m.

[2] The data cited are based on discussions in June of 1978 with airport personnel and attorneys in Los Angeles, and on July 1980 follow-up conversations with these individuals.

reference suggests the following possible pattern of easement costs:

Noise Level	Cost (percent of property value)
75-80 L_{dn}	17%
70-75 L_{dn}	9%
65-70 L_{dn}	2.5%

These figures should be viewed as quite tentative. They can be used, together with data on the value of housing, to estimate the aggregate cost of securing easements on the dwellings around O'Hare Airport. We do not have data on dwelling values for dwellings specifically within the 65 L_{dn} contour.[1] However, Census of Housing data for the suburbs outside the City of Chicago indicate for a single-family dwelling an average 1979 value of $61,800. The same data give a basis for estimating the average value of a multi-family unit at $26,500.[2]

Using these figures in conjunction with the percent-of-property-value figures cited above results in the estimates of easement costs shown in Table II-9. The total for the approximately 42,000 dwellings within the 65 L_{dn} contour is $113 million, with about one-fourth of this sum attributable

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[1] Landrum and Brown, in hearings testimony, provide data indicating an average value per housing unit of approximately $51,600 for an estimated 2320 units within its 1979 80 L_{dn} contour and $49,600 for 2295 units within its projected 1985 80 L_{dn} contours. A corresponding figure is not given for housing units with the 65 L_{dn} contour.

[2] The Bureau of the Census Volume, Annual Housing Survey: 1975, Housing Characteristics for Selected Metropolitan Areas, reports a median 1975 value for owner occupied homes in the Chicago SMSA (outside of central cities) of $42,800. Updating this figure by the homeownership index component of the Consumer Price Index gives a 1979 figure of $61,800. The same source reports a 1975 median gross monthly rental figure of $215. Updating this figure to 1979 by means of the Index of Residential Rent, also a component of the CPI, gives $276 or $3312. Applying a gross (annual) rental multiplier of 8, which real estate specialists suggest as appropriate for the O'Hare area, gives an estimated average value per rental unit of $26,500. With a mix of 70% single family and 30% multi-family, these housing value figures result in a weighted average value for a housing unit of $51,200.

Table II-9

Cost of Purchasing Noise Easements at O'Hare Airport[1,2]

(in $ millions)

Dwelling Type	Noise Zone 65-75 L_{dn}	75-85 L_{dn}[3]	Total
Single-family	$72.2	$23.3	$95.5
	(27,397)	(1,964)	(29,361)
Multi-family	13.3	4.3	17.6
	(11,742)	(842)	(12,584)
Total	$85.5	$27.6	$113.1
	(39,139)	(2,806)	(41,945)

Source: See text

[1]After instituting modified takoff procedure and modified nighttime procedures.

[2]Figures in parentheses show number of dwellings.

[3]Easement cost for a property in the 80-85 L_{dn} range was taken to be 25% of property value. This figure represents a simple extrapolation of the 2.5, 9, and 17% figures given in the text for the respective 65-70 L_{dn}, 70-75 L_{dn}, and 75-80 L_{dn} zones.

to the relatively nominal number of dwellings subject to noise levels over 75 L_{dn}.[1]

As noted, these estimates are based on limited information on experience at the Los Angeles International Airport. The estimates do not include litigation or administrative costs. Presuming that the Los Angeles awards approximate actual property damages from aircraft noise, one might expect that courts and juries in Illinois, in similar proceedings, would make similar awards. But there is no certainty that in any systematic program to purchase easements around O'Hare airport, the Los Angeles experience and costs would be duplicated. The airport situations differ, as do the legislative and judicial environments, and the attitudes of courts and juries could also differ. A number of years ago, the Northeast Illinois Planning Commission, after referring to the McClure study discussed above, provided illustrative estimates of easement costs for the O'Hare area, on the assumption that those costs would average 20% of the market value of homes.[2] Use of a 20% figure would not much change the estimated cost in Table II-9 for dwellings subject to noise levels of more than 75 L_{dn}. The estimated cost for dwellings in the 65-75 L_{dn} range would, however, be about 4.7 times as great. The Commission noted[3] that in implementing any easement program, a number of issues would require resolution, including:

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[1] The cost figures in Table II-9 can be translated into landing charges and ticket price add-ons in the manner explained in the preceding section on insulation (pp. 26-7). The total estimated easement cost of $113.1 million could be defrayed by an added charge per arriving aircraft of about $31 or by a charge per ticket for departing passengers of about $0.55. The respective figures to defray the $27.6 million of easement costs for the dwellings over 75 L_{dn} would be about $7.56 and $0.13.

[2] Northeast Illinois Planning Commission, Metropolitan Aircraft Noise Abatement Policy Study, July, 1971 (prepared for U. S. Department of Housing and Urban Development and U. S. Department of Transportation), p. 91.

[3] Ibid., p. 92.

a. the extent of the program,

b. the appropriate agency responsible for securing the easements,

c. the method for fixing compensation,

d. the interrelationship between the program and any related property acquisition efforts,

e. the timing of easement acquisition activities,

f. the method for financing the program.

E. Property Acquisition as a Remedy

The acquisition of residential (or other) property by an airport authority represents a further strategy for alleviating the problem of excessive noise. Under this approach dwellings would be purchased and demolished and the land reserved to noise-compatible uses. Depending on circumstances, such uses might entail commercial or industrial activity, or the land might be dedicated to parks and open space. The acquisition approach can also be used in conjunction with other approaches. For example, a dwelling might be purchased, insulated, and resold with a noise easement attached. Or, more simply, the insulation step might be skipped.

The acquisition approach tends to be expensive, because it is to be expected, out of equity or legal considerations, that the prices paid for dwellings would approximate their full market value, undiminished by any effects of aircraft noise. Moreover, the cost is likely to be augmented by a need to pay relocation benefits to occupants and by administrative costs. A source of useful data is the experience of the Port of Seattle with Sea-Tac International Airport. From 1975 through 1978 POS purchased 340 residential properties for removal. The salvage value of the dwellings, amounting to about 8.6% of the value of house and lot, served to reduce the net cost of acquisition, but this was more than offset by the cost elements just noted - relocation benefits amounting to 22.9% of property value and administrative costs at 4.2% of property value. Allowing for these elements, total costs per property amounted to 118.6% of the property's value.[1]

The costs of an acquisition program can be offset to the extent that acquired property can be reallocated to noise-compatible uses. The

[1]The data are cited in Doyle, R. H. and Orman, J. C., op. cit., pp. 22-24.

opportunities for such reallocation are dependent upon the presence of industrial-use and commercial-use needs for the sites in question, and these needs are in turn dependent on the intensity and spatial characteristics of prevailing economic activity. The judgement offered in one airport land-use study, with reference to major metropolitan airports, may be of interest with respect to O'Hare airport:[1]

> Redevelopment was found to be an effective and permanent but generally very expensive solution, because of high land acquisition costs and low demand for reuses. Redevelopment can be justified only in selected, small, heavily impacted areas.

At Sea-Tac International, consideration was given to rezoning acquired properties for manufacturing and commercial uses, but it was concluded that the land was not well suited to these purposes.[2]

With reference to O'Hare Airport, the Northeastern Illinois Planning Commission, in 1971, considered at some length the problems that might arise in a property acquisition program and the alternative forms that it might take. The Commission's views are summarized in part in the following excerpts:[3]

> Any program by the airport operator or other local governmental units to acquire noise impacted property around O'Hare for use other than that directly associated with the needs of the airport certainly would meet with opposition. This opposition and other barriers would hinge largely on the nature and extent of the acquisition program. Two basic situations would be involved; acquisition in fee of vacant property, and acquisition of developed property (most likely property in residential use). Under the vacant acquisiton

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[1]Urban Systems Research and Engineering, Inc., Land Use Control Strategies for Airport Impacted Areas, October 1972. (Prepared for the FAA, Document no. FAA-EQ-72-1). The airports studied were Los Angeles International, Miami International, Long Island-MacArthur and Dallas-Fort Worth.

[2]Interview by the authors with Port of Seattle personnel, June 1979.

[3]Northeast Illinois Planning Commission, op. cit., p. 95-96.

alternative, property could subsequently be utilized for airport purposes or it could be resold or leased for uses which were compatible with aircraft noise. Under the developed alternative a number of options would be available, including: leaseback to the original owner with a covenant restricting the nature of use and an avigation easement protecting the airport operator against litigation, redevelopment for airport related use, redevelopment and leaseback for noise compatible use (property would remain in public ownership), and redevelopment and resale for noise compatible use (property would return to the tax rolls).

If the property were purchased and leased back to its original owner the question of removing taxable property from the tax rolls would still be faced. Any large scale program of this nature could have a drastic impact on communities in the O'Hare environs. Legislation could provide for the taxation of these properties on a continuing basis thus eliminating the tax drain objections.

The most formidable barriers would be encountered if developed single or multi-family residential properties were acquired, cleared and redeveloped for noise compatible uses. If large areas of structurally substandard properties existed in the O'Hare environs, the likelihood of redevelopment would be plausible. This is not the case. Residential properties surrounding O'Hare are generally in good physical condition, and would not qualify for redevelopment under federal or state law. The pressure from community residents and interest groups against the large scale removal of standard residences would be overwhelming. Governmental reaction would be mixed depending on the degree of redevelopment and the nature of the noise compatible uses which were subsequently developed. . . . Any substantive acquisition program would be a costly endeavor. . . . [Among the problems] would be that of relocation of residents displaced by government action. Housing shortages in the metropolitan area would argue against any large scale redevelopment undertaking and would likely extend the time period for completing relocation activities.

A redevelopment strategy which is least likely to meet with widespread government and citizen opposition would be one which concentrated on selective acquisition within a concentrated high noise impact area. Property owners who were unable to sell their property or obtain fair market values could offer it to the airport operator or to a not-for-profit development corporation, which could lease or sell the property with noise related covenants governing its future use. If the property remained in public ownership, local governmental opposition would still be substantial.

Any acquisition activities by the airport operator, for uses or purposes other than those directly related to

> airport expansion, would require legislative sanction. Institutional barriers would no doubt be raised at all levels (including the airport operator) to quell passage of acquisition and redevelopment authority based primarily on alleviating aircraft noise conflict. . . . Given the costs involved, only a limited acquisition program would appear to warrant consideration. A program of this nature could include selected acquisitions in high noise areas. No definitive program of selected acquisition can be outlined, as it would have to depend upon availability of properties and financial ability of the airport operator.

The gross financial implications of a large scale acquisition program can be seen by costing out the purchase of dwellings lying within the 65 L_{dn} contour. For this purpose, cost data from the Sea-Tac experience, cited above, are used as a point of departure. A review of these data through consultation with the Illinois Division of Highways, which has extensive experience in acquiring properties pursuant to highway development, and further consultation with Sea-Tac personnel, suggests the following:

1. Supplemental payments to displaced residents to cover their relocation costs - mainly moving costs, temporary housing outlays, and any mortgage interest differential - tend in Illinois to run in the neighborhood of 23% of property value, or about the same as at Sea-Tac.

2. The estimated salvage value of 8.6%, indicated by the Sea-Tac experience, can generally be obtained only if the dwellings can be physically relocated. Most of the dwellings in the Sea-Tac case were relocated rather than demolished, and virtually all were of wood frame construction. It is generally not feasible to relocate masonry or other types of structures, nor is it feasible to relocate

multifamily structures. In the O'Hare area, wood frame structures appear to represent from 25% to 40% of all dwellings, with the lower figure applying nearer to the airport.[1] For structures other than wood frame, there is little or no salvage value, and there may be a net cost (from demolition). Relocation opportunities may be further limited by the scale of the acquisition program. In the Sea-Tac case, only a few hundred dwellings were involved. Siting problems could arise in a program involving thousands of units.

3. Administrative costs in Illinois have typically been somewhat lower than the 8.6% experienced at Sea-Tac. A good approximation might be 5%.

On the basis of these considerations, we provisionally estimate the following percentage breakdown for acquisition costs:[2]

Housing unit	100
Relocation costs	23
Administrative costs	5
Salvage value	-2
Total	126

[1] Ibid., p. 27.

[2] Landrum and Brown, in its testimony for the City of Chicago, referred to the provisions of the Federal Uniform Relocation Assistance Act in developing its estimates of acquisition costs. Specifically, it used the maximum limits provided in the act for various categories of compensation - relocation expenses, replacement housing payments, and last resort housing payments. However, in practice the statutory maxima are rarely paid. Landrum and Brown also provided for demolition costs, apparently without regard to offsets from relocation or salvage of building materials. See e.g., Exhibit 19 in Exhibits - Testimony of the City of Chicago Before the Pollution Control Board, Airport Noise Regulation, June 16-20, 1980.

The costs of acquisition may be considerably diminished if the land so acquired can be redeveloped for commercial or industrial purposes. The Northeastern Illinois Planning Commission[1] cited two examples of residential land, both within the 65 L_{dn} contour, that, from its evaluation, held potential for profitable conversion to commercial or industrial use. One of these consisted of 64 acres in Schiller Park.[2]

> As previously noted, the existing eight-block residential area is surrounded on three sides by industry and is located due east of the tollway and O'Hare's eastern boundary. Sizeable vacant industrial sites immediately surrounding O'Hare are getting scarce, therefore boosting market demands for sites with accessible locations and of ample size. These considerations warrant consideration of the eventual redevelopment of this 64-acre site for industry.

A second example consisted of 30 acres in Rosemont, abutting a commercially zoned area on the east along Mannheim Road. The Commission anticipated that this site could be redeveloped for hotel, motel and office center purposes. It estimated that the land and improvements in their new uses would have double their original value for the Schiller Park site and 26 times their original value for the Rosemont site.

However, it is not possible to generalize as to redevelopment possibilities. Such possibilities depend, among other things, upon access of a redevelopment site to highway, tollway and rail transportation, the nature of adjacent zoning patterns, and the availability of nearby alternative, vacant sites. The scale of any redevelopment plan also would be a factor. Suitable conversion opportunities might well exist for a limited

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[1] Ibid., ch. 19.

[2] Ibid., p. 73.

number of selected land parcels of modest size. But such opportunities may be much more restricted in the context of a large scale program in which hundreds or thousands of acres are to be converted. It should be further noted that property acquisition on a sufficient scale, with accompanying displacement of the occupants, may itself exert a depressing effect on the local economy, thereby inhibiting the opportunities for redevelopment.

An effect of acquisition without redevelopment is the loss of tax revenues to local government. While the demand for government services could be expected also to decline, it may not fall proportionately, and there may be a loss of economies of scale in delivering those services. Moreover, timing disparities would be expected, with tax revenues declining first and savings in government outlays following only with a lag.[1]

In the absence of information on redevelopment opportunities specific to the O'Hare area, and in light of the experience cited earlier for other major airports, we shall ignore the offsets to acquisition costs that might come from a redevelopment program. However, it should be borne in mind that the potential for such offsets exists and that for an acquisition program of limited scope, it could be substantial. It should also be noted that redevelopment actions take time and that several years may elapse between the initiation of such actions and the time when revenues begin to be realized from them.

Table II-10 below supplies estimates of acquisition costs for residential dwellings located in the 65-75 L_{dn} range and above 75 L_{dn}. The estimates use the values for single- and multi-family housing units previously

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[1] Landrum and Brown provide analyses of the tax consequences for local governments when property is acquired within the 80 L_{dn} contour. See, for example, their Exhibits 20 through 22 and 30 through 32.

Table II-10

Cost of Property Acquisition at O'Hare Airport[1,2]

(in $ millions)

Dwelling Type	Noise Zone 65-75 L_{dn}	Over 75 L_{dn}	Total
Single-family	$2,133	$153	$2,286
	(27,397)	(1,964)	(29,361)
Multi-family	392	28	420
	(11,742)	(842)	(12,584)
Total	$2,525	$181	$2,706
	(39,139)	(2,806)	(41,945)

Source: See text.

[1]After instituting modified takeoff procedures and modified nighttime procedures.

[2]Figures in parentheses show number of dwellings.

developed, together with a supplement of 26%, as discussed several paragraphs above, to cover relocation and administrative costs and salvage value. The aggregate cost for acquiring dwellings in the over 75 L_{dn} zone is estimated at $181 million, and the corresponding cost for all dwellings within the 65 L_{dn} contour is about $2.7 billion. These estimates make no allowance for additional outlays to purchase non-residential structures located on Class A land, such as schools, hospitals, churches and hotels. Landrum and Brown, in their analysis of acquisition costs, include estimates

of purchase costs for hotels/motels and schools. Their Exhibit 36, for example, provides estimates of such costs for their estimated 1985 80 L_{dn} contour. (This contour contains 2295 housing units, whereas our 75 L_{dn} contour reflecting modified takeoff and nighttime procedures, contains 2806 such units.) Their data indicate that for every dollar spent to purchase residential property, about $0.41 was spent to acquire hotels, motels and schools. Applying this relationship for our over-75 L_{dn} zone would raise the estimated acquisition cost by about 40%, to 255 million.

In terms of scope, a property acuqisition program needn't be defined by the 75 or 65 L_{dn} contours. It could be applied on a selective basis to only those properties experiencing very high noise impaction, or to only those properties having both high noise impaction and a promising potential for redevelopment. This more limited approach would limit cost, but of course it would also limit the gains in noise relief.

It should be noted that in an economic sense, in the absence of redevelopment opportunities, property acquisition will generally not be advantageous. Residential dwellings, including noise-impacted dwellings, typically have substantial market value. Buyers, including knowledgeable buyers, willingly purchase and occupy these dwellings. To acquire and demolish such dwellings results simply in the destruction of valuable assets. It represents, in effect, a loss of wealth to the community. If it is judged appropriate to relieve existing owners of burdens they bear because of aircraft noise, or to offset those burdens, that might be done through compensation payments, as by the purchase of noise easements, or through purchase of properties at fair market value (undiminished by the effects of noise) and their resale with noise easements attached, to new buyers at prices adjusted to reflect any noise damages. These procedures respond to

the problem of equity, while at the same time protecting the community's wealth.

F. A Purchase-Guarantee Program

An alternative to a program of outright acquisition, and one likely to be far less expensive over time, is a purchase-guarantee arrangement under which the airport authority guarantees the fair market value of noise-exposed properties. Under this type of program, if an owner elects to sell his property on the open market, and if he cannot obtain fair value for it - that is, a value undiminished by any noise damages[1] - the airport authority would either purchase it from him at fair value for subsequent resale or else pay him the difference between fair value and the best market offer.

Two features of this approach contribute to keeping costs relatively low. First, the airport authority pays only for such damage to a property as the market may determine to exist. These costs would be augmented in some degree by the costs of negotiation and occasional litigation. But a well designed program could help to minimize these costs. Second, not all owners are equally desirous of selling their properties. Moreover, the guarantee itself, by removing a source of uncertainty and concern for owners, may reduce the number of potential sellers in any period. Hence expenditures under the program will tend to be distributed over an extended period and, thereby, their financing more easily managed.

A purchase-guarantee program constitutes one element in the Port of Seattle's long-term noise abatement plan for Sea-Tac International Airport. The program would apply to properties with noise levels of 70-75 L_{dn}. There has not yet been any activity under this program, but it is slated for implementation within the next four to five years.[2]

[1] Such a value might be determined by real estate appraisals of the usual kind.

[2] Interview with Joseph Sims, Assistant Director of Planning, Port of Seattle, June 15, 1979.

At this time, in the absence of any actual experience with a purchase-guarantee program, it is difficult to anticipate the mechanics of its application, the institutional and legal problems it might encounter, or how it might be received by property owners. The same lack of experience makes it difficult to estimate the costs of such a program. It seems a reasonable surmise that the costs would not exceed those of an easement program and could be significantly less.

It should be added that the proposed regulation by the Illinois Attorney General makes no provision for the kind of approach just described.

G. The Use of a Night Curfew to Reduce Noise

1. Introduction

The objective of a curfew on jet aircraft operations is to provide nighttime quiet and noise relief between 10 p.m. and 7 a.m. to residents living near Illinois airports. The curfew might be utilized following the application of modified takeoff and landing procedures for all dwellings remaining above 65 L_{dn}. Or it might be used selectively, in combination with other mitigation techniques like insulation and property acquisitions.

The opportunity for noise reduction by curfews increases as the volume of nighttime aircraft activity rises. At O'Hare Airport, night operations represent about 10% of total aircraft activity.[1] The numbers of operations between 10 p.m. and 7 a.m. vary over the year, ranging between 41,250 and 70,810 annually.[2] According to data presented in Tables II-12 and II-17 below, approximately 55 percent of these flights represent passenger carrier movements and the remainder freighter movements.

In days of rising prices night coach passenger flights are becoming increasingly popular. In 1977, approximately 6,900 passengers daily passed through O'Hare on night coach fares. By 1979-1980, an estimated 3,685,000 passengers, over 10,000 a day, flew night coach into or out of O'Hare.[3] The volume of air cargo moved via O'Hare has grown at about 8 percent a year during the recent years before 1978; approximately 3 points above the

[1] This figure covers air carrier type jet aircraft only. The corresponding figure for all aircraft, including general aviation-type aircraft, is about 12%.

[2] This range for number of nighttime operations is a summary of hearings testimony from various sources, e.g., the City of Chicago, and I. Branand.

[3] Correspondence from William M. Dickson to Terry E. Cox, August 22, 1980.

national average growth rate of about 5 percent. According to Flying Tigers and others, between 1 and 1.7 billion pounds of cargo and mail were shipped through O'Hare in 1978. Between 40 and 60 percent of that was moved between 10 p.m. and 7 a.m. O'Hare currently handles about 6 percent of the total national air cargo volume.[1]

A nighttime curfew at O'Hare could cause rescheduling of flights, cancellation and elimination of flights, or the purchase of new equipment. The ultimate degree to which any one of the possible alternatives would occur is uncertain. There are, however, several scenarios that are possible. The U.S. E.P.A., for example, assumes that the effects of a curfew between 10 p.m. and 7 a.m. will result in the following changes: one third of the affected flights are rescheduled to non-curfew hours, one third of the affected passengers and cargo switch to existing non-curfew hour flights, increasing load factors and decreasing costs, while the remaining one third of the flights would call for the purchase of new equipment or be cancelled. The passengers would no longer fly but would seek other forms of transport.[2]

The assumptions used by the Massachusetts Port Authority in their study of noise at Boston-Logan Airport are somewhat different. They assume that 20 percent of the common carriers' flights would be easily rescheduled to daytime, 30 percent would be rescheduled with difficulty, and 50 percent would be cancelled outright.[3]

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[1] Landrum and Brown, Chicago's O'Hare International Airport Master Plan Study, v. 8, October 1979, p. 4.

[2] H. G. Meindl, et al., Costs and National Noise Impact of Feasible Solution Sets for Reduction of Airport Noise, Wyle Research for U.S. E.P.A., WR 75-9, February 1976, p. 3-24. For a variation of the E.P.A. assumptions see Sperry, William C., et al., Noise Source Abatement Technology and Cost Analysis Including Retrofitting, U.S. E.P.A., NTID 73.5, 1973.

[3] Massachusetts Port Authority, The Costs of Limiting Night Flights at Logan Airport, 1976, p. 46-48.

However, with the current levels of daytime congestion and the premium on gate availability at O'Hare, it may be difficult to reschedule a substantial number of night flights to non-curfew hours. As a result, the discussion below is developed on the assumption that 100 percent of the operations affected by a 10 p.m. to 7 a.m. curfew are eliminated. But the reader should bear in mind that, in event of a curfew, some operations would be rescheduled.

A curfew at O'Hare will have effects on the commercial air carriers, passengers, the air cargo carriers and users, mail, and the transport of funds. Major examples of each of these effects will be discussed in detail below, following examination of the effects of a curfew on housing and land use.

2. The Effects of a Curfew on Noise-Impacted Acreage and Housing

The Technical Study (V. III, p. 58) examines the effect of a complete nighttime curfew on the 65 and 75 L_{dn} contours. The curfew is assumed to be imposed following the implementation of modified takeoff procedures, with the overall activity level reduced by the number of night flights eliminated. (That is, no night flights are moved to daytime hours.) The resulting noise contours are shown in Figure II-5 (which reproduces Figure 4-9 of the Technical Study), and the consequences for the acreage and housing lying within the respective contours are shown in the last two columns of Table II-11. For comparison purposes, similar data are given for the case reflecting normal (1985) activity levels, but including modified takeoff and nighttime procedures (See Table II-4).

Impacted residential acreage and housing drop quite substantially. The number of dwellings over 65 L_{dn} falls by just over 40%, with the major part of the decline occurring in the 65-75 L_{dn} range.[1] The curfew serves

[1] The L_{dn} measure incorporates a 10 dB penalty for night flights. Because of this, elimination of these flights, which account for about 10% of total operations, has the same effect on the L_{dn} level as would a reduction of over 50% in daytime flights.

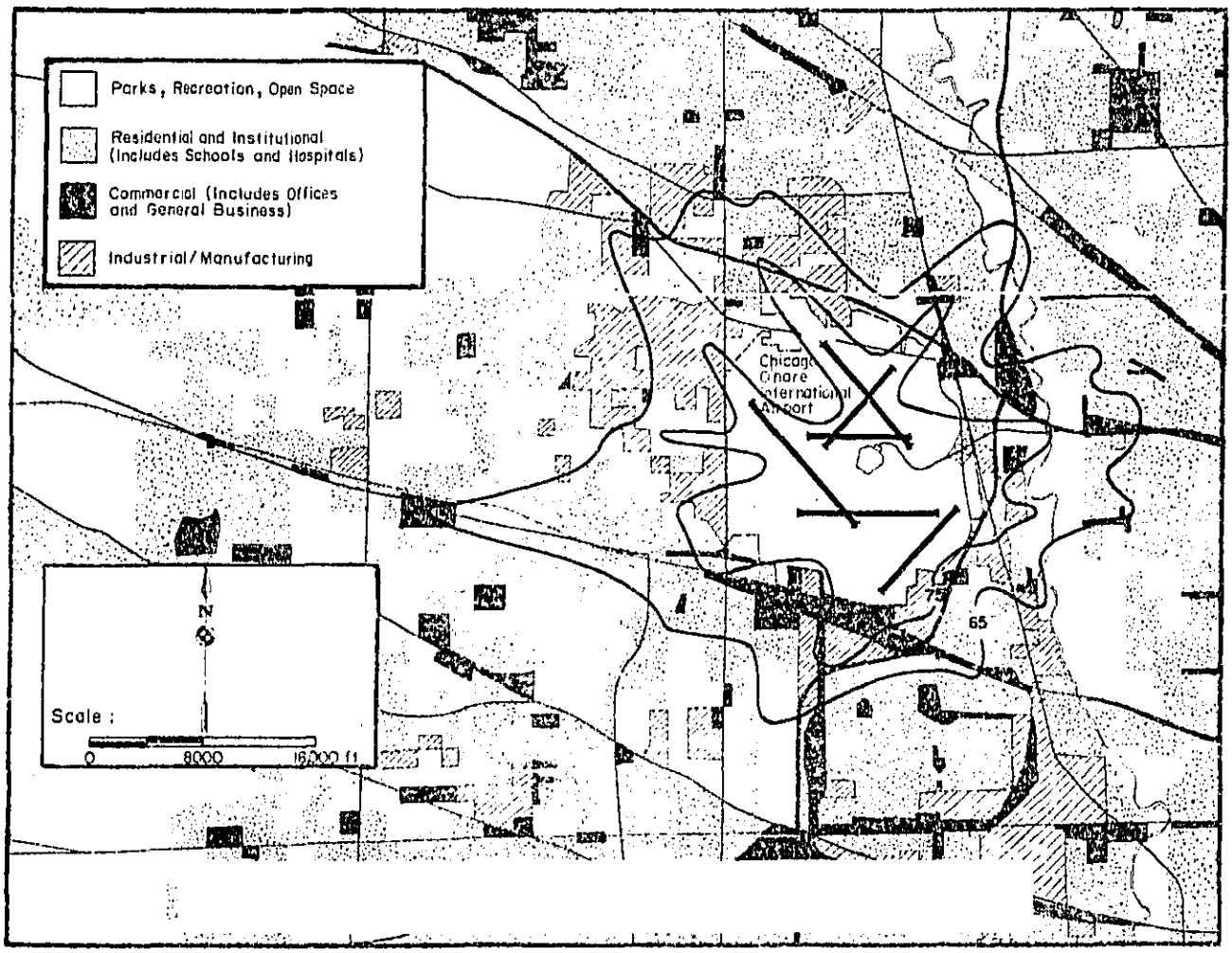

Figure II-5. L_{dn} Contours for O'Hare Airport, Reflecting a Complete Night Curfew (Figure 4-9 of Vol. III).

Table II-11

Effects of a Complete Night Curfew on Impacted Acreage and Housing

Land Use	After Modified Takeoff and Nighttime Procedures[1]		After Complete Night Curfew[2]	
	65-75 L_{dn}	Over 75 L_{dn}	65-75 L_{dn}	Over 75 L_{dn}
Housing (acres)	6,556	470	3,776	353
Housing Units (number)	39,139	2,806	22,544	2,107
Commercial (acres)	1,485	353	1,219	294
Industrial (acres)	3,072	1,073	2,483	676
Open Space (acres)	6,600	706	3,453	499
Airport (acres)	809	6,424	5,642	1,587
Total, excluding Airport (acres)	17,713	2,602	10,931	1,822

Source: Technical Study, Part III, Table 4-3

[1]The figures are for Quieted Case 2-1985 (4-4).

[2]The figures are for Quieted Case 1 with total curfew (4-9).

also to reduce the amounts of noise-impacted commercial and industrial acreage, though generally by lesser amounts. Thus, as an instrument for quieting, it produces significant effects.

3. The Costs to Air Carriers

A 10 p.m. to 7 a.m. curfew at O'Hare will reduce the current activity

levels at O'Hare. Table II-12 below presents daily nighttime commercial air carrier activity, while Table II-13 presents load factor data for O'Hare air carriers' night flights. According to Table II-12, a curfew would have eliminated approximately 39,000 annual commercial air carrier operations alone in 1979-1980. Recall that this figure excludes commuter flights, all cargo, military, and general aviation flights.

The elimination of flights due to a curfew at O'Hare would cause disruptions to air carrier programming and passenger schedules. The opportunities for flexible and effective aircraft use would be diminished. The airlines maintain that a curfew and subsequent elimination of flights would create restrictions that would damage their ability to operate. It would be difficult to institute a curfew at O'Hare and eliminate flights without also disrupting air carrier activity throughout the entire system.[1]

Flight schedules are one of the most significant variables in determining the economic impact of a curfew on the air carriers. They are the basis upon which airline staffing, aircraft activity, and cargo and passenger flows are developed. Flight patterns are carefully worked out and can easily become less efficient or, perhaps, infeasible if certain constraints are imposed. For example, a curfew at O'Hare might lead to less efficient connecting schedules and passenger flows. A curfew controls the hours when flights from another city can depart for O'Hare. Their departure depends on:

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[1] There are several exhibits and accompanying testimony in the Hearings volumes that illustrate and describe the effects of an O'Hare curfew upon the scheduling and routing patterns throughout the air system. See for example, Exhibit 162, "Routing of a B727-200 Aircraft Unit, Seven-Day Cycle" and the accompanying testimony by Ian M. Bamber, December 5, 1979. In it Mr. Bamber explains the process of scheduling airline services, and how airline services could be affected by the elimination of flights as a result of the adoption of the proposed regulation.

Table II-12

Daily Nighttime Commercial Air Carrier Activity at O'Hare (February 1980)

Time	Arrivals	Departures	Total
2201 - 2300	17	6	23
2301 - 2400	10	5	15
0001 - 0100	2	-	2
0101 - 0200	4	-	4
0201 - 0300	-	2	2
0301 - 0400	1	1	2
0401 - 0500	5	3	8
0501 - 0600	18	5	23
0601 - 0700	6	21	27
Total	63	43	107

Source: From Exhibit 201 of the Hearings Testimony. Based on February 1980 operations as reported in the Official Airline Guide.

Table II-13

Percent Load Factor Data for O'Hare Air Carriers' Night Flights[1]

Airline	Passengers (Two month total August 1979 and February 1980)				
	Inbound	% Load Factor	Outbound	% Load Factor	Total
American	58,536	59%	35,549	58%	97,085
Braniff	------	---	1,603	40%	1,603
Continental	11,764	53%	10,636	52%	22,400
Delta	49,424	62%	50,518	62%	99,942
Eastern	26,554	61%	22,486	61%	49,040
Northwest	2,017	36%	5,304	59%	7,321
Ozark	1,110	49%	------	---	1,110
TWA	26,714	72%	10,046	66%	36,760
United	162,947	60%	135,933	56%	298,880
Total	339,066	60%	275,075	58%	614,141

Source: CAB ER586 Service Segment Data, available through William M. Dickson, Mayer, Brown, and Platt, correspondence dated August 22, 1980 to Terry E. Cox, Illinois Pollution Control Board.

[1]Assumes a 10 p.m. to 7 a.m. curfew, excludes commuter and international flights.

1. the O'Hare curfew (10 p.m. to 7 a.m.)
2. the elapsed flight time, and
3. any time zone changes.

To illustrate, in 1980, United Flight 156 left Portland, Oregon at 11:55 p.m. Pacific Time and arrived in Chicago at 5:25 a.m. the next morning. The flight was not only important in aircraft positioning but it also provided the Portland traveler with O'Hare connections to 43 other destinations served by commercial air carriers departing between 6:00 a.m. and 8:00 a.m.[1] The O'Hare curfew would have prevented the arrival of Flight 156 and it would have interfered with efficient connections and passenger flows.

A curfew could also affect early evening flights that operate during non-curfew times. A variety of flights leave the west coast about 4:00 p.m. Pacific Time from various cities including Seattle, San Francisco, and Los Angeles. They arrive at O'Hare between 9:30 p.m. and 10:00 p.m., and make connections to a significant number of other cities on flights that leave O'Hare between 10:30 p.m. and 11:00 p.m. If the 10:30 p.m. and 11:00 p.m. departures are cancelled, the connections available to inbound passengers will be reduced. Flights leaving the west coast would become less economical since they would lose their connecting passengers and would be forced to rely on Chicago local traffic. As a result, these flights might also have to be eliminated despite the fact they operate entirely during non-curfew hours at O'Hare.

Early morning departures would also be affected by O'Hare's curfew. Often the first flights of the day depend upon aircraft positioning that occurred with the previous night's inbound flights. The aircraft that operate inbound service after 10:00 p.m. are often being positioned for early morning flights out of O'Hare. If the airplane could not arrive

[1] Testimony of Ian M. Bamber before the Pollution Control Board, December 5, 1979, p. 4016.

at O'Hare until after 7:00 a.m. the next morning, then it would be unavailable to operate an early morning departure out of O'Hare.

The curfew would also act as a constraint in routing crews and determining maintenance schedules. Flight crews are changed for almost every flight at O'Hare, while every 3 days or 30 hours of flight time an aircraft must be at a maintenance installation. Currently, American, Braniff, Delta, Eastern, Republic, Northwest, Ozark, TWA, and United have maintenance facilities at O'Hare Airport. The imposition of a curfew could lead to excess maintenance capacity. Currently only about half of the aircraft arriving at O'Hare for maintenance have arrived by 10:00 p.m. The remaining half arrive during the curfew hours. Note that these percentages vary somewhat with the season and routing schedules.[1]

In addition to the physical problems of efficiently moving airplanes and people, the air carriers may suffer some revenue and operating cost effects as the result of a curfew at O'Hare. Costs may rise if additional personnel and equipment must be bought to handle any new congestion caused by the elimination of nighttime service and by night passengers switching to non-curfew hour flights. There may be increasing costs in repositioning crews and reoptimizing aircraft schedules. At the same time general passenger and business inconvenience may lead to a loss of demand as other forms of transport are sought and could partially offset any revenue gains that occurred as night coach passengers switched to day coach fares.

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[1] Sperry et al. have expressed doubt that the effects of a curfew upon maintenance would result in significant cost increases. Nationwide, only about 2 percent of current flights are non-revenue maintenance, training, or repositioning flights. Usually, they are planned well in advance and Sperry suggests that schedule changes could avoid most curfew conflicts. See Sperry, William C., et al., Noise Source Abatement Technology and Cost Analysis Including Retrofitting, U.S. E.P.A., NTID 73.5, 1973, p. 4-69.

Nonetheless, a curfew could carry some beneficial offsets for the air carrier. Passengers shifting from curfew hour flights would help to increase non-curfew hour load factors, reducing per passenger mile costs and, in some measure, cushioning any overall decrease in revenue. In addition, operating costs might be reduced as a result of a decrease in nighttime station costs, particularly the payroll for nightshift labor.

Throughout the above discussion of the effects of a curfew upon air carriers, we have dealt with aggregate economic impacts. As a result, the magnitude of these results upon an individual air carrier might not have been fully reflected. It is possible that a particular carrier's loss could be greater than its pro-rata share of the aggregate incremental losses depending upon the relative post-curfew competitive positions of each airline. It should also be remembered that activity levels change over time. A curfew would eliminate not only current flights but potential future flights as well. Thus, the future costs of a nighttime restriction could be significantly greater than the present costs.

4. The Costs to Passengers

Night coach fare passengers at O'Hare have increased from about 6,900 each day in 1977 to over 10,000 daily in the year ended June 30, 1980. Approximately 8.1 percent of the total number of passengers inbound or outbound from O'Hare in the two months August 1979 and February 1980 were flying night coach. A glance back to Table II-13 shows the night coach passengers during these two months for the domestic commercial air carriers operating night flights at O'Hare. Table II-14 is an annualized estimate of the number of passengers using O'Hare. It is based on data presented in Table II-13.

Table II-14

Estimated Annual Night Coach Passengers for O'Hare 1979-1980

Airline[1]	Passengers[2]		
	Inbound	Outbound	Total
American	351,216	231,294	582,510
Braniff	---	9,618	9,618
Continental	70,584	63,816	134,400
Delta	296,544	303,108	599,652
Eastern	159,324	134,916	294,240
Northwest	12,102	31,824	43,926
Ozark	6,660	---	6,660
TWA	160,284	60,276	220,560
United	977,682	815,598	1,793,280
Total	2,034,396	1,650,450	3,684,846

[1]Table excludes international and commuter flights.

[2]Data are from Table II-13 above multiplied by 6 to obtain annual estimates.

A curfew at O'Hare would eliminate all passenger flights between 10 p.m. and 7 a.m. This would eliminate nearly 3,685,000 night coach fares and according to the City of Chicago's testimony would also have resulted in 1,560,000 passengers not being served.[1] The implication is that 42 percent of the passengers will no longer fly. This figure may be somewhat high. The assumptions concerning the effects of a curfew noted in the introduction to this section and used by the U.S. E.P.A., Sperry, Wyle Research Labs, and others seem to suggest that as many as two-thirds, or 66 percent, of night coach passengers would still fly in the event of a curfew. In other words, 33 percent of the passengers would no longer be served. A survey conducted at Boston's Logan Airport supports this view. Two out of three passengers questioned were flexible and would fly at other times of the day, another 25 percent would no longer fly via the Logan Airport, and 9 percent were unsure what they would do.[2]

A curfew at O'Hare would also eliminate the less expensive night coach fares currently available. Night coach discounts range from 10 percent to 30 percent of regular daytime fares at the discretion of the airline. Such fares are particularly attractive to people who don't mind traveling at night: families, students, retired people, youths, and the less affluent. The loss of this nighttime service cannot be replaced by daytime service for those passengers to whom low night fares are an important factor in their decisions to fly. There are some experimental discount fares available during

[1] Testimony of Jeffrey N. Thomas before the Pollution Control Board, June 16, 1980, p. 5957.

[2] The Survey concluded that:
38.3% of passengers would reschedule earlier
27.0% of passengers would reschedule the next day
10.7% of passengers would travel by other means
8.5% of passengers would use another airport
6.9% of passengers would not go
8.5% of passengers were unsure what they'd do.

Source: Massachusetts Port Authority, The Effects of Limiting Night Flights at Logan Airport, August 1976, p. 114.

the day but they are generally subject to advance bookings and seat restrictions.[1]

A curfew could create passenger inconvenience by interfering with the arrival of connecting traffic. One potential effect of the O'Hare curfew could be to force rescheduling of flights at their point of origin. For example, a curfew at O'Hare can interfere with overnight traffic bound for Chicago or further east via connections at O'Hare. To continue an example described above, if United flight 156 from Portland to Chicago were no longer feasible due to a Chicago curfew the Portland traveler would have the following alternatives. He might reschedule his journey 11 hours earlier, departing Portland at 1:15 p.m. (instead of 11:55 p.m.) and arrive at O'Hare at 7 p.m. before the curfew. He could also travel the next day by delaying his departure 8 hours and leaving Portland between 7:45 a.m. and 8:00 a.m. to arrive in Chicago at 1:30 p.m. Each of these alternatives would make it inconvenient to make timely connections for travel further East. There is a third possible alternative which would be not to travel via O'Hare at all but to attempt to fly east via another gateway.[2]

Another possible effect of a curfew at O'Hare relates to passengers traveling on flights that operate during otherwise permissible hours. There are flights which were discussed above that leave from the west coast around 4:00 p.m. The passengers on these flights arrive at O'Hare between 9:30 p.m. and 10:00 p.m. and make connections to other large cities on flights departing O'Hare between 10:30 p.m. and 11:00 p.m. If the departures between 10:30 p.m. and 11:00 p.m. are eliminated the connections available to passengers would be eliminated too. Such late day connections are oftentimes

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[1] Ian Bamber, testimony on December 5, 1979, p. 4013-4014.

[2] Ian Bamber, testimony December 5, 1979, p. 4017.

important. Their loss can create systemwide difficulties and passenger inconvenience.

In addition to disrupting the evening flight schedules, a curfew could also disrupt early morning passenger departures from O'Hare. There are currently many eastbound departures from Chicago between 6:00 a.m. and 7:00 a.m. They are popular because they provide the businessman with a full work day on the east coast and still allow him to return to Chicago that same evening. A curfew would eliminate these early departures, add delay, shrink the work day, and decrease the value of time savings that jet aircraft currently provide.[1]

An increase in delay times would be one of the major costs of a curfew. Based on the calculated curfew costs found in Sperry and summarized in Wyle, the per minute delay costs per operation as the result of a curfew and its consequences would be $7.02 per minute (1973 dollars) for the years 1974 through 1980 inclusive.[2] Table II-15 below is taken from Sperry and presents,

Table II-15

Estimated Total Delay Time and Cost for O'Hare Airport, 1978-1980

Year	Delay Time (1000 minutes)	Passenger Delay Cost ($ million)*
1978	5,995.1	$42.06
1979	6,208.9	43.56
1980	6,422.7	45.06

Source: See text.

*1973 dollars.

[1] Ian Bamber, testimony December 5, 1979, p. 4021.

[2] Sperry, William C., et al., op. cit., and Wyle Research Labs, Costs and National Noise Impact of Feasible Solution Sets for Reduction of Airport Noise, February 1976. Curfew delay costs were calculated using the U.S. E.P.A. assumptions.

simply as an illustration, the total estimated delay time and cost arising from a curfew for O'Hare Airport for 1978, 1979, and 1980. In addition to delay costs, passengers might experience a fare increase if the operating costs of air carriers increase as a result of a curfew.

5. The Effects on Air Cargo Carriers and Customers

As noted in the introduction to this chapter, O'Hare currently handles about 6 percent of the nation's air cargo volume. In addition, air cargo handling at O'Hare has grown about 3 percent faster than the national average growth rate during the 5 years preceding 1978. Table II-16 shows total enplaned cargo for selected years at O'Hare. Since 1962, total transported cargo at O'Hare has increased about 400 percent. Various sources have suggested that between 45 percent and 65 percent of total air cargo activity moves between 10:00 p.m. and 7:00 a.m.[1] It is also interesting to note that while less than 1 percent of the total volume of all cargo transported (including surface transport) moves by air, it can be worth as much as 25 percent to 30 percent of the value of commerce. This is apparent from the type of goods shipped by air.[2]

Table II-16
Total Enplaned Cargo (Selected Years) at O'Hare

Year	Tons of Cargo
1962	95,000
1977	393,000
1978	420,000
1979	384,000

Source: Testimony of the City of Chicago, June 16, 1980, Jeffrey N. Thomas, p. 5907.

[1] See for example, the testimony by both the City of Chicago and Air Express International.

[2] See Flying Tigers testimony, p. 4727 for a list of the type of goods typically moving as air cargo.

In addition to the major all-cargo carriers, over 30 other air carriers also handle air freight. They use either freighter aircraft or the belly space of passenger aircraft.[1] As an example of passenger carrier cargo transport, American Airlines has 5 freighter flights daily from O'Hare. Three of them occur between 10:00 p.m. and 1:00 a.m.[2] Table II-17 below is taken from Hearings Testimony Exhibit 201. It shows the average hourly arrivals and departures of passenger and all-cargo aircraft at O'Hare. According to the table, a curfew at O'Hare would disrupt the following percentages of all-cargo activity:

Curfew Hours	Percent of All-Cargo Activity Disrupted
2200 - 0700	74.0%
2200 - 0600	64.7%
2300 - 0600	63.9%
2400 - 0600	55.5%

These figures differ somewhat from the testimony of the City of Chicago. The City of Chicago suggests that 58 percent of all-cargo operations, or about 7,000 operations, would be eliminated by a curfew at O'Hare. (Note that the City of Chicago's figure is quite low when compared to 58% of the annual number of all-cargo operations cited in Table II-17 below. The calculation based on Table II-18 gives 25,192 operations.)

The major effects of a curfew upon the movement of air cargo would accrue to the users of air cargo transportation. As a result, rather than

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[1] On a national level, according to Sperry, about 50% of total air cargo moves aboard passenger aircraft. The other half moves aboard all cargo carriers. Sperry, William C., et al., op. cit.

[2] Testimony of Ed Koziatek, April 9, 1980.

Table II-17

Average Hourly Arrivals and Departures of Cargo-Carrying Aircraft at O'Hare[1]

Time	Arrivals		Departures		Total	
	PAX	All-Cargo	PAX	All-Cargo	PAX	All-Cargo
0001-0100	2	5	-	2	2	9
0101-0200	4	7	-	4	4	11
0201-0300	-	9	2	1	2	10
0301-0400	1	6	1	6	2	12
0401-0500	5	5	3	7	8	12
0501-0600	18	7	5	5	23	12
0601-0700	6	3	21	8	27	11
0701-0800	49	-	38	3	87	3
0801-0900	46	2	71	1	117	3
0901-1000	54	-	51	4	105	4
1001-1100	72	1	69	-	141	1
1101-1200	49	1	74	-	123	1
1201-1300	49	-	48	-	97	0
1301-1400	61	2	49	2	110	4
1401-1500	83	2	78	1	161	3
1501-1600	54	-	69	1	123	1
1601-1700	76	-	57	2	133	2
1701-1800	57	-	81	1	138	1
1801-1900	67	-	61	-	168	0
1901-2000	58	2	56	-	114	2
2001-2100	50	2	45	2	95	4
2101-2200	31	-	34	2	65	2
2201-2300	17	1	6	-	23	1
2301-2400	10	8	5	2	15	10
Totals	919	63	924	56	1843	119

[1]Based on February 1980 operations as scheduled in the Official Airline Guide.

attempting to determine the effects of a curfew upon shipments by examining the carrier's performance, it would, perhaps, be more enlightening to examine the effects upon the shipper.

Nighttime cargo schedules have been developed according to the delivery requirements of businesses, manufacturers, and the U.S. Post Office to fulfill a transportation need that cannot be adequately satisfied by other modes of transportation. Speed is the central purpose of air freight service, and its higher cost as compared to other transportation modes is secondary to the need for timely activity. Night flights from O'Hare allow overnight delivery to many domestic destinations and second day delivery to most places abroad. Such nighttime air cargo service contributes to maintaining Chicago's and the Central midwest's competitive position in national and international markets, particularly in high technology industries. Table II-18 provides an example of the freight destination points available from O'Hare at night.

One of the most important areas in which all-cargo users would be affected is in O'Hare's capacity as a major international gateway. International traffic moves via gateways. Local stations collect freight destined for overseas from shippers in their respective service areas and transport it to the gateway. There, the cargo is consolidated according to destination, processed for export, and loaded for transport to the overseas gateway where the procedure is reversed. The freight is unloaded, processed for import, broken down according to ultimate destination and finally forwarded to local stations for delivery to individual consignees. Such a gateway requires a significant investment in equipment, maintenance of storage facilities, training specialized personnel, and a 24-hour operating capability.[1] For

[1]Hearings Testimony by Air Express International, March 25, 1980.

Table II-18

An Example of Outbound Freight Service at O'Hare[1]

Destination	Flight	Estimated time of Departure
Anchorage	Flying Tigers 71	0645
Burlington	Ozark 803	0600
Dayton	Blackhawk 0000	0200
Dallas Fort Worth	American Airlines 809	0340
Detroit	Desert Air Service 443	0115
Detroit	United Airlines 2892	0203
Houston	Braniff Intl. Airlines 851	0140
Wichita	Great Western 002	0320
Indianapolis	Desert Air Service 443	0600
Jacksonville	Delta 1073	0245
New York	Flying Tigers 440	0310
Los Angeles	United Airlines 2837	0355
Lexington	Burlington Air 702	0230
Kansas City	Great Western 002	0320
Memphis	Falcon 206	0500
Portland	Flying Tigers 341	0405
Philadelphia	Great Western 534	0230
Pittsburgh	Skyline 625	0400
Pittsburgh	Flying Tigers 920	0045
Seattle	Flying Tigers 341	0405
San Francisco	United Airlines 2855	0255
Tulsa	Great Western 002	0320
Quincy	Ozark 803	0600

Source: Testimony of Airborne Freight Corporation.

[1]Airborne moves outbound Chicago cargo via these flights.

international cargo, the other major United States gateways are New York and Los Angeles.

O'Hare is a sizeable domestic and international gateway that funnels shipments originating from or destined for distinations other than Chicago.[1] The following example, taken from Air Express International's testimony, may prove useful in illustrating the importance of night departure times for the smooth flow of international air cargo transport. AEI uses Pan Am Flight 162 departing O'Hare for Brussels, Belgium and Frankfort, Germany at 2:30 a.m. Tuesday through Friday. It is a wide body, all-cargo 747. A typical AEI shipment may include freight from Cincinatti, Denver, Indianapolis, Kansas City, and St. Louis. Caterpillar, in Peoria, often ships goods bound for their distribution center in Brussels. The freight arrives in Brussels at 4:30 p.m. the same day. There is enough time for import processing, freight segregation, and reconsolidation according to final destination. Caterpillar receives final forwarding instructions. The freight is loaded aboard other aircraft for second morning service to places such as Antwerp or, perhaps, Paris.

Since an international gateway must operate in a world of time zones (7 hours between Chicago and Europe) and flight times (also 7 hours between Chicago and Europe), a 10:00 p.m. to 7:00 a.m. curfew in Chicago would have repercussions upon the international freight system. According to AEI, a 9 hour curfew in Chicago means a 9 hour shutdown in Europe, thereby disrupting the coordination explained above. With pre-10 pm departures, shipments from the west coast using O'Hare as a gateway would have to leave the coast no later than 3:00 p.m., while once at Chicago the international freight would have to sit an extra day at O'Hare. There would be inadequate time

[1]Testimony from Emery Freight, March 25, 1980, p. 4611.

prior to a pre-10:00 p.m. departure to process and load the freight for export. Similarly, if the freight left O'Hare after 7:00 a.m., it would arrive too late in the day in Europe (around 9:30 p.m.) to allow unloading, import processing, and timely second morning arrival.

Accordingly, a curfew upon O'Hare's international gateway activity would lead to a disruption in air cargo schedules at home and abroad both in gateway activity and in connecting service to and from the gateways. There would also be increased costs as the result of equipment downtime, congestion, and the need for increased storage capacity. In addition, there may be some shift in cargo traffic to other gateways, leading to further increases in transit time, costs, and delay.

By jeopardizing the smooth and timely flow of cargo, a curfew would weaken the competitive position of local businesses. Overnight delivery is an important competitive tool in high technology markets such as machinery, farm equipment, and medical supplies. Such timely transport is also important for movement of unplanned, highly time sensitive emergency traffic.[1]

Such freight is shipped in the following way: At the close of the business day freight is either trucked by the shipper to the freight forwarder or picked up at the shipper's by the forwarder. It is hauled to the forwarder's terminal for consolidation and routing with other freight. It is then reloaded onto trucks for transport to the airline cargo terminal and final loading on either combination or all-cargo aircraft.

A night curfew would cause changes in the freight schedules so that overnight delivery may no longer be feasible. If flights must be rearranged

[1] See Sperry, William C., et al., op. cit., pp. 4-66, 4-67 for an interesting discussion on the effects of a curfew upon the air freight movement of emergency and time-sensitive traffic.

so that they depart before 10 p.m., there may not be adequate time for the above freight process to be completed and the freight to be loaded on the aircraft before pre-10 p.m. departure. The freight must leave the shipper's facility earlier in the afternoon or it would have to stand in a warehouse overnight awaiting departure after 7 a.m. the next day. Again, such a situation could lead to increased transportation costs, increased freight charges, increased inventory costs, and, perhaps, the need for more warehouses. Businesses would be faced with time delays, increased costs, and congestion. Some businesses might decide to find other means of cargo transport.

There has been substantial hearings testimony concerning not only the benefits that nighttime air cargo brings but also the costs that would result from the elimination of that cargo service. This testimony is from Chicago area businesses as well as from firms as far away as the west coast that depend on O'Hare for portions of their cargo transport.[1]

In addition to the effects upon air cargo users, a curfew would also have adverse impacts on the air cargo carriers and freight forwarders. Flying Tigers, Emery Air Freight, Airborne Freight and Air Express International all testified at the hearings on the role of O'Hare Airport in their operations and on the contributions of those operations to the Chicago area economy.[2]

Freight forwarders are the middlemen in air freight movement. They are highly dependent on demand for their services from shippers on the one hand and on the flight schedules and services of the airlines on the other. Freight forwarders anticipate that a reduction in night operations would impair their effective functioning. A principal selling point is the guarantee of overnight delivery via night flights. A nighttime curfew at O'Hare would create

[1] For examples see such testimony as that of R. R. Donnelley and Sons, Eli Lilly, Abbott Labs, John Deere, TRW Defense and Space Systems Group, and Sperry Univac.

[2] For Flying Tigers testimony, consult the hearings transcript of April 8, 1980; for Emery Air Freight, Airborne Frieght, and Air express International, the transcript of March 25, 1980.

a higher cost of operations, loss of jobs within the Chicago Station, poorer service to the customers of Chicago, the suburbs, and, indeed, for cities quite far away. For example, the repercussions of a curfew at O'Hare would affect AEI operations in New York and Los Angeles and the cities they serve as transportation hubs. Shippers throughout the midwest, the central plains, and the pacific northwest would suffer service disruptions, delay, and increased transit costs due to the need to shift international traffic elsewhere.[1]

6. The Effects of a Curfew on Mail Transport

Table II-19 below shows the current activity levels at O'Hare for mail transportation. According to the U. S. Postal Service, in November 1977, there were 1687 operations daily at O'Hare carrying between 500,000 and 600,000 pounds of mail.[2] Approximately 40 percent of that moves at night.[3]

According to exhibits presented for testimony before the Pollution Control Board, the mail bound for O'Hare transport typically moves in the following fashion: Between 4:00 p.m. and 8:00 p.m. Chicago area mail is collected and processed for outbound shipment. Between 8 p.m. and 10 p.m. the mail is transported to O'Hare and loaded aboard aircraft. Air travel time may be as long as 4½ hours, say, 10:00 p.m. to 2:30 a.m. Over the next 1½ to 2 hours the mail is unloaded from the aircraft and transported to the post office. Between 4:00 a.m. and 8:00 a.m., the mail goes through additional processing and is prepared for early morning delivery or further transit.[4] A typical O'Hare flight providing mail service would be Northwest Flight 901 which carries mail service to Seattle and its surrounding area. Another flight, Braniff Flight 851 to Dallas and Houston, carries mail to Amarillo, Austin, Corpus Christi,

[1] Air Express International Testimony of March 25, 1980.

[2] Exhibits contained in "Notice of Testimony and Sponsored Exhibits", Nov. 3, 1977.

[3] Ian M. Bamber, December 5, 1979 testimony.

[4] Exhibits contained in "Notice of Testimony and Sponsored Exhibits", Nov. 3, 1977.

Table II-19

Daily Mail Activity Levels at O'Hare Airport, 1977

Hour	Number of Inbound Flights[1]	Pounds of Inbound Mail[2]	Number of Outbound Flights[1]	Pounds of Outbound Mail[2]	Total Flights[1]	Total Pounds Mail[2]
2100-2159	31	17,000	28	9,000	59	26,000
2200-2259	16	16,500	9	12,200	25	28,700
2300-2359	12	19,000	8	10,000	20	29,000
2400-0059	5	9,800	5	8,100	10	17,900
0100-0159	7	15,400	10	4,200	17	19,600
0200-0259	4	3,900	6	15,600	10	19,500
0300-0359	4	6,600	7	1,500	11	8,100
0400-0459	4	4,400	6	7,300	10	11,700
0500-0559	4	2,400	6	15,500	10	17,900
0600-0659	5	15,200	28	32,000	33	47,200
0700-2059	744	174,800	738	184,600	1482	359,400
24 Hour Total	836	285,000	851	300,000	1687	585,000 (292.5 tons)

Source: Sponsored Exhibits presented for testimony before the Illinois Pollution Control Board, "Notice of Testimony & Sponsored Exhibits," dated Nobember 3, 1977.

[1]Exhibit A

[2]Exhibits I and II. The figures represent average pounds per day Tuesday-Saturday. Volumes for Sunday are 50 percent above and for Monday 75 percent above.

Lubbock, Oklahoma City, San Antonio, Tulsa, and Wichita, while Delta Flight 1073 carries mail to Atlanta, Miami, San Juan, and their respective surrounding areas.

In 1977 and with a 10:00 p.m. to 7:00 a.m. curfew, 199,600 pounds or 99.8 tons of mail daily would not be carried at night. In other words, approximately 36,427 out of 106,762.5 tons of mail annually, about 34 percent, would no longer be transported at night. Note that this figure is a good deal higher than the 1979 figures with the same curfew presented during the City of Chicago testimony. In their Exhibit 33, the City of Chicago suggests that 7,900 out of 92,212 tons of mail annually, about 9 percent, would no longer be carried as a result of a curfew.

The most notable result of the decrease in nighttime transport of mail would be a decrease in next-day delivery. The following excerpt from the Hearings Testimony indicates how important overnight mail delivery can be.

> Our Dwight [Illinois] manufacturing Division [of R. R. Donnelley and Sons] prints a number of restricted credit card lists or "hot card" lists weekly in quantities of millions. They are distributed as first class mail...If air service [at O'Hare] is reduced, we anticipate that Donnelley's credit card customers may...begin to look at alternate printers with better air service capabilities. These customers simply cannot wait even one extra day for distribution of their product; if they did the usefulness of the weekly listing would be minimal and delay could, in fact, result in cards already known to be stolen or lost being accepted by local merchants.[1,2]

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[1] Testimony of Charles T. Albright, April 9, 1980.

[2] Sperry, William C. et al., op. cit., p. 4-68, suggests that the effects of a curfew on mail might be minimized through various compensatory adjustments. Given the assumption that the peak volume processing periods for mail can be shifted to coincide with the curfew schedule, it concludes that the impact on air system costs and revenues due to changes in mail carriage would be small. Much of the possible inconvenience of disrupted overnight mail delivery could be minimized by revised pickup and delivery schedules. A change in postal pickups would allow earlier sorting, delivery to planes and pre-curfew departure thus preserving overnight delivery. Another possibility is if the postal service would shift its delivery schedule to the afternoon, thereby allowing most N, S and W bound flights to depart after 7 a.m. and still arrive in time to deliver the day's mail.

The curfew would create no income or employment dislocation of postal workers as no one can be dismissed due to labor contract terms. Some night workers would still process mail from late arrivals and for early departures while others would be relocated in nearby postal facilities.

7. The Costs of a Curfew to the Banking System

Metropolitan Chicago banks depend on night flights, scheduled mail operations, and non-scheduled aircraft to carry Federal Reserve checks. Drafts, receivables, and deposits are all transported at night and depend upon timely movement to make funds available for reinvestment. A curfew would affect the banking community's lock box and cash letter activities.

Chicago banks serve as a concentration point for accounts receivable payments for many large corporate customers through lock box operations. Lock box activities are handled through the airmail facilities and collected by the bank. The bank processes incoming remittances, prepares deposits to customer accounts and forwards the checks for collection. Lock box units operate 24 hours daily, 7 days a week. The banks promise immediate availability of funds, and therefore depend upon nighttime activity. Without the advantages of O'Hare's complete, 24 hour air transportation schedule, much of the lock box activity could be diverted to other financial centers in the country.

Cash letters are one bank's check deposits with another bank. Incoming cash letters are checks drawn on Chicago banks, deposited at other banks around the country, and delivered to Chicago for payment. In 1979-1980, $2.5 billion or 54 percent of the daily incoming cash letters were received at banks between 10:00 p.m. and 7:00 a.m. Outgoing cash letters are checks deposited at Chicago banks which must be processed, sorted, and forwarded

to other parts of the country. Chicago banks must operate within the constraints of the national check-clearing system. Sending times are the result of time constraints established to allow prompt processing by receiving banks throughout the country. The availability of nighttime service at O'Hare has helped Chicago financial institutions to grow and remain competitive as a financial center of the United States.

Closing O'Hare between 10:00 p.m. and 7:00 a.m. would delay the availability of funds to bank customers. For example, a curfew would cause the Federal Reserve to change the deadlines for incoming work from the commercial banks. If a 10:00 p.m. curfew were imposed, the Federal Reserve's 8:30 p.m. deadline for consolidated check shipments would have to be advanced to 4:30 p.m., seriously interfering with customer service. Late deposits from commercial banks would be delayed one day leading to a loss of availability of funds. (If the Federal Funds rate is 18 percent, loss of the ability to invest $1 million for one night or one business day costs $720.) Chicago area bankers project that the end result of a curfew could be that Chicago corporations would move their depository accounts to another financial center to maintain early access to their funds.[1]

8. The Effects upon International Flights

As of March 10, 1980, other than all-cargo flights most international operations arrive and depart outside of the proposed 10:00 p.m. to 7:00 a.m. curfew hours. Nonetheless, these long haul flights might occasionally be delayed as the result of such things as the wind and flight distances involved, government clearances, and air traffic control slowdowns. A delay in scheduled arrival times could result in violation of a curfew or diversion

[1]This discussion is based on testimony from the Chicago Clearing House Association, March 25, 1980.

to another airport. But diverting international flights is difficult because of customs and port of entry immigration requirements and the problems that might arise if a noncurfew hour departure is delayed until after 10:00 p.m. To require that the departure be made only after 7:00 a.m. the next day could impose a large burden for the airlines and their passengers.[1]

9. Concluding Remarks on a Curfew

The burdens and difficulties a night curfew would impose, as described above, indicate the benefits foregone from such action. It is the worth of these foregone benefits that, in turn, represent the costs of a curfew. An appropriate measure of these foregone benefits would be the willingness of the users of night services to pay (over and above what they presently pay) to retain them. Unfortunately, we lack information on user willingness to pay. While we are able to describe the benefits in question in a general way and indicate their nature and importance, we are not able to provide a measure of their value.

A helpful approach in this kind of situation is to look at the other side of the cost-benefit picture and consider the benefits that would accrue to households near the airport from a curfew-associated noise reduction. Suppose the magnitude of these benefits could be acceptably estimated. We might then ask, how great are the aggregate daily benefits (to households) generated by the curfew? Relatedly we might ask, how great are the benefits generated per operation eliminated? Given our general and specific knowledge of the functions performed and needs served by night flights, the answers to these questions may help us to assess the relative gains and losses from a curfew. Such a procedure is followed in Section III-C-4 below.

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[1] Testimony by Richard Shaw, p. 4406.

H. Operations Cuts as a Means of Noise Reduction

1. Introduction

An obvious way to reduce aircraft noise impacts on residential properties is a reduction in the number of overflights. In considering this approach, it is desirable at the outset to distinguish between two situations:

1. Reducing the number of flights over certain properties by shifting takeoff and landing runways or altering flight paths, leaving the total number of operations unchanged.

2. Reducing the total number of operations at the airport.

At airports where the surrounding area is heavily built up, there is but limited opportunity for use of the first method, since noise is not on balance reduced but merely displaced to other residential locations. This is the case at O'Hare and Midway Airports. Apart from such special procedures as O'Hare already is employing, and the special nighttime procedures considered earlier, there appears to be little scope or prospective advantage from runway shifts or flight path changes.

In considering overall operations cuts as a quieting method, it is useful to keep in mind the role of air travel in meeting public needs. At its inception air service, like rail service in an earlier era, represented an innovation in transportation. Over subsequent years, it evolved, improved and expanded, as it came to capture important segments of the transportation market. Like other innovations, it served to fulfill heretofore unfilled needs, to augment productivity and, for many users, to reduce costs. Like many other worthy economic activities, it also has as a byproduct generated a so-called externality, in this instance in the form of unwanted noise.

Operations cuts would serve to reverse the innovation process that has

taken place. Such cuts, undertaken to mitigate the externality, would withdraw from some number of users the benefits they have enjoyed through ready access to air transportation. It is this withdrawal of benefits that constitutes the cost of operations cuts. A curfew, treated in the previous section, represents a special form of operations cuts, and the kinds of costs associated with a curfew are in considerable degree indicative of the sorts of costs that further daytime operations cuts would involve. This section should thus be understood as an extension of the preceding discussion.

2. The Scale of Operations Cuts

O'Hare Airport will remain in violation of the proposed noise guidelines after a 10:00 p.m. to 7:00 a.m. curfew. Table II-20 taken from Hearings testimony presented by the City of Chicago, lists the 1979 activity levels and the daily reductions, both nighttime and daytime, that would have been necessary to comply with the 80 L_{dn} level (i.e., a level of reductions such that no Class A land would have been exposed to noise levels exceeding 80 L_{dn}).

As the table shows, overall cutbacks of around 46% would have been needed. This is not surprising in view of energy level-noise level relationships. A full 43 percent of daily domestic scheduled activity, 33 percent during the daytime alone, must be eliminated to achieve 80 L_{dn} or below on Class A land. International flights would, according to the scenario shown in the table, have been cut by between 45 and 50 percent overall, again the largest fraction coming as a result of daytime cuts. All-cargo and military flights would have been completely eliminated while the shorter-haul commuter, air taxi, and general aviation activities would have faced overall cuts of about 45 percent of their 1979 levels.

Parenthetically, it is useful to note that while the quantities of

Table II-20

Daily Operation Reductions at O'Hare in 1979

	Original Schedule[1]	Curfew Reductions[2]	Daytime Reductions[4]	Reduced Schedule	Percent Decrease
Domestic Scheduled	1,645	164.5	543.5(33)	937	43%
Domestic Nonscheduled	2	0	0	2	0
International Scheduled	78	7.8	28.2(36.2)	42	46
International Nonscheduled	4	0.4	1.6(40)	2	50
Commuter	300	30	105(35)	165	45
Air Taxi	58	5.8	20.2(34.8)	32	45
All-Cargo	98	98[3]	0	0	100
Military	10	1	9(90)	0	100
General Aviation	168	16.8	59.2(35.2)	92	45
Total	2,363	324.3	766.7(32.5)	1,272	46

Source: Exhibit 26, City of Chicago Testimony.

[1]The original schedule is Master Plan, Alternative 2.

[2]Assume a curfew reduces total activity levels by 10 percent.

[3]Assume that the entire body of all-cargo flights operate at night.

[4]The numbers in parentheses are the percent decrease in total activity levels due to daytime cutbacks.

eliminations listed above seem large, achieving 65 L_{dn} or below on all Class A land would call for much more severe cutbacks. It would have been necessary to eliminate in the neighborhood of 95 percent of the 1979 daily activity at O'Hare to comply with a 65 L_{dn} noise guideline.

3. The Effects of Eliminating Daytime Flights

Aircraft flights occur when they are mutually beneficial to the public and the airlines. The Director of Schedule Planning and Analysis for United Airlines in Chicago testified before the Illinois Pollution Control Board that

> . . . to a large degree every airline schedule represents the satisfaction of a public transportation need that is unique in terms of point-to-point service, time of day, and other factors and that need will not be satisfied by other airline schedules if it is cancelled.[1]

The prevailing degree of service can be taken to be warranted by market conditions and to represent a variety of net social benefits exclusive of any environmental externalities. The costs of cutting flights, then, would be the loss or decrease of the benefits of air transportation. In the logical sequence of noise quieting measures, a curfew would most likely occur first.[2] Thus, the effect of daytime operations cuts would be to further intensify the effects of a curfew which have been discussed in detail above.

One of the greatest economic values of an airport obviously lies in the transportation services it provides. Air transportation facilitates

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[1] Illinois Pollution Control Board, Public Hearing in the Matter of Airport Noise Regulations R77-4, December 5, 1979, p. 4004.

[2] Recall people's increased sensitivity to noise at night and the nighttime weighting factor of 10 in the L_{dn} equation.

business and personal travel and can lead to significant time and cost savings. The availability of air travel is a productive addition to the community. The degree of daytime reductions listed in Table II-20 would obviously impair the quality of transportation service currently available at O'Hare. A notable effect of cancelling flights to and from O'Hare would be to make it more difficult for passengers to get connecting flights. Since one of O'Hare's main functions is to act as a transportation hub and to provide a large bank of connections, the effectiveness of air service at O'Hare would be compromised by cutbacks. In addition, because of the way airline routings are put together, service cuts would have a multiplicative effect. Loss of service would not be confined to the city that cancels the flight. It can also extend to other downline cities which are not directly affected by service to and from the city which cancelled the flight. To illustrate, suppose a flight originates in City A and lands in several other cities before traveling to City B where a large bank of connecting flights is available. If the aircraft could no longer operate out of City B, it would lead not only to the loss of connecting opportunities for that city's passengers but to a similar loss for other cities.

Another effect of daytime cutbacks would be to further decrease available air cargo capacity. A curfew could be expected to remove half or more of the all-cargo flights currently available. Daytime cutbacks would further intensify the situation by the possible removal of the remaining all-cargo flights and the reduction of cargo-carrying passenger flights. Such changes would cause disruptions for the users of air cargo and their extensions - the freight forwarder. Over the long term, adjustments would be made by carriers and users, as new transportation patterns emerged. But the withdrawal of a substantial portion of O'Hare's cargo service could only bring

reduced efficiency and higher costs.

Daytime cutbacks would intensify the curfew effects upon mail transportation and the check-clearing process by making it still more difficult to maintain timely, next day delivery of mail. According to the U. S. Postal Service, in 1977 mail was transported on over 1,680 flights daily. Approximately 585,000 pounds of mail moved through O'Hare each day, Tuesday through Saturday. Over 1,490 of these flights, with 359,000 pounds of mail arrive and depart between 7:00 a.m. and 10:00 p.m. The volumes of mail for Sunday are 50 percent above and those for Monday are 75 percent above these figures. Even though U. S. mail has priority over all cargo for air shipment, the cutback levels estimated above are bound to compromise and disrupt the current levels of efficiency and service.

In general, carriers would tend to cancel those flights which were the least advantageous economically. These often involve the shorter-haul markets that use smaller aircraft and have higher costs and lower profits for each arrival and departure than the long-haul flights.[1] Eliminating those flights could change such things as airline staffing, aircraft activity, and passenger and cargo flows. Costs might increase if additional personnel must be hired to handle any peaking and passenger congestion on the remaining flights, while at the same time general passenger inconvenience might lead to an overall loss of demand as passengers seek new forms of transportation.

Despite the potential costs which cancelling daytime services poses for the air carriers, passengers and shippers, it also might create certain offsets that, in some measure, would cushion the increase in costs caused by a disruption of current activity. Passengers shifting to the remaining flights would tend to increase load factors, reducing the per passenger-mile costs.

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[1]Testimony before Illinois Pollution Control Board, p. 4055.

In addition, of course, overall operating costs could be expected to fall as the total number of flights provided decreased.

Both daytime operation cuts and a curfew could be expected to induce economic repercussions throughout the Chicago metropolitan area. The possible magnitude of these impacts is outlined in the next section.

I. Indirect and Induced Effects of a Curfew and Operations Cutbacks

In addition to the direct effects described above, a curfew and operations cutbacks would lead to both indirect and induced effects throughout the Chicago Metropolitan area. The literature contains differing definitions for the terms "direct", "indirect", and "induced". Typical of several studies is the Los Angeles International Airport study[1] in which "direct" refers to effects on airport industry employment or payroll, "indirect" refers to air visitor industry and travel agency employment effects, and "induced" employment effects refer to those employment changes that occur in the wholesale and retail services, real estate, finance, insurance, and other local population-serving employment categories. "Induced" dollar effects, in turn, are those multiplicative changes that occur in an economy as a result of changes in the airport and air visitor industries' payroll, capital investment, local purchases of goods and services, and air visitor expenditures.

Landrum and Brown's use of the three terms differs somewhat from that in the Los Angeles study. "Direct" employment (or payrolls) relate to on-airport employment and any immediate extensions, such as travel agents in the city. "Indirect" employment related to (the pro-rata share of) employment by the suppliers of goods and services to airport tenants and to employment in establishments, such as hotels and restaurants, directly serving air travelers. "Induced" employment denotes the additional employment arising through the familiar multiplier process and resulting from expenditures by employees in the first two categories. The same three terms, with variant but consistent definitions, are used for the category, "Expenditures, Airport-Related", and the first and third are used for the category, "Air Traveler".[2]

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[1] Waldo and Edwards, The Economic Impact of Los Angeles International Airport on its Market Area, August 1976, p. 61.

[2] Information provided in communication to the authors from Landrum and Brown.

The Boston-Logan Study uses a somewhat different approach.[1] "Direct" effects are those effects which occur between 6 months and a year after the initiation of quieting measures. "Indirect" effects are those effects borne by airlines and shippers more than a year later. They are of uncertain magnitude until the airlines and businesses determine how quieting measures have affected their short run competitive position.

In 1977, there were approximately 24,700 direct employees at O'Hare. Such on-airport employment represented about 0.7% of total Chicago SMSA employment. Total payroll was over $513 million.[2] Expenditures for materials and equipment, support services, and capital improvements by O'Hare tenants (including government) totaled more than $392 million.[3] By 1979, employment had grown to 27,300 and the payroll was over $536 million.[4]

A curfew and operations cutbacks would, as noted above, significantly change the current activity levels at O'Hare. These changes would lead to decreases in direct employment, payrolls, and expenditures for local goods and services by airport tenants, resulting, ultimately, in a variety of indirect and induced changes throughout the Chicago area economy. Multipliers are generally used to measure the effects of such changes. At O'Hare, for example, each job lost as a result of the quieting measures might be expected to result in the loss of an additional 1.5 indirect and/or induced jobs throughout the Chicago area. Similarly, the direct payroll decrease

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[1] Massachusetts Port Authority, The Effects of Limiting Night Flights at Logan Airport, August 1976, p. 12-14.

[2] Landrum and Brown, Airport Master Plan Study, Economic Impact Study, v. 8, October 1979, p. 5.

[3] Landrum and Brown, Airport Master Plan Study, Economic Impact Study, v. 8, October, 1979, p. 8.

[4] Testimony by Jeffrey N. Thomas, City of Chicago, June 16 and 17, 1980.

could decrease income throughout the Chicago area by between 1.5 and 2 times the drop at O'Hare. Expenditures for local goods and services in the Chicago area may decrease by 1.25 to 1.3 times the O'Hare expenditure decrease.[1]

Landrum and Brown, using its categories and terminology as described above, estimated O'Hare Airport's 1979 economic impact at both the 100% activity level and at the reduced, or 55% level needed to meet an 80 L_{dn} limit.[2] The results are shown below in Table II-21. The table suggests a direct employment decrease of over 11,600 people, with a decrease in direct payroll of almost $220 million. This in turn leads to induced and indirect effects on employment and payroll in the Chicago area of, respectively, more than 35,168 and $345 million. The decrease in direct airport related expenditures of over $194 million would cause an indirect and induced decrease of $538.3 million dollars.

In addition to the effects resulting directly from changes at O'Hare, the proposed noise measures would reduce the number of air visitors to Chicago. The resulting decrease in air visitor expenditures might be expected to result in an additional induced change in expenditures of perhaps 1.5.[3] Referring again to the illustration in Table II-21, the City of Chicago's 1979 data suggest that a direct decrease in air traveler expenditures of $289 million would lead to an associated induced further decrease of $433.5 million.

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[1]The multipliers used here are taken from Waldo and Edwards, Inc., The Economic Impact of Los Angeles International Airport on its Market Area, August 1976, p. 60-61, and Urban Systems Research and Engineering, Inc., for the Federal Aviation Administration, The Chicago Midway Airport Study: Final Report, Washington, 1974.

[2]See Exhibit 25 in its hearings testimony for the City of Chicago and p. 5943-44 of the transcript. The airport activity level for this scenario is about 17% higher than that used in Table II-2 for our base or reference case.

[3]Waldo and Edwards, Inc., op. cit., p. 60-61, and Urban Systems and Research Group, Inc., op. cit.

Table II-21

The 1979 Economic Impact of O'Hare Airport

Type of Impact	Impact with 100% activity	Impact Reduction as the Result of Curfew & Cutbacks	Impact with 55 percent Activity
Employment			
Direct	27,316	11,685	15,631
Indirect	21,435	6,961	14,474
Induced	75,652	28,207	47,445
Total	124,403	48,653	77,550
Payroll			
Direct	$536,600,000	$219,850,000	$316,750,000
Indirect	165,060,000	54,500,000	110,560,000
Induced	753,710,000	290,630,000	463,080,000
Total	$1,455,370,000	$564,980,000	$890,390,000
Expenditures			
Direct	$446,180,000	$194,210,000	$251,970,000
Indirect	412,060,000	131,350,000	280,710,000
Induced	1,072,800,000	406,950,000	665,850,000
Total	$1,931,040,000	$732,510,000	$1,198,530,000
Air Traveler Expenditures			
Direct	$916,920,000	$289,020,000	$627,900,000
Induced	1,375,380,000	433,530,000	941,850,000
Total	$2,292,300,000	$722,550,000	$1,569,750,000
TOTAL	$5,678,710,000	$2,020,040,000	$3,658,670,000

Source: Exhibit 25, City of Chicago Testimony before the Pollution Control Board, June 16 through 18, 1980.

The Boston-Logan study, with its somewhat different definitions of "direct" and "indirect" effects, also provides somewhat different multipliers. It suggests that a multiplier of 1.875 for employment and 1.775 for payroll could be applied to the direct and indirect effects of quieting methods to estimate the potential ripple effects of such changes.[1]

[1] Massachusetts Port Authority, op. cit., p. 125-126.

J. Other Abatement Approaches

Besides the major abatement approaches discussed above, a few others deserve note. Certain of them are simply variant forms of curfews and operations reductions.

One approach is illustrated by actions at Heathrow and Gatwick Airports near London establishing nighttime quotas on jet aircraft movements. There are separate quotas for "quieter" and "noisier" aircraft, with the size of the quotas varying as between winter months and summer months.[1] The government's indicated intention is to progressively reduce over time the quota on noisy aircraft while increasing the quota for quiet ones. A second approach would limit the overall number of operations, or capacity, of an airport. The airport at Osaka, Japan, for example, restricts jet operations to 200 per day. Efforts also are being made at Heathrow to contain the number of operations.[2] A third approach, employed at the Nice and Le Bourget Airports, prohibits takeoffs but not landings, during nighttime hours.[3] Under a fourth approach, the noisier types of jet aircraft would be subject to restrictions on permissible hours of operations, limited in number of operations, or prohibited entirely from operating. The Swiss, for example, have decided that after December 31, 1984 non-Annex 16 (ICAO) planes will not be accepted at their airports.[4] A fifth approach involves the imposition on aircraft of a

[1] Spencer, Frank A., Transport Jet Aircraft Noise Abatement in Foreign Countries: Growth, Structure, Impact, V. I. Europe, July 1980, NASA CR 152,356, pp. 56-59.

[2] Ibid., v. II, The Pacific Basin, p. 133 and V. I, pp. 59-60.

[3] Ibid., v. I, p. 80.

[4] Ibid., v. I, p. 80.

noise-related landing charge. A number of countries - the United Kingdom, Switzerland, Germany, Holland and Japan - are either considering or have imposed such a charge at one or more of their airports.

The effects of these various constraints, if one or more of them were imposed in O'Hare's unique setting, would depend on the severity with which they were applied. Night quotas, if set significantly below the level of current operations, become simply a form of curfew, with cost implications that already have been discussed. If set modestly below or proximate to current levels, they become a means primarily of containing the future growth of noise. The costs of this approach and the benefits lie also in the future. The costs are in the form of the foregone advantages that larger numbers of flights, if allowed, would bring - advantages of the kinds generally associated with expansion and growth, as earlier described. The benefits take the form of avoiding the increment in noise, and the noise-associated burdens, that would come with such growth. Quotas would place pressure on aircraft operations, as they contemplated future opportunities, to favor the more productive and more profitable flights over the less productive and marginal ones. If the quota provisions allowed for tradeoffs between noisy and quiet aircraft, with the goal of keeping total noise energy constant, operators would also have added incentive to phase out noisier planes in favor of quieter ones.

Like night quotas, a limit on overall operations, if set below current levels, would be equivalent to operations cuts, as already discussed. If set proximate to current levels, it becomes a means of dealing with future noise growth, and considerations like those in the preceding paragraph apply. The question of future noise levels and their containment is clearly an important one, since O'Hare's operations are projected to grow significantly

over the coming 10 to 15 years. The Technical Study indicates that under Chicago Master Plan projections, there would be about a 35% growth in operations by 1995, as compared to 1978, with the L_{dn} contours increasing by about 1 1/3 dB. Accompanying this growth would be an increase in the residential acreage over 65 L_{dn} from 7000 to 12,300, a rise of 75%.[1]

Restrictions on the older, noisier aircraft, such as the 707's, 727's and DC-8's, would, contingent on the dates set for implementation, hasten the elimination of those planes from the fleet. As a practical matter, however, this would not appear to be a promising approach. The noisier aircraft are already scheduled for retrofit to meet FAR Part 36 requirements and for replacement with quieter aircraft by 1985.[2] Hence little opportunity exists for accelerating schedules. The effort to do so would likely create expensive dilemmas for carriers, who are constrained by their forward commitments and by the lead times required to modify or replace equipment.

Noise-related landing charges represent, from an economic vantage point, an appropriate and constructive approach to the aircraft noise problem. Negative environmental impacts, including those from aircraft noise, can be thought of as situations entailing the use of a resource, such as clean water or quiet air, for which proper payment is not made. A charge, scaled to the damage caused, would remedy this deficiency. In the context of aircraft noise, this might mean a levy on each aircraft via, say, a landing charge, related to its contribution of noise energy to overall noise energy levels. The resulting revenues might be used by the airport authority for purposes relating to noise abatement, such as runway extensions, purchase of close-in residential

[1] See the Technical Study, Figures 4-4 and 4-6, and Table 4-3.

[2] Technical Study, pp. 30-31.

properties, or insulation of residences. Or the revenues might be paid directly to affected property owners, who might then use them to cover the costs of insulating their dwellings or, should they prefer to move, to defray their relocation expenses, or in any other manner they wished. If in fact the charges on aircraft, and the resulting payments to homeowners, accurately reflected noise damages, this approach would, in economic terms, constitute a "complete" solution to the problem.

Under the terms of Illinois' Environmental Protection Act, the Pollution Control Board lacks authority to impose a noise tax or charge. However, airport authorities are able to set landing charges and presumably could include a component related to aircraft noise. An advantage in principle of an externality charge or tax, in this case a noise tax, is that it gives incentive to the emitter to abate his emissions. In the present case, though, it is not clear that the incentive effect would be large, since the size of any plausible set of charges tends to be modest or small relative to aircraft operating costs. In the absence of such incentive, the approach would not contribute to a reduction in overall noise levels. As a matter of political reality, environmental taxes or charges have not won much favor and, to date, have not been much used. However, current and pending actions at airports abroad - in Switzerland, Holland, Germany and Japan - suggest some interest in charges as an approach to the aircraft noise problem.[1]

None of the foregoing approaches, or combination of them, unless applied in a way that would make it the equivalent of large operations cuts, gives promise of reducing the noise level to the 65 L_{dn} proposed in the regulation.

[1] Organization for Economic Cooperation and Development, Pollution Charges in Practice, Paris, 1980, pp. 94-97. An alternative to a charge would be a partial rebate of normal airport charges, or landing fees, for quieter aircraft. Examples of this approach are found in Germany and the United Kingdom.

The attainment of even 80 L_{dn} at the nearest residential property is unlikely.

K. Some Additional Impacts

Among the indirect impacts of potential interest are those on Illinois governments, on Illinois agriculture, and on energy consumption in the state. These impacts are briefly discussed in the few paragraphs below. In each case, the possible impact varies with the abatement method considered. Certain methods have little or no effect, while others have perceptible consequences.

Three abatement options - property acquisition, curfews, and operations cuts - could be expected to produce impacts on local governments. Property acquisition would remove dwellings from the property tax roles and thereby reduce the revenues available to support local services. Data presented at the Hearings by Landrum and Brown[1] indicate that 2320 homes would have to be removed under an acquisition program in order to meet Landrum and Brown's estimated 80 L_{dn} contour. The elimination of these homes would reduce both municipal and school district revenues. Landrum and Brown estimate that the affected communities would experience a loss in aggregate revenues of about $250,000 or 1.2%, while the affected school districts would lose about $1.5 million, or 1.6% of their total funds. There would, however, be offsets. Some of the displaced households might relocate within their communities, inducing the addition of new properties to the tax rolls. In addition, as Landrum and Brown have noted,[2] households leaving the area would reduce the demand for services, so reducing revenue needs, and some of the vacated land might be redeveloped for business uses. But there can be no presumption that

[1] See Exhibits 20-22 and 55-57 in the Exhibit Book submitted by the City of Chicago in its testimony of June 16-20, 1980. Also see pp. 5936-39 and pp. 5995-6000 of the Hearings transcript.

[2] Hearings testimony, pp. 5939-41.

these latter factors would be fully offsetting, at least in the short run. It takes time for redevelopment to occur. It takes time also for schools to adjust their services and costs to enrollment changes, and it may not be possible, even in the long term, to reduce costs proportionately with the decline in service demand.

Operations cuts and a curfew would exert effects on local governments indirectly through such impacts as they might have on employment, incomes and expenditures in the communities serving and depedent upon O'Hare. Any expenditure decline would reduce sales tax revenues, a portion of which goes to local governments through the 1.0% addition to the state levy. Expenditure effects would arise from job losses among those serving the transportation industry, from reduced outlays by travelers, and from the secondary or follow-on impacts of both of these factors. Property values would tend to benefit from the improved noise climate, taken by itself. But these same property values would also be subject to the depressing effects of reduced employment and incomes. Again, the short and intermediate term effects would be more serious than those of the long term, since with time unemployed resources would relocate to other productive activity.

Chicago area communities generally could expect adverse impacts from the reduced demand by travelers for services. If operations cuts were large, the City of Chicago could face a decline in its role as a convention and tourist center, with repercussions for service and other businesses.

Some of these same effects would be felt by the state government, though with diminished strength. Reduced incomes and expenditures by those directly or indirectly dependent on O'Hare Airport and air transportation would be reflected in declines in both sales and income tax revenues. Also, any job losses among those serving the air transport sector would contribute to an

increase in state outlays for various other income-support arrangements.

The magnitude of these several effects is speculative, since they depend on the scale of operations cuts, on the rapidity with which displaced workers are re-employed, on the manner and form in which displaced air passengers work out substitute travel arrangements, on the extent to which operations discontinued at O'Hare might over time be shifted to other Illinois airports, and on the size of the various secondary impacts that occur.

None of the abatement options appear to carry a significant potential for adverse impacts on Illinois agriculture. Agriculture would, along with other sectors, share in the effects of any general weakening of the Illinois economy, such as large operations cuts would tend to produce. But there do not appear to be any special implications for Illinois agriculture. There might on occasion be situations in which the transport of parts and personnel for emergency service to agricultural equipment was slowed. But such situations would be localized and infrequent.

With respect to energy consumption, the savings arising as a byproduct of the noise insulation of dwellings has already been mentioned. These savings (from reduced use of fuel for heating and cooling), while significant for the affected dwellings, would be of minor significance in the state's energy picture, both because of the limited number of households involved relative to the 4.5 million or so in the state, and because household energy consumption represents only a portion of total energy consumption. Of the other abatement methods, only operations cuts (including curfews) could be expected to have a perceptible impact on energy consumption. Aircraft are intensive users of fuel, as compared with other transportation vehicles. A reduction in flights, even with the users shifting to other forms of transportation, thus would result in net fuel savings. Yet taken over the entire

state, and measured against statewide energy consumption, the savings that might result from, say a 20% to 30% reduction in O'Hare's activity would be modest for two reasons. First, aviation fuel consumption comprises less than 2% of total energy consumption.[1] Second, O'Hare's operations, while far more numerous than those of any other airport in the state, still represent but a portion of all jet operations and of all aviation activity in the state. Within the context of impact assessment it is useful to remember that energy represents but one of many inputs in the production of transportation service, and its consumption, taken alone, does not provide a sufficient criterion for policy decisions.[2]

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[1] The transportation sector, including aviation, represents 25% of total energy consumption, and civil aviation takes about 8% of the fuel used in that sector. See the 1979 Statistical Abstract of the United States, Tables 1013, 1017 and 1137.

[2] The observations in this section refer to O'Hare airport. With due allowance for differences in the nature and scale of operations between O'Hare and Midway and in land use configurations, they also would apply to the latter airport. Since Midway's activity rate is but one-third or so of O'Hare's, with most flights in the general aviation rather than air carrier category, one would rightly expect smaller impacts on local and state governments, on agriculture, and on energy consumption from the various abatement strategies.

L. Enforcement Costs

Three entities, or groups, will incur costs in the administration and enforcement of the proposed regulation: the airport authority, the Illinois EPA and the Illinois PCB. The largest share of these costs will be borne by the airport authority in responding to the reporting requirements of the regulation and the conditions for obtaining variances. More modest costs will be carried by the IEPA in reviewing and evaluating airport data, possibly in making some on-site noise measurements and in participating at variance proceedings. Comparatively nominal costs will be faced by the PCB in conducting hearings for variances and rendering decisions. Unfortunately, considerable error ranges attach to the specific estimates of these several cost elements, particularly those to be carried by airport proprietors, because of uncertainties as to how the regulation may be interpreted and applied.

Under Rule 504 of the regulation, each airport proprietor must maintain a record of daytime arrivals and departures and nighttime arrivals and departures, of all jet aircraft, classified by type (e.g. DC-9, Boeing 727, etc.). The record must indicate the runway used and, for each departure, the length of flight (in 500 mile increments). The record must further be submitted to the IEPA on a monthly basis. These kinds of information are already a part of O'Hare Airport's record-keeping system, and with modest additional effort could be made available in the form sought by the regulation.

In the absence of drastic operations cuts, the airport will require and presumably seek a variance from the 65 L_{dn} limit. Rule 505 specifies the kinds of information and analysis that an application for a variance must contain. Broadly, the application must provide: (1) a map of the land area impacted by aircraft noise in excess of the prescribed limits, an indication of existing land uses and zoning classifications, and estimates of the number

of persons presently occupying Class A land and the number who would occupy presently vacant land if it were developed for Class A uses; and (2) a plan to control the noise impact of the airport, including an analysis of some 16 specific abatement methods. Consideration of each of the options "must include estimates of the reduction in land area and population presently impacted by airport noise in excess of the limits . . . and its costs or effects on the service provided by the airport."[1]

It is further provided that a variance request must show the following:

> (2) That the proprietor of the airport has incorporated in the plan, to the maximum extent feasible, each of the noise abatement options designated (a) through (j) above which would reduce the noise impact of the airport.
>
> (3) That the proprietor of the airport has made good faith efforts to induce the Federal Aviation Administration to implement each of the noise abatement options designated (k) through (n) above which would reduce the noise impact of the airport.
>
> (4) That the proprietor of the airport has made good faith efforts to induce the appropriate land use control authorities to implement the noise abatement options designated (o) and (p) above which would reduce the noise impact of the airport.
>
> C. The effect of the proposed plan on reducing noise impact in the surrounding community for time frames of two (2), five (5), and ten (10) years from the date of submission, given reasonable assumptions concerning the future operations at the airport and projected population changes in the community.
>
> D. Options available to local and State authorities to preserve, or bring about, land use which is compatible with the airport.
>
> E. A schedule for implementation of the proposed noise abatement plan.

Unfortunately, it is not clear how stringently these provisions would be adhered to or what level of analysis of each of the several options and requirements would be deemed sufficient by the PCB.

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[1] See "Proposed Airport Noise Regulations", as submitted to the PCB, dated June 12, 1978.

To perform a detailed and exacting assessment of every option would entail a study of major proportions, including the generation of noise contours in many variations and extensive land use analyses.

For purposes of estimation here, it will be assumed that the L_{dn} contours generated by the airport as a part of its masterplanning process, and presumably slated for periodic updating, will serve for the purpose of variance requests.[1] It will be further assumed that the airport will wish to install a fixed noise monitoring system to assist in meeting a range of compliance needs - providing data for use in variance requests, in planning and evaluating abatement strategies, and to assist with public relations. The Technical Study suggests (p. 161) that such a system would carry an initial cost of $250,000 and would require 2-3 full-time persons to maintain and operate. Estimating the cost of a man-year for this purpose at $20,000, the annual personnel costs would be about $50,000. To this let us add one additional full-time professional to oversee the noise abatement program and carry responsibility for the preparation of variance requests. The cost for such a person might run $25,000 per year.

The costs to be borne by the IEPA like those to airport proprietors, also are somewhat problematic. They depend upon the Agency's efforts in reviewing and evaluating the monthly reports filed by the airport, the extent to which it might consult with airport personnel on their noise problems and undertake any noise monitoring of its own, and the degree to which it might feel it necessary to prepare materials in response to variance requests. The equivalent of perhaps one-half of a professional person per year might be needed for these tasks. The annual cost would thus be $10,000.

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[1] Noise contours are required by the FAA as a part of the environmental assessment.

The costs to the Pollution Control Board might involve roughly three days of hearings for each variance request, or an average of one day per year, with three of the Board's staff in attendance, an additional two to three days for a staff member to summarize and assess the hearings testimony and submissions, and some further amount of time for each Board member to review the case and reach a decision. In addition, participation in a hearing would involve perhaps two or three persons each for the airport and the EPA. In all, a dozen man-days per year might be required at, say $150 per day. Allowing for travel and related expenses, the cost per year would be around $2,500. Costly litigation beyond the variance stage is possible in some cases. These contingent costs are here ignored.

Enforcement costs may therefore be summarized as follows:

Monitoring system, initial outlay	$250,000
Personnel for monitoring system, per year	50,000
Airport noise program supervisor, per year	25,000
IEPA costs (excluding hearings), per year	10,000
PCB and hearings costs, per year	2,500

Of the foregoing five entries, the last four are on an annual basis, whereas most other cost (and benefit) estimates in this study represent capitalized sums. In lieu of formally capitalizing these costs at some specified discount rate over some specified number of years, we might simply note their 5-year and 10-year totals. The respective combined sums for the four items in question are $437,500 and $875,000. Adding to these figures the one-time outlay of $250,000 gives respective 5-year and 10-year totals of $687,500 and $1,125,000.

Enforcement costs associated with Midway Airport would augment these totals somewhat. Because both Midway and O'Hare are operating under the same

management, there may be certain scale-like economies for the proprietor in responding to the needs of the regulation. There may also be some economies for the IEPA in utilizing its enforcement personnel. But again, estimates are unavoidably quite speculative. Let us assume, as with O'Hare, that needed noise contours and related data are generated as a part of the master planning process. Let us assume further that a monitoring system is neither needed nor installed. Because Midway's traffic is considerably lower than O'Hare's and its operations considerably less complex, let us additionally and somewhat arbitrarily make the following estimates for the remaining cost categories cited above: PCB and hearings costs, two-thirds those of O'Hare, or $1668 per year; airport noise program supervisor (part-time), one-third those of O'Hare, or $8332 per year; and IEPA costs, one-third those of O'Hare, or $3333 per year. The sum of these costs is $13,333 per year. The five year total is $66,665 and the ten-year total is $133,330. The respective five- and ten-year combined totals for both airports would thus be $754,200 and $1,258,300.

III. THE BENEFITS FROM REDUCING AIRCRAFT NOISE AT O'HARE AIRPORT

A. Ways of Evaluating Benefits

There are two basic methods by which to assess damages caused by noise or, alternatively, benefits that would accrue from its abatement. One approach describes only the physical and related effects of the noise, such as interference with speech and sleep, annoyance, and hearing loss. The second assigns dollar values to noise damages (abatement benefits) by estimating property value losses and personal injury damages attributable to the noise. Both approaches are pursued below.

B. The Physical and Related Effects of Noise

1. Introduction

The range of physical effects associated with noise exposure were reviewed in the analysis of downstate airports. (See Volume II, Section III-B). That discussion is applicable here also, but two distinguishing circumstances should be noted. First, the number of affected households is far greater at airports like O'Hare and Midway. Second, the dwellings subject to more than 75 L_{dn}, where the more severe effects occur, are far more numerous at the Chicago airports. Whereas there were but four such dwellings at all of the downstate airports, there are approximately five thousand of them at O'Hare and two thousand at Midway. It must be expected, therefore, that the physical effects under consideration will, in an overall sense, be more pronounced than they were found to be at the smaller downstate airports. Hearing loss is the health effect most often associated with noise. In addition, high levels of noise cause sleep and speech interference, annoyance, stress, changes in the cardiovascular system, blurred vision, colitis,

migraine headaches, and can aggravate existing physical and mental health problems. While the literature dealing with the medical effects of noise generated specifically by aircraft is limited,[1] each of the major effects listed above will be discussed below.

2. Hearing Loss

As stated above, hearing loss is the health effect most often associated with high levels of noise. Excessive exposure to sound damages the auditory mechanism of the inner ear. The degree of nonregenerative hearing loss depends upon the amount of damage. The injuries can range from mild distortion to complete deafness.

The effects of noise on hearing may be temporary in nature, or they may be permanent. The ear is capable of recovering from temporary but not permanent changes in hearing sensitivity. Permanent threshold shifts occur after many years of repeated, near-daily exposures to excessive noise. As daily exposure continues year after year, the ear loses its ability to recover from temporary threshold shifts and the temporary shift becomes permanent.

Much research has been done to measure the hearing changes brought about by noise exposure. The results of this work are not uniformly

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[1] Papers from the Workshop in Medical Effects of Environmental Noise, Gothenburg, Sweden, 1977, published in Journal of Sound and Vibration, Academic Press, New York, v. 59, No. 1, p. 59-143; Miller, James D., "Effects of Noise on People," Journal of the Acoustical Society of America, v. 56, No. 3, September, 1974, p. 729 ff; U.S.E.P.A. Public Health and Welfare Criteria for Noise, Washington, D. C., July 1978; K. E. Nelson and T. D. Wolsko, Transportation Noise: Impacts and Analysis Techniques, Argonne National Laboratory, Energy and Environmental Studies Division, prepared for Illinois Institute for Environmental Quality, October, 1973, p. 13, 17. Considerable uncertainty remains as to various of the medical or physiological effects of noise. See Miller, James D., op. cit., p. 761, who states that the only conclusively established effect of noise on health is that of noise-induced hearing loss. See also R. Rylander, "Medical Effects of Noise Exposure: Basic Considerations," Journal of Sound and Vibration, 1978, 59-1, p. 61, and testimony of Dr. Fred Schoenfeld on the effects of intermittent noise on health before the Illinois Pollution Control Board, May 7, 1980, p. 5232-5247.

conclusive and, as a result, there remain some uncertainty and controversy over the precise noise thresholds and exposure times necessary to induce a change in hearing sensitivity. However, there does appear to be general agreement that for typical 8-hour everyday exposures to continuous industrial noises, levels below 80 dBA do not cause permanent hearing loss.[1] A study done by James D. Miller, concludes that the average person may experience a temporary threshold shift if he is exposed to noise levels in excess of 70-80 dBA for extended periods of time.[2] A review of the data on industrial noise exposure concludes that permanent hearing damage may occur at levels as low as 75 dBA if exposure continues for 10 or more years.[3]

The type of noise emanating from airports is typically time-varying and intermittent, rather than steady and continuous. As an aircraft passes overhead, the peak noise on some properties adjacent to the airport might average 90-95 dBA outdoors, or 70-75 indoors. The noise rises to this peak as the aircraft approaches and diminishes as it moves away. With each operation, this noise pattern is repeated. For a given residence or group of residences, flyovers will typically be irregular in the course of a day. There will be one or more peak periods, with other intervals of low activity. Moreover, there may be considerable variation from day to day, and even within a day, because of shifting wind conditions. Such variation may also occur because of efforts by the airport tower to limit the noise impact on a given residential sector. In addition, the everyday activities of daily living often take family members away from home to locations where aircraft noise will be

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[1] U.S. E.P.A., Public Health and Welfare Criteria for Noise, Washington, D. C., July 27, 1973, p. 5-23.

[2] Miller, James D., "Effects of Noise on People," Journal of the Acoustical Society of America, v. 56, no. 3, September 1974, p. 733.

[3] U.S. E.P.A., op. cit., p. 5-27.

decreased or altogether absent.

All of these factors suggest that the noise to which households are subjected, even those located in the higher noise zones, will not be sufficiently continuous or prolonged to cause permanent hearing loss. It is not clear to what extent temporary threshold shift might occur.

3. Cardiovascular Effects

The human body reacts defensively to various types of noise. Intermittent noises, for example aircraft flyovers, can cause hypertension, rising arterial pressure, and frequent capillary spasms.[1] These physiological changes are part of a generalized stress reaction by the body.

There is evidence that noise levels below 120 dBA cause no permanent cardiovascular effects. Up to 120 dBA it has been shown that people can at least partially adapt to noise.[2] For example, once a noise is anticipated, or is discovered to pose no threat, it may no longer startle a person or induce a defensive reaction. The noise levels emanating from Chicago area aircraft flyovers, even at their peak, are well below 120 dBA for those exposed on the ground.

Even if the noise does not cause a defensive reaction, persistence or frequent repetition may produce a stress reaction; and to the extent that stress is harmful to health, such noise may affect the human cardiovascular system.[3]

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[1] Nelson and Walsko, op. cit., p. 13.

[2] Sataloff, M. D., Joseph, Industrial Deafness, McGraw-Hill, New York, 1957, p. 50.

[3] Illinois Institute for Environmental Quality, Economic Analysis of Environmental Regulation in the Racing Industry, p. 104.

4. Effects on Vision

There is evidence[1] that noise levels above 90 dB can affect vision thorugh vasoconstriction. Noise reduces the blood supply to the conjunctiva (white of the eye) by causing the small peripheral blood vessels to constrict. It can also cause the pupils and the blood vessels in the retina to dilate, making it more difficult to focus.

In addition to these physical effects on the eye, studies have shown that noise above 90-100 dB may adversely affect performance of tasks that require a great deal of visual attention. Above 120 dB, noise affects the muscles which control the lens of the eye and reduces both the speed at which the eye focuses and its ability to move through certain angles.[2] In general, these effects are temporary and performance returns to pre-noise levels shortly after noise cessation.

5. Sleep Interference

Noise from passing aircraft can disturb sleeping people, causing them to either awaken or experience a change in sleep level, and thereby affecting both the quantity and the quality of sleep. Insufficient sleep has been found to increase susceptibility to disease, intensify depressive conditions, and to aggravate existing physical and mental health problems.[3]

Throughout the testimony before the Illinois Pollution Control Board there have been numerous complaints concerning sleep disruptions caused by nighttime flyovers from O'Hare Airport. Representative of some of that

[1]Berland, Theodore, The Flight for Quiet, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1970, p. 100; Still, Henry, In Quest of Quiet, Fred Herner Publishing Projects, Stackpole Books, Harrisburg, PA, 1970, p. 192.

[2]Still, Henry, op. cit., p. 200-201.

[3]Berland, op. cit., p. 68.

testimony is the following quotation:

> ... I think the precious few hours of sleep you have that is the worst of it... [the flyover noise] used to stop at 9:00, 9:30, and you would hear nothing for the rest of the night. But that doesn't seem to be the case anymore.[1]
>
> ... within the last about eleven, twelve months, ... cargo flights are coming in from 12:00 midnight until 6:00 in the morning, ... they are coming in one right after the other .... I have even invested money in sleep devices to try to muffle the noise. This is something we have never had before. I can't understand.[1]
>
> We have late-night takeoffs. We have had them as late as 10:00, 11:00, 12:00 o'clock at night.
>
> If you are sleeping, you would have to be rather hard of hearing not to be woken up by the noise of the jet.[2]

The probability of sleep disturbance and the severity of disturbance increase as aircraft passbys increase in frequency and noise level. The ability to adapt sleep to repeated noise exposures is only partial. Awakening may be reduced by as much as 50% in three weeks but there is no adaptation to sleep level disturbances.[3]

In general, outdoor noise levels of 45 dBA with the windows open and 55 dBA with the windows closed are considered adequate for uninterrupted sleep.[4] The nighttime operations at O'Hare generate peak sound levels inside many residential dwellings that are often significantly above these levels.

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[1]Robert Charley before the Illinois Pollution Control Board, April 9, 1980, p. 4965-4967.

[2]Robert Strasser, Sugar Grove, Illinois before the Illinois Pollution Control Board, April 10, 1980, p. 5090.

[3]Thessen, G. J., "Effects of Noise During Sleep," Psychological Effects of Noise, Welch, B. L. and Welch, A. S., eds., Plenum Press, New York, 1970, pp. 271-275.

[4]Dietrich, C. W., Development of Regulations for Noise at Property Lines, Illinois Institute for Environmental Quality, July 22, 1971, p. 5.

6. Speech Interference

The presence of fluctuating noise levels caused by aircraft flyovers interferes with speech and other types of auditory communication. There has been substantial testimony on this point. For example, a resident of Bensenville states,

> We have trouble conversing with our families in our homes, we have trouble hearing our television, we have trouble using our telephones, we cannot listen to our radios or stereos, church services are interrupted, classroom studies are interrupted, and meetings of all types are interrupted.[1]

A sergeant of the Bensenville Police Department says,

> Virtually every bit of [our] communication comes over the radios. Whatever communication is not heard due to the jet problem causes a vital break in the link between us and the service we can give the residents of the village.
>
> Many times these are not emergency services, but occasionally they are and I have occasioned several times when a total communication blackout occurs because of the jets going over.[2]

The extent to which noise disrupts communication varies depending upon the circumstances surrounding the conversation. The location of the speakers, whether they are indoors or outdoors, the distance between them, the noise characteristics and levels, and the available amount of insulation from unwanted sound are all important factors in determining the level of speech interference.[3]

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[1] Statement of Gary Cushaney at hearings on September 9, 1980, p. 6589.

[2] Statement of Sergeant Mosher at hearings on September 9, 1980, p. 6586-6587.

[3] For a discussion of ambient noise levels causing both indoor and outdoor speech interference see Volume II, Economic Impact Study of Proposed Noise Regulations R77-4, p. 78-79. For a more complete discussion see also Shepherd, William, "Speech Interference Assessment - An Overview and Some Suggestions for the Future," Noise and Speech Interference - Proceedings of

Because of its interference in auditory communication, aircraft noise can be especially disruptive at school. As the following testimony indicates, noise can disrupt normal classroom activities and reduce the spontaneity of the educational process by making student-teacher communication difficult. It can affect student recall and increase the time needed to process information, thus effectively reducing a student's accuracy.

From a sixth grade teacher in Bensenville,

> I believe that the noise interruption lasts for about thirty seconds. During that time, we stop and wait. Sometimes the windows rattle... It interrupts, it's annoying, it ruins concentration, it hinders learning and it's easier to teach without that.[1]

Another sixth grade teacher indicates the possible severity of the interruptions that aircraft flyovers may cause, and following that a sixth grade student reports his/her reactions to the noise.

> ... last Friday from the period of time 9:21 a.m. to 2:48 p.m., excluding our thirty-five minute lunch period and thirty minutes for P.E. ... [my students and I] logged 160 flights over Chippewa School of which 120 were moderate, which meant we could yell over the airplanes, and 40 of which were severe where we absolutely had to interrupt and stop instruction.
>
> It's very ammoying, especially where planes are landing. In class we stop all the time because of planes every sixty seconds. It keeps happening when the teacher reads a book or a story to us.[2]

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a Mini Symposium, Shepherd, William, ed., NASA Langley Research Center, Hampton, VA, September, 1975, p. 7. U.S. E.P.A., Public Health and Welfare Criteria for Noise, Washington, D.C., July, 1973, Section 6. U.S. E.P.A., Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, Washington, D. C., March, 1974.

[1] Hearings September 9, 1980, p. 6572-6573.

[2] Both quotes are from the hearings testimony on September 9, 1980. The first is taken from p. 6664, the second from p. 6574.

Several studies point to the difficulty created by a noisy environment for the development of a child's auditory and verbal skills.[1] Our review of the land use patterns surrounding O'Hare Airport indicate that there are an estimated 158 schools located within the 65 L_{dn} contour (for our 1985 base case).

7. Annoyance

Annoyance is a psychological response to a given noise exposure. It has a variety of causes, not the least of which is the unpleasantness of the noise. Annoyance can also be due to " . . . the disruption of ongoing activities, [the] physiological or psychological reactions to noise, [or] the meaning carried by a given noise.[2] According to one witness at the hearings, a registered nurse at Lutheran General Hospital in Park Ridge,

> It appears the patients do become irritable and nervous when noisy aircraft are heard. The noise interrupts conversation, not to mention the patients' experience when trying to rest.[3]

In studies done with jet noise, one of the factors which added most to people's annoyance was their implicit fear of a plane crash.[4] Several people testified to feelings of anxiety and fear as a result of aircraft flyovers.

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[1] The effects of noise on the classroom and learning situations are discussed in the Technical Study, v. III, Chapters 6, 7, and 8.

[2] Illinois Task Force on Noise, Economic Impact Study of the Proposed Motor Vehicle (In-Use) Noise Regulations, Illinois Institute for Environmental Quality, Chicago, Document #76/10, May, 1976, p. 109.

[3] Testimony of Kathleen Luckritz, p. 4241.

[4] U.S. E.P.A., Summary of Public Health and Welfare Criteria for Noise, Washington, 1974, p. 1.

> During these years [of O'Hare's Existence] there have been two major air crashes. In one sense, that's a remarkable safety record. However, it does not lessen the feeling of anxiety that we live under day by day...[1]

> ... the stress factor ... during the day I'm afraid to get home. I go to work and I stay late, and, ... if I'm off a day, we get to the city ... to put it mildly, [the airport noise makes me] very nervous, very anxious, very stressful.[2]

> I have witnessed some terrifying experiences. One day there was a cargo plane leaving O'Hare and we were in the back yard. We ran because we didn't think he was going to make the telegraph wires. He put out all the lights in the parking lot, the vapor lights, which took about fifteen minutes to go back on. I would say that he just missed the high wires on Route 83 over Indian Hill.[3]

The existence of an annoyance can be experimentally tested, but it is difficult experimentally to find the annoyance value of noise because the degree of annoyance depends upon the characteristics of the situation in which the noise is heard. Some of the factors influencing the degree of annoyance are:[4]

(1) The intensity and spectral characteristics of the noise.

(2) The frequency and duration of the noise.

(3) The informational content of the noise and the degree of interference it causes with other activities.

(4) The time of day during which the intruding noise occurs.

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[1]Testimony of Warren Seyfert, Pastor of East United Church of Christ, Bensenville, September 9, 1980, p. 6583.

[2]Testimony of Marvin Lovitz, April 6, 1980, p. 5060-5061.

[3]Testimony of Edward Pichle, Bensenville, September 9, 1980, p. 6665.

[4]Illinois Institute for Environmental Quality, Control of Noise from Motor Vehicles, Report of the Task Force on Noise, No. 74-42, 1974, p. V-36.

(5) The attitude of people toward the noisemaker.

(6) The background noise against which a particular noise event occurs.

According to the United States Environmental Protection Agency, the incidence of actual complaints about noise is not a good measure of the incidence of annoyance. Typically, only a fraction of those annoyed are moved to openly complain. According to a study by the Agency, with a sound level of 65 L_{dn}, about 33% of the population could be annoyed while only 5% would register complaints.[1]

8. The Extent of Noise-Induced Health Effects at O'Hare Airport

Which of the above health effects are significant at O'Hare Airport? To attempt to answer this question, one must recall the actual noise levels experienced at the airport. In the 1985 base case, approximately 99,000 dwelling units experience outdoor noise levels between 65 and 75 L_{dn}. There are also about 3,800 dwelling units that have noise levels above 75 L_{dn}. Remember also that aircraft noise is typically time-varying and intermittent. As an aircraft passes overhead, the noise level on properties adjacent to the airport may rise to a peak of 90-95 dBA outdoors and 70-75 dBA indoors.

For many residents, the noise interruptions due to aircraft overflights are a regular and routine part of their lives and cause varying and, in many instances, significant amounts of speech and sleep interference and annoyance. Classroom communication in nearby schools is also subject to disturbance. Studies cited above further suggest the noise may also lead to temporary cardiovascular changes as part of a reaction to stress and anxiety.

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[1] U.S. E.P.A., The Effects of Noise on People, Washington D.C., NTID 300.7, December 31, 1971.

Generally, however, it appears that the noise levels emanating from O'Hare are not severe enough to permanently damage the hearing of nearby residents or cause other lasting impairments of a physiological nature. Unfortunately, evidence in this area is sparse. It is especially limited with regard to the specific effects of aircraft noise, with its episodic and time-varying characteristics, as compared to various forms of steady-state or continuous noise.

C. Benefit Measures Based on Property Values

1. The Regression Method as a Source of Benefit Data

Although we are not able to express our preference for quiet, or reduced noise, by the direct, specific purchase of it in the marketplace, we do engage in certain transactions in which, implicitly, we place a value on it. An important type of such transaction is the purchase of a house. One's assessment of a particular dwelling depends on the many characteristics of that dwelling, including various features of the neighborhood in which it is located, and on the flow of benefits which those characteristics are perceived to bring. Among the characteristics in question are the style of house, its age, its size, number of bedrooms, whether it has air conditioning, proximity to schools, accessibility to downtown, noisiness of the neighborhood, whether the neighborhood is affected by air pollution, etc. Accordingly, we may think of these characteristics as the variables that determine the value of a house. To the extent that they are favorable, a dwelling will sell for more; to the extent that they are unfavorable, a house will sell for less. The relationship involved here may be written

$$V = f(Z_1, Z_2, Z_3, \ldots, Z_n)$$

where Z_1, Z_2, etc. are the characteristics that determine the dwelling's value, and V is the dwelling value. Once decisions have been made as to the independent variables to include and the specific form of the relationship, and given a sufficient set of observations on each of the variables, regression procedures will yield numerical estimates of the coefficients associated with each of the independent variables. The coefficients provide a measure of the influence of each variable on the dwelling price. The partial derivative of V with respect to an independent variable, e.g.,

$$\frac{\partial V}{\partial Z_1} = \frac{\partial f}{\partial Z_1} \quad ,$$

in turn expresses the change in dwelling value arising from a small change in the independent variable. Thus if Z_1 is the average neighborhood noise level measured in dB(A), the derivative will tell us by how much a 1 dB(A) change in that level will affect the dwelling price. Differently, it will tell us the worth that a homebuyer attaches, on the average, to a 1 dB(A) reduction (or increase) in residential noise. The worth in this case represents a capitalized sum or present value of the expected flow of benefits to the buyer from a 1 dB(A) reduction that continues over an indefinitely long succession of future years.[1]

A number of investigators have employed an econometric approach of this kind in order to estimate how individuals evaluate the effects of

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[1]The benefits to property owners from a noise reduction represent bona fide economic gains. But it does not follow from this that all existing owners previously suffered a loss from the earlier, higher noise level. Those who purchased their properties after the onset of that higher noise level would have obtained them at a discount because of noise damage. (Their predecessors in title, who were owners at the onset of the higher noise level would have suffered a loss.) The discount may be understood as a (capitalized) compensation to such buyers for the noise damage they will suffer. Looked at from a different vantage point, those who generate the noise that impacts others, in this case the air carriers and air travellers, may be thought of as benefiting from the free use of a common property resource, namely quiet surroundings.

A 1980 federal law, P.L. 96-193, 94 Stat. 51, 49 U.S. Code 2101-2108, encourages airport operators to submit to the Secretary of Transportation "noise exposure maps" which identify "noncompatible uses" in each area of the map. Section 107 provides that no person who subsequently acquires property in an area shown on such a map may recover damages with respect to noise attributable to the airport if he had "actual or constructive knowledge" of the map, unless there has been a significant change in airport operations. The constitutionality of this provision is likely to be challenged if and when it is asserted by an airport operator. Section 107 does not seek to limit damage recoveries by persons who acquired their land prior to submission of relevant noise exposure maps.

various kinds of pollution, including noise pollution. With regard to the latter, the inquiries have been directed primarily toward the more pervasive noise sources, namely motor vehicle and aircraft noise.[1] A mathematical relationship of semi-logarithmic form is often used in this type of study. Specifically, we might have

$$\ln V = aN + bZ_1 + cZ_2 \ldots$$

where

V = the market value of a particular dwelling;

N = the value of an index that measures the noise level at this property;

$Z_1, Z_2, \ldots$ = measures of other characteristics of the property which, with N_o determine its value;

$a, b, c,$ = numerical coefficients resulting from regression analysis.

The semi-log form, as explained below, has the effect of making damages from noise, or benefits from its reduction, dependent not only on the noise level, but also on the value of the affected property. This is the kind of outcome one would expect. That is, one would expect that the dollar damages from a given noise level would be greater for properties of greater value. With the semi-log form, damages turn out to be a constant percentage of property value. In a given noise environment, if a $40,000 dwelling suffered damages of $1200, a $60,000 dwelling would experience damages of $1800. The semi-log form also has the characteristic of being consistent with sound measurement methods. In the relationship above, dwelling value is expressed

[1] For a brief review of some of the literature, see Jon P. Nelson, Economic Analysis of Transportation Noise Abatement, Ballinger Publishing Co., 1978, Ch. 6.

in log form, but the noise variable is not because the noise measure is itself based on a logarithmic scale. The appropriateness of the semi-log form is further suggested by data indicating this type of relationship between subjective ratings of annoyance and noise expressed in decibels.[1]

While the semi-log form may be preferred on these grounds, its use in seeking to measure noise damages is technically not essential, and relationships of other forms are used in some of the studies referred to below.

Several studies of the effects of aircraft noise or property values have been completed within the past thirteen or fourteen years, and the most recent of them within the past two years. Collectively, they cover some 16 cities and 17 airports. Most of them employ a cross section of property value data along with information on characteristics of housing and some measure of aircraft noise exposure. While all of them are econometric in form, they vary in certain of their methodological aspects. There are variations in sample size, in criteria for sample coverage, in sources of data on dwelling values, and in methods of determining noise levels. There are differences also in both the functional forms used to relate the dependent to the independent variables and in the numbers and kinds of independent variables, besides the noise variable, that are recognized. The methodological adequacy of the studies varies, some of them being stronger than others. At the same time, taken as a group, they do provide a body of data and findings, and a measure of concensus, concerning the possible extent or worth

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[1] Bishop, D. E., "Judgements of the Relative and Absolute Acceptability of Aircraft Noise," Journal of the Acoustical Society of America, v. 40, July 1966, pp. 108-122.

of noise damage to property values.[1]

The results of these studies - twelve in number[2] - are summarized in a recent paper by Nelson.[3] For purposes of comparability, each set of findings is expressed in terms of a Noise Depreciation Sensitivity Index (NDSI) which indicates, for a typical property, the percentage reduction in property value per unit of added noise. For the semi-log form referred to above, derivation of the NDSI is straightforward. Restating a previous expression, we have

$$\ln V = aN + bZ_1 + cZ_2 \ldots$$

taking the derivative of both sides gives

$$\frac{1}{V} dV = a \cdot dN + b \cdot dZ_1 + c \cdot dZ_2 \ldots$$

Since we are considering changes only in the noise variable, with all else constant, terms on the right other than the first have zero value. Setting $dN = 1$ to reflect a unit change in the noise variable we may write

$$\frac{dV}{V} \cdot 100 = a \cdot 100 = NDSI$$

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[1]The estimation of pollution damages by reference to differential property values involves certain conceptual and procedural problems, and the results from this type of study must, at this stage, be regarded somewhat tentatively. For a discussion of some of the issues see, for example Polinsky, A. M. and Shavell, Stephen, "The Air Pollution and Property Value Debate," Review of Economics and Statistics, Vol. LIII, p. 415, (1971); and Freeman, A. M., "On Estimating Air Pollution Control Benefits from Land Value," Journal of Environmental Economics and Management, Vol. 1, p. 74 (1974). See also Nelson, op. cit., Chs. 4 and 5.

[2]Two studies consist, in effect, of distinct sub-studies and cover more than one city and airport.

[3]Nelson, Jon P., "Airports and Property Values: A Survey of Recent Evidence," Journal of Transportation Economics and Policy, January, 1980.

The twelve studies yield a total of 18 NDSI's. They are summarized in Table III-1. The indexes range from 0.29% to 1.10%, though a majority of them are concentrated in the 0.50% - 0.60% interval. The median of the 18 values is 0.535% and the mean is 0.58%. For the purpose of the estimates that follow, the mean value will be used. To illustrate the application of this NDSI, consider an Illinois property (house and lot) which, in the absence of aircraft noise, has the average (1978) value for such properties in the state of $40,800. If now, with other things unchanged, the introduction of aircraft noise, or its increase, were to raise the L_{dn} by 5 dB, say from 65 to 70, we would estimate a decline in the property's value of $1183 (5 x .0058 x $40,800 ≈ $1,183). Alternatively, abatement measures that reduced the noise level from 70 L_{dn} to 65 L_{dn} would bring an increment in property value, and a benefit, of the same amount.[1]

2. Inverse Condemnation Recoveries as a Measure of Property Value Benefits

In Section II-D, which developed the costs of easement, there was discussion of judgements and settlements for noise damages to properties near Los Angeles International Airport. An important component of evidence in these judgements and settlements was testimony by real estate appraisers of the degree to which the value of noise-impacted properties had been impaired. This testimony was often conflicting, in that appraisers for property owners typically claimed higher damages than the damages represented

[1]Strictly speaking, the NDSI should be applied to the value of the property subjected to the mean noise level of the properties in the regression sample, rather than to the value of a property undamaged by noise. In the present situation, however, differences in estimates from the two procedures would be small.

Table III-1

The Effect of Noise on Property Values: Summary of NDSI Measures

Study Area	NDSI[1]
Cleveland	0.29%
New Orleans	0.40
Sydney-Marrickville	0.40
Sydney-Rockdale	0.50
Edmonton	0.50
Toronto-Etobicoke	0.50
San Francisco	0.50
St. Louis	0.51
Buffalo	0.52
Rochester	0.55
San Francisco	0.58
Minneapolis	0.58
Dallas	0.58
London	0.68
San Jose	0.70
San Diego	0.74
Boston	0.83
Washington, D. C.	1.10

Source: Nelson, Jon P., "Airports and Property Values: A Survey of Recent Evidence," Journal of Transportation Economics and Policy, January, 1980.

[1]The Noise Depreciation Sensitivity Index measures the percentage depreciation (appreciation) in property value per decibel increase (decrease) in the noise level.

by appraisers for the airport authority. Moreover, the outcomes of the litigation have not been systematically collected and summarized. In consequence, the data base available to us from the Los Angeles experience is limited and uneven. Nonetheless, the results, as best we have been able to distill them, are somewhat at variance with the regression studies described above. In the lower noise range of 65-70 L_{dn}, they indicate damage values, or benefits from abatement, that are sometimes lower and sometimes higher than those obtained with the regression method, depending on the abatement method being considered. In the higher noise zones of 70-75 and 75-80 L_{dn}, they consistently indicate higher damage values.[1] In terms of the Noise Depreciation Sensitivity Indexes summarized in Table III-1 above, the implied coefficients for all noise zones would lie toward or above the upper end of the values.

The two sets of coefficients, the one based on regression studies and the other on inverse condemnation recoveries, are summarized in the table below. To interpret the table, a 7.5 dB noise reduction, from 72.5 L_{dn} to 65 L_{dn}, would generate estimated benefits of 4.35% (of property value) using the regression data and 9.0% using the inverse condemnation data. A 4 dB reduction, from 69 dB to 65 dB, would yield estimated benefits of 2.32% (or 4 x .0058) by the regression method and 2.5% using the inverse condemnation data (since this figure applies for the entire 65-70 L_{dn} zone). Note that if, as a result of implementing a particular abatement method, a group of dwellings is moved from the 65-70 L_{dn} zone to the 60-65 L_{dn} zone, we would credit each dwelling with a 5 dB noise reduction. In this case, the benefit per dwelling by the regression method would be 2.9%, whereas it would be the lesser amount of 2.5% using the inverse condemnation data.

What possible explanations are there for the disparities in the two

[1] Much of the data available to us on litigation proceedings for Los Angeles International Airport were kindly provided by Mr. James H. Pearson, Senior Assistant City Attorney, City of Los Angeles (Airport Division).

Table III-2

Summary of Noise Abatement (Damage) Coefficients

Noise Level	Benefits from Abatement (Percent of Property Value)	
	Regression Studies[1]	Inverse Condemnation Data[2]
65-70 L_{dn} (1-5 dB Reduction)	1.45% (0.58-2.90%)	2.5%
70-75 L_{dn} (6-10 dB Reduction)	4.35% (3.48-5.80%)	9.0%
75-80 L_{dn} (11-15 dB Reduction)	7.25% (6.38-8.7%)	17.0%

[1]The single figure entries in this column show, respectively, benefits from noise reductions of 2.5 dB, 7.5 dB and 12.5 dB. The figures in parentheses show the range of benefits associated with the indicated range of noise reduction.

[2]The figures show benefits to a property from a reduction in noise to 65 L_{dn} or below. The data provide but one figure for each noise zone.

sets of estimates? One partial explanation is that errors in the data bases used in the regression studies, specifically errors in the measurement of the (explanatory) noise variable, may possibly have biased the damage or benefit coefficient downwards. Another is that specification of the functional forms or models used in the regression studies may be incomplete or inaccurate, giving rise to errors in the estimated coefficients.[1] A third is that the inverse condemnation data are fragmentary. They come only from one airport jurisdiction and only in a relatively gross form that precludes systematic breakdown and evaluation.. Fourth, the legal forums in which actions to recover damages for injuries caused by aircraft noise are resolved are not analogs of the market processes by which prices are typically determined. Factors extraneous to those processes may influence the decisions of judges and juries, and the resulting damage awards may not accurately reflect the underlying economic reality. The methods of estimation and their limitations are discussed further below.

In view of the differences in results from the two approaches, as shown in the table above, the consequences of each for the estimation of benefits are indicated in Section C-3 below. Benefit estimates based on the regression studies are designated as R-based and those based on the litigation data as L-based.

In the economic valuation of an item, be it an ordinary good (or service) or an amenity like an uncongested beach or quiet surroundings, the orientation is toward the consuming individual (or group) and his (or their) preferences. The test to be met by a valuation measure is whether it accurately reflects the consumer's willingness-to-pay for an item. More specifically, in the

[1] While these comments suggest that the noise coefficients may be understated, the possibility remains that, to the contrary, they are overstated.

present instance one seeks to determine the homeowner's maximum willingness-to-pay for a given amount of quiet, rather than to forego it. A preferred way of determining willingness-to-pay is through observation of how people actually behave, as in a market setting in which bona fide transactions occur. However, in the valuation of amenities, this approach often is not possible.

The regression studies discussed above are consistent with the willingness-to-pay concept, and they appropriately give recognition to the behavior of consumers in the housing market. Yet like all regression studies, they face certain limitations: There may be errors in the specification of explanatory variables or the functional form in which they are expressed; there may be errors in the data base for one or more variables; relevant interdependencies may have been overlooked, etc. Such factors can affect the resulting estimates of the coefficients. Notwithstanding such possibilities, the regression method as applied to differential property values is well established in the economic literature as an approach to the valuation of damages from aircraft (and highway) noise. While not recognized by all economists as capable of yielding satisfactory estimates, it commands a substantial acceptance from among those who have worked professionally in the valuation area as a valid and constructive approach. As a method of valuation, it has received extensive study and review, and it has been given extensive application. There have been well over a dozen such applications by various authors, as described in Table III-1. Collectively, these studies represent the most substantial body of evidence available on the measurement of damage from aircraft noise. The litigation based material is significantly weaker in terms of both its breadth - it covers but one airport - and the adequacy of the underlying data.

A reservation occasionally expressed about these regression studies, taken collectively, is their variation in outcomes. The results in Table III-1

show a rather wide divergence with the figures ranging from a low of 0.29% per dB to a high of 1.10%. Since pertinent economic and related circumstances vary among the several communities involved in the studies, some variation in outcomes is to be expected. But these circumstances alone may not explain the full range of differences, and it is possible that limitations of methodology or data have played a role. It should be noted that the estimates actually are more closely grouped than might at first glance appear. If the single lowest and two highest figures are excluded, the remaining 15 estimates fall within a range of 0.40 - 0.74, with a standard deviation of 0.098. (The standard deviation of all 18 estimates is 0.183.) In any case, it seems wise at this stage to regard the results as provisional and subject to revision in the light of further research.

Noise damage estimates based on inverse condemnation proceedings also reflect, though perhaps less directly than the regression estimates, the willingness to pay criterion as expressed in the marketplace. It is customary in these proceedings for plaintiffs and defendants to present, through real estate appraisals of the properties involved, estimates of the diminished value of those properties due to aircraft noise. One might expect plaintiffs' estimates to be substantially in excess of defendants' estimates, as has typically been the case in the Los Angeles International Airport litigation. But these estimates serve legally to fix the boundaries of any damage awards, and any awards made fall within them. The appraiser's task is not easy, since he must try to isolate the effect on property value of one among many influences, namely aircraft noise. Moreover, the process of objective assessment and the ultimate legal decision may be colored by the litigation process itself, including its adversarial setting and the emotions of the participants. But if the appraisals are conscientiously undertaken, one might

expect the outcomes to roughly indicate market valuations.

It should be emphasized that such diminution in property value as may occur from aircraft noise does not arise from physical damage to the property.[1] Rather it reflects an impairment in the flow of services to users of the property that its quiet surroundings would otherwise provide. Differently, the diminished value of a noise impacted property, as compared to a quiet one, reflects injuries to users that take such forms as speech interference, disturbance of sleep, annoyance or emotional distress. The impaired service flows become capitalized in the housing market in the form of reduced property values.

In recent legal proceedings involving Los Angeles International Airport, generally referred to as the Westchester case,[2] state courts have allowed plaintiffs actions to be entertained as a "personal injury" (or "nuisance") action rather than as an action based on inverse condemnation. From an economic point of view, this distinction is, in an important sense, a distinction without a difference. For as noted immediately above, personal injury is precisely what is at stake in the inverse condemnation proceedings. Indeed, the factors for which damages were sought in the Westchester case are much the same as those previously enumerated - speech interference, annoyance etc. However, the legal distinction illustrated by Westchester serves to allow such claims without reference to property values as a means of evaluating or measuring them. As a result, the link to market behavior and the willingness-to-pay criterion is severed. Judges and juries hear conflicting allegations

[1] There can, of course, be such damage from overflights that produce heavy vibration or sonic boom. But such situations are exceptional and of minor or negligible importance in the litigation that has occurred at airports like Los Angeles International.

[2] See Greater Westchester Homeowners Association vs. City of Los Angeles (14 ERC 1064, 160 Cal. Rptr. 733).

and claims and decide what awards should be made, but without reference to the kinds of external, observable market processes that customarily determine economic worth.[1]

In the Westchester case, a total of $86,000 was awarded to 15 families containing 41 persons for damages sustained during the period 1967-1975. A number of other persons who were parties to either the original suit or another, similar one were settled with the airport authority prior to trial. Unfortunately, information from the case does not add usefully to data on the economic measurement of damage from aircraft noise. Apart from the major difficulty cited in the preceding paragraph, there are a number of other problems. We do not know the noise levels to which the plaintiffs were subjected or the time periods intended to be covered in the individual distributions. The decision was rendered by a court rather than a jury, and the sums involved thus represent essentially one man's opinion. (The inverse condemnation data covered in the text, though still offering a thin data base, cover a total of 15 separate cases involving court trials, jury trials, and settlements.) We do not know what considerations affected the judge's decisions as to the particular sums awarded, and we do not know to what extent, if at all, economic criteria may have played a meaningful role.[2] Hence it is not possible to appraise the case in economic terms or attach economic significance to the results. The purport of these observations applies equally to the settlements

[1] In some kinds of personal injury cases, it may of course be possible to refer to relevant economic events in rendering damage judgements. For example, there may be lost wages or hospital costs. But such factors are not present in the kinds of noise damage proceedings under discussion.

[2] According to Mr. James H. Pearson, Senior Assistant City Attorney, City of Los Angeles (Airport Division) plaintiffs sought varying amounts of damages and explained the ways in which noise disturbed them. But the proceedings did not provide any economic criteria by which the amounts of awards might be determined.

that were reached.

A particular shortcoming of litigation data generally, as well as in a case like Westchester, for purposes of damage measurement, lies in their lack of representativeness of the affected population. The plaintiffs in a case or set of cases ordinarily comprise a relatively small, self-selected group out of the thousands of households in high noise zones. It may be reasonably presumed that those who join in a lawsuit, though not identical in attitude and motivation, are among those who are most concerned about and bothered by noise. Those with lesser or little concern are less likely to participate. Hence one would expect such suits to present worst or near-worst cases, not the situation of the typical household. Accordingly, the awards in these cases, quite apart from the other qualifications noted, are unlikely to represent the overall situation accurately.

At this time, there is no way of knowing to what extent the personal injury (as distinct from inverse condemnation) basis for damages will be sustained in jurisdictions outside of California or whether any future awards on this basis, whether in California or elsewhere, will bear any relation in magnitude to those of the Los Angeles court.[1]

The benefits that are measured by reference to property values might be expected, in a well-functioning real estate market, to cover all those benefits that property owners would perceive, or be aware of, in buying or occupying a home. Examples would be the benefits that a quieter environment provides from lower levels of speech and sleep interference, from less disturbance to reading and concentration, and from less annoyance. Buyers'

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[1] In a personal injury type of proceeding in Orange County, California, decided in July 1981, the jury, finding in favor of the defendants, awarded no damages to plaintiffs (numbering about 220 individuals). Anderson et al. v. County of Orange, Superior Court No. 27-39-16.

demand functions, or bid prices, and sellers' offer prices, would reflect such factors. On the other hand, to the extent that there might exist benefits of a more subtle kind that would show themselves only over long periods of time, home owners and prospective buyers might well not be aware of them, and they would not therefore exert an influence on dwelling demand and supply and resulting dwelling prices.

It is fundamental to the methods under discussion that they seek to measure the impact of aircraft noise on property values, not the impact of the airport on those values. The introduction or expansion of an airport tends to stimulate economic activity, encouraging the growth of commerce and industry and of employment. This in turn tends to strengthen the demand for nearby land, including land for residential purposes. Property values tend to rise as a result. Aircraft noise works in the opposite direction, exerting a negative effect on residential property values. The overall effect of the airport on property values is a consequence of these two forces. The studies referred to above are designed to measure only the (negative) noise effect. The studies tell us that if the noise were eliminated or reduced, with all else unchanged, the value of a property would rise. It is nonetheless possible, and for many situations is likely to be the case, that even with the noise, a property is worth more than it would be in the absence of the airport. Expressed differently, in such situations, the overall effect of the airport on property values, including the (negative) noise effect, may be favorable.

3. The Dollar Benefits of Some Alternative Abatement Methods

Consider first the estimation of benefits from the modified takeoff procedure involving a deep thrust cutback and quick flap retraction. The

data in Table II-3 indicate a slight reduction from the use of this procedure in the number of housing units over 75 L_{dn} and a substantial reduction in the number between 65 and 75 L_{dn}. In order to estimate the benefits of these reductions in accord with the methods described above, it is helpful to reorganize the housing data in terms of 5 dB increments. This can be done through the application of the coefficients showing the percentage of land in a 1 dB interval, as given in Table II-7. The resulting estimates are presented in the first three rows of Table III-3. As previously explained, 70% of the housing units are estimated to be single-family dwellings, with an average market value (before any noise damage) of $61,800, and the remainder are multi-family units, with an average market value of $26,500 per unit. The weighted average value for both types of dwellings is $51,200.

When an abatement method like modified takeoff procedure is employed, and (say) the 70 L_{dn} contour is pulled in, some dwellings originally in the 70-75 L_{dn} zone, notably those closest to the 70 L_{dn} boundary, will be shifted down to what is now the 65-70 L_{dn} zone. Other dwellings in the original 70-75 L_{dn} zone, notably those more toward the 75 L_{dn} boundary, though benefitting also from the noise reduction, may not change noise zones (unless the noise reduction is great enough). Thus the noise reduction might be 2 dB for all dwellings, but only a fraction of the total will be observed to change noise zones. In these circumstances, one procedure for calculating benefits would be to credit all dwellings with a 2 dB reduction. An alternate procedure, giving approximately the same results under limiting, though not unduly restrictive, conditions is to credit with a 5 dB reduction the dwellings shifting down from one 5 dB

Table III-3

Housing Units and Estimated Benefits for Modified Takeoff Procedure

	Noise Zone (L_{dn})			
	65-70	70-75	75-80[1]	80-85[1]
1985 Base Case (Number of Housing Units)	72,002	26,766	2,781	1,034
After Modified Takeoff Procedure (Number of Housing Units)	32,436	12,058	2,624	976
Number of Housing Units Shifting to Next Lower Zone	54,489	14,923	215	58
Estimated Benefits, R-Basis ($ Millions)	$80.90	$22.16	$0.32	$0.09
Estimated Benefits, L-Basis ($ Millions)	$69.74	$49.66	$0.88	$0.24

Total Benefits, All Noise Zones:

R-Basis = $103.47 million
L-Basis = $120.52 million

Source: See text.

[1]Dwellings subject to noise levels of over 75 L_{dn} are assumed to lie within the 75-85 L_{dn} range.

zone to the next, with no credit allowed for other dwellings. For convenience the latter procedure is employed here.[1]

Estimated benefits from the modified takeoff procedure, on both the regression or R-basis and the litigation or L-basis are shown in Table III-3. A pair of illustrations will clarify the calculation procedure. Consider the 14,923 housing units originally in the 70-75 L_{dn} zone that shift down to the 65-70 L_{dn} zone. Under the R-based method, they are credited with a 5 dB reduction. Benefits accrue to a unit at the rate of .0058 per dB times the property value. The calculation is therefore

$$.0058 \times 5 \times \$51,200 \times 14,923 = \$22.16 \text{ million}$$

Under the L-based method, benefits accrue to each of the housing units shifting to the next lower zone at the rate of .065 times the property value. (.065 = .09 - .025. See Table III-2.) The calculation is therefore

$$.065 \times \$51,200 \times 14,923 = \$49.66 \text{ million}$$

For the L-based method, no data are available to estimate the benefits of a noise reduction for dwellings in the 80-85 L_{dn} zone. (Table III-2 gives figures for 5-dB zones only in the range of 65-80 L_{dn}.) The procedure used here (as in the earlier section on easement costs) is to extrapolate the figure shown in Table III-2 for the lower noise zones. Thus, were we to extend the figures in Table III-2 to cover 80-85 L_{dn}, the entry for the L-based method would be 25% (for a 16-20 dB reduction). Dwellings in this noise zone that shift to the next lower zone would accordingly be credited with a benefit equal to 8% of property value (25% - 17% = 8%).

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[1] The distinction between the two procedures is relevant only for the calculation of R-based benefits. Under the L-based procedure, a benefit is credited only when a dwelling shifts to a lower noise zone.

The aggregate of benefits shown in Table III-3 for the modified takeoff procedure is $103.47 million on the R-basis and $120.52 million on the L-basis. In the R-based estimate, almost 80% of total benefits are generated by dwellings in the 65-70 L_{dn} zone, whereas in the L-based figure, the benefits generated by dwellings in the 65-70 L_{dn} zone - about 58% of the total - are only about 40% greater than those generated by dwellings in the 70-75 L_{dn} range. With respect to each estimate, the contribution from dwellings located above 75 L_{dn} is small because their relative numbers are small.

The benefits gained from the modified nighttime procedures, which are assumed to be implemented following the institution of the modified takeoff procedure, are developed in an analogous manner and are shown in Table III-4. These procedures add modestly to the benefits arising from the modified takeoff procedure. On the R-basis, the additional benefits are about $14 million and on the L-basis $20 million. These added benefits are generated predominantly in the lower noise zones, simply because the bulk of the impacted housing is located there.

In the earlier analysis, insulation as a quieting method was considered for implementation following the application of modified takeoff and nighttime procedures. The relevant housing population for the estimation of insulation benefits is therefore the number of dwellings remaining above 65 L_{dn} after adoption of these other procedures, as shown in the 2nd row of Table III-4 and the first row of Table III-5.

If dwellings were insulated in 1 dB increments to a degree just sufficient, for each dwelling, to achieve compliance with the 65 L_{dn} limit, the resulting aggregate of benefits, as shown in Table III-5, would be

Table III-4

Housing Units and Estimated Benefits for Modified Nighttime Procedures

	Noise Zone (L_{dn})			
	65-70	70-75	75-80[1]	80-85[1]
After Modified Takeoff Procedure (Number of Housing Units)	32,436	12,058	2,624	976
After Modified Nighttime Procedures (Number of Housing Units)	28,532	10,607	2,046	760
Number of Housing Units Shifting to Next Lower Zone	6,193	2,289	838	260
Estimated Benefits, R-Basis ($ millions)	$9.20	$3.40	$1.24	$0.39
Estimated Benefits, L-Basis ($ million)	$7.93	$7.62	$3.43	$1.06

Total Benefits, All Noise Zones: R-Basis = $14.23 million
L-Basis = $20.04 million

Source: See text.

[1]Dwellings subject to noise levels of more than 75 L_{dn} are assumed to lie within the 75-85 L_{dn} range.

Table III-5

Benefits from the Insulation of Dwellings[1]

(Benefit Figures in $ Millions)

	Noise Zone (L_{dn})			
	65-70	70-75	75-80	80-85
Number of Housing Units	28,532	10,607	2,046	760
Estimated Benefits from Insulation in 1 dB Increments[2]				
R-Basis	$22.10	$23.96	$ 7.66	$3.97
L-Basis	$36.52	$48.88	$17.81	$9.73
Estimated Benefits from Insulation in 5 dB Increments				
R-Basis	$42.36	$31.50	$ 9.11	$4.51
L-Basis	$36.52	$48.88	$17.81	$9.73

Total Benefits, All Noise Zones:

Insulation in 1 dB Increments
R-Basis = $57.69 million
L-Basis = $112.94 million

Insulation in 5 dB Increments
R-Basis = $87.48 million
L-Basis = $112.94 million

Source: See text.

[1]After the implementation of modified takeoff and nighttime procedures.

[2]These benefits apply also for property acquisition, which is discussed below in the text.

about $58 million on the R-basis and $113 million on the L-Basis. In both cases, the great bulk of these benefits - over 75% - would accrue to dwellings at or below 75 L_{dn}. Alternatively, if dwellings were insulated in 5 dB increments - 5 dB for those in the 65-70 L_{dn} zone, 10 dB for those in the 70-75 L_{dn} range, etc. - the R-based total would rise to $87 million. The L-based total would not change.

These estimates are overstated, since the procedures underlying them assume that an abatement method provides noise reduction both indoors and outdoors, whereas insulation offers no outdoor noise relief. Moreover maximum interior effectiveness from insulation is obtained only when doors and windows are closed. In the context of benefit estimation, the relevant question is, "How much more is a dwelling worth to a property owner if the general noise environment is reduced by 10 dB (from say 80 dB) than if only the interior of the dwelling is reduced by 10 dB?" One can only speculate as to the answer, but it is a plausible surmise that the benefits from insulation are but a half to two thirds as great as the benefits from general quieting.

The Technical Study considers (on pp. 124-5) the adverse effects of aircraft noise on schools and classroom activity. Communications are disrupted and there is lost time. Students are distracted and teacher morale is unfavorably affected. The insulation of noise impacted schools would substantially mitigate these classroom disruptions and their attendant effects. How might one estimate the resulting benefits? One approach, consistent with the basic economic precepts of valuation, would be to try to apply the willingness to pay principle. That is, how much would those adversely affected by noise in the schools be willing to pay for quieter surroundings? Unfortunately, the question cannot be meaningfully addressed

to the school children involved. It might be addressed to their parents who, however, can be only imperfectly aware of classroom conditions. In any event, data that would provide an answer do not exist. An alternative approach would be to try to measure the damages suffered by youngsters, whether of a temporary or permanent kind, from the classroom disturbances. (Such damages conceivably could take various forms: nervousness, anxiety and other forms of personal distress; lower scores on examinations; and possibly reduced levels of educational attainment and, in subsequent years, of occupational or professional attainment.) Again, data that would permit meaningful estimates are not available.[1] Yet another approach, and one suggested in the Technical Study, is based on lost time. Time is lost to the learning process due to the disruptions from aircraft overflights. To the extent that this occurs, it may reasonably be argued, the resources provided to schools and classrooms are wasted. The dollar cost of these wasted resources might be taken, therefore, as a measure of the loss from aircraft noise, or the benefit to be gained from its elimination. A difficulty with this approach is that the lost time may not represent a net loss, for it may be compensated for, or offset, through more efficient use of the remaining classroom time. Or it may be the case that the marginal productivity of classroom time is, in any event, near zero, so that no real loss results from the intermittent noise disruptions.

Notwithstanding these caveats, the lost-time approach is an interesting

[1]The Technical Study, in Chapter 8, suggests that while class achievement levels, in terms of overall averages, is not adversely affected by interruptions from aircraft noise, the achievement levels of students in the lower one-third of the class is permanently reduced, with consequent adverse effects on their occupational attainments and lifetime incomes. However, the evidence offered in support of this outcome is minimal. It comes from a single study that has not been published in the open literature or subject to peer review. There apparently are no other studies affirming similar effects.

one whose implications are worth considering. The Technical Study (pp. 153-4) estimates that aircraft flyovers cause interruptions to the educational process averaging 1000 seconds, or 0.2778 hours, per classroom per school day (with 180 school days per year). It further estimates the ownership and operating costs per classroom at $37.20 per hour at 1977 prices. At 1979 prices, the approximate figure would be $44.56 per hour.[1] In our earlier analysis of insulation costs, we estimated that there were 65 schools within the 65 L_{dn} contour (after use of the modified takeoff and nighttime procedures), and the Technical Study suggests there are an average of 30 classrooms per school.

Using these data, one obtains an estimated cost, or worth, of the time lost from aircraft noise of $4.34 million per year. This figure may be understood as an annual benefit to the schools, or the educational process, of the abatement of aircraft noise in the classroom. In lieu of formally capitalizing this annual benefit, let us take the five-year and ten-year totals which are, respectively, $21.7 million and $43.4 million.

The total cost of insulation for residential dwellings, based on the 1 dB increment assumption, was earlier (in Section II-C) estimated at $210 million. This compares with estimated benefits for residential dwellings of about $58 million on the R-basis and $113 million on the L-basis. Insulation cost on the 5 dB increment assumption was put as $341 million, which compares with benefits, on the same assumption, of $87 million. Allowance for energy savings might reduce the respective cost figures by about half. However, the benefit figures also should be adjusted downward since, as explained above, insulation provides only indoor refief from noise. The

[1] The Consumer Price Index was used for updating.

two types of adjustment are thus in offsetting directions, and if both were made, it does not appear that the balance between costs and benefits would change. For example using the 1 dB increment assumption, if costs as originally estimated were reduced by 50% and L-based benefits as originally estimated by 25%, then resulting costs would be $105 million and resulting benefits $84.5 million.

With regard to schools, insulation costs were previously estimated at $12.4 million. This figure is appreciably below the respective five- and ten-year benefit totals of $21.7 million and $43.4 million.

The purchase of noise easement does not, of course, reduce the noise level, and the worth to property owners of the payments that are made is equal simply to the value of those payments. Hence no meaningful distinction can be made between the cost and benefit sides. Accordingly, for easements, no benefit estimates are given. Easements nonetheless represent a legitimate approach to the airport noise problem, and their possible use should be kept in mind in evaluating alternative strategies. Estimates of the costs of purchasing easements were presented in Table II-9.

With property acquisition, displaced homeowners presumably relocate to quieter surroundings and thereby gain real benefits. For purposes of estimating these benefits, let us assume that relocation is to an area with a noise level of 65 L_{dn}, or the maximum allowed by the proposed regulation. Then households originally at, say, the 79 L_{dn} level would gain a 14 dB reduction, those at the 68 L_{dn} level a 3 dB reduction, etc. The dwellings eligible for acquisition are taken to be those remaining above 65 L_{dn} after the use of the relatively simple and low cost abatement methods, namely the modified takeoff and nighttime procedures.

The resulting benefit estimates are identical to those shown in

Table III-5 for the benefits from insulation in 1 dB increments. The aggregate figure on the R-basis is about $58 million and on the L-basis $113 million. These benefits are far below the estimated total acquisition cost, shown in Table II-10, of $2.7 billion. Benefits remain below costs for the individual noise zones. For dwellings in the 80-85 L_{dn} zone, whose occupants would gain the most from acquisition and relocation, benefits are about $4 million on the R-basis and $10 million on the L-basis, while costs would be approximately $49 million. These estimates, as noted in the preceding paragraph, rest on the assumption that households relocate to the 65 L_{dn} level. Were they to relocate to lower noise levels, estimated benefits when measured on the R-basis would rise, though those benefits would remain far below costs. (Estimated benefits on the L-basis would not change, since the litigation data suggest there are no benefits below 65 L_{dn}.) For example, if displaced households moved to the 60 L_{dn} level, total benefits would rise from $57.69 million to $119.97 million. The latter figure, while modestly larger than the L-based benefit figure, remains far below the cost of acquisition.

It is, of course, to be expected that the costs of acquisition will exceed the benefits from it, since the effect of aircraft noise is to impair the value of residential property, whereas the purchase and demolition of a dwelling, in the absence of opportunities for conversion to other uses, reduced the value of the property essentially to zero. This circumstance reinforces the view that property acquisition, when used as a remedy for noise, should be used in a selective and limited way.

In the face of potential remedies that are not cost-beneficial, is there any approach that would afford some relief or compensation to property owners while restraining the costs to airport authorities? One such approach

is a version of the purchase-guarantee arrangement referred to previously. Under this arrangement, the homeowner would be assured a price for his property, when he chose to sell it, equal to that of equivalent properties in a specified lower noise zone, with any difference being made up, or compensated by the airport authority.

4. Benefits from Curfews and Operations Cutbacks

Like insulation and property acquisition, a nighttime curfew is considered for application following the use of the modified takeoff and nighttime procedures (operations cutbacks, if undertaken, would be applied following the use of curfews). The estimated dollar values of benefits resulting from this abatement strategy are presented in Table III-6. The effect of a curfew is to shift specific numbers of dwellings from their pre-existing zones, e.g. 70-75 L_{dn}, to the next lower zone. Accordingly, the affected dwellings are credited with 5 dB of quieting. The method of calculation is similar to that described above for estimating benefits from modified takeoff and nighttime procedures. Dwellings which, as a result of these prior abatement actions, had been brought below 65 L_{dn} are not recognized as receiving possible additional benefits from the curfew. The results are shown in Table III-6. Aggregate benefits on the R-basis are about $35 million and on the L-basis $43 million. The bulk of the benefits are realized by dwellings in the lower noise zones simply because most of the impacted dwellings are located in those zones.

Since it did not prove possible to develop estimates of the dollar costs of curfews, no comparison of such costs with the estimated benefits presented in Table III-6 can be made. However, a partial basis for assessment was developed earlier in Section II-G, which considered the specific

Table III-6

Estimated Benefits from a Night Curfew

	Noise Zone (L_{dn})			
	65-70	70-75	75-80[1]	80-85[1]
No. Housing Units after Modified Takeoff and Nighttime Procedures	28,532	10,607	2,046	760
No. Housing Units after a Night Curfew	16,434	6,110	1,536	571
No. Housing Units Shifting to Next Lower Zone	17,294	5,196	699	189
Estimated Benefits, R-Basis ($ millions)	$25.68	$ 7.72	$1.04	$0.29
Estimated Benefits, L-Basis ($ millions)	$22.13	$17.29	$2.86	$0.78

Total Benefits, All Noise Zones: R-Basis = $34.73 million
L-Basis = $43.06 million

Source: See text.

[1]Dwellings subject to noise levels of over 75 L_{dn} are assumed to lie within the 75-85 L_{dn} range.

kinds of impacts that a curfew could have on air carriers, passengers, shippers, and the community at large. Further aid in assessment can be gained by examining the benefits of a curfew on a "per airport day" and "per operation eliminated" basis. That is, we can ask: How great are the daily benefits to the surrounding, noise-affected households from the elimination of night flights? Also, how great are these benefits per operation curfewed?

Bear in mind that the benefit figures in Table III-6 are capitalized sums and reflect the curfew's application and effects not for a year or some other brief period, but rather for the indefinite future. It is appropriate therefore, in responding to the questions just asked, to think of allocating or amortizing the benefits over some extended future period, such as five or ten or twenty years. As a specific example, let us consider a ten year period and use a benefit figure of $38.9 million, which is an average of the R-based and L-based values. The estimated average benefit generated per day (or night) to households from an airport curfew is as follows:

$$\$38.9 \text{ million} \div (365 \times 10) = \$10,658$$

This figure should be judged against the collection of daily benefits - to carriers, passengers, shippers and the community - that night flights bring and that would be lost if they were eliminated. Landrum and Brown, in its hearings testimony for the City of Chicago, offered data that permit estimates of air traveler and other airport-related expenditures arising from night flights.[1] Night flight contributions in two categories on an annual basis, are shown below:

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[1] Exhibit 27 in the City of Chicago exhibit book.

Air Traveler Expenditures		
	Direct	$62.9 million
	Induced	94.4 million
	Total	$157.3 million
Airport Related Expenditures		
	Direct	$38.1 million
	Indirect	29.9 million
	Induced	85.0 million
	Total	$153.0 million

On a daily basis, these outlays are about $431,000 for the air traveler category and $419,000 for the airport-related category. These sums cannot be directly compared to the daily benefit figure cited above, since they represent expenditures or costs from night airport activity, rather than benefits from it. But they suggest a scale of benefits from such activity substantially in excess of the benefits that would flow from a curfew. Suppose, for example, the net benefits for each of the categories were but 5% of the outlays. Then such benefits would total about $21,500 per day for the air traveler category and but slightly less for the airport related categories. Each of these figures is double that of the estimated daily benefits of a curfew.

A curfew would on the basis of data in Table II-1, eliminate approximately 143 nightly jet cargo and passenger operations. The daily benefit to households from a curfew of $10,658 thus amounts to about $75 per operation curfewed. In a cost-benefit context, as a first approximation, the question to be asked is whether the net gain from a typical night cargo or passenger operation is equal to or greater than $75. Differently, would

those served by such an operation be willing, collectively, to pay $75 to preserve the service? ($75 would defray about 2.1 minutes of the operating cost of a B-727-200 or about 0.8 minutes of the operating cost of a B-747 freighter.)

It seems safe to conclude, even in the absence of consideration of the short- and intermediate-term dislocation costs that a curfew would bring, that the costs of a complete night curfew would exceed its benefits.

It was earlier pointed out (in Section II-H) that the Technical Study did not develop the implications of operations cutbacks as an abatement action. Hence we are unable to explore any specific scenarios that relate degree of cutback to noise impacted acreage and number of noise-impacted dwellings. However, it is possible to give some definition to the cost-benefit boundaries within which the effects of any cutbacks would fall. Cutbacks would presumably follow a curfew; that is, night flights would be eliminated first. We found immediately above that a large number of dwellings remain above 65 L_{dn} after a curfew. These dwellings are not clustered in one or a few locations, but are distributed widely in all directions from the airport. Suppose the goal were to meet the 65 L_{dn} limit for all, or most dwellings. Then the remaining (daytime) operations, numbering about 1450 per day, would, on an energy basis, have to be reduced to fewer than 100. Such a reduction would completely transform the airport, eliminating it as a major transportation center and altering its role to that of a much smaller facility. The quieting benefits to households from the change would, on an R-basis, total about $89 million,[1] which is about 2.5 times as great as the benefits from curfews. On the L-basis, the benefits would be about

[1] This estimate credits benefits to dwellings down to the 55-60 L_{dn} level.

$70 million, which is about 60% greater than the benefits from curfews. However, the operations cuts needed to generate these benefits would be more than ten times those involved in a curfew. One would expect the costs of the cuts, or benefits foregone as a result of them, to be correspondingly greater also.

The most promising setting in which to consider operations cuts would be one in which dwellings located above, say, 80 L_{dn}, were clustered off the end of a single runway. One might then hope to bring them down to 80 L_{dn} by reductions in the useage of that runway. But in this case one would first want to consider, not cuts, but the shift of traffic to other runways with lower noise impacts. One would also want to consider whether another remedy, such as insulation, easement purchase or a limited acquisition program might not be prefereble.

D. Summary of Costs and Benefits for O'Hare Airport

The costs and property-value-based benefits for alternative abatement strategies are shown in Table III-7. Of the several abatement strategies considered, benefit estimates were developed for all[1] and cost estimates for all but curfews and operations cuts. In the cases where a direct comparison of costs and benefits is possible, only the operational changes and the insulation of schools are clearly cost beneficial. With regard to the operational changes, the modified takeoff procedure incurs but nominal costs - $0.5 million - compared to estimated benefits in excess of $100 million. The modified nighttime procedures involve elements of cost arising from the extension of a runway, but because of a reduction in taxi time and associated fuel savings, there is an overall saving. At the same time, these procedures bring benefits of $14 to $20 million. Benefits from the insulation of schools, estimated at about $43 million, are 3.5 times the costs of that quieting method.

The figures for the costs of insulating residential dwellings make no allowance for the fuel savings that insulation would bring. These savings could cut the effective cost of insulation by perhaps half. At the same time, the benefit estimates are overstated, since they neglect the fact that insulation gives noise protection only when the subject is indoors. Adjusting for the overstatement could reduce the estimates by a third to a half. There is uncertainty as to the proper size of each type of adjustment, but they tend to be offsetting. In the absence of such adjustments, the costs of insulation are well above the benefits it would bring, whether those benefits are measured on an R- or L-basis. It seems unlikely that the adjustments, if they could be accurately made, would alter the basic cost-benefit balance.

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[1] An upper bound for benefits from operations cuts is indicated and discussed in the text, but not shown in Table III-7.

Table III-7

Summary of Costs and Property-Value-Based Benefits for Alternative Abatement Strategies (Figures in $ Millions)

Abatement Method	Costs	Benefits	
		R-Basis	L-Basis
Operational Changes			
Modified Takeoff Procedure	$0.5	$103.5	$120.5
Modified Nighttime Procedures	s	14.2	20.0
Total	s	117.7	140.5
Insulation, 1 dB Increments[1]			
Properties at 65-75 L_{dn}	150.4	46.1	85.4
Over 75 L_{dn}	59.8	11.6	27.5
Total	210.2	57.7	112.9
Insulation, 5 dB Increments[2]			
Properties at 65-75 L_{dn}	266.2	73.9	85.4
Over 75 L_{dn}	74.4	13.6	27.5
Total	340.6	87.5	112.9
Insulation of Schools	12.4	43.4[3]	
Easements[4]			
Properties at 65-75 L_{dn}	85.5	----	----
Over 75 L_{dn}	27.6	----	----
Total	113.1	----	----
Property Acquisition			
Properties at 65-75 L_{dn}	2,525	46.1	85.4
Over 75 L_{dn}	181	11.6	27.5
Total	2,706	57.7	112.9
Curfew			
Properties at 65-75 L_{dn}	n.a.	33.4	39.4
Over 75 L_{dn}	n.a.	1.3	3.7
Total	n.a.	34.7	43.1
Curfew			
Benefits per Airport Day (in dollars)		$10,700[5]	
Benefits per Operation Restricted (in dollars)		75[5]	

Source: See text.

[1]Under this method of estimation, dwellings are assumed to be insulated just in the degree needed to bring them to 65 L_{dn}. The figures shown are before energy savings. Allowance for these savings would reduce costs to perhaps half the levels shown.

[2]Under this method of estimation, dwellings are insulated for 5, 10, 15 or 20 dB of quieting, depending on their respective noise zones. The costs shown are before energy savings. Allowance for these savings would reduce costs to perhaps half the levels shown.

Easements, which would substitute compensation for abatement, bring benefits that are equal to their costs. Estimated total easement costs range from about one-third to a little over one-half of insulation costs (before energy savings), depending on how the latter costs are estimated. Thus, following operational changes, easements appear to represent a least-cost approach.

Property acquisition (and demolition) is the most expensive of the several approaches, with costs far above the benefit estimates. It is reasonable to suppose this approach would be seriously considered only in special instances - where properties were subject to unusually high noise impaction, or where, in a given location, the number of affected properties was few and their removal would facilitate compatible uses of the land, or where the physical safety of the occupants was a central consideration.

Benefit estimates are shown for a curfew, but no satisfactory procedure was discovered for estimating, in a manner conceptually sound, the dollar costs of this abatement strategy. It is helpful to an understanding of the curfew benefit figures to adjust them to an "Airport Day" or

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Footnotes from Table III-7 (continued)

[3]Neither the R-based nor L-based method is used to estimate this figure, as explained in the text.

[4]With the purchase of easements, the noise level remains unchanged. The benefits to property owners are equal simply to the easement costs, or compensation paid.

[5]To calculate this figure, an average of the R-based and L-based totals was taken and a ten year time horizon was used. A longer time horizon would lower the figure and a shorter one would raise it.

[s]denotes saving rather than cost. Annual costs of $0.45 million arising from the modified takeoff procedure and capital costs of $6.3 million arising from the modified nighttime procedure are more than offset by annual savings of $3.1 million arising also from the latter procedure.

n.a. Not available.

"Operation Restricted" basis. The results of this adjustment are shown toward the end of Table III-7. One may then ask, for example, how the benefit of $75 from the elimination of a night flight compares with the probable cost, or benefit foregone, from eliminating that flight. Both curfews and operations cuts represent relatively severe abatement methods as compared to other approaches. This is so because of their categorical nature. With a curfew, for example, a night flight is simply prohibited, regardless of the scale of benefits it may bring to users. Contrast this with an arrangement under which a night flight is permitted, but required to cover its costs, including any noise damages it may cause. (Thus a special charge, scaled to the damage caused, might be imposed on each night flight.) In this latter case, a flight bringing sufficient advantage to its users, as reflected in the revenues it was able to generate, would be able to continue to operate.

This outcome, unlike that from the flat prohibition a curfew would impose, is consistent with the criterion of economic efficiency. Curfews and operations cuts are distinctive also in the extent to which they produce a series of repercussions affecting airport use, carrier scheduling and aircraft utilization, and convenience and mode of passenger travel.

The foregoing findings are based on benefit estimates that rely on the results of differential property value studies. These results as discussed previously, show a degree of concensus, but also of variability. There is the possibility that the true parameters for estimating the benefits from noise abatement are, for one or more noise intervals, somewhat higher or lower than the values used here.

Certain of the cost and benefit estimates given in Table III-7 (and earlier in the text) are in turn based upon estimates of the various noise

contours and the residential acreage contained therein. Errors, for whatever reason, in the latter estimates will thus give rise to errors in the cost and benefit figures. Suppose, for example, that the modified takeoff procedures cannot, in practice, be fully implemented or, if implemented, do not have the full quieting effects anticipated. Then the numbers of dwellings within the 65 and 75 L_{dn} contours will be greater than the numbers on which estimates in this study are based. Accordingly, the insulation, easement and property acquisition costs will also be greater than those here estimated, and so also will be the benefits. But as long as the proportions of dwellings in the respective noise zones do not change, the relation of costs to benefits will not change. Moreover, since the dwellings above 75 L_{dn} constitute a relatively small fraction of total dwellings above 65 L_{dn}, even a significant increase in the dwelling count for the high noise zone would not be likely to affect the cost-benefit balance. The situation with respect to a curfew or operations cuts is different, for benefits are directly dependent on dwelling counts, while costs are independent of them. Hence if more dwellings than has been estimated remain above 65 L_{dn} after application of the modified takeoff procedures, benefits per airport day or per operation restricted will rise.

Of the several abatement options considered, only three - operational changes, curfews and operations cuts - actually reduce noise on the receiving property in the manner required by the proposed regulation. Of the other four options discussed - insulation, easements, property acquisition, and a purchase guarantee arrangement - one would reduce noise only inside the home, while the other three would have no effect on the noise level. Property acquisition would serve to change the land use classification, thereby achieving compliance with the regulation. The securing of easements also would achieve compliance. The regulation makes no mention,

however, of insulation or purchase guarantee. Nonetheless, each represents a valid approach to the problem.

It is difficult to integrate the potentially adverse health and health-related effects of aircraft noise into a cost-benefit framework, since we have not been able to measure directly the dollar losses of these effects or the dollar benefits from reducing them. But some qualitative and approximate judgements are possible. First, in the 1985 base or reference case, before any abatement actions that might result from the proposed regulations, about 103,000 households are subject to noise levels above 65 L_{dn}. (See Table II-3.) Of these, a little under 4%, or 3800, experience levels of more than 75 L_{dn}. It is among this latter group that there is a possible risk of hearing loss if the exposure continues for perhaps 15 or more years. With the use of modified takeoff and nighttime procedures, the size of this potentially vulnerable group would decline by about one-fourth, to 2800 households. Second, for the vulnerable group, noise levels may be sufficiently high to cause some incidence of adverse effects in cardiovascular or other basic functions. Data on this point are lacking, however. But third, the noise levels are sufficient to cause significant degrees of annoyance not only to those subject to more than 75 L_{dn}, but to those at lower noise levels as well. They also are sufficient to cause significant amounts of speech interference and, for those at selected locations, a significant degree of sleep interference.

These adverse effects, except to the extent that they may be of a subtle and long term nature, are not additive to the damages measured by property value changes or differences. Rather the property value differences should reflect those effects and, in their absence, would presumably be negligible or zero.

The mitigation of existing noise impacts at O'Hare through the application of one or more of the abatement methods considered in this study will not, by itself, assure a permanent reduction of the problem. The current situation results essentially from the operation of two forces: first, the growth in commercial jet traffic over the past two decades and the expansion of the airport to accommodate this traffic; second the development of land proximate to the airport for noise-incompatible, residential purposes.[1] Both of these forces can be expected to continue. A considerable amount of open space remains within the 65 L_{dn} contour. Indeed, following the implementation of the modified takeoff and nighttime procedures previously discussed, these would remain within the 65 L_{dn} contour approximately the same amount of acreage given to "open space" (7306 acres) as is presently devoted to residential purposes (7026 acres).[2] Within the 75 L_{dn} contour, the "open space" figure of 706 acres is appreciably larger than the residential figure of 470 acres. Not all of this open space is available for or suited to residential purposes. Some is committed to forest preserves and some to parks, and some is unsuited for homes or apartments because of its topography or location. But a substantial amount of residentially eligible land remains. In the absence of countervailing policy further residential development around the airport seems very likely to take place.

Commercial jet operations are also predicted to grow. The Technical

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[1] There has been significant residential development of land near the airport since the late 1950's. Both infill development - the filling in of empty land within existing built-up areas - and new development have occurred. From 1960 to 1970, for example, Bensenville's population grew by 40% and Wooddale's by 188%. Factors encouraging this growth include expansion of the interstate highway system linking the outlying suburbs with City of Chicago and the growth of the airport itself. See the hearings testimony of Jill D. Tiedt, June 17, 1980, pp. 6220-23.

[2] See the Technical Study, p. 63, Table 4-3, Quieted Case 2.

Study (pp. 53 and 63), on the basis of traffic growth projections in the Master Plan and apart from any further residential construction, anticipates an increase to 1995 of land within the 65 L_{dn} contour used for residential purposes. In 1985, following the implementation of modified takeoff and nighttime procedures, residential acreage would total a bit over 7,000. By 1995, this figure would be expected to grow to about 12,300 acres, an increase of 75%. Projected traffic growth would thus bring the attenuation of favorable effects from any abatement measures that may have been taken or, absent such measures, an intensification of present impaction.

To cope with this problem, consideration might well be given to measures to adapt land uses around the airport to noise compatible purposes. For already developed land that is incompatible, particularly land in the higher impact areas, selective rezoning, intended to bring about conversion over the long term, could be employed. For undeveloped land, direct zoning to compatible uses would be possible. Such measures might be supported by legislation at state or local levels or might be achieved through cooperative efforts by airport authorities and local zoning bodies. They might be further aided through the preparation and publication of noise maps indicating the noise status of the land surrounding the airport. Such maps, if available to all parties during land-use planning deliberations, to developers considering the use of particular tracts, and to the parties to transfers of residential and other properties, would contribute to a fuller and more accurate understanding of the noise problem, to an improved allocation of land among alternative uses, and to a more efficient distribution of properties among users.

IV. SUPPLEMENT ON MIDWAY AIRPORT

A. Introduction

Several factors should be borne in mind in considering Midway Airport's aircraft noise problem and the potential for abatement. First, the airport is not buffered at its periphery by open space or by commercial or industrial development. Residential properties abut the airport solidly to the west and south, and somewhat unevenly but still closely to the north and east. Alternate land uses interrupt the residential pattern only as one moves away from the airport, to the north and south-west. Second, while the airport handles a significant amount of commercial air service, it is still, in terms of numbers of operations, predominantly a general aviation facility. Over 90% of operations fall into this latter category. Third, because of the residential pattern and restrictions arising from runway lengths, there is little opportunity for achieving noise abatement through operational changes of the kind discussed for O'Hare. The modified takeoff procedure recommended for O'Hare, for example, does not produce beneficial effects until about 3.5 miles from start of roll, a distance beyond the 65 L_{dn} boundary for Midway; and alternate runways for shifting traffic are not available. Fourth, there is currently little nighttime activity at Midway and hence no significant opportunity for noise relief through a curfew. Finally, future activity levels at the airport are highly uncertain. Ambitious plans exist for the expansion of air traffic, including plans for the future use of Midway as a reliever facility for O'Hare. But the extent to which such expansion will materialize is quite unclear. As a result, it is difficult to specify the set of noise contours that should be used in alternative approaches to the noise problem.

The noise impacts resulting from four different activity levels are described in Table IV-1. The first and second entries are based respectively on the 1977 Master Plan contours and the projected contours for 1995. The third and fourth are based respectively on the 1979 and 1985 contours presented by Landrum and Brown in its hearings testimony. The 1977 and '79 entries appear best to reflect the recent and current situation. However the '79 entry gives information only for the 80 L_{dn} contour, which is insufficient for the needs of this study. Accordingly our analysis will rely on the '77 Master Plan data of entry (1). While the '77 data are based on a number of total operations about 20% greater than for the '79 data, the number of jet operations is similar for both cases. Hence the underlying contours should be fairly close to one another. Contours for the two sets of data are shown in Figures IV-1 and IV-2.

The sections that follow evaluate for Midway Airport several of the same quieting options considered earlier for O'Hare: insulation, easements, property acquisition, and operations cuts.[1] The costs and benefits for each option are reviewed jointly, in the same section, in contrast to the approach followed previously. However, the methods of analysis are essentially the same as those used above for O'Hare. Since the earlier methodological discussion is not repeated, the treatment of each option is com-

[1] The Technical Study (pp. 21-2) suggests as a noise reduction option for Midway the construction of a new airport. Table 2-13 of the study identifies three possible sites to the south and southwest of the city. Two of these are 18-19 miles from Midway and about 26 miles from downtown Chicago. The third is about 22 miles from Midway and 32 miles from downtown. The Technical Study does not indicate whether a new airport would be a replacement for Midway, with the latter facility closed down; or a supplemental facility intended to hold Midway traffic to current or reduced levels; or an airport that would serve both as a full or partial replacement for Midway and as a facility for traffic displaced from O'Hare. Nor does the Study suggest what the physical characteristics or activity levels of the airport might be or the time frame in which it might become operational. Hence there is no information base on which to develop an economic analysis of a new airport or to assess its economic impact. These factors aside, consideration of a new airport would appear to fall outside the scope of the present study and beyond the intent of the proposed regulation.

Table IV-1

Noise Impacts at Midway Airport, Classified by Data Source

Data Source and Noise Level	Area (acres)	Population	Housing Units
1. 1977 Master Plan contours, 320 daily departures			
65-75 L_{dn}	1,280	20,000	6,000
Over 75 L_{dn}	640	7,000	2,000
2. 1995 Master Plan contours, 510 daily departures			
65-75 L_{dn}	17,280	217,000	65,000
Over 75 L_{dn}	3,200	36,000	11,000
3. 1979 Landrum and Brown Hearings Exhibit 51, 265 daily departures			
Over 80 L_{dn}	n.a.	n.a.	344
4. 1985 Landrum and Brown Exhibit 53, 378 daily departures			
Over 65 L_{dn}	4,300	118,500	36,600

Sources: (1) and (2) from "Airport Development Alternatives", Chicago O'Hare and Midway Master Plan Public Information Meetings, November 6, 7 and 8, 1979. Entries (3) and (4) are from the exhibits contained in Testimony of the City of Chicago Before the Illinois Pollution Control Board, June 16-20, 1980.

n.a. is not available.

paratively brief. The reader may find it helpful at points to refer back to the pertinent parts of that earlier discussion for clarification and elaboration.

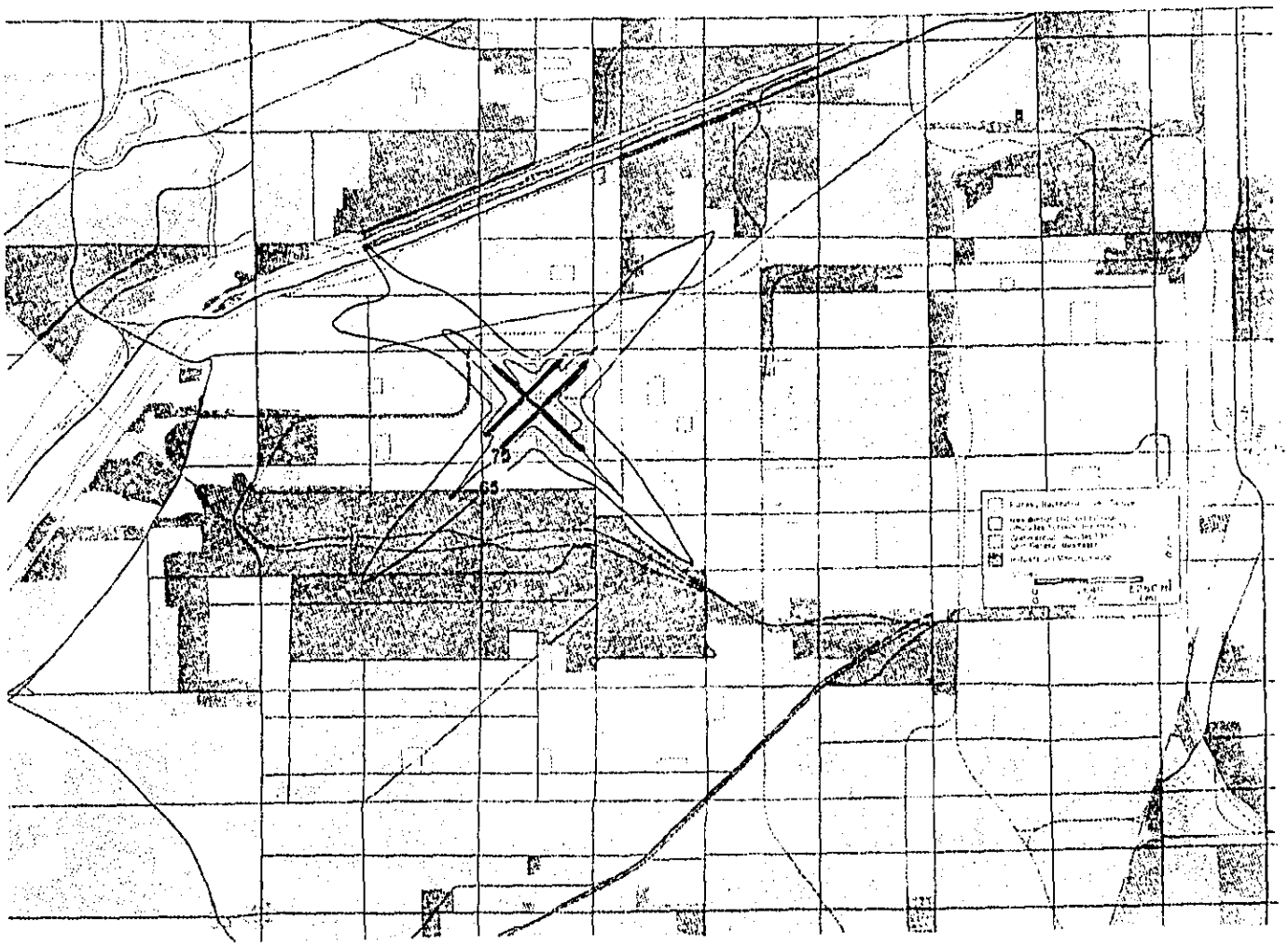

Figure IV-1. 1977 Master Plan Contours for Midway Airport (Figure II-1 of Vol. III).

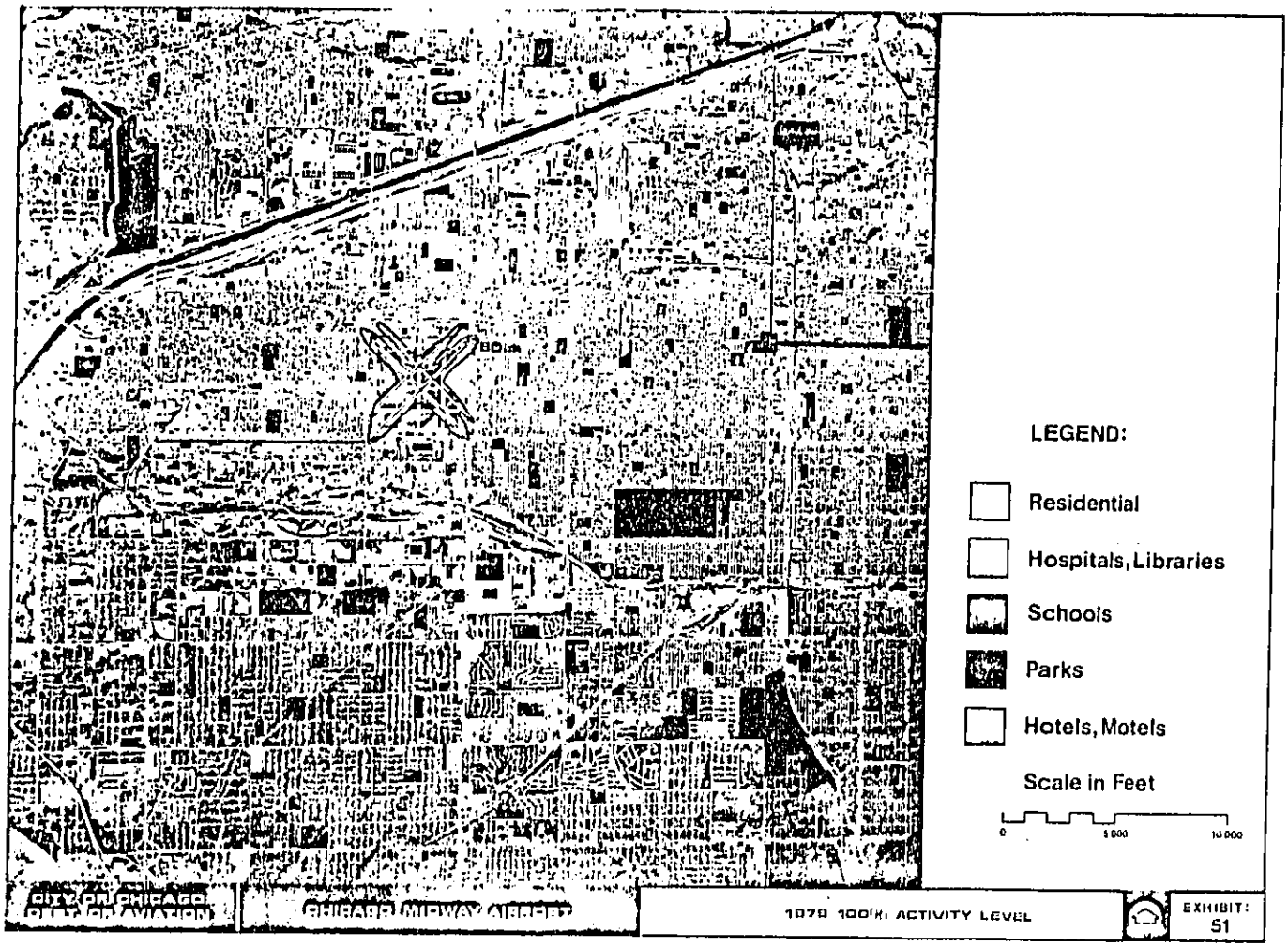

Figure IV-2. 1979 Contours for Midway Airport

B. The Costs and Benefits of Insulation

The costs of insulation are estimated for two distinct cases. The first assumes that dwellings are insulated in 1 dB increments, as needed to meet the 65 L_{dn} limit. The second assumes that dwellings are insulated for 5, 10, 15, or 20 dB of quieting, depending on their respective locations in the 65-70, 70-75 L_{dn} etc. noise zones. The Master Plan reports housing counts only for the 65-75 L_{dn} and over 75 L_{dn} intervals. Housing units have, for present purposes, been further allocated to each of the 5 dB ranges in the manner described earlier in Section II-C. Of these housing units, census tract data indicate that around 80% are single-family dwellings and the remainder multi-family structures.[1] Other coefficients needed for estimation purposes - the cost (per square foot of dwelling) for various amounts of quieting, and the average square footage of single-family and multi-family units (1500 and 800) are taken to be the same as those used for O'Hare.

The resulting costs of insulating dwellings are shown in the first two rows of Table IV-2. The total for all 8000 housing units is estimated at $71 million for the 1 dB increment case and $102 million for the 5 dB increment case. The figures make no provision for the reduction in fuel costs that insulation would bring. Allowance for this factor would reduce the cost figures by perhaps half.

The estimated benefits from insulation are calculated following the same procedures as for O'Hare. However, since these estimates are property-value dependent, it is necessary to use a figure for average dwelling value

[1] U. S. Bureau of the Census, Census of Population and Housing, No. 43, Table H-1, 1972.

Table IV-2

Costs and Benefits of Insulating Dwellings at Midway Airport[1]

(Figures in $ Millions)

	Noise Zone (L_{dn})				
	65-70	70-75	75-80	80-85	Total
Costs, Insulation in					
1 dB Increments	$ 9.8	$15.1	$29.1	$17.3	$ 71.3
5 dB Increments	21.4	22.9	37.2	20.3	101.8
	(4,374)	(1,626)	(1,458)	(542)	(8,000)
Benefits, Insulation in 1 dB Increments					
R-Basis	2.8	3.0	4.5	2.3	12.6
L-Basis	4.6	6.1	10.4	5.7	26.8
Benefits, Insulation in 5 dB Increments					
R-Basis	5.3	4.0	5.3	2.6	17.2
L-Basis	4.6	6.1	10.4	5.7	26.8

Source: See text.

[1]Figures in parentheses indicate number of housing units.

that is appropriate for Midway. Data provided by Landrum and Brown in Exhibit 52 of their hearings testimony, covering 344 housing units within their 80 L_{dn} contour, indicate a mean value per unit of $43,735; while data in their Exhibit 54, covering 36,600 housing units within their 65 L_{dn} contour, indicate a mean value per unit of $41,950. The latter figure, because it is the more representative, is chosen for use here.[1]

The resulting estimates are shown in the lower rows of Table IV-2 on both the R-basis and the L-basis. Benefits are seen to be rather consistently below costs, even when the latter figures are reduced by half to allow for energy savings. The gap is least when one compares the total cost of insulation in 1 dB increments with the corresponding L-based benefits. In this instance, one-half of the cost figure is $35.6 million, while the benefit figure is $28.6 million.

It is appropriate to consider also the costs and benefits from the insulation of schools around the airport. The Master Plan materials do not contain information on the number of schools within the 65 L_{dn} contour, but it may be estimated at perhaps a dozen.[2] However, jet takeoffs occur on only four runways - 13R, 4R, 31L and 22L - aligned in the northeast-southwest and northwest-southeast directions, and only the schools off these runway ends would be subject to the adverse effects of noise. Hence only perhaps six schools would be affected. The number of daily jet operations averages about 135, of which possibly one-half or 68 occur during school

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[1] Supplementary calculations from census data by the present authors suggest that this figure is to be preferred to the higher one.

[2] The O'Hare data suggest the presence of one school per 645 housing units, and statewide data suggest one school per 2000 persons. Both of these sources lead to an estimate of about a dozen schools.

hours. Dividing these 68 among the four runway ends gives 17 operations per day for each of the affected schools. With an average of 20 seconds of lost classroom time per overflight, the daily lost time per classroom and school is 340 seconds, or 0.094 hours. This time would be saved if the affected schools were insulated. This is only about a third of the corresponding time saved at O'Hare. Using the same general estimating procedure as was used for schools at O'Hare, the estimated annual benefits for the six schools at Midway are about $136,000 and benefits over a ten year period would be $1.36 million. Insulation costs would be expected to be about the same as at O'Hare, or $191,000 per school, and the six school total would be $1.15 million. Thus 10-year benefits are modestly in excess of costs. This outcome differs somewhat from that for schools near O'Hare. There, with much higher jet activity rates, 10-year benefits were found to be substantially in excess of costs.

C. The Cost of Noise Easements

To estimate prospective easement costs at O'Hare Airport, reliance was placed on data from inverse condemnation actions at Los Angeles International Airport. Those data indicated that easement costs, as a percent of property value, would run about 2.5% for properties in the 65-70 L_{dn} range, 9% for properties in the 70-75 L_{dn} range, and 17% for properties in the 75-80 L_{dn} range. An extrapolation of these figures suggests perhaps 25% for properties in the 80-85 L_{dn} range.

The properties (housing units) around Midway were noted above to have an average value of $41,950. Using this value in conjunction with the stated percentages produces, for properties within the 65 L_{dn} contour, the estimated easement costs shown in Table IV-3. The total is $26.8 million, with 60% of the total arising from dwellings located close in to the airport at over 75 L_{dn}. Easement costs are considerably less than insulation costs - only 26% to 38% as great, depending on the insulation alternative chosen.

Easements may be thought of as substituting compensation for abatement. Hence they bring benefits that are equal to their costs.

Table IV-3

Costs of Easements at Midway Airport[1] (Figures in $ Millions)

	Noise Zone (L_{dn})				
	65-70	70-75	75-80	80-85	Total
Costs of Easements	$4.6 (4,374)	$6.1 (1,626)	$10.4 (1,458)	$5.7 (542)	$26.8 (8,000)

Source: See text.

[1]Figures in parentheses indicate number of housing units.

D. The Costs and Benefits of Property Acquisition

Property acquisition at Midway Airport, if employed in literal fashion to comply with the regulation, would entail the purchase and demolition of some 8000 housing units. To estimate the cost of such a program, the same general procedure is followed here as was followed, and fully explained, for O'Hare Airport (See Section III-E). The cost per dwelling is put at 1.26 times the dwelling's value, to allow for relocation benefits and administrative costs. As at O'Hare, no allowance is made for possible offsets to costs through redevelopment of the acquired properties.

Estimated acquisition costs are shown below in the first row of Table IV-4. The total is $423 million, of which 75% is for the 6000 dwellings in the 65-75 L_{dn} range and the balance for the 2000 dwellings above 75 L_{dn}.

Table IV-4

Costs and Benefits of Property Acquisition at Midway Airport[1]

(Figures in $ Millions)

	Noise Zone (L_{dn})				
	65-70	70-75	75-80	80-85	Total
Cost of Property Acquisition	$231.2 (4,374)	$85.9 (1,626)	$77.1 (1,458)	$28.6 (542)	$422.8 (8,000)
Benefits from Property Acquisition					
R-Basis	2.8	3.0	4.5	2.3	12.6
L-Basis	4.6	6.1	10.4	5.7	26.8

Source: See text.

[1]Figures in parentheses denote number of housing units.

With the purchase of their dwellings, households would relocate, generally to quieter areas. The benefits from relocation are shown in the last two rows of the table. The figures reflect the assumption that relocation is to the 65 L_{dn} level. Even on the higher or L-basis, the benefits remain far below costs for each of the respective noise zones. Aggregate benefits of $26.8 million compare with costs that, at $423 million, are over 15 times as great. If dwellings were to relocate to yet lower noise levels than the assumed 65 L_{dn}, estimated benefits would rise when measured on the R-basis (though not on the L-basis). For example, if displaced households moved to the 60 L_{dn} level, total benefits would rise from $12.6 million to $22.3 million. The latter figure, however, is still somewhat below the L-based benefit measure.

The cost-benefit outcome is essentially the same as that found for property acquisition at O'Hare Airport. Indeed, it could not be otherwise, given the cost and benefit coefficients used in estimation. The conclusion is therefore the same as in the O'Hare case: Property acquisition, if used at all, should be reserved to special, localized situations in which other remedies may be inappropriate, and preferebly to situations where redevelopment opportunities may exist.

E. The Costs and Benefits of Operations Cutbacks

1. Introduction

Just as drastic decreases in activity would be necessary at O'Hare to achieve 65 L_{dn} at the nearest residential property, so would substantial cuts need to made at Midway, notwithstanding its considerably lower activity levels. Different scenarios are possible, depending on the form or pattern the reductions take. One option would be to eliminate all jet operations, which presently constitute a little more than 20% of total operations. The effect of this action would be to transform the airport into a limited-service facility for propeller-driven commuter and general aviation aircraft. Besides shrinking current operations, such action would foreclose not only current commercial jet activity, but the planned expansion thereof.

A second option would be to implement "across-the-board" reductions in flights, with the operations of different aircraft types reduced by an equal percentage. With this option, the permissible number of operations consistent with 65 L_{dn} would fall drastically to the neighborhood of 15 to 25 per day. The general dimensions of this approach are illustrated in Hearings testimony by the City of Chicago. Table IV-5 below, based on this testimony, lists the estimated 1985 activity levels as well as the projected daytime cutbacks necessary to achieve 65 L_{dn} or less. As the table shows, all commercial air carrier activity would have to be eliminated. In addition, all but 20 general aviation operations daily including four jet operations, also would be eliminated to reach 65 L_{dn}. Such levels of cutbacks represent an effective, but severe method of noise reduction. Overall, operations at Midway estimated for 1985 would be reduced by 97%. This reduction is based on the projected 1985 activity levels shown in Table IV-5. These levels are roughly double the

Table IV-5

1985 Estimated Daily Activity Reductions, Midway Airport

Aircraft Type	Original Schedule	Daytime Reductions	Reduced Schedule	Percent Decrease
Two Engine Wide Body	4	4	-	100%
DC 9 with SAM[1]	66	66	-	100
727 with SAM[1]	28	28	-	100
727 Adv. with SAM[1]	26	26	-	100
Light Turbojet	39	37	2	95
Medium Turbojet	17	17	-	100
Heavy Turbojet	17	17	-	100
Medium Turbofan	18	18	-	100
Medium Twin Engine Turboprop	48	46	2	96
Light Twin Engine Piston 6 Place	48	46	2	96
Light Single Engine Piston 4 Place	172	166	6	97
Medium Single Engine Piston 6 Place	172	166	6	97
Medium Twin Engine Piston 10 Place Quiet	14	14	-	100
Medium Twin Engine Piston 10 Place Loud	28	28	-	100
Light Twin Engine Turbofan Quiet	58	56	2	97
Total	755	735	20	97

Source: Exhibit 58, City of Chicago Testimony.

[1]With SAM: Aircraft which meet FAR 36 with Sound Absorbing Material.

1979 levels. But with this scenario, no matter which level we start from, the number of permissible flights to achieve 65 L_{dn} remains the same. The required reduction from the lower 1979 level would thus be around 94-95%.

To achieve 80 L_{dn} (rather than 65 L_{dn}) at the nearest property through "across-the-board" cuts would require smaller, but still substantial activity reductions. Operations would have to be cut to perhaps 35-40% of the existing level. In terms of the 1977 Master Plan scenario, this would mean a reduction in the number of daily departures from 320 to around 120, with the number of jet departures declining from about 70 to 26.

2. The Role of Midway Airport

One of the greatest economic values of Midway lies in its location and the resulting convenience of its services to users. In contrast to O'Hare, by far the majority of traffic at Midway is general aviation business and personal travel. Air cargo and commercial passenger activity at Midway are minor portions of total traffic. The levels of cutbacks needed would seriously impair the flow of such traffic. Indeed, 20 operations per day is far below the minimum needed to justify retention of the airport.

The contributions of general aviation aircraft, including business aircraft, are varied. They allow individuals and businesses to utilize time and manpower more efficiently. The growth of corporate flying, in particular, has led to sizeable savings for business. Some statistics may help reveal the growing importance of corporate aviation. In 1979, approximately 27 percent of the total general aviation fleet in the United States, or about 50,000 aircraft, were business aircraft. Nearly 10 percent of these were turbine powered. In addition, a recent study shows that 514

of the top 1,000 American industrial firms listed by Fortune Magazine operate their own business aircraft - a total of 1,773 planes.[1]

Business aircraft are used because they are convenient, flexible, and highly mobile. The plane can be scheduled to go where the firm wants it to go, and to arrive at a specified time. Greater mobility and flexibility allow the firm to decentralize and to maximize the potential of plant locations. It can diversify its operations and compete in previously unpenetrated markets. In addition, executives lose no time waiting for scheduled aircraft and need not break off their activities in order to "catch a plane". They frequently hold conferences, empty their briefcases of work, or plan the day's meetings on board.

Airport development and the availability of air transportation bring a variety of primary and secondary benefits to the near-Midway community. They increase economic activity, and with it the economic well-being of the area. As the airport expands, its revenues grow: landing fees, gasoline sales, handling fees, parking and concession fees all rise. The air facilities also attract new business, create new investment and jobs, and increase the demand for local goods and services. With these changes, the tax base grows and local revenues increase.[2]

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[1] McCarthy, Michael J., "The Impact of General Aviation on a Local Economy," Conference on General Aviation Airport Noise and Land Use Planning, Georgia Inst. of Tech., Atlanta, GA, October 3, 1979, p. 86.

[2] When substantial portions of Midway's activity were moved to O'Hare in the early 1960's, there was a major reversal in the benefits that the airport brought. See Urban Systems Research & Engineering, Inc., The Chicago Midway Airport Study: Final Report, prepared for the Federal Aviation Administration, Washington, 1974.

3. Some Effects of Operations Cutbacks

The prevailing degree of air service at Midway is supported by the existing market and may be presumed to represent a variety of net social benefits exclusive of any environmental externalities. The cost of operations cutbacks, through the elimination of daytime flights, should be measured by the loss of these benefits.

Testimony by the City of Chicago illustrates the possible impact of a reduction in activity of the magnitude needed to achieve 65 L_{dn} at the nearest residential properties. The testimony suggests that such a reduction would lead to the elimination of 874 direct employee positions and a decrease in direct payroll of over $12.2 million per year. In addition, direct airport-related expenditures would fall by more than $14.4 million.[1] Operations cutbacks could also be expected to create indirect and induced effects upon the local economy of relative magnitudes similar to those previously described in the section on the multiplicative effects of quieting measures at O'Hare (See Section II-I).

4. The Benefits of Operations Cutbacks

The regression and litigation approaches to estimating the benefits to households from noise reduction, designated respectively as R-based and

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[1] See Exhibit 47 of the exhibits accompanying the City of Chicago's testimony before the Pollution Control Board, June 16 thru 18, 1980. The figures reflect a reduction from estimated 1985 activity levels, which are about double those of 1979.

L-based, were explained earlier in Section III-C. Those same approaches are used here to estimate benefits at Midway Airport.

The properties closest to Midway presently experience noise levels in the range of 80-85 L_{dn}. Operations cuts sufficient to bring those levels to 65 L_{dn} would, of course, bring more distant properties to noise levels below 65 L_{dn}. (The cuts would also, as noted above, eliminate Midway as a viable airport.) It is problematic, when estimating on the R-basis for this latter group, as to how far below 65 L_{dn} to credit benefits. If we allow for benefits down to the 55-60 L_{dn} level, then the estimated total of such benefits would be about $26.3 million. On the L-basis the benefits would be essentially the same, or $26.8 million. These totals would be augmented slightly by the benefits previously estimated for schools (on a 10-year basis) of $1.4 million. The resulting overall totals would be $27.7 million on the R-basis and $28.2 million on the L-basis. For convenience in further discussion, let us use the mean value of these two figures, or $28.0 million.

We have no direct estimate of the cost of the operations cuts required to generate these benefits. It is helpful, however, as an aid in assessment, to follow the procedure used earlier for O'Hare and calculate the benefits "per airport day" and "per operation eliminated". Since the benefit figure is a capitalized sum that reflects the flow of benefits over the indefinite future, it is appropriate to allocate or amortize the $28.0 million over some extended interval, such as five or ten or twenty years. As a specific example, let us consider a ten year period. The estimated average benefit generated per day to households from a reduction in operations to about 20 per day is then:

$$\$28.0 \text{ million} \div (365 \times 10) = \$7,671 \ .$$

This figure is about $3000 less than the corresponding daily benefit estimated to accrue to O'Hare households from a night curfew. It amounts to a little under $1 per day for each of the 8000 affected households. It should be judged against the collection of daily benefits to the users of Midway - commercial carriers and their passengers, business aircraft and other general aviation aircraft - indicated in the preceding section.

The operation cuts in question, under our base case scenario of about 640 daily operations, would eliminate all but 20 of those operations. The daily benefit to households of $7,671 thus amounts to approximately $12 per operation eliminated. In a cost-benefit context, the question to be asked is whether the net gain to air service users from a "typical" flight at Midway is equal to or greater than $12? Differently, would those served directly and indirectly by such a flight be willing collectively to pay $12 or more to preserve the service?

F. Summary of Costs and Benefits for Midway Airport[1]

The costs and property-value-based benefits for alternative abatement strategies are shown in Table IV-6. Of the several abatement strategies considered, benefit estimates were developed for all and cost estimates for all but operations cuts. In the cases where a direct comparison of costs and benefits is possible, only the insulation of schools appears to be cost beneficial. Benefits from the insulation of schools, estimated at $1.4 million, are modestly in excess of insulation costs, estimated at $1.2 million.

The estimates for the costs of insulating dwellings make no allowance for the fuel savings that insulation would bring. These savings could cut the effective costs of insulation by perhaps half. Allowing for this reduction; for the case of insulation in 1 dB increments, costs would remain well above benefits, whether the latter be measured on the R- or L-basis. The most favorable case for insulation is that for dwellings in the 65-75 L_{dn} range. In this instance, allowing for energy savings, costs are only about 20% above L-based benefits. With insulation in 5 dB increments, the resulting costs, even when reduced by half, remain well-above benefits, whether measured on the R- or L-basis.

Easements, which bring benefits equal to their costs, appear to represent a least-cost approach. They cost significantly less than insulation, even with allowance for energy savings, and far less than property acquisition. Not surprisingly, given the methods of measurement, they match the benefits (when measured on the L-basis) from operations cuts.

The benefits per airport day figure of $7671 shown at the end of the

[1]Regulatory enforcement costs associated with Midway Airport are briefly considered in Section II-J above.

Table IV-6

Summary of Costs and Benefits for Alternative Abatement Strategies

(Figures in $ Millions)

Abatement Method	Costs	Benefits R-Basis	Benefits L-Basis
Insulation, 1 dB increments[1]			
Properties at 65-75 L_{dn}	$24.9	$ 5.8	$10.7
Over 75 L_{dn}	46.4	6.8	16.1
Total	71.3	12.6	26.8
Insulation, 5 dB Increments[2]			
Properties at 65-75 L_{dn}	44.3	9.3	10.7
Over 75 L_{dn}	57.5	7.9	16.1
Total	101.8	17.2	26.8
Insulation of Schools	1.2	1.4[3]	
Easements[4]			
Properties at 65-75 L_{dn}	10.7	-	-
Over 75 L_{dn}	16.1	-	-
Total	26.8	-	-
Property Acquisition			
Properties at 65-75 L_{dn}	317.1	5.8	10.7
Over 75 L_{dn}	105.7	6.8	16.1
Total	422.8	12.6	26.8
Operations Cuts			
Properties at 65-75 L_{dn}	n.a.	16.6	10.7
Over 75 L_{dn}	n.a.	9.7	16.1
Total	n.a.	26.3	26.8
Operations Cuts			
Benefits per Airport Day (in dollars)		$7,671[5]	
Benefits per Operation Eliminated (in dollars)		12[5]	

Source: See text.

[1]Under this method of estimation, dwellings are assumed to be insulated just in the degree needed to bring them to 65 L_{dn}. The figures shown are before energy savings. Allowance for these savings would reduce costs to perhaps half the levels shown.

[2]Under this method of estimation, dwellings are insulated for 5, 10, 15, or 20 dB of quieting, depending on their respective noise zones. The costs shown are before energy savings.

[3]Neither the R-based nor L-based method is used to estimate this figure, as explained in the text.

[4]With the purchase of easement, the noise level remains unchanged. The benefits to property owners are equal simply to the easement costs, or compensation paid.

[5]To calculate this figure, an average of the R-based and L-based totals was taken and a ten year time horizon was used. A longer time horizon would lower the figure and a shorter one would raise it.

n.a. - not available

table indicates the gains to households (from noise reduction) through operations cuts to achieve 65 L_{dn}. Cuts of this order would effectively eliminate the airport. It follows that if the airport is to remain open, it should provide (net) daily benefits to users, and to others who may be secondary and indirect beneficiaries, in excess of $7671. Reference to the material in Sections II-H and I and IV-E 2 and 3 above is helpful in seeking to assess this issue. The same issue can be considered in terms of the benefits per operation eliminated figure of $12. Assessment in this case might more easily focus on the (average) worth to a user, or willingness to pay, for continued opportunity to use the airport.

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