BOSTON-LOGAN INTERNATIONAL AIRPORT ENVIRONMENTAL IMPACT STUDY

VOLUME 1

Submitted to

MASSACHUSETTS PORT AUTHORITY

MAY, 1971

By

LANDRUM & BROWN, INC.

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massport
470 ATLANTIC AVENUE, BOSTON, MASSACHUSETTS 02210 (617) 482-2930

June 2, 1971

Gentlemen:

Transmitted herewith is a copy of the Draft Environmental Statement and Report regarding the proposed improvements to the Boston-Logan International Airport as required by the Environmental Protection Act of 1970.

The Report is both voluminous and technical. Recognizing this and wishing to be of as much assistance as possible to all interested parties, the Port Authority is starting today, Wednesday, June 2, 1971, providing a representative to answer any questions which may occur. Questions can be directed to this representative at the Massachusetts Port Authority's Environmental Services Office, telephone 482-2930, Ext. 272. This office will be open daily Monday through Saturday, 9 AM to 6 PM.

Sincerely,

MASSACHUSETTS PORT AUTHORITY

Edward J. King

Edward J. King
Executive Director

EJK/cab
Attachments

NOTE

The analysis of the impact of aircraft noise in the vicinity of the Boston-Logan International Airport contained in this report is based on methodology designed to compare the past, present and future noise situation and not intended to indicate a lack of responsible operation action on the part of any organization or individual.

THIS ENVIRONMENTAL IMPACT STUDY

IS PRESENTED IN TWO VOLUMES

VOLUME I - Presents Detailed Reports of Studies Performed by the Consulting Team

VOLUME II - Presents Additional Research Reports Prepared by the Consulting Team and by the Massachusetts Port Authority

(DRAFT) ENVIRONMENTAL
IMPACT STATEMENT

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<u>BOSTON-LOGAN INTERNATIONAL AIRPORT</u>

(DRAFT) ENVIRONMENTAL IMPACT STATEMENT PURSUANT TO SECTION 102 (2) (c), P.L. 91-190

Submitted To

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

MAY, 1971

By

MASSACHUSETTS PORT AUTHORITY

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
(DRAFT) ENVIRONMENTAL IMPACT STATEMENT
PURSUANT TO SECTION 102 (2) (c), P. L. 91-190

The Massachusetts Port Authority, Suffolk County, City of Boston, Massachusetts has submitted a request for Federal financing assistance under the Airport Development Act of 1970 for a project to improve Boston-Logan International Airport by adding parallel runway 15L-33R, extensions to runways 4L and 9 and STOL runway 15-33, to the airport.

1. Description and Purpose of the Project.

a. Description. The proposed airport improvement program is depicted on Exhibit 11-5 and consists of the following items:

(1) A new 9,200 foot runway 15L-33R, 1,200 feet from and parallel to existing runway 15R-33L, together with associated taxiways, extended runway safety area, and navigational aid facilities. In order to construct the new runway 15L-33R the following will be required:

- Dredging, disposal of dredged material and landfill as shown below with reference to the areas designated on the master plan Exhibit 11-5.

Area	Dredging Required	Landfill Required
BH-A	250,000 cubic yards	2,700,000 cubic yds.
BH-B	-	2,600,000 cubic yds.
BH-C	-	200,000 cubic yds.

- Construction of earth and stone dikes as designated on the master plan.

- Interceptor drain construction.

All of the fills will be accomplished within airport property as shown on Exhibit 11-5. The specifications for the fill material and the general design of the dikes has been completed by the firm of Fay, Spofford and Thorndike. The latter is discussed in Chapter IV of the attached report and in Appendix D.

(2) Extension of Runway 9 by approximately 1,900 feet and Runway 4L by approximately 1,200 feet, together with associated taxiways. The existing landing thresholds will remain in the same positions.

(3) A new STOL Runway 15-33 approximately 2,400 feet in length, together with associated taxiways.

(NOTE: The latter two airfield improvements will be located within the Bird Island Flats area where filling operations commenced prior to May 27, 1970, and are not subject to this application.)

NOTE No. 1 - The master plan is fully discussed in Chapter II of the attached report.

b. Purpose. Traffic and passenger demand at Boston-Logan International Airport will increase. The present national economic downturn and corresponding curtailment of aviation growth represents a periodic fluctuation on the effect of the forecasted long-term growth of air carrier usage. Airport improvements are required to accommodate the demand in 1975 and to make a major reduction in noise exposure compared to today's airport. At the same time only the improved airport allows for a significant reduction in particulate air pollutant emissions compared to today's airport and limits the increase of other air pollutants.

(1) Runway 15L-33R. This new runway is of highest priority and is urgently needed if Bostón-Logan International Airport is to adequately serve the expanding air transportation requirements of the Boston region and to minimize environmental impact. The demand for air service at Boston-Logan International Airport, both scheduled and other, will continue to increase in the future. The traffic forecasts are shown below.

Landrum and Brown Aircraft Operations Forecasts

	1975	1980	1985
Air Carrier	246,300	274,300	295,200
Other	142,100	181,400	216,300
Total Aircraft Operations	388,400	455,700	511,500

FAA Forecasts	1973	1977	1982
Air Carrier	220,000	255,000	296,000
Other	118,000	120,000	141,000
Total Aircraft Operations	338,000	375,000	437,000

NOTE No. 2 - Traffic forecasts are completely discussed in Chapter I of the attached reports.

(2) Parallel Runway 15L-33R is required to meet the forecasted traffic demand. The capacity of the existing airport is compared to the improved airport in the table below:

	1970*	1975**	1980***
	Condition 1	Condition 4	Condition 5A
Existing Airfield	368,000	313,000	340,000
	Condition 6A	Condition 6	Condition 6C
Improved Airfield	417,000	348,000	398,000

* Without wide-body jets.
** With wide-body jets and preferential runway use. The wide-body vehicles require greater spacing.
*** With computer aided approach sequencing and reduced separation requirements which should be realized in the 1980 time period.

Other major reasons for the improved airport are discussed briefly below and in detail in the attached report.

- Parallel runway 15L-33R will substantially reduce overall noise exposure by providing the capability for preferential runway utilization permitting maximum use of overwater approaches and departures. This technique will provide maximum noise relief as compared to the other operational alternatives to cope with the 1975 traffic projections.

- Without the new parallel runway, aircraft delay will be significantly increased as shown by the delay figures below and as discussed in detail in Chapter II and in Appendix A of the attached report.

	Existing Airport Noise Abatement Plan No. 1	Existing Airport Noise Abatement Plan No. 2	Improved Airport
Total Annual Delay Hours	20,573	15,480	11,274

The delay hours above for the existing airport are probably understated compared with what might actually be achieved since the PANCAP is so much lower for the existing airport. This level of delay would create an extremely difficult air traffic management program because of the low PANCAP during problem periods such as bad weather. In addition, the air pollution caused by the extra delay time should be prevented.

- Runway 15L will provide capability for a Category II instrument landing system on a runway heading which will permit aircraft operations under a wider variety of weather conditions than the present runway system can accommodate.

- Operational flexibility of Boston-Logan International Airport's existing runway system is severely limited in comparison with other major airports by two principal factors.

  - Only one set of parallel runways is presently available.

  - This single set of parallels is only partially usable due to restrictions on heavy aircraft takeoffs to the northeast and landings to the southwest (Runway 4L-22R).

In summary, the purpose is to meet the traffic demand with an airport which has enough capacity to permit management for minimum environmental impact since the number of residents within the NEF-40 contour can be minimized and the air pollution emissions will be reduced. To compliement the airfield development, the planned terminal facility improvement program presents an excellent solution to major terminal complex development within a severely restricted land area.

NOTE No. 3 - Capacity is discussed in detail in Chapter II and Appendix A.

2. <u>The Probable Impact of the Project on Both the Human and Natural Environment.</u>

a. The analysis of the impact on the human environment has been the major emphasis of the study which resulted in the attached report and its appendices. The various operational patterns were explored to determine how to minimize the residents within the NEF-40 contours while meeting the demand for air transportation. The results and conclusions will be summarized below but, in general, the improved airport will provide a net benefit in its impact on the human environment. This mainly is due to the major reductions in number of residents within the NEF-40 contours and reduction in delay time with a corresponding reduction in air pollution. At the same time the improved airport will reduce the number of schools and hospitals within the NEF-40 contours. The conclusions reached on significant actions affecting the human environment in connection with the development proposed in this project are as follows:

(1) As evidenced by the minutes of the public hearing held on February 26, 1971, numerous newspaper articles and statements by public officials on the project are considered controversial. Opposition was strongly expressed during the initial public hearing. This statement and its supporting data and report answers the questions raised at the hearing. The complete analysis clearly demonstrates that the improved airport will minimize the impact of noise which was and has been for a long time the source of complaint by some community residents.

(2) The results of the calculations performed by Bolt, Beranek, and Newman, Inc. show that the construction of the new runway and the introduction of new aircraft will reduce the number of residents within the NEF-30 and NEF-40 contours by forty percent (40%) and sixty-four percent (64%) respectively in 1975, as compared to conditions existing in 1970.

The results of the BBN calculations are shown below and are discussed.

Condition	1	2	3	4	5	6
Airport Configuration	Existing	Existing	Existing	Existing	Existing	Improved
Traffic Projections	Actual 1970	1975	1975	1975	1975	1975
Runway Utilization	Historic	Maximum Capacity	Historic	Noise Abatement Alt. No. 1	Noise Abatement Alt. No. 2	Maximum Noise Abatement
NEF - 30						
Acres (1000's)	12.1	14.7	13.2	8.3	10.4	8.8
Population (1000's)	121.4	139.9	127.3	71.6	92.7	72.8
NEF - 40						
Acres (1000's)	3.1	2.8	3.1	2.5	2.7	2.1
Population (1000's)	24.4	17.0	23.8	11.4	14.2	8.9

This significant reduction of noise impact with airport improvement will be possible because of preferential runway use which can be carried out with a minimum of air traffic management problems. It is the only way to provide short-term noise relief and will provide even more noise relief for the long-term as the new quieter aircraft enter service. As can be noted from the above table, the improved airport provides the best solution of all alternatives because Condition (4), the next best alternative, results in an increase of twenty-eight percent (28%) as compared to the improved airport with respect to residents within the NEF-40 contour. In addition, Condition (4) results in increased air pollution as will be discussed below.

Environmentally, the approach to runway 15L, which will be primarily a landing runway, is better than the approach to 15R as now extended. The reasons are: Not only is there sufficient land for full ILS and ALS systems, but the approach to 15L is over an area containing fewer close-in residences. In fact, the distance now between the closest residence on the extended centerline, from the physical end of 15R is approximately 1, 870 feet, and 2, 750 feet with its displaced threshold. The closest residences to the physical end of the proposed runway 15L will be from 3, 550 ft. (off extended centerline) to 4, 550 ft. (on extended centerline). The sideline distances from the proposed 15R-33L runway and Winthrop range from 2, 460 ft. to 3, 230 ft. The existing runway, the longer of the two, will be used for departures. This is shown in Exhibit III-14.

This new runway has also been positioned to provide maximum distance from Winthrop and yet maintain adequate separation from the existing runway 15R-33L. This runway is not anticipated to increase the degree of existing lateral noise levels in Winthrop. The measured distances from the nearest residences in Winthrop to 15L-33R are 2, 460 feet in a lateral direction as compared to 1, 000 feet from the end of existing runway end 22L.

NOTE No. 4 - Noise is discussed in detail in Chapter III and Appendix B of the attached report.

(3) Air pollution as a result of airport operation is small in comparison to other sources in the area. The improved airport will further reduce air pollution in comparison to today's operations because of the reduction in waiting time during taxiing and waiting for takeoff that are made possible by the new runway.

- Field measurements of air pollutants included oxides of nitrogen, oxides of sulfur, carbon monoxide and particulate matter and showed lower levels on the present airport than in the surrounding communities by a factor of approximately two (2) which means that the concentrations of pollutants at the airport are about one-half those existing in the surrounding communities.

- The reduced aircraft departure waiting time, made possible by the construction of the new runway, will result in reductions of air pollution generated by aircraft ground operations expected to occur in 1975, when compared to 1975 ground operations using the existing airport (i.e. with no new parallel).

  - Carbon Monoxide (CO) will be reduced by 7,823.6 Tons/Year

  - Nitrogen Oxides (NO_x) will be reduced by 214.1 Tons/Year

  - Particulates (C) will be reduced by 1,110.6 Tons/Year

  - Hydrocarbons (HC) will be reduced by 429.3 Tons/Year

- New "smokeless" aircraft power plants will cut particulate emission by approximately one-half.

  - The J8TD retrofit programs on DC-9's, 727's, 737's will be essentially completed by the end of 1972.

  - The new engines in the 747, DC-10 and other wide-body aircraft will incorporate the "smokeless" engine.

- Strict enforcement against "venting" of holding tanks will eliminate liquid fuel emission.

- Current and projected levels of air pollutants at the airport are below the generally accepted safe levels as defined by the Environmental Protection Agency and thus will not adversely influence any activity including recreation and swimming.

NOTE No. 5 - Chapter V includes an in-depth analysis of air pollution.

(4) Water pollution will not be significantly affected by the proposed project as a result of fill and dike construction. There will be a net decrease in harbor pollution, although the contribution was minimal, as a result of measures already taken by the Massachusetts Port Authority and new oil separation facilities which the Authority has planned to install on their drainage systems.

- The firm of Fay, Spofford, and Thorndike have written specifications for the dredging and disposal process which have been given approval by the Environmental Protection Agency as a non-polluting method.

- The same firm has issued specifications for fill material and dike construction that will result in no pollution from these sources.

- The only possible impact on human health would come from the City of Boston sewer which discharges into the BH-C embayment. The landfill currently planned is so small that measurement of its effect would be impossible since the BH-C fill will only reduce the BH-C embayment area volume by about 3.7%. Thus, the dilution volumes remain essentially unchanged. This is compared to a volume of thirty-seven percent (37%) which was originally planned for the fill prior to completion of the environmental studies.

NOTE No. 6 - A complete analysis of water pollution and calculations relative to the BH-C embayment is included in Chapter IV and Appendix C.

(5) No displacement of people will be required for this project. Also mentioned earlier it will provide noise relief.

to nearby residents in terms of greater physical separation from existing residences.

b. The improved airport with the addition of runway 15L-33R will have a minimal effect on the natural environment. There will be a net decrease in particulate air pollution. Other air pollutants will not exceed the levels prescribed by the Environmental Protection Administration for primary and secondary standards. The clam beds which are now restricted will be moved to a new location where they may be rehabilitated. The water around the airport will be improved as a result of the action that is already underway to install separation devices to separate any possible oil spills from the drainage water. The major conclusions reached on significant actions affecting the natural environment, which include considerations in accordance with Section 4 (f) of the DOT Act are .

(1) The project is exempt from the DOT Act Section 4 (f) because none of the land involved is privately or publicly-owned since the construction is entirely within the boundaries of the airport.

(2) The project will not alter, destroy, or derogate from any recreational areas or public parks. There will be a net improvement on the general area as demonstrated by the reduced noise contours. The noise reductions, discussed in greater detail elsewhere, will improve the recreational uses of Castle Island, South Boston, and Orient Heights Beaches.

The recreational use of Orient Heights beach will not be affected as a result of the project because the fill now planned is so small that dilution will not change. The recreational changes with respect to the use of the clam beds in the BH-B and BH-A areas will increase because these beds will be moved at Massachusetts Port Authority expense to a new location. At present, these beds are restricted to commercial use and relocation will result in a degree of rehabilitation that will be suitable for recreational clam digging. This will be discussed later.

Navigation of small craft, both power and sail, can continue to be safely conducted near the vicinity of the airport provided the craft are kept within the marked channels as indicated on Chart 248 of the U. S. Coast and Geodetic Survey.

The proposed airport improvements will have no effects on the safety of the navigation of small craft near Boston-Logan International Airport and will not present a hazard to vessels in the harbor ship channel or the President Roads Anchorage.

NOTE No. 7 - Chapter VII includes a full discussion of recreational impact.

(3) The proposed project will alter the pattern of certain wildlife species which will be discussed below:

- The clams in the three "fill" areas are restricted to commercial operation because of high coliform counts, thus making them unfit for use by amateur clam diggers. The Massachusetts Port Authority has developed a plan for relocation based on the Martha's Vineyard experience, the cost of which will be defrayed by the Authority. When relocated in a new area they will provide a net improvement if an area can be found where they can be rehabilitated. The clams are currently restricted because they have been considered unsafe for human consumption in the BH-C area as a result of pollution from the City of Boston sewer.

- Available marshes, adjacent rocky shoreline and tidal flats currently provide suitable habitat areas for a limited population of water fowl, shoreline birds, and shellfish. Proposed landfill required for the airport improvement programs will partially eliminate these areas.

- <u>Birds</u>

  Tidal flat areas which border the airport have historically been a year-round as well as seasonal habitat for various species of birds. Among these are: (2)

  - All year

    - Herring Gulls
    - Black Back Gulls
    - Least Terns

- During migratory seasons

  - Sandpipers

  - Black Bellied Plovers

  - Yellowlegs

  - Ducks (Black and Scaup also winter in significant numbers)

Seagull feeding populations greatly increase on the mud flats during periods when clams are being harvested. The presence of birds in the immediate landing and take-off areas of the airport presents a potentially serious hazard to the safe operation of aircraft and, of course, to the birds themselves. The Massachusetts Port Authority has, for this reason, maintained a substantial bird control program for many years to minimize the risk of bird strikes on aircraft and their ingestion by jet engines.

- <u>Lobsters</u>

There are no known lobster colonies in the harbor waters surrounding the airport with the exception of a newly created colony along the rock dike recently constructed by the Massachusetts Port Authority around the Bird Island Flats area, where over 50 lobster floats were observed in May of 1971.

- <u>Fin Fish</u>

The harbor waters surrounding the airport support a limited population of flounder, striped bass and smelt and may serve as a spawning grounds for winter flounder.

Conversations with the Massachusetts Department of Natural Resources indicate that the areas BH-A and BH-B may sustain some finfish population. The proposed fills will tend to decrease the amount of nutrients available for this type of marine life. The reduction resulting from the proposed fills will not have a significant effect on the quantity of nutrients available in Boston Harbor.

In summary, there will be no detrimental effects and there will be some possible beneficial effects to the wildlife. There is no indication that any rare species will be threatened.

NOTE No. 8 - Chapter VII includes a discussion of wildlife and clam relocation.

(4) The proposed project will not be detrimental to the surrounding area from an aesthetic standpoint. In general, the perimeter around the airport is cleaner and better ordered than other nearby areas. The Massachusetts Port Authority plans to remove some of the current solid waste material in the area and to provide regular clean up service of the whole perimeter. The general condition of the area has been recorded with more than 100 photographs taken during this study and some are included in the attached report. The current rock dikes are clean and in excellent condition as confirmed visually and by photographs. The new dikes, as designed by the engineer, will be equal to the present ones.

As confirmed by calculations in the attached report, there will be no changes in erosion rates because of this program.

(5) The proposed project will not significantly affect ambient air and water pollution. As described in the attached report and cited above the air pollution levels will not exceed the new Federal Health Standards if the new runway is built. The air pollution emanating from the aircraft is about 0.5% of that in the whole Boston area. The prevailing winds are such that pollution from the airport moves to seaward most of the year as shown by the weather rose in the attached report. The total air pollutants will be reduced by 9,586 tons per year with the improved airport as compared to operations in 1975 with the existing airport. The particulate pollutants will be reduced by 24.9 tons per year as compared to today's airport and operation. The latter is particularly significant since particulates are nearer the limit of the new health standards than any of the other pollutants.

The only effective way to reduce water pollution in area BH-C is to stop overflows of raw sewage from the City of Boston sewer located at the intersection of Coleridge & Moore Streets.

- The landfill as originally planned in the inner lagoon known as area BH-C will reduce the volume of this area by thirty-seven percent (37%) and will reduce dilution by about eighteen percent (18%) resulting in greater concentrations of pollutants overflowing from the sewer located at Coleridge and Moore Streets.

  - Due to the unfavorable environmental effects of the fill on the existing conditions in BH-C, a waiver is to be requested from the FAA. The waiver will request that a postponement of the fills in BH-C be allowed until the overflows from the sewer are stopped by the City of Boston.

  - A small fill will still be required in BH-C. The fill represents less than 3.5% of the initial fill in BH-C and will have insignificant effects on the dilution.

- The full proposed landfill in the inner lagoon, if constructed, would not have affected the velocity of tidal flows nor cause any erosion of shoreline and beach areas in the channel between the Airport and Winthrop. The effects of the smaller landfill on the velocity of the same tidal flows are insignificant.

- The other two fill areas located in BH-A and BH-B will not alter existing harbor conditions because the fills will reduce the cross sections of the channels by small amounts.

- The effects of dredging, fill materials, and dike design have been analyzed by Fay, Spofford, and Thorndike, Inc. Their study concluded that the dikes as designed will have no detrimental environmental effects on water pollution.

NOTE No. 9 - Detailed discussion on these factors are included in Chapters III, IV, V and VII.

(6) The proposed development will have no effect on water tables, tides, erosion or other factors related to the surrounding waters because the essential condition remains unchanged from the current airport.

(7) Certain peripheral factors will be involved; however, the improved airport will have a limited effect on these factors.

- The 15L-33R runway will not represent a hazard to vessels in the harbor ship channel or the President Roads Anchorage.

- Extension of runway ends 9 and 4L will have no effect on shipping as their existing landing thresholds will not be relocated.

- Vehicular traffic to and from Boston-Logan International Airport will increase whether or not the improvement program is undertaken.

- Boston-Logan International Airport generated access trips do contribute to the peak hour congestion problems in the Boston Roadway Network. However, Logan is but one segment of a metropolitan roadway and transit system which requires improvement and expansion.

- Shifts in Boston-Logan International Airport's passenger demand to alternate transportation modes will not reduce peak hour congestion problems in the Boston Roadway Network, but merely redistribute this traffic from one area to another.

NOTE No. 10 - Chapter VI includes a full discussion of peripheral factors.

3. Probable Adverse Effects Which Cannot Be Avoided. The only possible adverse environmental effect, had the Massachusetts Port Authority elected not to defer the full program for fill of the 15L overrun area until the City of Boston corrects the sewage problem, would have been the reduction of dilution volume in the BH-C area. However, the reduced fill requirements have made this reduction so small that there will be essentially no change. Nevertheless, a complete correction can be affected only if the City of Boston sewer is prevented from overflowing and thus dumping raw sewage into the embayment.

There will be a reduction of area available for shellfish habitats. Since they are currently restricted, however, and since Massachusetts Port Authority is committed to relocation there will be a net improvement. Fin Fish will have a very small reduction in nutrients.

Elimination of an existing habitat for significant numbers of seagulls, ducks, and shorebirds will be caused by placement of the proposed landfills.

The public safety will be served by removal of this habitat from close proximity to the airport.

Re-establishment of the shellfish beds in another Boston Harbor location can initiate the development of a similar habitat for the same types of waterfowl and shoreline life as are currently found in proposed fill areas.

NOTE No. 11 - These effects are discussed in Chapters IV and VII.

4. <u>Alternatives</u>. The alternatives considered were:

(1) Do nothing. This alternative would have the following adverse effects:

- Increased noise impact on communities as a whole.
- Increasing air traffic delays, resulting in reduced, inconvenient, and less dependable air service for the Boston area.
- Increase in air pollution resulting from aircraft delays.
- Reduction in safety margins.
- Substantial adverse effects upon business, employment, and on the economy of this region in general.

(2) Other landing area modifications. This could include:

- Greater lateral spacing of the parallel 15L-33R Runway. While providing greater operational capacity, environmental effects grow as the distance is increased beyond the spacing selected. The optimum spacing would have been 5,000 feet which would permit simultaneous independent instrument operations and a greater IFR capacity. However, the obvious and totally unacceptable impacts on surrounding communities and the environment were too great to even consider.

- Development of a new parallel runway system in the East/West (9-27) direction. This development would not provide the required additional all weather capacity because of its orientation toward high rise structures in downtown Boston would severely limit its use unless extended seaward through Point Shirley in Winthrop. This alternative was totally unacceptable due to the community and environmental impacts which would be unavoidable.

(3) Develop a V/STOL airport. While V/STOL may ultimately extend Boston-Logan International Airport's capacity, there is virtually no likelihood that a V/STOL air transportation system will be developed and in substantial operation before Logan's capacity becomes saturated.

(4) High Speed Rail. A high speed rail transportation system for the Northeast Corridor is still a long way off and cannot be expected to reduce demand soon enough to eliminate the need for airfield improvements at Boston-Logan International Airport.

(5) Second Air Carrier Airport. Through extensive site selection studies (1), it has been determined that a second air carrier airport, which would supplement rather than replace Boston-Logan International Airport, would have a substantially greater environmental impact than the projects proposed. Even were all other obstacles overcome and an acceptable site already acquired, a 7 to 10 year planning, design, and construction period would still be necessary and near term demands could not be satisfied.

(6) Operational Alternatives. The specific operational alternatives include using the existing airport to achieve maximum noise abatement or to make a greater improvement by adding the new parallel runway 15L-33R.

The table below shows a comparison of these two alternatives and a discussion of each of the major factors follows the table.

Condition	4	6
Airport Configuration	Existing	Improved
Traffic Projections	1975	1975
Runway Utilization	Noise Abatement Alt. No. 1	Maximum Noise Abatement
Noise Population NEF-40	11,400	8,900
Air Pollution Tons/Yr.	17,421	10,211
Delays Hrs. Per Year	15,480	11, 725
PANCAP-Movements Per Yr.	313,000	348,000

- The operational feasibility of Condition "4" is unsatisfactory because of the difficulty involved with air traffic management in changing over to the overwater runways during peak hours, and would not accomplish the desired noise abatement procedures without unacceptable delays with the resulting air pollution. The improved airport would permit necessary peak hour management.

- Condition "4" shows an increase of 28% or 2,500 people residing within the NEF - 40 contour. This is a major improvement and warrants selection of Condition "6" (the improved airport) in its own merits.

- The improved airport results in a far better air pollution figure because of the reduction in delay. Condition 4 represents a calculated seventy per cent (70%) increase in air pollutants as compared to 6. It is also likely that delay would be even greater with resultant greater air pollution because of the difficulty with air traffic management and the lower PANCAP.

- The delay, as calculated, would actually be even greater for Condition 4 because of air traffic management and lower PANCAP as mentioned above

- Condition 4 presents little operational flexibility and from a practical standpoint it will be difficult to achieve the noise reduction indicated, without increasing the delay level, resulting in a corresponding increase in air pollution.

- In summary, because of the above reasons, this condition (4) is not a practical alternative and the airport could not be operated in this manner.

(7) Of all the alternatives considered for reducing noise exposure, with the exception of noise reduction at the source, the implementation of a rigid and comprehensive preferential runway use system offers the greatest potential for substantial noise abatement without producing completely unacceptable penalties on the airport user.

- Banning of 4-engine jets would make a minor improvement in overall noise exposure, however, the effects on the air transportation industry negate the small benefits derived.

- Locally established maximum noise level restrictions are legally questionable and would create chaos in the air transportation system due to lack of conformity from area to area.

- Surcharges for noisier aircraft including landing fee differentials at night would not provide sufficient economic leverage to induce changes in equipment types or schedules.

(8) From the standpoints of capacity, noise exposure and air pollution the proposed improvement program represents the most advantageous alternative.

- Condition 6, which represents the improved airport, is superior from a standpoint of noise and other environmental factors.

- Condition 6, the improved airport, is the only condition which satisfies projected 1975 aviation demand.

(9) Operational alternatives cannot practically be used to reduce total aviation demand to within the constraints imposed by the existing airfield facility capacity without a derogatory effect on air service.

- Eliminating general aviation traffic as required to reduce congestion and eliminate need for increased capacity will not noticeably reduce Boston-Logan International Airport's environmental impact.

- Reducing and consolidating schedules and increasing aircraft load factors will not eliminate the need for increased capacity.

- The establishment of landing fee and fare differentials to penalize peak hour use will have limited effect during the daylight hours of heavy demand and could shift additional operations into the more noise critical nighttime hours.

(10) Political and environmental objections to a second air carrier airport must be overcome before site selection, planning and design, and construction could be undertaken. Such considerations place a second air carrier airport beyond the time requirment for Boston-Logan International Airport improvement to meet the demands placed upon it by the Boston area.

5. <u>The Relationship Between Local Short-Term Uses of the Environment and Enchancement of Long-Term Productivity.</u>

(1) The Short-Term Uses of the Environment:

Construction for the improvement program will take about four years. The disposal of dredged material will be performed in such a way that no adverse environmental effects will result. The materials required for the proposed landfills will be obtained from borrow pits located in surrounding communities. These borrow pits are under local ordinance controls.

(2) Enhancement of Long-Term Productivity.

The long-term effects to be realized include the improvements in the appearance of the areas since some of the unsightly mud flats will be eliminated and replaced by rock dikes.

(3) Additional long-term benefits include Boston-Logan International Airport's significant economic contribution to the Boston Metropolitan area, a contribution that will be enhanced by the proposed improvement program.

- The impact upon the income of the economy of the Boston Metropolitan area created by the direct payrolls and purchases of Boston-Logan International Airport was $728 million in 1970. With the improved airport this impact is expected to grow to $1,274 million ($1.27 billion) in 1975. All of this $546 million increase in impact will not occur if the number of operations at the airport in 1975 is restricted.

- If the existing airport were operated in 1975 on the same basis as is projected for the improved airport in 1975 (same delay levels and noise abatement procedures) to approach the reduced levels of air and noise pollution made possible by the improved airport, an estimated 21,600 scheduled air carrier operations with 1,200,000 passengers or 600,000 trips would be lost. This reduction in the level of air transportation services in 1975 would create a loss to the economy of $116 million per year by 1975.

- The present average level of construction expenditures (1967 - 1970) at Boston-Logan International Airport creates a total impact upon the Boston Metropolitan economy of $76.3 million per year with an estimated 900 construction jobs. The increase in the economy created by the proposed improvement program will average $191.9 million per year with 1,900 jobs over the period 1971-1974.

- The cost to the Boston Metropolitan area resulting only from the loss of airport employment caused by a curfew imposed on night jet flights between 10:00 p.m. and 7:00 a.m. is estimated to be $18 to $28 million per year in 1971. In addition, such a curfew will cause increases in transportation costs and competitive disadvantages for selected firms in the Boston Metropolitan area whose operations are highly sensitive to transportation delays.

6. Irreversible or Irretrievable Commitments of Resources. No irreversible or irretriveable commitments of resources would be involved in the proposed improvement program.

- The wildlife and shellfish habitats being covered by fill were originally created by the harbor fills placed during construction of the existing airport and every effort will be made to again create new habitats in another more suitable area.

- The commitment of labor and material associated with construction would be consumed in the implementation of the projects.

7. Problems and/or Objections. The Massachusetts Port Authority has received permits from the Commonwealth of Massachusetts Water Resources Commission, and permits from the Massachusetts Department of Public Works as attached hereto for the proposed project. Several Federal agencies have been contacted and have raised questions which should be answered by the enclosed report.

Major objections have been raised by some members of the community and the Mayor of Boston.

The public hearing on February 26, 1971 showed major community objections but many did not have all of the facts. Consequently the attached study represents the intense investigation made that was considered necessary to answer all aspects of the project. with emphasis on the potential environmental impact.

There is no practical or feasible alternative to the project. The only realistic way that the number of people currently affected by noise can be reduced is through the construction of the new runway.

Any other noise abatement alternative would not achieve similar reductions in population exposed to noise but additionally would result in much greater air pollution

Form WD 54
2M–11–67–946226

8375 653

The Commonwealth of Massachusetts

No. 5759.

Whereas, the Massachusetts Port Authority------------------

of Boston----------, in the County of Suffolk-----------and Commonwealth aforesaid, has applied to the Department of Public Works for license to place fill in Boston Harbor east of Logan Airport, at its property in the city of Boston,---

and has submitted plans of the same; and whereas due notice of said application, and of the time and place fixed for a hearing thereon, has been given, as required by law, to the Mayor and City Council of the city---------of Boston------------;

Now said Department, having heard all parties desiring to be heard, and having fully considered said application, hereby, subject to the approval of the Governor, authorizes and licenses the said --

Massachusetts Port Authority-------, subject to the provisions of the ninety-first chapter of the General Laws, and of all laws which are or may be in force applicable thereto, to place and maintain fill in Boston Harbor east of Logan International Airport, at its property in the city of Boston, in conformity with the accompanying plan No. 5759.

A coarse granular fill dike having a riprap faced outboard slope may be constructed having a top width of 15 feet at elevation 19 feet above mean low water and having a side slope of 1½ horizontally to 1 vertically with an inboard slope of 1½ horizontally to 1 vertically extending 2,900 feet, more or less, between the mean high water lines shown at 2 feet shoreward and parallel to the harbor line established by Chapter 733 of the

Acts of 1966, beginning at a point on the present mean high water line located southeasterly of runway designated as 22-4 and 2 feet south of the Massachusetts Harbor Line designated as F and E extending in a southeasterly direction a distance of 2,900 feet, more or less, to the mean high water line on the northwesterly side of runway designated as 29-9; thence southwesterly parallel to and 2 feet southeasterly of the Massachusetts Harbor Line designated as F and D to the property line of the airport, in the location shown on said plan and in accordance with the details there indicated.

A second dike constructed in the same manner with a 25 foot top width beginning at the mean high water line adjacent to the west end of runway designated as 9-27 and 2 feet southwesterly of the Massachusetts Harbor Line designated as D and C to extend parallel to the harbor line in a southeasterly direction a distance of 2,300 feet, more or less; thence in a southwesterly direction 2,400 feet, more or less, parallel to the Massachusetts Harbor Line designated as C and J; thence turning in a northeasterly direction a distance of 3,200 feet, more or less, to the mean high water line adjacent to the southwesterly taxiway adjacent to the runway designated as L33-R15 and terminating at this point, in the location shown on said plan and in accordance with the details there indicated.

The two areas enclosed by the dikes and the present mean high water line encompassing tidal flats or land of the licensee may be filled solid, as indicated on said plan numbered 5759.

This license is granted upon the following express conditions:

That the fill will not within the 5 year period for performing the work under this license or any future time be placed at an elevation in excess of 20 feet above the mean low water line except with the consent of the Department of Public Works, or its successors.

The dike will be constructed in the authorized location and in the manner indicated herein including removal of underlying silt in the dike location as needed.

The fill material shall consist of only earth and rock fill free of organic material.

The Department of Public Works may make a continuing inspection of the material being used in the dike and the fill area and of the method of dike construction, including the underlying silt removal, and if not deemed satisfactory may require that the work be suspended until satisfactory material and methods are used.

A hydrographic record plan satisfactory to the Department of Public Works showing the depths at and channelward of the dike location shall be made by the licensee sufficiently in advance of any portion of its construction to constitute a record of existing conditions, and for a period of 2 years after completion of the work, the Department may require removal by the licensee at its own expense, of any shoaling deemed to be a result of the work authorized hereby, as indicated by said record plans.

The hydrographic survey required before construction and any subsequent surveys of this nature necessitated to establish conditions adjacent to the area, shall be provided by the licensee at no expense to the Department.

Silt removed as a requirement of this license shall be deposited at sea in such location as may be assigned by the United States Corps of Engineers, and the transportation and dumping shall be subject to applicable provisions of Chapter 91 of the General Laws.

Nothing in this license shall be construed as authorizing work on land or flats not owned or controlled by the licensee except with the consent of the owner or owners thereof.

Nothing in this license shall be construed as authorizing any encroachment beyond a line 2 feet back from the established State Harbor Line.

This license is granted subject to all applicable Federal, State, County and Municipal laws, ordinances and regulations, and upon the further express condition that any other authorizations necessitated due to the provisions hereof shall be secured prior to the commencement of any work under this license.

Acceptance of this license shall constitute an agreement by the licensee to conform to the conditions herein contained.

The plan of said work, numbered --------5 7 5 9,-------- is on file in the office of said Department, and duplicate of said plan accompanies this License, and is to be referred to as a part hereof.

The amount of tide-water displaced by the work hereby authorized shall be ascertained by said Department, and compensation therefor shall be made by the said------------ Massachusetts Port Authority, its--------------------~~heirs~~, successors

8375 660

and assigns, by paying into the treasury of the Commonwealth thirty-seven and one-half (37½) cents for each cubic yard so displaced, being the amount hereby assessed by said Department.

Nothing in this License shall be so construed as to impair the legal rights of any person.

This License shall be void unless the same and the accompanying plan are recorded within one year from the date hereof, in the Registry ------ of Deeds for the ------ ~~District of the~~ County of Suffolk.

In Witness Whereof, said Department of Public Works have hereunto set their hands this ------twenty-fourth------day of ----------June,-----------in the year nineteen hundred and seventy.

Edward Ribb
Robert S. Foster
Peter Donnelly
John P. K
Charles A. Bisbee Jr.

Department of Public Works

EC

THE COMMONWEALTH OF MASSACHUSETTS

~~This license is approved in consideration of the payment into the treasury of the Commonwealth by the said~~

~~of the further sum of~~

~~the amount determined by the Governor as a just and equitable charge for rights and privileges hereby granted in land of the Commonwealth.~~

BOSTON, JUN 29 1970

Approved by the Governor.

Francis W. Sargent
Governor

JUL 9 1970 AT 10 O'CLOCK & 11 MINS. AM REC'D. ENT'D. & EXAM. #28

License No. ____________ 27

DEPARTMENT OF PUBLIC WORKS

TO

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To ____________________

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Dated ____________________

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3.00

646

JUL 31 9 47 AM '70

Massachusetts Port Authority
c/o Neil L Lynch Esq
470 Atlantic Ave
Boston, Mass 02210

Received and Entered with
Suffolk Deeds, Book 8375 Page 653.

Attest:

Joseph D. Coughlin
Register

The Commonwealth of Massachusetts

Department of Public Works

DIVISION OF WATERWAYS

100 Nashua Street, Boston, 02114

July 7, 1970

Edward J. King, Executive Director
Massachusetts Port Authority
470 Atlantic Avenue
Boston, Massachusetts 02210

Dear Mr. King:

The Department of Public Works sends you herewith, License No. 5759 and tracing plan bearing same number, authorizing the Massachusetts Port Authority to place and maintain fill in Boston Harbor east of Logan International Airport, at its property in the city of Boston.

A certified copy of this license and a blueprint of the signed tracing plan are being forwarded to the U. S. Engineer, New England Division, Corps of Engineers, U. S. Army, 424 Trapelo Road, Waltham, Massachusetts 02154, for his information.

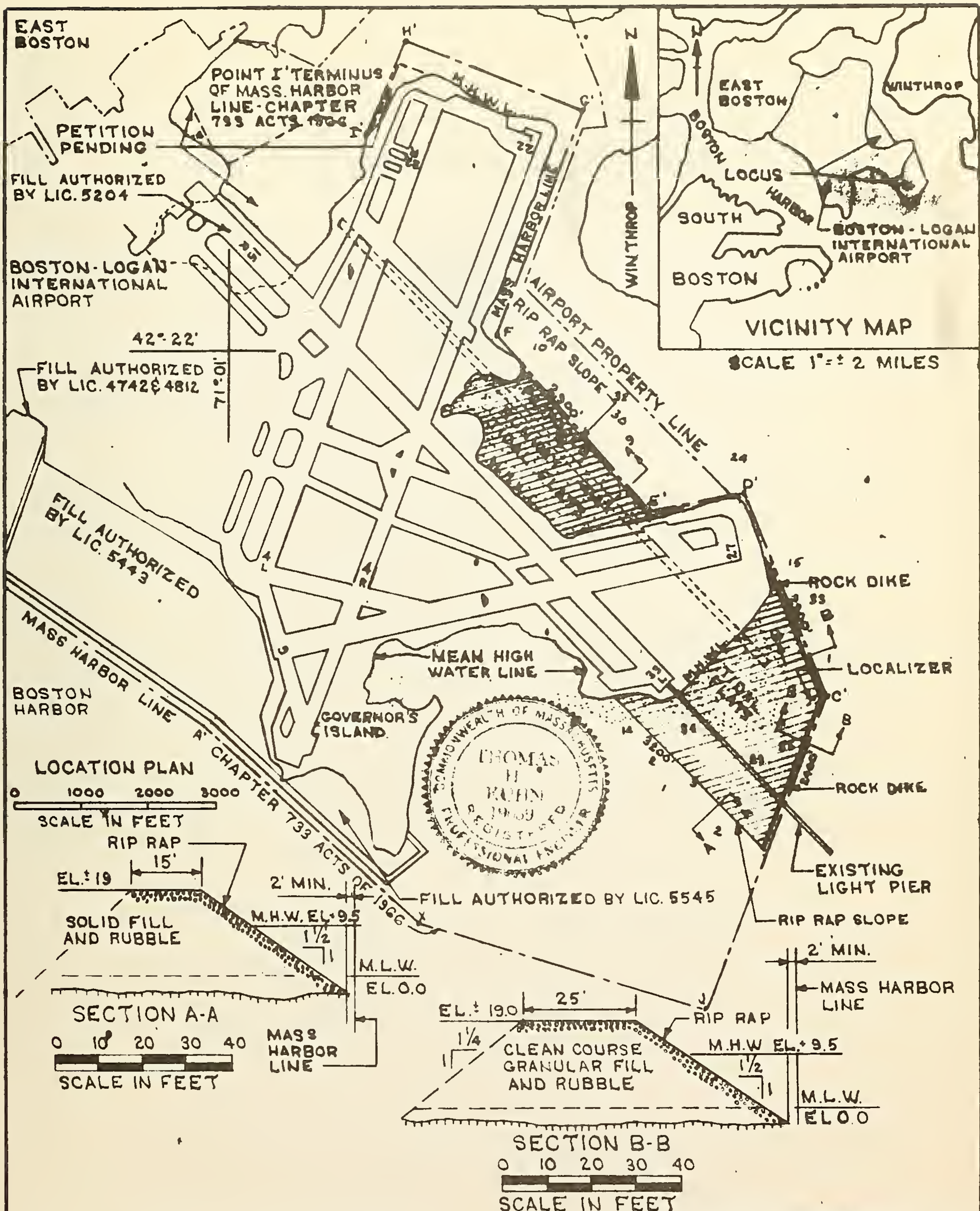
The Department will appreciate receiving notice as to the date upon which this license is recorded in the Registry of Deeds for the County of Suffolk and the date when the work is completed.

Very truly yours,

John T. Hannon

JOHN T. HANNON
Deputy Chief Engineer

jck



PLAN ACCOMPANYING PETITION OF
MASSACHUSETTS PORT AUTHORITY
FOR PROPOSED DIKE AND FILL
IN BOSTON HARBOR
NORTH AND EAST OF
BOSTON LOGAN INTERNATIONAL AIRPORT
BOSTON, MASS
APRIL 1970

LICENSE PLAN NO 5759
APPROVED BY DEPARTMENT OF PUBLIC WORKS OF MASSACHUSETTS

COMMISSIONER - DEPT. OF PUBLIC WORKS

ASSOCIATE COMMISSIONERS

8375 657

Form WD 54

2M–11–67–946226

The Commonwealth of Massachusetts

No. 5758.

Whereas, the Massachusetts Port Authority-------- ------ ----

of Boston--- ----, in the County of Suffolk-----------and Commonwealth aforesaid, has applied to the Department of Public Works for license to place fill in Boston Harbor northwest of Logan Airport in the vicinity of Wood Island Park, at its property in the city of Boston,-------

and has submitted plans of the same; and whereas due notice of said application, and of the time and place fixed for a hearing thereon, has been given, as required by law, to the Mayor and City Council of the city--------- of Boston-- -----------;

Now said Department, having heard all parties desiring to be heard, and having fully considered said application, hereby, subject to the approval of the Governor, authorizes and licenses the said --

Massachusetts Port Authority-------, subject to the provisions of the ninety-first chapter of the General Laws, and of all laws which are or may be in force applicable thereto, to place and maintain fill in Boston Harbor northwest of Logan International Airport in the vicinity of Wood Island Park, at its property in the city of Boston, in conformity with the accompanying plan No. 5758.

A stone dike may be constructed with a top width of 15 feet at elevation 19 feet above mean low water having a riprap faced outboard slope at 1½ horizontally to 1 vertically with an inboard slope of 1½ horizontally to 1 vertically consisting of solid fill and rubble in three locations.

The first area located northerly of Wood Island Park with the riprap faced dike extending northwesterly 1,000 feet, more or less, between the mean high water lines shown beginning at a point on the present mean high water line located 650 feet, more or less, northeasterly as measured along a perpendicular to the center line extended of the airport runway designated as 15-33, in the location shown on said license plan No. 5758 and in accordance with the details there indicated.

The second area located northerly and adjacent to the dike authorized by License No. 5204 of the Department of Public Works to have a riprap faced dike commencing at the present mean high water line located 650 feet, more or less, northeasterly as measured along a perpendicular to the center line of the airport runway designated as 15-33, in the location shown on license plan No. 5758; thence extending in a northeasterly direction 1,500 feet, more or less, thence in a southeasterly direction 700 feet, more or less, to the terminus point of the Massachusetts Harbor Line established by Chapter 733 of the Acts of 1966 and designated as point "I".

The third area located westerly of the taxiway of airport runway designated as R22-L4 to have a riprap faced dike commencing 2 feet east of the terminus point of the Massachusetts Harbor line established by Chapter 733 of the Acts of 1966 designated as point "I" and extending in a northeasterly direction 1,100 feet, more or less, parallel to the said harbor line designated as "I-H"; thence extending in a southeasterly direction 400 feet to terminate at the mean high water line north of airport runway designated as R22-L4, in the location shown on license plan No. 5758.

The three areas enclosed by the dikes and the present mean high water line encompassing tidal flats on land of the licensee may be filled solid, as indicated on said plan numbered 5758.

This license is granted upon the following express conditions:

That the fill will not within the 5 year period for performing the work under this license or any future time be placed at an elevation in excess of 20 feet above the mean low water line except with the consent of the Department of Public Works, or its successors.

The dike will be constructed in the authorized location and in the manner indicated herein including removal of underlying silt in the dike location as needed.

The fill material shall consist of only earth and rock fill free of organic material.

The Department of Public Works may make a continuing inspection of the material being used in the dike and the fill area and of the method of dike construction, including the underlying silt removal, and if not deemed satisfactory may require that the work be suspended until satisfactory material and methods are used.

A hydrographic record plan satisfactory to the Department of Public Works showing the depths at and channelward of the dike location shall be made by the licensee sufficiently in advance of any portion of its construction to constitute a record of existing conditions, and for a period of 2 years after the completion of the work, the Department may require removal by the licensee at its own expense, of any shoaling deemed to be a result of the work authorized hereby, as indicated by said record plans.

The hydrographic survey required before construction and any subsequent surveys of this nature necessitated to establish conditions adjacent to the area, shall be provided by the licensee at no expense to the Department.

Silt removed as a requirement of this license shall be deposited at sea in such location as may be assigned by the United States Corps of Engineers, and the transportation and dumping shall be subject to applicable provisions of Chapter 91 of the General Laws.

Nothing in this license shall be construed as authorizing work on land or flats not owned or controlled by the licensee except with the consent of the owner or owners thereof.

Nothing in this license shall be construed as authorizing any encroachment beyond a line 2 feet back from the established State Harbor Line.

This license is granted subject to all applicable Federal, State, County and Municipal laws, ordinances and regulations, and upon the further express condition that any other authorizations necessitated due to the provisions hereof shall be secured prior to the commencement of any work under this license.

Acceptance of this license shall constitute an agreement by the licensee to conform to the conditions herein contained.

The plan of said work, numbered --------5 7 5 8,-------- is on file in the office of said Department, and duplicate of said plan accompanies this License, and is to be referred to as a part hereof.

The amount of tide-water displaced by the work hereby authorized shall be ascertained by said Department, and compensation therefor shall be made by the said ----------- Massachusetts Port Authority, its ------------------~~heirs,~~ successors

8375 660

and assigns, by paying into the treasury of the Commonwealth thirty-seven and one-half (37½) cents for each cubic yard so displaced, being the amount hereby assessed by said Department.

Nothing in this License shall be so construed as to impair the legal rights of any person.

This License shall be void unless the same and the accompanying plan are recorded within one year from the date hereof, in the Registry ------ of Deeds for the ------ ~~District of the~~ County of Suffolk.

In Witness Whereof, said Department of Public Works have hereunto set their hands this ------twenty-fourth------day of ----------June,-----------in the year nineteen hundred and seventy.

EC

Edward Ribbs
Robert S. Foster
Peter Donovan
John P. K[illegible]
Charles A. Bisbee Jr.

Department of Public Works

THE COMMONWEALTH OF MASSACHUSETTS

~~This license is approved in consideration of the payment into the treasury of the Commonwealth by the said of the further sum of the amount determined by the Governor as a just and equitable charge for rights and privileges hereby granted in land of the Commonwealth.~~

Boston, JUN [illegible] 1970

Approved by the Governor.

Francis W. Sargent
Governor

JUL 9 1970 AT 10 O'CLOCK & 11 MINS. AM REC'D. ENT'D. & EXAM. # 28

The Commonwealth of Massachusetts
Department of Public Works
DIVISION OF WATERWAYS
100 Nashua Street, Boston, 02114

July 7, 1970

Edward J. King, Executive Director
Massachusetts Port Authority
470 Atlantic Avenue
Boston, Massachusetts 02210

Dear Mr. King:

The Department of Public Works sends you herewith, License No. 5758 and tracing plan bearing same number, authorizing the Massachusetts Port Authority to place and maintain fill in Boston Harbor northwest of Logan International Airport in the vicinity of Wood Island Park, at its property in the city of Boston.

A certified copy of this license and a blueprint of the signed tracing plan are being forwarded to the U. S. Engineer, New England Division, Corps of Engineers, U. S. Army, 424 Trapelo Road, Waltham, Massachusetts 02154, for his information.

The Department will appreciate receiving notice as to the date upon which this license is recorded in the Registry of Deeds for the County of Suffolk and the date when the work is completed.

Very truly yours,

John T. Hannon

JOHN T. HANNON
Deputy Chief Engineer

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Plan

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Massachusetts Port Authority
℅ Neil L Lynch Esq
470 Atlantic Ave
Boston, Mass 02210

License No. ____________

DEPARTMENT OF PUBLIC WORKS

TO

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To ____________________

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Dated ____________________

Received and Entered with
Suffolk Deeds. Book 8375 Page 654
Attest: Joseph D. Coughlin
Register

LANDRUM AND BROWN, INC.
1200 Central Trust Tower
NE (513) 721-1149 CINCINNATI, OHIO 45202 CABLE ADDRESS: LANBRO

May, 1971

Mr. Richard E. Mooney
Director of Aviation
The Massachusetts Port Authority
470 Atlantic Avenue
Boston, Massachusetts 02210

Dear Mr. Mooney:

The enclosed report presents the Airport Improvement and Environmental data in keeping with your Research assignment. This assignment was to study the need for improvements at Boston-Logan International Airport and to measure the environmental impact of the improved airport facilities.

Several firms have been involved in the performance of the research for this report. The primary objective of the efforts of these contributors has been to search for fact and truth. The firms involved and their general contributions are as follows:

- Bolt, Baranek and Newman - Noise Contour Data - Appendix B.
- Booz, Allen & Hamilton - Airport Planning, Noise Analysis, Water and Air Pollution, and Economic Impact.
  - Landrum and Brown - Traffic Forecasts, Master Planning and general coordination - Chapters I, II, VI, VII, and VIII.
  - Environmental Resources Group - Noise Analysis, Water and Air Pollution - Chapters III, IV, and V plus assist input on Coordination for Chapters VI through IX.
    - Geodyne Corporation - Water Pollution - Appendix C.
    - Tracor - Additional Noise Data.
  - Development Research Associates - Economic Impact - Chapter IX.
- R. Dixon Speas Associates - Analysis is of Airport Capacity - Appendix A.
- In addition to the above efforts there was a great amount of support research by other consultants for the facility design and from members of the Massport Staff. This material is consolidated in Appendix D.

The Introduction sets forth the report organization and the Findings and Conclusions presents a capsule of the research contained in Chapters I through IX and the Appendices.

A series of basic statements drawn from the support data are:

- Continued growth in air traffic volumes is expected.
- The present facilities are limited in their ability to accommodate the expected demand caused by traffic growth.
- The proposed airport improvements will permit improved noise impact conditions.
- Water pollution will not be increased by the improvements because the MPA has elected to defer the 15L overrun until the City of Boston corrects the sewage problems in the BH-C area.
- Air pollution will be lessened with improvements.
- Without improvements aircraft operations at the airport may not meet Federal Air Pollution Standards.
- The improvements will cause little or no effect on shipping, access or other peripheral factors.
- The improvements will produce better conditions for marine life.
- There is no indication that there will be an upset of ecological balance caused by the improvements.
- Of the numerous alternatives, none are as feasible or practical as the proposed improvements.
- The declaration of an improvement moratorium could have a disastrous economic impact on the Boston area.

In conclusion we highly recommend that Massport continue its effort to improve the existing Airport as planned.

The assessment of any social cost related to transportation is beyond the scope of this study and perhaps beyond the scope of any single study since this is a national social systems problem. However, as our report shows, the improved airport presents the best opportunity to realize a reduction of current social impacts. This betterment is a result of noise and air pollution control provided only by the new runway without sacrificing economic benefits to the entire community.

It has been a great pleasure to work with those associated with the Massachusetts Port Authority, the Federal Government, the Governor's council, the Corps of Engineers and others during the performance of this assignment.

Please advise if you have questions or would like further data regarding the program as presented.

Respectfully submitted,

Fay, Spofford and Thorndike Inc.

COL/jaj

TABLE OF CONTENTS
AND LIST OF EXHIBITS

VOLUME I

I. INTRODUCTION

The Massachusetts Port Authority has submitted a request for federal financial assistance under the Airport Development Aid Program on a proposed airport improvement program for Boston-Logan International Airport. In keeping with the emerging Federal Aviation Administration requirements, this report presents the findings, with appropriate supporting analyses, of a comprehensive study of the proposed Boston-Logan International Airport improvement program and its environmental consequences. This section of the report presents the approach to and the organization of this report.

1. PURPOSE OF THE ENVIRONMENTAL IMPACT STUDY

The Environmental Policy Act of 1969 requires the preparation of detailed environmental statements for all major federal airport development actions significantly affecting the quality of the environment. The Airport and Airway Development Act of 1970, which sets up a Planning Grant Program Trust Fund to be administered by the Federal Aviation Administration, makes submission of the environmental statements prerequisite to Federal Aviation Administration approval of an airport layout plan (ALP).

Preliminary guidance concerning the new Planning Grant Program (PGP) reaffirms that, as in the past, the ALP will continue to be a major milestone in the airport master planning process. That is, Federal Aviation Administration approval of the ALP will be prerequisite to approval by the Federal Aviation Administration of a request for federal funding participation under the Airport Development Aid Program (ADAP) and thus to any development contemplated thereunder.

The (Draft) Environmental Impact Statement, in management summary form, pursuant to Section 102 (2) (c) Public Law 91-190 is appended to the front of this report.

2. APPROACH TO THE EVALUATION OF THE IMPROVEMENT PROGRAM

This evaluation was approached using a multi-disciplinary team who were experienced not only in air traffic and capacity analysis but also in measuring environmental impact. Thus, the team included experts in noise, biology, water, air pollution and economic impact. Landrum and Brown spearheaded the effort assisted by the Booz, Allen & Hamilton Inc. Environmental Resources Group. In turn, Landrum & Brown, Inc. used the firm of Dixon Speas to assist in the capacity analysis; Bolt, Beranek and Newman, Inc. and Tracor Inc. to make noise calculations; Geodyne Inc. of Waltham, Massachusetts assisted in the analysis connected with the affect of the fill areas in the inner BH-C portion of the harbor. Each section of the work was approached as follows:

(1) Master Planning

Air traffic projections were made by Landrum and Brown, Inc. to support the planning and environmental analyses. These projections were made for the 1975, 1980 and 1985 time periods, taking into consideration the economic base, air service provided and historic trends at Boston-Logan International Airport and their relationships to national volumes and growth rates. Fleet mix by type and stage length was developed as a basis for the noise exposure forecasts. Analysis was given to the relationship of demand versus capacity and its impact on facility requirements. Master planning analysis also gave consideration to facility and operational alternatives in lieu of the 15L-33R improvement program.

The traffic projections were made by Landrum and Brown, Inc. using the expected increase in air traffic by the public. These projections were made for the 1975 and 1980 periods taking into account the change in travel habits and the adaptability of people to use aircraft for both public and private purposes. Allowances were made for the fewer number of flights resulting from the higher capacity aircraft such as the 747, the DC-10 and other wide bodied vehicles.

(2) Nomenclature for Analysis Of Airport Configurations

The two airport configurations studied include the existing and improved conditions.

- Existing refers to the airport as it stands today (1971),

- Improved refers to the airport as it is planned for 1975, i.e., with 15L-33R parallel runway, extensions to 4L and 9, and STOL runway 15-33.

Runway utilizations studied included five cases. The description of each is given herein.

- "Historic" refers to the current preferential runway use program and which has been in effect for some ten years.
- "Maximum Capacity" refers to runway use selections based entirely on achieving the highest capacity and minimum delay, and noise abatement is not a consideration.
- "Noise Abatement Alternate #1" refers to a revised preferential runway use program applied to the existing airport wherein runways are selected to maximize overwater approaches, but which uses the parallel 4-22 runways when needed to meet the peak hourly traffic demand.
- "Noise Abatement Alternate #2" refers to the application to the existing airport of the runway use achieved with "Maximum Noise Abatement."
- "Maximum Noise Abatement" refers to the revised preferential runway use program attainable with the improved airport, and which results in the highest percentage use of overwater approaches and departures of any of the runway use programs.

Table I shows the nomenclature used throughout the report. Color codes have been assigned to clarify the presentation of conditions.

(3) Capacity Analysis

R. Dixon Speas Associates developed a capacity analysis for the current airport as well as for the improved airport with the programmed runway and terminal facilities. They analyzed different runway utilizations in order to determine which operating pattern would result in a maximum number of overwater approaches and departures. In addition, they made calculations to maximize capacity as well as the historic utilization. The capacity calculations took into account the effect of increased separation standards for "heavy" aircraft and future improvements in air traffic control procedures and equipment.

TABLE I
ENVIRONMENTAL IMPACT STUDY
NOMENCLATURE FOR AIRPORT

Condition	1	2	3	4	5	5A	6	6A	6B	6C
Airport Configuration	Existing	Existing	Existing	Existing	Existing	Existing	Inproved	Improved	Improved	Improved
Traffic Demand	1970	1975	1975	1975	1975	1975	1975	1970	1975	1975
Runway Utilization	Historic	Maximum Capacity	Historic	Noise Abatement Alt. No. 1	Noise Abatement Alt. No. 2	Noise Abatement Alt. No. 2	Maximum Noise Atatement	Maximum Capacity	Maximum Capacity	Maximum Noise Atatement
Air Traffic Rules	1970	1975	1975	1975	1975	1980	1975	1970	1975	1980

Definitions:

Traffic Demand 1970 uses aircraft population (percent): A-15, B-47, C-13, D+E-25
Traffic Demand 1975 uses aircraft population (percent): AA-13, A-7, B-44, C-11, D+E-25
The text Section 4.2 describes aircraft classes.
Runway Utilization - See text Section 4.3
Air Traffic Rules - 1970-Rules Before Wake Turbulence Rules Enacted
1975-Current Rules With Wake Turbulence Rules in Effect
1980-Future Equipment and Reduced Separation Criteria - See text Section 4.4

Note: Detailed discussion of these sections is presented in Appendix A.

(4) Impact On Natural Environmental Factors

Noise analysis was conducted by the Booz, Allen & Hamilton Inc. Environmental Resources Group, assisted by the firms of Tracor Inc. and Bolt, Beranek and Newman, Inc. Work consisted of an analysis of the literature; a study of the various programs now under way by the aircraft and engine companies to lower noise levels from future aircraft; and a study to determine what research is under way so that it could be learned what might be expected from future aircraft. The NEF methodology was utilized as a relative measure of the noise impact and calculated the NEF 30 and 40 contours for several different runway utilizations as noted above in paragraph (2) for the existing airport as well as for the improved airport with the new runway 15L-33R, the extensions to runways 4L and 9 and STOL runway 15-33. The impact of noise was measured in terms of the acres within the two different contours and in terms of the number of people residing within those contours.

The situation with respect to air, water and solid wastes was considered by studying existing airport operations and determining potential sources of pollution from current operations and recommending procedures for servicing and handling aircraft that would minimize pollution levels both now and in the future. The handling of solid wastes within the airport including sewage, refuse and other items were studied in detail. The flow of each is plotted within the main body of the report.

During the past several weeks the Environmental Resources Group of Booz, Allen & Hamilton Inc. has made measurements of the levels of carbon monoxide, sulphur dioxide, the oxides of nitrogen and particulate levels. We have measured the quantities of these pollutants, not only in the airport, but in areas near the airport. An extensive survey was made of water pollution by actually taking samples as well as studying the periphery of the entire airport personally and visually. The results of the air and water analysis are included in tabular form in the main body of the report. Mathematical model of the so called BH-C embayments was conducted with the help of the Geodyne Corporation to predict the impact of the fill on tidal flow, current volume and velocity. In order to accomplish this, it was necessary to release drogues to study the direction of current flow. Actual depth soundings were made in BH-C, so that the current depth values could be used in the calculations. Water samples were taken on the perimeter of the airport to determine levels of pollution.

With respect to recreational impact, a general survey was performed. A detailed study plan was prepared to guide the relocation of currently restricted clam beds. The study plan was based on the Martha's Vineyard experience. In addition, a brief survey was conducted of the civic and recreational benefits in the area of Boston-Logan International Airport.

(5) Alternatives

The environmental study team evaluated alternatives to the Boston-Logan International Airport improvement program including facility and operational changes, alternate transportation modes and noise abatement procedures. The conditions studied are detailed in paragraph (2). These were evaluated in terms of feasibility, possible timing and effect on the need for the Boston-Logan International Airport facility improvement program.

3. ORGANIZATION OF THE REPORT

The report is organized in two volumes in the following manner:

VOLUME I

(1) The Letter Of Transmittal

The letter of transmittal sums up the overall findings and recommendations. The findings and conclusions are described broadly in the letter of transmittal.

(2) Introduction

The introduction describes how the study was accomplished and delineates the participating groups. In general, the introduction tells the specific broad actions that were taken to accomplish the work. For detailed discussion of the methodology, it is necessary to study the body of the report in detail.

(3) Findings and Conclusions

This is a summary of the principal findings and conclusions from each of the major chapters. It will be necessary to refer to each of the chapters for detailed reports, conclusions, results and findings.

(4) Main Body Of the Report

Detailed reports on the following major subjects are presented in the main body of Volume I.

- Chapter I - Air Traffic Forecasts Through 1985
- Chapter II - Airport Master Plan Analysis
- Chapter III - Analysis Of the Noise Levels Expected With the Present and Improved Airport
- Chapter IV - Impact Of Airport Improvements and Operations On Water Quality
- Chapter V - Studies Of Current and Projected Levels Of Airborne Materials at Boston-Logan International Airport
- Chapter VI - Peripheral Factors Connected With Airport Operations
- Chapter VII - Analysis Of Impact Of Airport Improvements On Civic and Recreational Activities
- Chapter VIII - Alternatives To Airport Improvement
- Chapter IX - Economic Impact Of Airport Improvement and Its Alternatives

VOLUME II

Research reports as appendices to Volume I are presented in Volume II as follows:

- Appendix A – Airport Capacity and Delay Analysis by R. Dixon Speas Associates
- Appendix B – Noise Exposure Forecasts by Bolt, Beranek and Newman, Inc.
- Appendix C – Water Pollution Field Study by Geodyne Corporation
- Appendix D – Massachusetts Port Authority Staff Study

CONCLUSIONS

II. FINDINGS AND CONCLUSIONS

For ease of reference, the basic conclusions of this study, which are of fundamental importance to the future success of aviation development at Boston-Logan International Airport are highlighted as follows:

1. THE DEMAND FOR AIR SERVICE AT BOSTON-LOGAN INTERNATIONAL AIRPORT BOTH SCHEDULED AND OTHER WILL CONTINUE TO INCREASE IN THE FUTURE.

(1) Total Enplaned Passengers Are Forecast To Increase To 6,335,200 by 1975 and To 8,256,100 by 1980.

(2) Total Scheduled Departures Are Estimated To Grow To 111,950 Departures by 1975 and 124,700 Departures by 1980.

(3) Total Aircraft Operations, Unrestricted by Facility Limitations Are Estimated As Follows:

Landrum & Brown Aircraft Operations Forecasts

	1975	1980	1985
Air Carrier	246,300	274,300	295,200
Other	142,100	181,400	216,300
Total Aircraft Operations	388,400	455,700	511,500

FAA Forecasts	1973	1977	1982
Air Carrier	220,000	255,000	296,000
Other	118,000	120,000	141,000
Total Aircraft Operations	338,000	375,000	437,000

(4) Domestic Enplaned Air Cargo Volumes Are Forecast To Be 118,900 Tons by 1975 and 184,200 Tons by 1980.

(5) An Increase in Utilization Of Wide-Bodied Jet Aircraft Of the Boeing 747 and McDonnell-Douglas DC-10/Lockheed L-1011 Type Is Expected at Boston-Logan International Airport by 1975.

2. RUNWAY 15L-33R IS URGENTLY NEEDED IF BOSTON-LOGAN INTERNATIONAL AIRPORT IS TO SERVE ADEQUATELY THE EXPANDING AIR TRANSPORTATION REQUIREMENTS OF THE BOSTON REGION. PARALLEL RUNWAY 15L-33R IS REQUIRED TO BEST MEET THE PROJECTED AVIATION DEMAND. EVEN WITH THE PARALLEL RUNWAY, UNRESTRAINED DEMAND WILL EXCEED AIRFIELD CAPACITY.

(1) The Analysis Shows the Following Capacities:

	1970*	1975**	1980***
	Condition 1	Condition 4	Condition 5A
. Existing Airfield	368,000	313,000	340,000
	Condition 6A	Condition 6	Condition 6C
. Improved Airfield	417,000	348,000	398,000

* Without wide-body jets.

** With wide-body jets and preferential runway use.

*** With computer aided approach sequencing and reduced separation requirements which should be realized in the 1980 time period.

(2) The Analysis Shows That Aircraft Delay Levels Will Be As Follows Without the New Parallel Runway.

	Annual Delay In Hours	Annual Cost of Delay
. Condition 4 - Existing Airfield Noise Abatement Alt. #1	15,480	$4,800,000

	Annual Delay* In Hours	Annual Cost of Delay
. Condition 5 - Existing Airfield Noise Abatement Alt. #2	20,575	$6,160,000
. Condition 6 - Improved Airfield Maximum Noise Abatement	11,725	$3,810,000

* Based upon the planning range demand level of 350,000 annual operations.

. Practical operating considerations indicate that to achieve the same degree of overwater operation possible with the improved airfield, the existing airfield must be operated at delay levels approaching those of Condition 5.

(3) Parallel Runway 15L-33R Will Provide the Capability For Preferential Runway Utilization Permitting Maximum Use Of Overwater Approaches and Departures.

. Operational flexibility of Boston-Logan International Airport's existing runway system is severely limited in comparison with other major airports by two principal factors.

- Only one set of parallel runways is available.
- This single set of parallels is only partially useable for simultaneous operations due to noise abatement limitations.

(4) Runway 15L Will Provide Capability for a Category II and III Instrument Landing System On a Runway Heading Which Will Permit Aircraft Operations Under a Wider Variety Of Weather Conditions Than the Present Runway System Can Accommodate.

(5) The Terminal Facility Improvement Program, As Planned by the Massachusetts Port Authority, Presents an Excellent Solution To Major Terminal Complex Development Within a Severely Restricted Land Area.

(6) Alternate Positioning Of the 15L-33R Parallel Runway With Increased Spacing Up To 3,500 Feet Creates Major Environmental Disruption With Minimal Operational Advantage.

(7) Concentration Of Primary Runway System Development in the East-West (9-27) Direction Is Not Possible Because It Is Subject To Obstructions by High-Rise Building Construction Taking Place in Downtown Boston and by Harbor Activity.

(8) Runway Extensions 9 and 4L Will Increase the Margin Of Operational Safety and Permit Departing Aircraft To Begin Their Takeoff at a Greater Distance From Residential Communities.

- The extensions will increase aircraft altitudes over the residential communities under their climb out path thus reducing noise levels.
- The existing landing thresholds will remain in present locations.

(9) STOL Runway 15-33 Offers the Opportunity To Increase Airfield Capacity in the Future As STOL Type Aircraft Become Operational.

- The STOL aircraft with short takeoff and landing characteristics can operate with separate traffic patterns to be established for this runway.

3. THE RESULTS OF THE CALCULATIONS PERFORMED BY BOLT, BERANEK, AND NEWMAN, INC. SHOW THAT THE CONSTRUCTION OF THE NEW RUNWAY AND THE INTRODUCTION OF NEW AIRCRAFT WILL REDUCE THE NUMBER OF RESIDENTS WITHIN THE NEF-30 AND NEF-40 CONTOURS BY FORTY PERCENT (40%) AND SIXTY-FOUR PERCENT (64%) RESPECTIVELY IN 1975 AS COMPARED TO CONDITIONS EXISTING IN 1970.

(1) The Population Reductions Within the NEF-30 and NEF-40 Contours Are Possible Because Of Introduction Of the New Quieter Aircraft and Because the Improved Airport Allows More Use Of Overwater Movements and Operational Flexibility. The Table Below Shows the Results for Each Of the Six Conditions Evaluated During This Study. Exhibits III-21 and III-21A Show the Contours for the Three Conditions Listed Below for Both NEF-30 and NEF-40:

Condition	Airport	Utilization	Traffic
1	Existing	Historic	1970
4	Existing	Noise Abatement Alt. #1	1975
6	Improved	Maximum Noise Abatement	1975

Condition	1	2	3	4	5	6
Airport Configuration	Existing	Existing	Existing	Existing	Existing	Improved
Traffic Projections	Actual 1970	1975	1975	1975	1975	1975
Runway Utilization	Historic	Maximum Capacity	Historic	Noise Abatement Alt.No.1	Noise Abatement Alt.No.2	Maximum Noise Abatement
<u>NEF-30</u>						
Acres (1000's)	12.1	14.7	13.2	8.3	10.4	8.8
Population (1000's)	121.4	139.9	127.3	71.6	92.7	72.8
<u>NEF-40</u>						
Acres (1000's)	3.1	2.8	3.1	2.5	2.7	2.1
Population (1000's)	24.4	17.0	23.8	11.4	14.2	8.9

(2) <u>The Existing Airport Operated for Maximum Noise Abatement in 1975 Results in an Increase Of Twenty-Eight Percent (28%) in the Number Of Residents Within the NEF-40 Contour As Compared To the Improved Airport.</u>

(3) <u>Reductions Of Twenty Percent (20%) in Terms Of Numbers Of Dwelling Units Within the NEF-40 Contour Resulted From Calculations Made On a Relative Basis Only Where the Same Aircraft (B-727) and the Same Number Of Movements Were Compared With and Without the Improved Airport for 1975 Traffic.</u>

(4) Significant Noise Reductions Should Result From Research On Noise Reduction Equipment As a Result Of Expenditures by the Industry Of $350,000,000 During the Last Five Years and by the Federal Government's Annual Expenditure Of Approximately $40,000,000.

(5) Subjective Perceived Noise Levels On the Newer Engines Which Include Those On the New Wide-Body Aircraft Are One-Fourth To One-Half Those That Would Be Perceived by an Observer On Present Four Engine Vehicles Such As the B-707.

(6) The NASA "Quiet Engine" Will Produce Less Noise Than Any Engine Now in Production. But This New Engine Is Probably Ten To Fifteen Years Away From Production.

(7) Continued Implementation Of the Boston-Logan International Airport Noise Abatement Program Together With the Federal Aviation Administration's Noise Regulations Should Provide Additional Future Improvements.

(8) The NEF Methodology Permits Only Relative Measure Of Aircraft Noise Under Various Operating Modes. It Cannot Be Used As an Absolute Measure. It Has an Individual Annoyance Correlation Coefficient Of About 0.35 and Is Therefore Not Useful for Predicting Individual Annoyance.

4. THE IMPROVED AIRPORT WILL NOT CAUSE AN INCREASE IN WATER POLLUTION IN BOSTON HARBOR. THE MASSACHUSETTS PORT AUTHORITY WILL REDUCE THE FILL REQUIRED IN THE BH-C AREA UNTIL THE CITY OF BOSTON CORRECTS THE SEWER OUTFLOW WHICH DISCHARGES RAW SEWAGE DURING PERIODS OF HEAVY RAINFALL INTO THE BH-C EMBAYMENT.

(1) The Landfill For a Full Runway Safety Overrun on 15L as Prescribed by the FAA in the Inner Lagoon Known As Area BH-C Would Reduce the Volume Of This Inner Lagoon by Thirty-Seven Percent (37%) and Reduce Dilution by About Eighteen Percent (18%) Resulting in Greater Concentrations Of Pollutants Overflowing From the City Of Boston Sewer Located at Coleridge and Moore Streets.

- Due to unfavorable environmental effects of the fill necessary for the extended runway safety area on Runway 15L in the BH-C area, a waiver is to be requested from the FAA. The waiver will request that a postponement of the fills in the BH-C be allowed until the overflows from the City of Boston sewer are stopped.

- A small fill will still be required in BH-C. This fill represents less than ten percent (10%) of the initial fill in BH-C and will have insignificant effects on the dilution.

(2) The Proposed Landfill in the BH-B and BH-A Areas, If Constructed, Would Not Affect the Velocity Of Tidal Flows Nor Cause Any Erosion Of Shoreline and Beach Areas in the Channel Between the Airport and Winthrop, the Effects Of the Smaller Landfill On the Velocity Of the Same Tidal Flows Are Insignificant.

(3) The Other Two Fill Areas Located in BH-A and BH-B Will Not Alter Existing Harbor Conditions Because the Fills Will Reduce the Cross Sections Of the Channels by Small Amounts.

(4) The Effects Of Dredging, Fill Materials, and Dike Design Have Been Analyzed by Fay, Spofford, and Thorndike, Inc. Their Study Concluded That the Dikes As Designed Will Have No Detrimental Environmental Effects.

(5) Fuel and Oil Spills, Although a Minor Contributor to Harbor Pollution, Will Be Reduced As a Result Of Corrective Steps Initiated by the Massachusetts Port Authority. These Include:

- Short-term steps in the form of clean up and daily inspections.

- Long-term steps in the form of installation of oil skimming devices at the northwest and southeast outfalls of apron drainage systems.

(6) The Venting Of Engine Holding Tanks Upon Takeoff Will Be Discontinued by December, 1971.

5. AIR POLLUTION IN THE BOSTON METROPOLITAN AREA AS A RESULT OF AIRPORT OPERATION IS SMALL IN COMPARISON TO OTHER SOURCES IN THE AREA. THE IMPROVED AIRPORT WILL FURTHER REDUCE AIR POLLUTION IN 1975 IN COMPARISON TO PROJECTED OPERATIONS WITH THE EXISTING AIRPORT BECAUSE OF THE REDUCTION IN WAITING TIME DURING TAXIING AND WAITING FOR TAKEOFF THAT ARE MADE POSSIBLE BY THE NEW RUNWAY. ALTHOUGH NOT CONSIDERED IN THE HEW PROCEDURE, THE HOLDING OF AIRCRAFT AT ALTITUDES OF ABOVE 3,000 FEET RESULTING FROM ARRIVAL DELAYS, CONTRIBUTES TO AIR POLLUTION. THIS IS ALSO BEING REDUCED BECAUSE THE NEW RUNWAY WILL REDUCE ARRIVAL DELAY.

(1) Field Measurements Of Air Pollutants Included Oxides Of Nitrogen, Oxides Of Sulfur, Carbon Monoxide and Particulate Matter and Resulted in Lower Levels On the Present Airport Than in the Surrounding Communities by a Factor Of Approximately Two (2) Which Means That the Concentrations Of Pollutants at the Airport Are About Half Those Existing in the Communities.

(2) The Reduced Aircraft Departure Waiting Time, Made Possible by the Construction Of the New Runway, Will Result in Reductions Of Air Pollution Generated by Aircraft Ground Operations Expected To Occur in 1975, When Compared To 1975 Ground Operations Using the Existing Airport (i.e. With No New Parallel).

- Carbon Monoxide (CO) will be reduced by 7823.6 tons/year
- Nitrogen Oxides (NO_x) will be reduced by 214.1 tons/year
- Particulates (C) will be reduced by 1110.6 tons/year
- Hydrocarbons (HC) will be reduced by 429.3 tons/year.

(3) New "Smokeless" Aircraft Power Plants Will Cut Particulate Emission by Approximately One Half.

- The JT8D retrofit programs on DC9's, 727's, 737's will be essentially completed by the end of 1972.
- The new engines in the 747, DC10 and other wide-body aircraft will incorporate the "smokeless" engine.

(4) Strict Enforcement Against "Venting" Of Holding Tanks Will Eliminate About 111 Gallons Per Day Of Liquid Fuel Emissions.

(5) Current and Projected Levels Of Air Pollutants at the Airport Are Below the Generally Accepted Safe Levels As Defined by the Environmental Protection Agency and Thus Will Not Adversely Influence Any Activity Including Recreation and Swimming.

- A thorough review of existing literature performed during this study is discussed in the text of this report.

6. THE AIRPORT IMPROVEMENT PROGRAM WILL HAVE A LIMITED EFFECT ON PERIPHERAL FACTORS.

(1) The 15L-33R Runway Will Not Represent a Hazard To Vessels in the Harbor Ship Channel Or the President Roads Anchorage.

(2) Extension Of Runway Ends 9 and 4L Will Have No Effect On Shipping.

(3) Vehicular Traffic To and From Boston-Logan International Airport Will Increase Whether Or Not the Improvement Program Is Undertaken.

(4) Boston-Logan International Airport Generated Access Trips Do Contribute To the Peak Hour Congestion Problems in the Boston Roadway Network. However, Boston-Logan International Airport Is Only One Segment Of a Metropolitan Roadway and Transit System Which Requires Improvement and Expansion.

(5) Shifts in Boston-Logan International Airport's Passenger Demand To Alternate Transportation Modes Will Not Reduce Peak Hour Congestion Problems in the Boston Roadway Network, but Merely Redistribute This Traffic From One Area To Another.

7. RECREATIONAL USES OF BOSTON HARBOR WILL NOT BE AFFECTED BY THE PROPOSED AIRPORT IMPROVEMENTS. THE CLAM BEDS THAT WILL BE DISPLACED BY THE PROPOSED FILLS WILL BE MOVED TO ALTERNATE AND SAFER LOCATIONS.

(1) A Plan for the Relocation Of the Existing Clam Beds, Which at Times Have Been Restricted Because Of Health Hazards Has Been Developed. Massachusetts Port Authority in Conjunction With the Massachusetts Department Of Natural Resources Is Currently Seeking a Suitable Site for Clam Relocation. Massachusetts Port Authority Will Eventually Defray the Costs Of Such Relocation.

(2) Continued Safe Navigation Of Sail and Motor Boats Within the Prescribed Channels As Shown by Buoys and Channel Markers Will Not Be Affected by the Present Or Improved Airport Operations.

(3) Marine Life Will Not Be Affected by Either the Present Or Improved Airport If the Dikes and Landfills Are Built As Engineered. The Program Initiated by the Massachusetts Port Authority To Install Oil Pollution Control Devices Will Further Improve Water Quality in the Immediate Vicinity Of the Airport.

(4) The Proposed Fills Will Eliminate Some Bird Habitats in the BH-A, BH-B and BH-C Areas. This Will Result in a Safer Environment To the Aircraft and To the Birds i.e. Ingestion and Also They Will Not Be Exposed To Possible Disease.

(5) Massachusetts Port Authority Plans To Continue Their Sponsorship Of Current Recreational Activities and To Support Additional Opportunities for Recreation in Cooperation With Responsible Members Of the Communities.

8. NONE OF THE ALTERNATIVES EXPLORED WERE AS PRACTICAL, FEASIBLE OR ENVIRONMENTALLY DESIRABLE AS THE PROPOSED IMPROVEMENT PROGRAM CONSISTING OF PARALLEL RUNWAY 15L-33R, EXTENSION OF RUNWAYS 9 AND 4L, AND STOL RUNWAY 15-33.

(1) Any Moratorium On Airfield and Terminal Improvements Would Have Adverse Legal, Financial, and Economic Impacts On the Boston Metropolitan Region.

(2) From the Standpoints Of Capacity, Noise Exposure and Air Pollution, the Proposed Improvement Program Represents the Most Advantageous Alternative.

- Condition 6, the improved airport, is the only condition which reasonably satisfies projected 1975 aviation demand.

- Condition 6, which represents the improved airport, is superior from a standpoint of noise and air pollution.

(3) Operational Alternatives Cannot Practically Be Used To Reduce Total Aviation Demand Existing Within the Constraints Imposed by the Airfield Facility Without a Derogatory Effect On Service.

- Eliminating general aviation traffic as required to reduce congestion and eliminate need for increased capacity will not noticeably reduce Boston-Logan International Airport's environmental impact.

(4) Political and Environmental Objections To a Second Air Carrier Airport Must Be Overcome Before Site Selection, Planning and Design, and Construction Can Be Undertaken. Such Considerations Place a Second Air Carrier Airport Beyond the Time Requirement for Boston-Logan International Airport Improvement To Meet the Demands Placed Upon It by the Boston Area.

(5) From a Practical and Technological Viewpoint, the Diversion Of the Short-Haul Passenger Market to Alternate Transportation Modes Must Be Considered As Possible Long-Range Factors, Which Could Ultimately Decelerate the Rate Of Increase Although the Demand for Air Service Will Continue to Increase.

- The practical operation of a competitive high-speed rail system in the Northeast Corridor doesn't appear probable by 1980.

- A competitive V/STOL system in the Northeast Corridor does not appear probable by 1980.

(6) Of All the Alternatives Considered for Reducing Noise Exposure, With the Exception Of Noise Reduction at the Source, the Implementation Of a Rigid and Comprehensive Preferential Runway Use System Offers the Greatest Potential for Substantial Noise Abatement Without Imposing Penalties On the Airport User and Airport Neighbors.

(7) No Other Facility Alternatives Explored Were As Practical, Feasible Or Environmentally Desirable As the Recommended Projects.

9. BOSTON-LOGAN INTERNATIONAL AIRPORT MAKES A SIGNIFICANT ECONOMIC CONTRIBUTION TO THE BOSTON METROPOLITAN AREA, A CONTRIBUTION THAT WILL BE ENHANCED BY THE PROPOSED IMPROVEMENT PROGRAM.

(1) The Impact Upon the Income Of the Economy Of the Boston Metropolitan Area Created by the Direct Payrolls and Purchases Of Boston-Logan International Airport Was $728 Million in 1970. With the Improved Airport This Impact Is Expected To Grow To $1,274 Million ($1.27 Billion) in 1975. All Of This $546 Million Increase in Impact Will Not Occur If the Number Of Operations at the Airport in 1975 Is Restricted.

(2) If the Existing Airport Were Operated in 1975 On the Same Basis As Is Projected for the Improved Airport in 1975 (Same Delay Levels and Noise Abatement Procedures) To Approach the Reduced Levels Of Air and Noise Pollution Made Possible by the Improved Airport, an Estimated 21,600 Scheduled Air Carrier Operations With 1,200,000 Passengers Or 600,000 Trips Would Be Lost. This Reduction in the Level Of Air Transportation Services in 1975 Would Create a Loss To the Economy Of $116 Million Per Year by 1975.

(3) The Present Average Level Of Construction Expenditures (1967-1970) at Boston-Logan International Airport Creates a Total Impact Upon the Boston Metropolitan Economy Of $76.3 Million Per Year With an Estimated 900 Construction jobs. The Increase in the Economy Created by the Proposed Improvement Program Will Average $191.9 Million Per Year With 1,900 Jobs Over the Period 1971-1974.

(4) The Cost To the Boston Metropolitan Area Resulting Only From the Loss Of Airport Employment Caused by a Curfew Imposed On Night Jet Flights Between 10:00p.m. and 7:00a.m. Is Estimated To Be $18 To $28 Million Per Year in 1971. In Addition, Such a Curfew Will Cause Increases In Transportation Costs and Competitive Disadvantages for Selected Firms in the Boston Metropolitan Area Whose Operations Are Highly Sensitive To Transportation Delays.

CHAPTER I

AIR TRAFFIC FORECASTS

I. INTRODUCTION

1. PURPOSE

Forecasts of air traffic volumes were made as a basis for facility master planning of future Boston-Logan International Airport improvement projects. Also estimates of aircraft type distribution by mileage category were prepared to support the environmental impact studies.

2. APPROACH

The approach to estimating air traffic volumes was as follows:

(1) Historic trends and possible changes to the economic base of the Boston area were analyzed.

(2) Current air service provided by the air carriers serving Boston along with future possible improvements were considered.

(3) Trends of historic traffic volumes at Boston-Logan International Airport were analyzed along with their relationship to national volumes and growth rates.

(4) Forecasts originally developed in Landrum and Brown's 1968 "A Study of the Air Transportation Potentials and Facility Requirements In The Metropolitan Boston Air Service Area, 1970 Through 1990" were utilized in a revised and expanded form.

(5) Estimated aircraft operations by type based on future fleet mix were related to current operations at Boston-Logan International Airport.

II. SUMMARY

The factors and analyses taken into consideration in forecasting air traffic at Boston-Logan International Airport all lend support to the expectancy that Logan's traffic will grow at a rate in keeping with the total United States. The current Landrum and Brown air traffic forecasts for the total United States are based upon analysis of long-term economic growth on both local and national scales and provide a reasonable basis on which to determine future facility requirements, as they are not unduly influenced by limited cyclical fluctuations.

The introduction of the larger wide-body aircraft, which are cleaner and less noisy will have a major impact on the Boston market as the airlines take delivery in the early 70's. These aircraft are expected to replace many of the noisier present day aircraft.

III. CONCLUSIONS

1. TRAFFIC VOLUMES AT BOSTON-LOGAN INTERNATIONAL AIRPORT ARE EXPECTED TO CONTINUE TO INCREASE IN THE 1975 AND 1980 TIME FRAMES.

(1) Total Enplaned Passengers Are Forecast To Increase To 6,335,200 by 1975 and To 8,256,100 by 1980.

These volumes of growth are in keeping with the growth forecast the total United States.

(2) Total Scheduled Aircraft Departures Are Estimated To Grow To 111,950 Departures by 1975 and 124,700 Departures by 1980.

These volumes are based on historic experience with load factors and estimates of increased volumes of larger capacity aircraft. The effect of load factor changes on future traffic volumes is discussed in Chapter VIII.

(3) Total Aircraft Operations, Unrestricted by Facility Limitations Are Estimated As Follows:

Landrum and Brown Aircraft Operations Forecasts

	1975	1980	1985
Air Carrier	246,300	274,300	295,200
Other	142,100	181,400	216,300
Total Aircraft Operations	388,400	455,700	511,500

FAA Forecasts	1973	1977	1982
Air Carrier	220,000	255,000	296,000
Other	118,000	120,000	141,000
Total Aircraft Operations	338,000	375,000	437,000

(4) Domestic Enplaned Air Cargo Volumes Are Forecast To Be 118,900 Tons by 1975 and 184,200 Tons by 1980.

These forecasts were based upon the most recent years relationship between Boston-Logan International Airport's volumes and the total United States.

2. AN INCREASE IN UTILIZATION OF WIDE-BODIED JET AIRCRAFT OF THE BOEING 747 AND McDONNELL-DOUGLAS DC-10/LOCKHEED 1011 TYPE IS EXPECTED AT BOSTON-LOGAN INTERNATIONAL AIRPORT BY 1975.

(1) Many Of the Non-Fan Type Jet Aircraft and Propeller Aircraft in Use Today by the Air Carriers Serving Boston Are Expected To Be Retired and Fewer Operating at Boston-Logan International Airport by 1975.

This reflects a national trend in substituting larger, quieter type aircraft for some of the present day aircraft. Boston-Logan International Airport is expected to receive a proportionate share of these new type of aircraft in stage length categories similar to those which they are replacing.

(2) The Day/Night Relationship Of Air Carrier Operations at Boston-Logan International Airport in 1975 Is Expected To Be Similar To the 1970 Experience.

However, without implementation of the proposed improvement program an increase in nighttime operations can be expected to develop, caused by rising delay and congestion levels.

IV. DISCUSSION

The air traffic forecast categories discussed for Boston-Logan International Airport are as follows:

- Enplaned Passengers (Domestic and International)
- Scheduled Airline Aircraft Departures (Domestic and International)
- Aircraft Operations
- Enplaned Cargo (Domestic)
- Operations By Aircraft Type and Stage Length

1. TOTAL ENPLANED PASSENGERS ARE FORECAST TO RISE FROM THE 1970 LEVEL OF 4,449,589 TO 6,335,200 IN 1975, TO 8,256,100 IN 1980, AND TO 10,177,100 BY 1985.

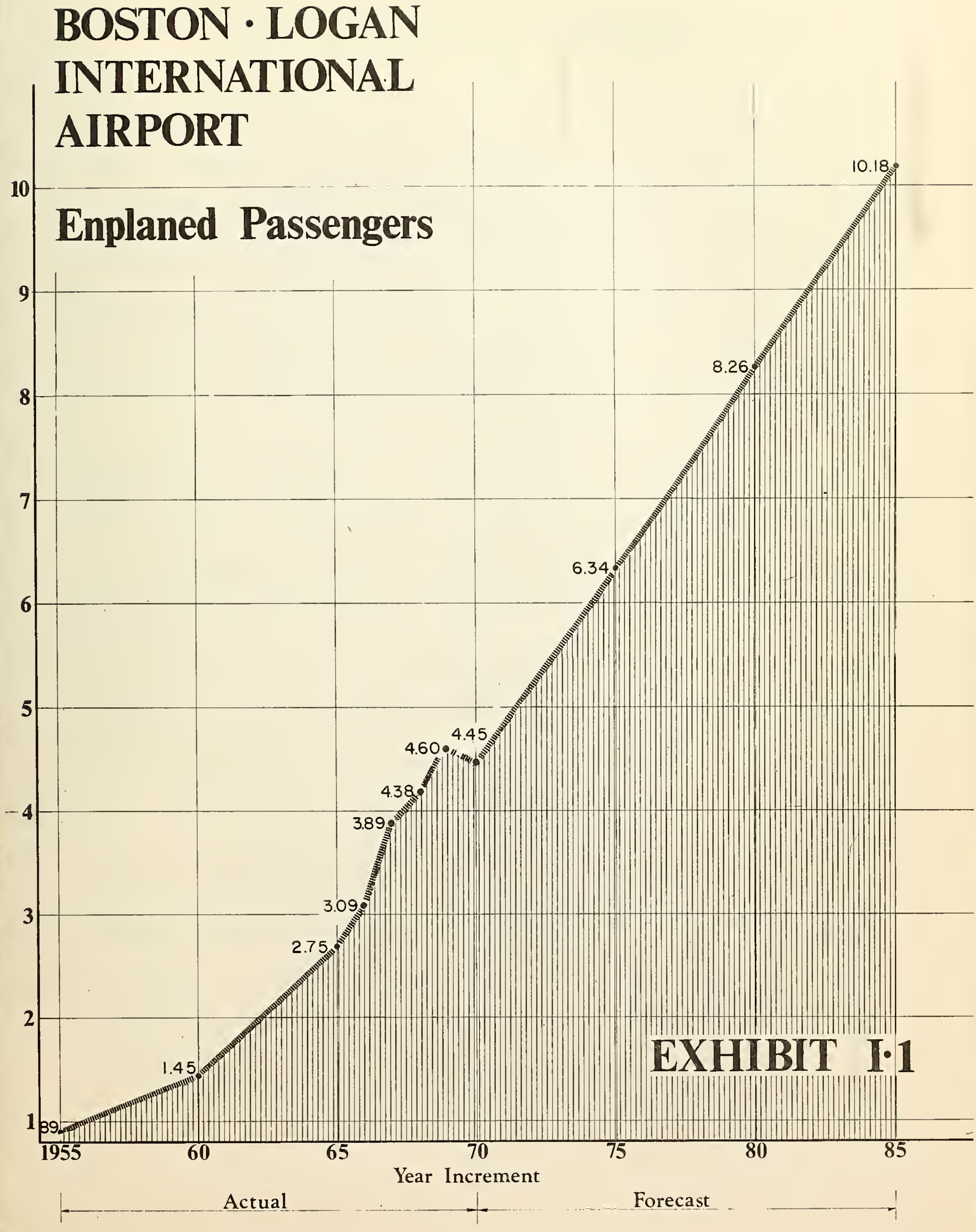
Factors which have affected air traffic growth in the United States as a whole have also affected air traffic growth at Boston-Logan International Airport. This is demonstrated, in part, by the fact that domestic traffic growth through Boston-Logan International Airport has increased at about the same rate as for the United States in recent years. Boston's economic growth, the general growth in the nation's economy and improvements in air service and air service authority have all been contributing factors.

Boston-Logan International Airport's share of the total scheduled domestic enplaned passenger market has shown an increasing trend since 1955. However, the most recent experience, based upon the last five to ten years of available data, indicates that this percentage relationship has tended to level at approximately three percent (3%) of the United States passenger volume.

International and overseas enplaned air passengers at Boston-Logan International Airport, those carried both by the United States Flag and Foreign Flag carriers, have historically been only a minor portion of total enplaned passengers, in the range of four percent (4%) to five percent (5%). The volumes realized at Boston-Logan International Airport have increased steadily between 1960 and 1970. The 1970 volume of international enplaned passengers was more than four times the volume realized in 1960. International passengers continue to be a small part of the total. They could potentially become greater depending upon the decisions of the Civil Aeronautics Board in air service cases affecting the distribution of international passenger service and the air carriers in implementing existing or new service authorizations. Congestion at other points of origination and destination, such as New York, is affecting the potential international traffic at Boston-Logan International Airport.

The following table and Exhibit I-1 show historic and forecast scheduled enplaned passenger volumes for Boston-Logan International Airport.

Period	Scheduled Enplaned Passengers Boston-Logan International Airport
Historic	
1955	895,407
1960	1,451,360
1965	2,746,360
1966	3,090,798
1967	3,892,691
1968	4,378,679
1969	4,604,668
1970	4,449,589
Forecast	
1975	6,335,200
1980	8,256,100
1985	10,177,100


BOSTON · LOGAN
INTERNATIONAL
AIRPORT
Enplaned Passengers
10
9
8
7
6
5
4
3
2
1
.89
1.45
2.75
3.09
3.89
4.38
4.60
4.45
6.34
8.26
10.18
EXHIBIT I·1
1955
60
65
70
75
80
85
Year Increment
Actual
Forecast

2. SCHEDULED AIRLINE AIRCRAFT DEPARTURES ARE FORECAST TO BE 111,950 IN 1975, 124,700 IN 1980, AND 134,200 IN 1985.

A study of average seating capacities for the total scheduled domestic air carrier fleet over the past twenty years has indicated that there has been an average increase of about 20 seats per five-year period. This relationship is illustrated on Exhibit I-2. The larger piston-engine aircraft in service prior to the introduction of jet aircraft had average seating capacities of about 70 passengers. The larger jet aircraft now in use have average seating capacities of approximately 110 passengers which represents a fifty-seven percent (57%) increase over the piston-type aircraft previously in use.

The wide-bodied jets, such as the Boeing 747 now entering service and the forthcoming air bus aircraft have seating capacities averaging from 250 to 450 seats. The air carriers have placed orders for substantial numbers of these wide-bodied jet aircraft. Based on the use of such wide-bodied jets in increasing number, the future average seating capacities should continue to increase for the total air carrier fleet. With such large aircraft anticipated to be in use during the forecast period, the increase in average seats should continue at a rate at least equal to that which has been demonstrated over the past two decades.

For purposes of forecasting scheduled domestic airline aircraft departures, an analysis was made of the historical experience over the last several years at Boston-Logan International Airport. In this historic analysis, a review was made of relationships between domestic enplaned passenger volumes, enplaned passenger load factors, the average seating capacities of the aircraft and the number of scheduled domestic air carrier departures. The

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INTERNATIONAL
AIRPORT

Aircraft Size Comparison

EXHIBIT I-2

enplaned passenger load factor is the ratio of domestic enplaned passengers to total scheduled aircraft departing seats. The enplaned passenger load factor has varied slightly, but averages about fifty percent (50%). Based on the historical experience in terms of domestic enplaned passenger load factors and growth in average seating capacity of aircraft and upon the previously forecast enplaned passenger volumes, the estimated number of scheduled domestic air carrier departures were determined for Boston-Logan International Airport.

Similar analyses were made of the historical international scheduled departures to provide data on enplaned load factors and seating capacities for forecasting the scheduled international and overseas airline aircraft departures. International and overseas scheduled airline aircraft departures have accounted for a small percentage of the total scheduled airline aircraft departures at Boston-Logan International Airport and are anticipated to continue as a relatively minor part of the total scheduled air carrier departures in the future. However, it should be noted that the seating capacity of the average aircraft used in international service is generally higher than the domestic average. The average seating of aircraft used in international service has historically grown at a faster rate than the domestic average, a trend expected to be continued by extensive use of air bus and 747 wide-bodied aircraft in international service.

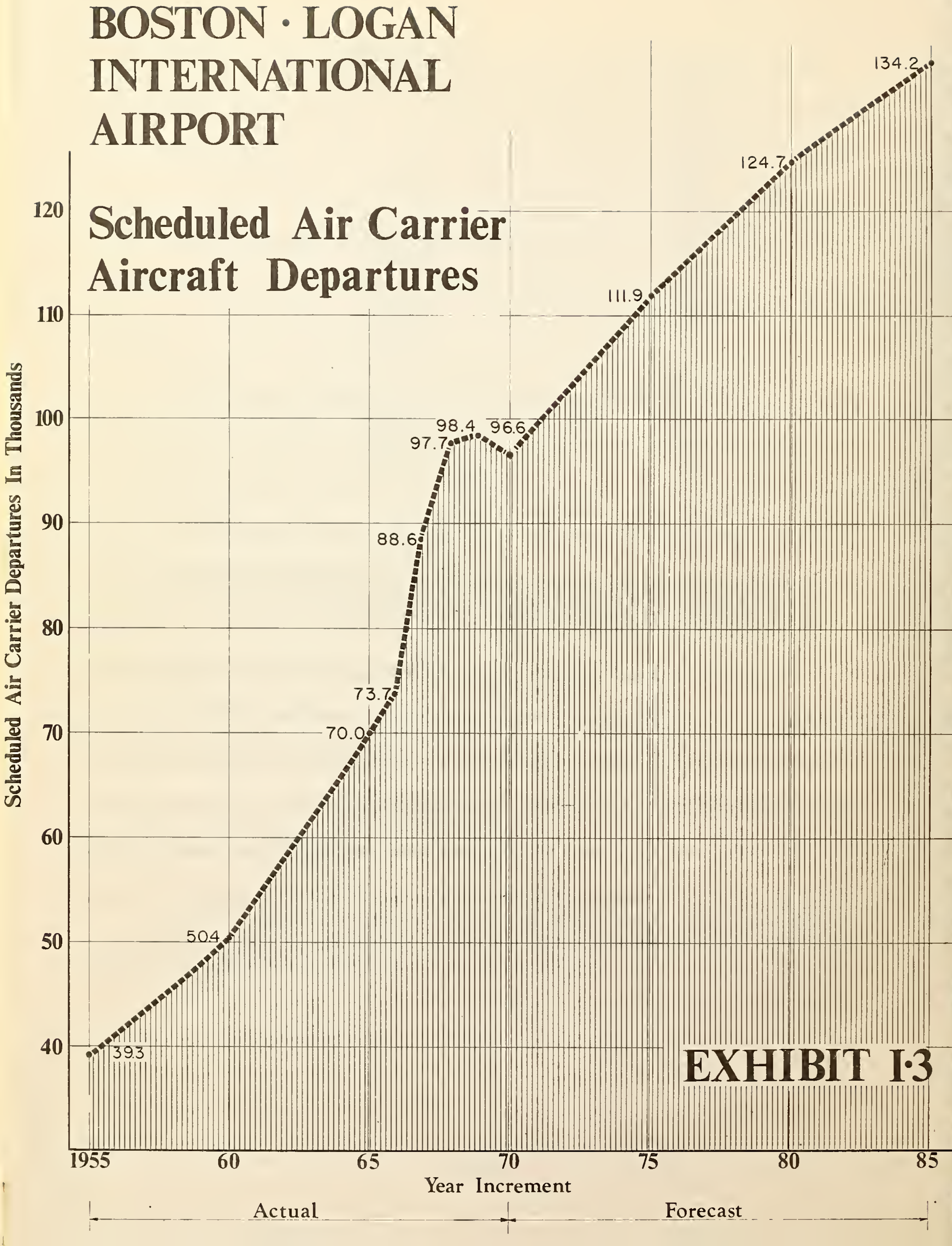
The following table and Exhibit I-3 show the total scheduled airline aircraft departures estimated for Boston-Logan International Airport.

Period	Scheduled Airline Aircraft Departures
Historic	
1955	N.A.
1960	N.A.
1965	70,000
1966	73,650
1967	88,612
1968	97,704
1969	98,397
1970	96,603
Forecast	
1975	111,950
1980	124,700
1985	134,200

N.A. - Not available.

3. TOTAL AIRCRAFT OPERATIONS ARE FORECAST TO INCREASE TO 388,400 BY 1975, 455,700 BY 1980 AND 511,500 IN 1985.

Air carrier aircraft operations are comprised of scheduled domestic, scheduled international and other, including cargo and supplemental operations. For forecast purposes, the estimated number of scheduled air carrier departures discussed previously was doubled to determine the estimated number of scheduled airline aircraft operations since the number of landings equal the number of departures. Historically, other air carrier aircraft operations have been approximately ten percent (10%) of the scheduled air carrier operations. They were forecast to continue at this level during the forecast period.


BOSTON · LOGAN
INTERNATIONAL
AIRPORT
Scheduled Air Carrier
Aircraft Departures
Scheduled Air Carrier Departures In Thousands
120
110
100
90
80
70
60
50
40
39.3
50.4
70.0
73.7
88.6
97.7
98.4
96.6
111.9
124.7
134.2
1955
60
65
70
75
80
85
Year Increment
Actual
Forecast
EXHIBIT I·3

Military aircraft operations at Boston-Logan International Airport have decreased substantially over the years, declining from approximately 20,000 in 1960 to 500 in 1970. A primary reason for this decrease was the movement off the airport of an air national guard unit. Because military aircraft activity is subject to Defense Department policies and the then current international situation, an estimate of 1,000 military aircraft operations at Boston-Logan International Airport is considered reasonable for each of the forecast periods.

To determine the forecast of general aviation aircraft operations, an analysis was made of the historical number of general aviation aircraft based at Boston-Logan International Airport and the number of general aviation aircraft operations. It can be anticipated that if general aviation is not restricted at Boston-Logan International Airport, the number of based aircraft would increase during the forecast period. In keeping with the demonstrated trend at Boston-Logan International Airport through 1970, the number of based aircraft could reasonably increase to 65 by 1975 and to 90 by 1985 if there were facilities available to handle these volumes economically and efficiently. This growth is in line with that experienced for the United States in total. Predicated upon the increased utilization of general aviation aircraft, as forecast by the Federal Aviation Administration for the total United States, it is expected that the general aviation aircraft operations per based aircraft will also increase at Boston-Logan International Airport. The forecast of operations per based aircraft, when applied to the estimated based aircraft, produces the forecast of unrestrained general aviation operations.

As part of the air traffic review and current evaluation, discussions were held with the Massachusetts Port Authority and the Federal Aviation Administration, which indicated a recent modification in counting procedures and definitions of aircraft operations within certain categories. Table I-1, on the following page, and Exhibit I-4 show aircraft operations by category of user at Boston-Logan International Airport for the periods 1975, 1980, and 1985. While certain constraints may occur due to operating limitations which are discussed in Chapter II, the forecasts were made without consideration of possible facility restrictions. Differences between the records of aircraft operations reported by the Massachusetts Port Authority and those reported by Federal Aviation Administration are substantially accounted for by the following types of operations which are not included in the Port Authority's figures:

- Low and missed approaches,
- Practice fixes on Boston-Logan International Airport's navigational aids,
- Overflights through the Boston-Logan International Airport control zone,
- Crew currency (training) flights by the air carriers,
- Some general aviation aircraft which use terminal gates and are not contacted by the fixed base operator, and
- Government-owned aircraft who are not required to pay landing fees at Boston-Logan International Airport.

Most of the foregoing types of flights would require the use of airfield capacity. While it is recognized that some of the foregoing types of traffic will not utilize available aircraft operations capacity directly it is not possible to establish the amounts for each type. However since these aircraft are handled by the control tower personnel they do add to the workload of the controller and some of these operations add to the demand on airport facilities. Hence they are a factor in total airport capacity requirements. Since the majority of these types of traffic do have an impact on the airport operations capacity requirements, the Federal Aviation Administration's reported aircraft operations data were used as being more representative of the total demand. The discussion in Chapter VII examines alternative

TABLE I-1

Aircraft Operations--By Category

Period	Scheduled	Other	Air Carrier	Military	Third Level Air Carrier	General Aviation 1/	Total
Historic							
1955	-	-	92,821	24,161	-	26,651	143,633
1960	-	-	119,593	20,086	-	54,620	194,299
1965	-	-	150,452	9,819	-	76,227	236,498
1966	147,300	11,248	158,548	7,211	-	86,045	251,804
1967	177,224	9,267	186,491	6,279	-	86,231	279,001
1968	195,408	12,350	207,758	4,867	-	99,676	312,301
1969	196,794	20,055	216,849	1,026	28,600*	73,485	319,960
1970	193,206	16,173	209,379	510	37,800*	75,736	323,425
Landrum and Brown Forecast							
1975	223,900	22,400	246,300	1,000	52,100**	89,000**	388,400
1980	249,400	24,900	274,300	1,000	75,400**	105,000**	455,700
1985	268,400	26,800	295,200	1,000	97,300**	118,000**	511,500
Federal Aviation Administration Forecast 2/							
1973	-	-	220,000	-	-	-	338,000
1977	-	-	255,000	-	-	-	375,000
1982	-	-	296,000	-	-	-	437,000

* Based on Massachusetts Port Authority records.

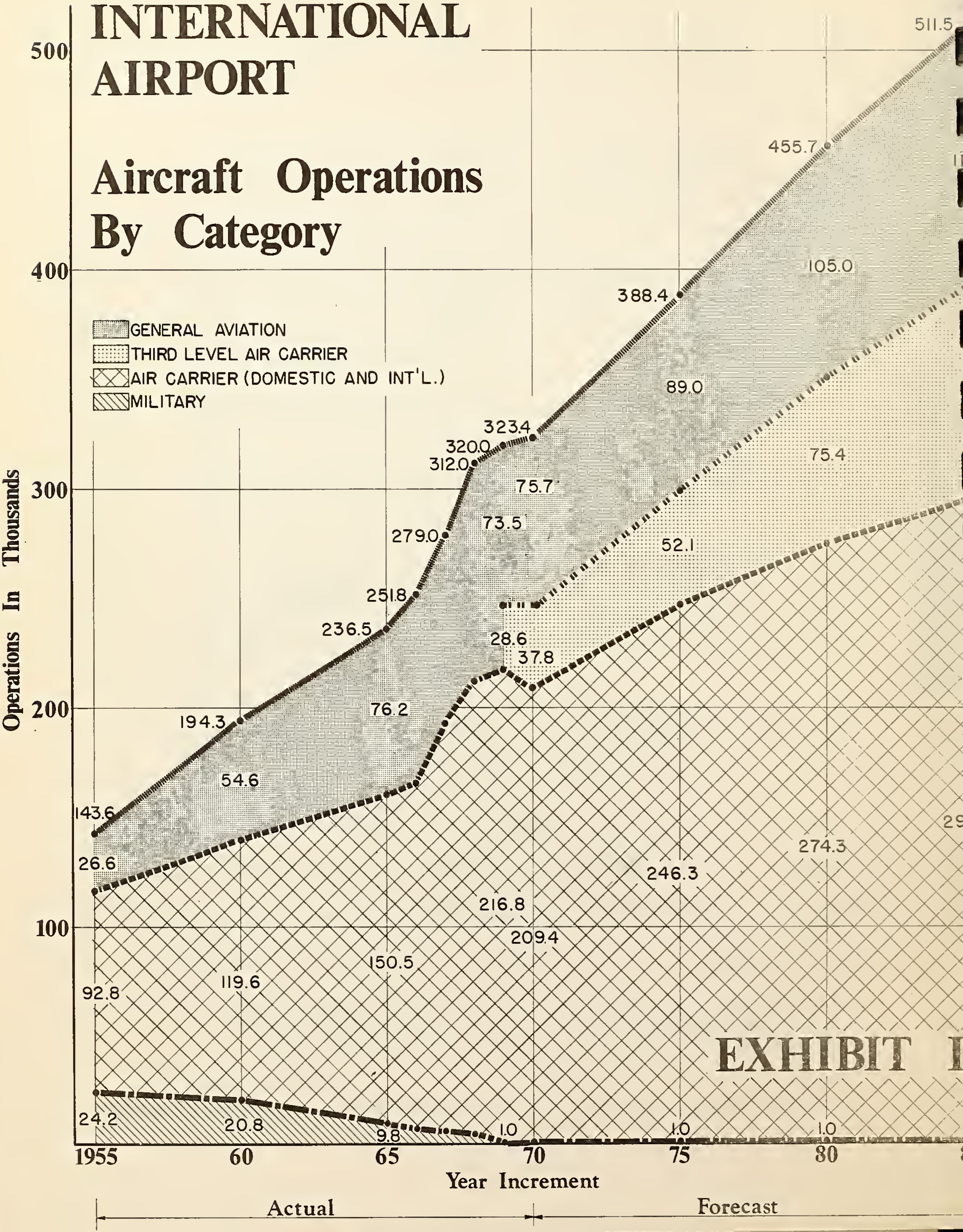
** Estimated based upon recent changes in definitions of operations within general aviation category. The volumes represent an unrestrained demand.

1/ Third level air carrier volumes included for 1955, 1960 and 1965 through 1968.

2/ Correspondence of May 5, 1971 from Chief of Aviation Forecast Division, Office of Aviation Economics.

BOSTON · LOGAN INTERNATIONAL AIRPORT

Aircraft Operations By Category



EXHIBIT

means of demand reduction, their feasibility and effectiveness as solutions in lieu of Boston-Logan International Airport facility improvement. The latest Federal Aviation Administration aircraft operations forecasts for Boston-Logan International Airport are presented for comparative purposes in Table I-1 on page I-15.

4. DOMESTIC ENPLANED AIR CARGO IS FORECAST TO INCREASE FROM THE 1970 VOLUME OF 57,828 TONS TO 118,900 TONS IN 1975, 184,200 TONS IN 1980 AND 249,500 TONS BY 1985.

The growth in enplaned air cargo volumes has been affected by the same economic factors which has accounted for the accelerated growth in air passenger volumes. The inflationary spiral in the economy has meant increased business activities. This, in turn, has resulted in greater production of goods for distribution and a greater use of air transportation in making such distribution nationally. Air cargo rates have become more competitive with surface transportation as a result of the increased use of jet aircraft with their larger air cargo capacities and lower ton-mile costs. Air transportation provides means of shipping necessary materials to defense contractors, particularly where time is a critical factor. Boston is an important center for the manufacture of electronic equipment and for electronic research. Air cargo is the principal mode of shipment used for such high value small sized shipments. The availability of the wide-bodied jets, particularly the air bus and the Boeing 747 can result in further reductions in air cargo rates and increased ability to serve a greater range of commodities and could provide impetus to the growth of the air cargo volumes in the future. This effect can reasonably be anticipated for the Boston Area as well as for the total United States.

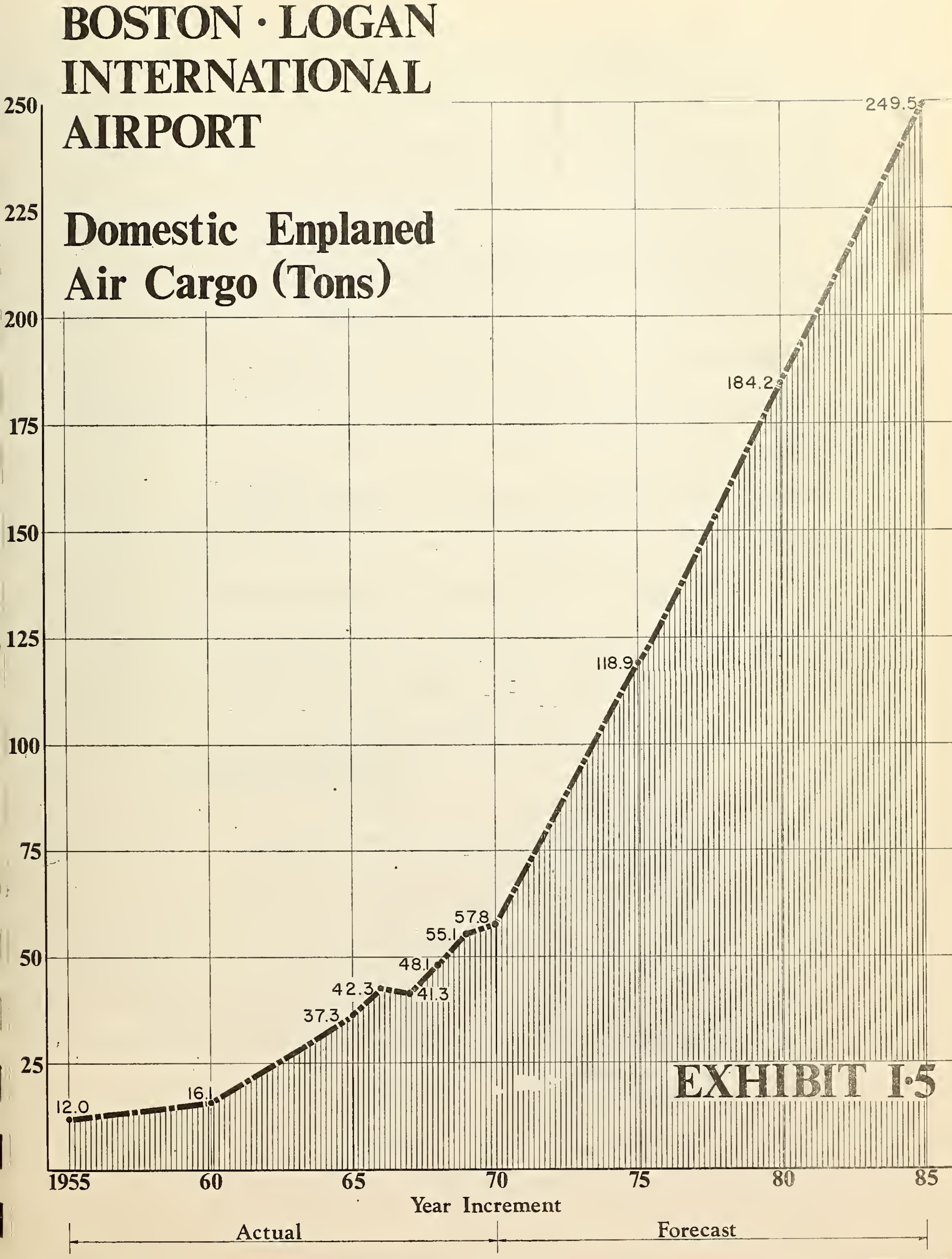
Between 1955 and 1970 scheduled domestic enplaned air cargo volumes realized at Boston-Logan International Airport have almost increased by five times. During recent years Boston-Logan International Airport's percentage relationship has been about 3.30% of the United States total. This percentage relationship to the forecast United States total was used as a basis for forecasting the scheduled domestic air cargo volumes at Boston-Logan International Airport for the periods 1975, 1980 and 1985.

The following table and Exhibit I-5 present the estimated 1975, 1980 and 1985 tonnages of domestic air cargo expected to be enplaned at Boston-Logan International Airport.

Period	Domestic Enplaned Air Cargo (Tons)
Historic	
1955	12,003
1960	16,159
1965	37,289
1966	42,297
1967	41,281
1968	48,117
1969	55,117
1970	57,828
Forecast	
1975	118,900
1980	184,200
1985	249,500

5 AIRCRAFT OPERATIONS BY TYPE IN 1975 WILL INCLUDE A LARGE PROPORTION OF WIDE-BODIED AIRCRAFT AND FEWER OF THE CURRENT GENERATION OF NOISIER AIRCRAF

For purposes of supplying input data for noise forecast contours at Boston-Logan International Airport, a breakdown of operations into eleven aircraft type categories was needed for 1970 and 1975. Also needed was a breakdown of operations by night/day and the takeoffs by mileage range category.


BOSTON · LOGAN
INTERNATIONAL
AIRPORT
Domestic Enplaned
Air Cargo (Tons)
250
225
200
175
150
125
100
75
50
25
12.0
16.1
37.3
42.3
41.3
48.1
55.1
57.8
118.9
184.2
249.5
1955
60
65
70
75
80
85
Year Increment
Actual
Forecast
EXHIBIT I·5

In describing the mix by aircraft type for 1975, the percentage relationship between the 1970 fleet mix and the actual 1970 mix of operations of the carriers serving Boston was applied to an estimated 1975 fleet based on air carrier orders, options and assumed aircraft retirements.

The majority of air carrier aircraft added are expected by 1975 to be of the Boeing 747 and the air buses (DC-10 and L-1011) classes. Aircraft considered for retirement were some of the pure turbojet and propeller aircraft classes. The new aircraft added to the fleet mix were categorized by the stage length ranges for which each was designed. For example, the Boeing 747 was designed as a long-range aircraft and the DC-10 and L-1011 as short and intermediate range aircraft. As a means of checking the reasonableness of the 1975 estimates, a seating analysis was made based on the 1975 aircraft which produced the average number of seats per operation. The results of this analysis when compared to those seats forecast in the previous Landrum and Brown 1975 forecasts showed good correlation.

	Aircraft Type	Percentage Distribution of Air Carrier Aircraft Operations	
		1970	1975
1.	4-Engine Turbojet	10.2%	3.9%
2.	4-Engine Turbofan 4-Engine "Stretch Fan"	12.0	9.7
3.	3-Engine Turbofan	11.7	17.5
4.	3-Engine "Stretch Fan"	14.6	9.7
5.	2-Engine Turbofan	43.6	37.0
6.	4-Engine HBPR Fan	.4	3.9
7.	2, 3-Engine HBPR Fan	- 0 -	13.6
8.	Supersonic Transport	- 0 -	- 0 -
9.	Gen. Aviation Jet	1.6	1.8
10.	4-Engine Propeller	2.1	.5
11.	2-Engine Prop > 12,500 lb.	3.8	2.4
	Total	100.0%	100.0%

Examination of the historic relationship of day/night operations at Boston-Logan International Airport reveals that aircraft arrivals exceed aircraft departures during nighttime hours and that no increasing or decreasing trend is apparent. Future day/night distributions were based upon these historic relationships with adjustment to reflect rising delay and congestion levels which will occur if the new runway is not built and in use by 1975. The day/night distributions reflect the airfield operating conditions which would occur at a demand level of 348,000 annual operations (capacity of the improved plan, see Chapter II and Appendix A) which was used as the common demand denominator in the environmental analyses. Three future distributions were developed as follows:

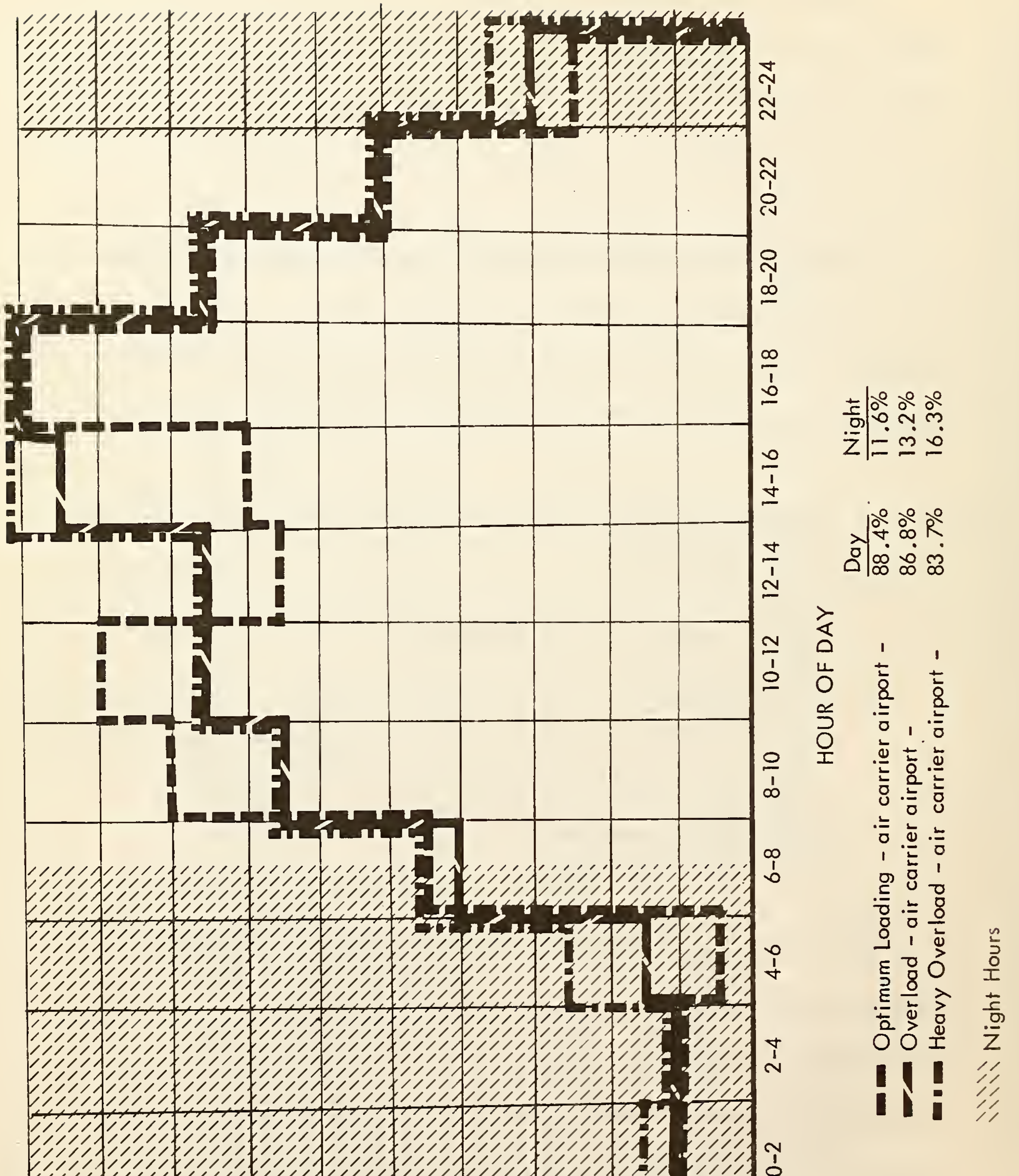
- 1975 Improved Airport - Airport operated at capacity with optimum loading yielding a day/night distribution similar to that occurring today.

- 1975 Existing Airport - Airport operated at overload causing a shift of operations into nighttime hours.

- 1975 Existing Airport - Airport operated to achieve a similar level of noise relief as improved airport. This operation involves the use of runway 15 departures and runway 33 arrivals to the greatest extent possible regardless of demand. This operation, while reducing overflight of populated areas, greatly increases airport delay and reflects a heavily overloaded facility and increasing nighttime use.

Exhibit I-6 presents daily distribution diagrams resulting from increasingly overloaded operating conditions. The day/night relationships indicated are similar to the 1975 projections for Boston-Logan International Airport. Observations at other airports where demand exceeds their rated capacity levels or which have hourly restrictions indicates that as delays occur, operations tend to spread into nighttime hours.

EXHIBIT I-6
DAILY DEMAND DISTRIBUTION
DAY/NIGHT RELATIONSHIP



Source: "Airport Capacity Handbook - Second Edition" - AD690470

In estimating the percentage distribution of takeoffs by aircraft type per mileage range, it was considered reasonable to utilize the current 1970 experience. Experience at Boston-Logan International Airport and other various major airports throughout the United States has shown an increase in the numbers of flights in the longer stage length categories, however, little change over the current experience is expected by 1975 at Boston-Logan International Airport.

After estimating the 1975 percentage distribution of operations by aircraft type, night/day and takeoffs by mileage stage lengths, the last step was that of converting these percentages to average daily operations. The forecast annual 1975 operations of the applicable aircraft types were divided by 365 days to compute the average daily operations (346.379). This daily amount was then distributed on a percentage basis. Tables I-2, I-3, I-4 and I-5 present the average daily operations at Boston-Logan International Airport for 1970 actual, forecast 1975 with the improved airfield and for the existing airfield with two 1975 operating conditions. As mentioned previously, this breakdown is shown by aircraft type, landings and takeoffs, day/night and takeoffs by stage lengths in nautical miles.

TABLE I-2

BOSTON-LOGAN INTERNATIONAL AIRPORT
1970 AVERAGE DAY
EXISTING AIRFIELD

	AIRCRAFT TYPE		TOTAL LANDINGS	TOTAL TAKEOFFS	TAKEOFFS - STAGE LENGTHS IN NAUTICAL MILES						
					0-500	501 - 1000	1001 - 1500	1501 - 2000	2001 - 3500	3501 - 4500	4501 and langer
1.	4 - Engine Turbojet	Day	27.571	22.399	1.791	10.752	.896	2.912	6.048		
		Night	2.564	7.736	2.243	2.863	-	-	2.630		
2.	4 - Engine Turbofan 4 - Engine "Stretch Fan"	Day	26.655	30.330	4.853	9.706	1.213	1.820	12.738		
		Night	8.847	5.172	3.207	1.293	-	-	.672		
3.	3 - Engine Turbofan	Day	26.223	30.223	20.249	5.138	4.231	.605	-		
		Night	8.217	4.217	2.109	2.108	-	-	-		
4.	3 - Engine "Stretch Fan"	Day	36.258	40.725	28.508	5.702	6.515	-	-		
		Night	6.620	2.153	2.153	-	-	-	-		
5.	2 - Engine Turbofan	Day	114.035	123.066	118.144	2.461	2.461	-	-		
		Night	14.311	5.280	5.280	-	-	-	-		
6.	4 - Engine HBPR Fan	Day	1.033	1.033	-	-	-	-	1.033		
		Night	-	-	-	-	-	-	-		
7.	2, 3 - Engine HBPR Fan	Day	-	-	-	-	-	-	-		
		Night	-	-	-	-	-	-	-		
8.	Supersanic Transport	Day	-	-	-	-	-	-	-		
		Night	-	-	-	-	-	-	-		
9.	Gen. Aviation Jet	Day	4.568	4.669							
		Night	.237	.136							
10.	4 - Engine Propeller	Day	4.867	4.355							
		Night	1.257	1.769							
11.	2 - Engine Prop > 12,500 lb.	Day	11.058	11.126							
		Night	.182	.114							
		TOTAL	294.503	294.503							

TABLE I-3

BOSTON-LOGAN INTERNATIONAL AIRPORT
1975 AVERAGE DAY
IMPROVED AIRFIELD

AIRCRAFT TYPE			TOTAL LANDINGS	TOTAL TAKEOFFS	TAKEOFFS - STAGE LENGTHS IN NAUTICAL MILES						
					0-500	501 - 1000	1001 - 1500	1501 - 2000	2001 - 3500	3501 - 4500	4501 and longer
1.	4 - Engine Turbojet	Day	12.641	10.019	.802	4.809	.401	1.302	2.705		
		Night	.840	3.461	1.004	1.281			1.176		
2.	4 - Engine Turbofan 4 - Engine "Stretch Fan"	Day	25.935	28.790	4.606	9.213	1.152	1.727	12.092		
		Night	7.765	4.910	3.044	1.228	-	-	.638		
3.	3 - Engine Turbofan	Day	47.342	53.232	35.665	9.049	7.453	1.065	-		
		Night	13.318	7.428	3.714	3.714	-	-	-		
4.	3 - Engine "Stretch Fan"	Day	29.209	32.008	22.406	4.481	5.121	-	-		
		Night	4.491	1.692	1.692	-	-	-	-		
5.	2 - Engine Turbofan	Day	116.626	122.792	117.880	2.456	2.456	-	-		
		Night	11.434	5.268	5.268	-	-	-	-		
6.	4 - Engine HBPR Fan	Day	11.952	11.516	1.382	4.606	.461	1.152	3.915		
		Night	1.528	1.964	.884	.609	-	-	.471		
7.	2, 3 - Engine HBPR Fan	Day	41.821	42.892	26.009	6.002	6.002	2.864	2.015		
		Night	5.359	4.288	2.847	.949	-	-	.492		
8.	Supersonic Transport	Day	-	-	-	-	-	-	-		
		Night	-	-	-	-	-	-	-		
9.	Gen. Aviation Jet	Day	5.127	5.489							
		Night	.879	.517							
10.	4 - Engine Propeller	Day	1.544	1.652							
		Night	.264	.156							
11.	2 - Engine Prop > 12,500 lb.	Day	7.090	7.590							
		Night	1.215	.715							
		TOTAL	346.379	346.379							

TABLE I-4

BOSTON-LOGAN INTERNATIONAL AIRPORT
1975 AVERAGE DAY
EXISTING AIRFIELD
NOISE ABATEMENT ALTERNATIVE 1

AIRCRAFT TYPE			TOTAL LANDINGS	TOTAL TAKEOFFS	TAKEOFFS - STAGE LENGTHS IN NAUTICAL MILES						
					0-500	501 - 1000	1001 - 1500	1501 - 2000	2001 - 3500	3501 - 4500	4501 and longer
1.	4 - Engine Turbojet	Day	12.262	9.615	.769	4.615	.385	1.250	2.596		
		Night	1.218	3.865	1.121	1.430	-	-	1.314		
2.	4 - Engine Turbofan 4 - Engine "Stretch Fan"	Day	25.157	27.779	4.445	8.889	1.111	1.667	11.667		
		Night	8.543	5.921	3.671	1.480	-	-	.770		
3.	3 - Engine Turbofan	Day	45.922	51.412	34.446	8.740	7.198	1.028	-		
		Night	14.738	9.248	4.624	4.624	-	-	-		
4.	3 - Engine "Stretch Fan"	Day	28.333	30.997	21.698	4.340	4.959	-	-		
		Night	5.367	2.703	2.703	-	-	-	-		
5.	2 - Engine Turbofan	Day	113.127	118.950	114.192	2.379	2.379	-	-		
		Night	14.933	9.110	9.110	-	-	-	-		
6.	4 - Engine HBPR Fan	Day	11.593	11.112	1.333	4.445	.445	1.111	3.778		
		Night	1.887	2.368	1.066	.734	-	-	.568		
7.	2, 3 - Engine HBPR Fan	Day	40.566	41.478	25.155	5.805	5.805	2.768	1.945		
		Night	6.614	5.702	3.833	1.277	-	-	.592		
8.	Supersonic Transport	Day	-	-	-	-	-	-	-		
		Night	-	-	-	-	-	-	-		
9.	Gen. Aviation Jet	Day	4.973	5.489							
		Night	1.033	.517							
10.	4 - Engine Propeller	Day	1.498	1.598							
		Night	.310	.210							
11.	2 - Engine Prop >12,500 lb.	Day	6.877	7.341							
		Night	1.428	.964							
		TOTAL	346.379	346.379							

TABLE I-5

BOSTON-LOGAN INTERNATIONAL AIRPORT
1975 AVERAGE DAY
EXISTING AIRFIELD
NOISE ABATEMENT ALTERNATIVE 2

	AIRCRAFT TYPE		TOTAL LANDINGS	TOTAL TAKEOFFS	TAKEOFFS - STAGE LENGTHS IN NAUTICAL MILES 0-500	501 - 1000	1001 - 1500	1501 - 2000	2001 - 3500	3501 - 4500	4501 and longer
1.	4 - Engine Turbojet	Day	11.858	9.211	.712	4.434	.373	1.212	2.480		
		Night	1.622	4.269	1.178	1.611	.012	.038	1.430		
2.	4 - Engine Turbofan 4 - Engine "Stretch Fan"	Day	24.135	26.768	4.202	8.578	1.078	1.617	11.293		
		Night	9.565	6.932	3.914	1.791	.033	.050	1.144		
3.	3 - Engine Turbofan	Day	44.102	49.592	33.274	8.339	6.982	.997	-		
		Night	16.558	11.068	5.796	5.025	.216	.031	-		
4.	3 - Engine "Stretch Fan"	Day	27.322	29.986	20.966	4.210	4.810	-	-		
		Night	6.378	3.714	3.435	.130	.149	-	-		
5.	2 - Engine Turbofan	Day	109.267	115.108	110.492	2.308	2.308	-	-		
		Night	18.793	12.952	12.810	.071	.071	-	-		
6.	4 - Engine HBPR Fan	Day	11.189	10.708	1.261	4.290	.431	1.078	3.648		
		Night	2.291	2.772	1.138	.889	.014	.033	.698		
7.	2, 3 - Engine HBPR Fan	Day	39.151	40.063	24.285	5.593	5.631	2.685	1.869		
		Night	8.029	7.117	4.703	1.489	.174	.083	.668		
8.	Supersonic Transport	Day	-	-	-	-	-	-	-		
		Night	-	-	-	-	-	-	-		
9.	Gen. Aviation Jet	Day	4.793	5.309							
		Night	1.213	.697							
10.	4 - Engine Propeller	Day	1.444	1.544							
		Night	.364	.264							
11.	2 - Engine Prop >12,500 lb.	Day	6.628	7.092							
		Night	1.677	1.213							
		TOTAL	346.379	346.379							

V. BIBLIOGRAPHY

(1) "A Study of the Air Transportation Potential and Facility Requirements in the Metropolitan Boston Air Service Area." Landrum and Brown, Inc. Cincinnati, Ohio., September 1968.

(2) "FAA Air Traffic Activity Calendar Year 1969." Federal Aviation Administration. U.S. Government Printing Office, Washington, D.C., February 1970.

CHAPTER II

MASTER PLAN ANALYSIS

I. INTRODUCTION

1. PURPOSE

The intent of the master plan analysis is to provide an effective airfield plan to aid the Massachusetts Port Authority in the orderly development of aviation facilities at Boston-Logan International Airport. Emphasis was placed upon a balanced development which matches terminal and land use capability with the effective capacity of the airfield system, giving major emphasis to physical configurations and operational procedures which minimize environmental impact.

2. APPROACH

The approach used in the master planning of facility improvements at Boston-Logan International Airport included:

(1) Forecasts of air traffic demand as presented in Chapter I.

(2) Inventory of existing facilities.

(3) Analysis of prevailing wind and weather conditions.

(4) Development of preferential runway use patterns to maximize overwater approaches and departures.

(5) Computation of annual and peak hour airfield capacity and comparison with demand requirements.

(6) Computation of annual hours of delay.

(7) Giving consideration to the following factors:

- Alternate airfield improvement schemes.
- Airport land use.
- Facility environmental impact factors.

II. SUMMARY

The master plan analysis shows clearly that Boston-Logan International Airport is presently operating near capacity and that relief will be urgently needed during the next five year period. The proposed airfield improvement plan, comprised of construction of a close parallel to the 15R-33L runway, extension of runways 9 and 4L and provision of STOL runway 15-33, is urgently needed if Boston-Logan International Airport is to serve the expanding air transportation requirements of the Boston Region adequately.

The major significance of this airfield improvement program, however, lies not only in direct operational considerations but in the environmental impact of these considerations on the communities adjacent to the airport. The significance of a preferential runway use program is evident in the airport noise analysis presented in Chapter III. The implications of increased aircraft departure delay conditions on air pollution are clearly evident in the air pollution analysis in Chapter V. The economic consequences of a deterioration in service quality are presented in Chapter IX. Alternatives to the proposed improvement program are highlighted in Chapter VIII.

III. CONCLUSIONS

1. RUNWAY 15L-33R IS URGENTLY NEEDED IF BOSTON-LOGAN INTERNATIONAL AIRPORT IS TO SERVE ADEQUATELY THE EXPANDING AIR TRANSPORTATION REQUIREMENTS OF THE BOSTON REGION.

2. PARALLEL RUNWAY 15L-33R IS REQUIRED TO BEST MEET THE FORECAST AVIATION DEMAND. EVEN WITH THE PARALLEL RUNWAY, UNRESTRAINED DEMAND WILL EXCEED AIRFIELD CAPACITY.

   (1) The Analysis Shows the Following Capacities:

	1970*	1975**	1980***
	Condition 1	Condition 4	Condition 5A
. Existing Arifield	368,000	313,000	340,000
	Condition 6A	Condition 6	Condition 6C
. Improved Airfield	417,000	348,000	398,000

   * Without wide-body jets.

   ** With wide-body jets and preferential runway use.

   *** With computer aided approach sequencing and reduced separation requirements which should be realized in the 1980 time period.

3. WITHOUT THE NEW PARALLEL RUNWAY AIRCRAFT DELAY WILL BE INCREASED.

   (1) The Analysis Shows That Delay Levels Will Be As Follows:

	Annual Delay* In Hours	Annual Cost of Delay
. Condition 4 - Existing Airfield Noise Abatement Alt. #1	15,480	$4,800,000
. Condition 5 - Existing Airfield Noise Abatement Alt. #2	20,575	$6,160,000
. Condition 6 - Improved Airfield Maximum Noise Abatement	11,725	$3,810,000

* Based upon the planning range demand level of 350,000 annual operations.

(2) Practical operating considerations indicate that to achieve the same degree of overwater operation possible with the improved airfield, the existing airfield must be operated at delay levels approaching those of Condition 5.

4. PARALLEL RUNWAY 15L-33R WILL PROVIDE THE CAPABILITY FOR PREFERENTIAL RUNWAY UTILIZATION PERMITTING MAXIMUM USE OF OVERWATER APPROACHES AND DEPARTURES.

(1) Operational flexibility of Logan's existing runway system is severely limited in comparison with other major airports by two principal factors.

- Only one set of parallel runways is available.
- This single set of parallels is only partially useable for simultaneous operations due to noise abatement limitations.

5. RUNWAY 15L WILL PROVIDE CAPABILITY FOR A CATEGORY II AND III INSTRUMENT LANDING SYSTEM ON A RUNWAY HEADING WHICH WILL PERMIT AIRCRAFT OPERATIONS UNDER A WIDER VARIETY OF WEATHER CONDITIONS THAN THE PRESENT RUNWAY SYSTEM CAN ACCOMMODATE.

6. THE TERMINAL FACILITY IMPROVEMENT PROGRAM, AS PLANNED BY THE MASSACHUSETTS PORT AUTHORITY, PRESENTS AN EXCELLENT SOLUTION TO MAJOR TERMINAL COMPLEX DEVELOPMENT WITHIN A SEVERELY RESTRICTED LAND AREA.

7. ALTERNATE POSITIONING OF THE 15L-33R PARALLEL RUNWAY WITH INCREASED SPACING UP TO 3,500 FEET CREATES MAJOR ENVIRONMENTAL DISRUPTION WITH MINIMAL OPERATIONAL ADVANTAGE.

8. CONCENTRATION OF PRIMARY RUNWAY SYSTEM DEVELOPMENT IN THE EAST WEST (9-27) DIRECTION IS NOT POSSIBLE BECAUSE IT IS SUBJECT TO OBSTRUCTIONS BY HIGH-RISE BUILDING CONSTRUCTION TAKING PLACE IN DOWNTOWN BOSTON AND BY HARBOR ACTIVITY.

9. EXTENSIONS TO RUNWAYS 9 AND 4L WILL INCREASE THE MARGIN OF OPERATIONAL SAFETY AND PERMIT DEPARTING AIRCRAFT TO BEGIN THEIR TAKEOFF AT A GREATER DISTANCE FROM RESIDENTIAL COMMUNITIES.

(1) The extensions will increase aircraft altitudes over the residential communities under their climb out path thus reducing noise levels.

(2) The existing landing thresholds will remain in their present locations.

10. STOL RUNWAY 15-33 OFFERS THE OPPORTUNITY TO INCREASE AIRFIELD CAPACITY IN THE FUTURE AS STOL TYPE AIRCRAFT BECOME OPERATIONAL.

(1) The STOL aircraft with short takeoff and landing characteristics can operate with separate traffic patterns to be established for this runway.

IV. DISCUSSION

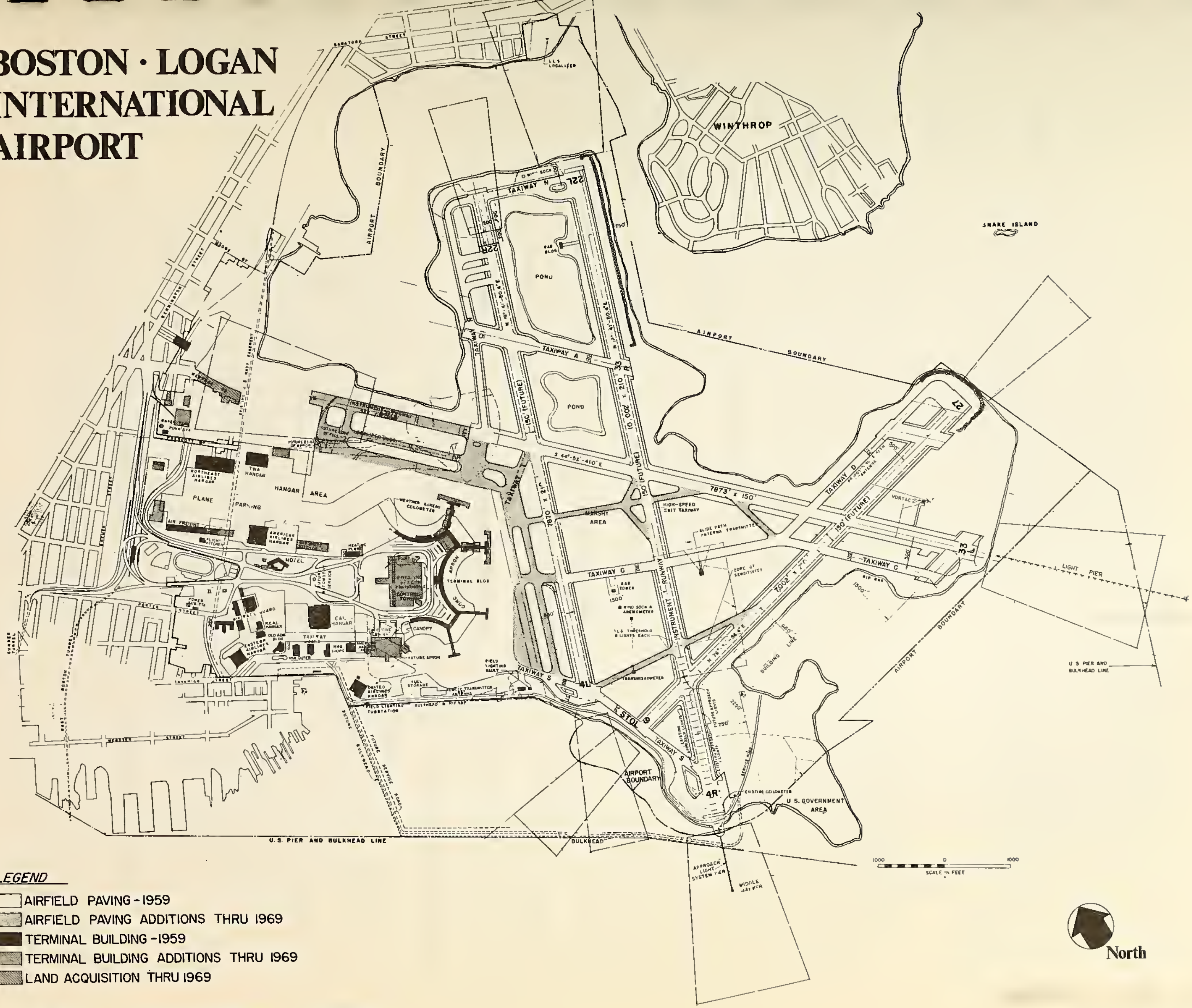
Boston-Logan International Airport first came under the auspices of the Massachusetts Port Authority in 1959. At that time the airfield system consisted of two runways in the northeast/southwest direction (4-22) with a 1,500 foot separation, and single runways in the northwest/southeast direction (15-33) and in the east/west direction (9-27). This airfield system, shown on Exhibit II-1, supported 202,000 operations consisting of air carrier, general aviation and military traffic in 1959.

Terminal facilities which handled approximately 1.4 million enplaning passengers consisted of a linear terminal building with approximately 30 aircraft parking positions. Boston-Logan International Airport in 1959 was an airport on the threshold of the jet age. Requirements for expansion to alleviate potential overcrowding are highlighted in the discussion below.

1. PRESENT CONDITIONS AT BOSTON-LOGAN INTERNATIONAL AIRPORT.

The airfield system at Boston-Logan International Airport today remains similar to that existing in 1959. Airfield improvements have consisted of a 2,200 foot extension to runway 15R, implementation of STOL runway facilities, addition of dual taxiways in the terminal area, and miscellaneous taxiway and runway turnoff improvements to aid aircraft circulation and increase capacity. Runways 33L and 4R have various instrumentation for operating during instrument weather conditions. The 4-22 close parallel runways function as the primary operating orientation with departures to the southeast preferred for noise abatement considerations. In 1970 total demand on this airfield system exceeded 323,000 movements, an increase in excess of sixty percent (60%) over the eleven year span since 1959.

BOSTON · LOGAN INTERNATIONAL AIRPORT



LEGEND

- AIRFIELD PAVING - 1959
- AIRFIELD PAVING ADDITIONS THRU 1969
- TERMINAL BUILDING - 1959
- TERMINAL BUILDING ADDITIONS THRU 1969
- LAND ACQUISITION THRU 1969

Logan Yesterday · 1959
Logan Today · 1971

EXHIBIT II-1

The terminal facilities handled approximately 4.5 million enplaning passengers in 1970. In the preceding ten years, construction was completed on new north and international terminal units with 27 aircraft parking positions, a new south-west terminal unit with 15 aircraft parking positions. Aircraft gate positions today total 71. Support facilities include grade and multi-level public parking lots which accommodate over 6,000 vehicles.

General aviation consists of a) scheduled "third level" or "commuter airlines" which serve communities within the sphere of the Boston marketing area, and b) corporate/executive aviation activity both of which are an integral and important part of the total Boston air service picture. The "third level" or "commuter airlines" are becoming an increasingly significant element of activity and no longer operate to any extent from the general aviation hangar and apron area. These airlines are now operating in the passenger terminal area. Future plans continue this relationship. A substantial portion of aircraft traditionally classed as "general aviation" or corporate/executive aviation are currently being accommodated in the southwest hangar and apron area. Services for this element of general aviation are provided by two fixed base operators.

Airline maintenance and hangar facilities serving six airlines have been expanded and now encompass 65 acres to the north and south of the main access road. Facilities housing air cargo, aircraft service and general public service functions occupy the remaining land to the west of the terminal complex.

Airport acreage above high mean water level totals 1,500 acres. Presently, Logan's airfield and available land is operating below capacity but relief will be urgently needed during the next five year period.

2. BOSTON-LOGAN INTERNATIONAL AIRPORT TOMORROW MUST BE DEVELOPED TO MEET THE ENVIRONMENTAL AND AIR TRANSPORTATION NEEDS OF THE COMMUNITY.

Landrum & Brown, Inc. as aeronautical consultant to the Massachusetts Port Authority has undertaken master planning studies which form the basis for the proposed airport improvement program. Expansion projects carrying forward the recommendations of these studies have been completed, are planned, or are now underway in almost every functional area of the airport.

The development of the Boston-Logan International Airport master plan included evaluation of the factors discussed in the following paragraphs.

(1) Meteorology Is a Major Consideration in the Design Of Airport Runway Systems.

Preliminary master planning was based upon a meteorological analysis of wind and weather data for a five year period from January, 1959 through December, 1963. The raw data were collected by the U.S. Weather Bureau Station at Boston-Logan International Airport and tabulated by the National Weather Records Center into a standard Ceiling/Visibility Wind Rose form for each month of the five year period. This analysis was based upon 15 mph cross-wind criteria in use at the time of the study. Because of subsequent airline and FAA acceptance, R. Dixon Speas Associates utilized 15 knot crosswind criteria and wind data from the latest available five year period of record in the recent capacity studies and in developing the preferential runway utilization patterns. This increase in crosswind criteria has only a slight effect on the following analysis.

Exhibit II-2 presents a tabulation of computed runway coverages for the existing runway orientations. From the table it is evident that:

- Surface winds at Boston-Logan International Airport are quite variable in direction and thus several runway directions are required to provide adequate coverage for all types of aircraft.

- Runway 9-27 provides the best single direction coverage except in one weather group. In this exception, runway 4-22 provides 1.84 percent better coverage than runway 9-27. However, runway 9-27 is subject to obstruction by high-rise building construction taking place in downtown Boston and by harbor activity. Due to these factors it is not possible to make this a primary operating direction.

- Runway 15-33 ranks second in coverage for all-weather and VFR conditions but drops to third throughout the IFR weather group with the exception of weather below 100 feet and/or 1/4 mile where it provides the best coverage.

- Runway 4-22 ranks third in coverage for all-weather and VFR weather conditions but jumps to first in one IFR weather group and second in total IFR time.

Comparison of directional coverages for 15 mph and 10 knot allowable crosswinds indicated that:

- During the all-weather time when no limits are placed on ceiling visibility, runway 27 provides the best coverage of 55.79 percent. Runway 33 is second with 52.19 percent and runway 22 is third with 44.57 percent coverage.

- During total IFR time runway 9 provides the best coverage of 61.82 percent. Runway 4 is second with 59.90 percent and runway 15 is third with 50.97 percent coverage. As indicated by these percentages, there is a definite shift in wind direction as the ceiling and visibility become increasingly lower.

EXHIBIT II-2

METEOROLOGICAL ANALYSIS (ANNUAL)

EXISTING RUNWAY SYSTEM

BOSTON-LOGAN INTERNATIONAL AIRPORT

Runway or Combination	All Weather No Limits	VFR Ceil. 1000' Vis. 3 mi.	IFR Ceil. 1000' Vis. 3 mi.	IFR Ceil. 1000' - 500' Vis. 3 mi.-1-1/2 mi.	IFR Ceil. 500' - 200' Vis. 1-1/2 mi.-1/2 mi.	IFR Ceil. 300' - 200' Vis. 3/4 mi.-1/2 mi.	IFR Ceil. 200' - 100' Vis. 1/2-1/4 mi.	IFR Ceil. < 100' Vis. < 1/4 mi.
20 KNOT COVERAGE								
4-22	90.70	90.34	95.18	95.74*	94.59			
15-33	93.37	93.35	92.19	91.85	91.56			
9-27	94.57*	94.54*	95.92*	93.90	95.11*			
4-22 and 15-33	99.14	99.25	98.55	98.90	98.40			
4-22 and 9-27	98.37	98.03	99.21**	99.23**	99.16**			
15-33 and 9-27	99.27**	99.36**	98.56	98.93	98.93			
4-22, 15-33 and 9-27	100.00	100.00	100.00	100.00	100.00			
15 MPH COVERAGE								
4-22	77.16	75.37	87.46*	87.61*	86.26			
15-33	81.65	81.23	82.17	80.50	80.68			
9-27	83.51*	82.89*	87.00	84.58	87.15*			
4-22 and 15-33	92.20	91.87	93.77	94.31	92.74			
4-22 and 9-27	90.99	90.21	95.49**	95.14**	95.30**			
15-33 and 9-27	94.28**	94.54**	92.67	91.28	93.15			
4-22, 15-33 and 9-27	99.60	99.63	99.33	99.48	99.37			
10 KNOT COVERAGE								
4-22						78.98	76.71	87.00
15-33						75.12	78.13	87.24
9-27						82.35*	87.77*	91.95*
4-22 and 15-33						89.54	87.35	93.46
4-22 and 9-27						92.66**	92.[illegible]**	95.24**
9-27 and 15-33						90.23	92.84	94.97
4-22, 15-33 and 9-27						97.36	96.74	97.21
PERCENT OF OCCURRENCE	100.00	85.16	14.84	6.95	5.23	1.44	1.39	1.27
HOURS OF OCCURRENCE	8,760	7,400	1,300	680	458	126	123	110
CALMS ASSOCIATED WITH WEATHER GROUP (%)	4.02	3.07	9.48	8.38	8.37	9.35	11.31	18.02

* Best single direction
** Best combination of two runways.

- For the weather group with ceiling between 500 feet to 200 feet and visibility between 1-1/2 to 1/2 miles, the best coverage is provided by runway 9 with 64.91 percent. This weather group is important to analyze from an instrument flying viewpoint as it is below the circling minimums and thus only straight-in approaches would be allowed. Runway 4 provides the second best coverage of 63.42 percent and runway 15 is third with 47.55 percent. These percentages reveal and confirm that for the present weather minimums, the existing ILS system is properly located on runway 4R. Runway 15 provides better coverage than the present runway 33 ILS system. This conclusion is based on the fact that runway 9-27 cannot be practically instrumented.

- In the weather groups 200 feet to 100 feet ceiling and 1/2 - 1/4 mile visibility (CAT. II) and 100 feet ceiling and 1/4 mile visibility (CAT. III) - runway 4 provides the best coverage by 61.39 percent for Category II and second best of 68.40 percent for Category III. Runway 15 provides the second best coverage for Category II with 56.63 percent and the best for Category III with 72.81 percent.

The percentages of coverage were weighed in combination with the other aspects of the planning criteria before the final runway system was established. The prevailing wind and weather conditions play a major role in the development of a preferential runway operation to maximize overwater arrivals and departures.

(2) <u>The Addition Of New Parallel Runway 15L-33R Is Of Primary Importance in Attaining the Greatest Overwater Operation.</u>

The results of the NEF contour study using TRACOR, Inc. described in Chapter III, gave a positive indication that the improved airport in 1975 would expose fewer people to NEF-40 levels than the existing airport. To verify these findings, a more complete and in depth analysis of expected NEF contours for alternate airfield configurations and runway utilization patterns was conducted using Bolt, Beranek and Newman, Inc. This study is described and analyzed in Chapter III and presented in its entirety in Appendix B.

As a basis for the Bolt, Beranek and Newman noise exposure forecasts, it was decided to develop new preferential runway use programs to maximize overwater approaches and departures for the existing and improved airfield configurations. Data for these preferential runway use programs were developed by R. Dixon Speas Associates. During the course of this work new concepts were discussed with Federal Aviation Administration personnel at the Boston-Logan International Airport Control Tower. The R. Dixon Speas Associates report is included in Appendix A. The results of their analysis can be summarized as follows.

- Present Preferential Runway Criteria

  Boston-Logan International Airport was one of the first airports to establish a preferential runway program. The current program has been in use for some ten years with improvements being made throughout this period. In the present program the controller is given a priority of runway use as a guide in selecting which runways will be utilized for both arrival and departures. The order of preference is as follows:

  - Arrivals - no preference except 22R to be used last.
  - Departures - 15R, 9, 22R/L, 4R, 33L, 27 and 4L.

  Table II-1 summarizes the results of the present preferential runway program in Condition I.

- Revised Preferential Runway Use Program

  In order to explore this approach thoroughly, a new weather analysis was accomplished in which the historical weather records for a five year period were evaluated by computer to sort them into day and night periods for the summer months apart from the winter months.

The assignment of weather into these categories, permitted the assignment of runway use against wind direction and velocity to maximize overwater operations during less than peak hour demand situations and for daytime use. This analysis yielded the results shown in Conditions 4 and 6 of Table II-1. This type of runway utilization pattern is instituted by application of two new concepts as follows:

- Assigning specific runway use combinations for specific wind velocity directions.
- For hours of low demand during the day and at all times during the night in VFR weather, assigning runway use combinations which maximize overwater operation even though these runway combinations are not the most efficient for that wind condition.

A review of the runway utilization figures presented in Table II-1, show that Condition 6 with the added parallel runway 15L-33R provides a greater use of runway 33 for landings and runway 15 for takeoffs. Runway 15 takeoffs and runway 33 arrivals traverse the outer harbor water area and are excellent from a noise abatement standpoint. In fact, the improved airport approximately doubles the overwater operation achieved in Condition 1, today's operation. Condition 4, is a substantial improvement over today's operation, however to achieve this or the same degree of overwater operation with the existing airport configuration will reduce capacity and increase delay to operations. The magnitude of capacity reductions and delay increases are described in the following paragraphs.

(3) <u>The Extent Of Airfield Development Is Dependent Upon the Relationship Of Traffic Demand To Airfield Capacity.</u>

In order to determine accurately the need for and timing of airfield improvements it is necessary to reconcile the accounting practice discrepancies

TABLE II-1

Runway Use Summary

Runway Utilization Airport Configuration	Condition 1 Historic Existing		Condition 2 Maximum Capacity Existing		Condition 4 Noise Abatement Alt. #1 Existing		Condition 6 Maximum Noise Abatement Improved	
	Arr.	Dep.	Arr.	Dep.	Arr.	Dep.	Arr.	Dep.
Overwater Operations								
33 - landing / 15 - takeoff	25.1	14.6	9.8	.2	38.0	22.2	53.7	26.7
Next Preference Use								
4R/L & 27 - landing / 22L & 9 - takeoff	36.7	37.0	44.5	45.6	29.6	39.6	18.2	36.1
Overland Operations								
Other runways	38.2	48.4	45.7	54.2	32.4	38.1	28.1	37.2

noted in the analysis of historic aircraft operations in Chapter I. For the purposes of this environmental impact study, due to the magnitude of the disparity in historic operations figures of the FAA and Massachusetts Port Authority, a planning range has been developed to represent a reasonable level of total aircraft operations for physical facility requirement planning. The figures evolved for planning purposes are as follows:

Year	Planning Range Operations
1970	300,000
1975	350,000
1980	400,000
1985	450,000

These figures reflect a reduction in the general aviation operations category and are representative of the future demand on the airfield facilities.

Capacity is also dependent upon the number and length of runways, their location with respect to each other, and the types of aircraft using the facility. The following discussion relates this forecast aviation demand to airfield capacity. Detailed description of the capacity analysis methodology and findings can be found in Appendix A.

Presently, Boston-Logan International Airport's airfield is operating below capacity, however, a recent change in the FAA separation criteria and increasing volumes of aircraft weighing in excess of 300,000 pounds will reduce the current capacity level in the next several years. In addition, other factors are important considerations in airport capacity analysis.

- **The Effect Of Wake Turbulance On Separation Criteria and Capacity Is Substantial**

  The FAA has recently determined that aircraft weighing more than 300,000 pounds gross weight cause wake turbulance affects to the degree that aircraft following them in takeoff or landing must have increased longitudinal separation. In general, this ruling says that an aircraft weighing less than 300,000 pounds and following one weighing more than 300,000 pounds in the same operational mode will be required to maintain at least a two minute interval on landing or takeoff. This interval of time is substantially greater than normal separations which generally vary from 90 down to 40 seconds for various maneuvers. The extent of the wake turbulance problem is related to the mix of aircraft which will be operating at the airport. It is anticipated that by 1975 jets weighing more than 300,000 pounds will comprise thirteen percent (13%) of total aircraft operations at Boston-Logan International Airport.

- **Maximum Use Of Noise Abatement Procedures (Preferential Runway Use) Also Reduces Airport Capacity**

  The use of runways in a preferential operation to minimize overflight of populated areas and maximize overwater operations, will in some cases result in less capacity than that achievable if noise problems are disregarded. For example, with the existing airport configuration the direction of operations required to meet high demand will be the 4-22 parallels, the noise abatement preferred single runway 33 can be used only when demand lowers to the point that the landing demand can be accommodated. If a 33 landing operation is maintained in order to maximize overwater operations, regardless of demand, airfield capacity is reduced. With the improved airport configuration all landings can be accommodated on the preferred 15-33 parallels up to the 15 knot crosswind component limit. Consideration was given such factors including the effect of procedural turns in the capacity and delay analysis.

- **Future Increases In Practical Capacity Can Be Expected Beginning About 1975 Through the Use Of New Equipment and Reduced Separation Criteria**

  New navigation equipment already under contract will provide the capability to increase capacity by providing mechanization of programming to utilize constant metering and spacing of aircraft.

This system known as Automated Radar Traffic System III (ARTS III) in itself will not have any appreciable effect on capacity, but will provide the capability to increase capacity. This equipment will be installed at Boston-Logan International Airport in 1971 and be operational by January 1972. The capacity increase will result when the ARTS III equipment is programmed to utilize Metering and Spacing techniques. The benefit of using Metering and Spacing will be that the controllers will be able to more uniformly achieve minimum separation criteria. In addition the Metering and Spacing can be programmed to automate new techniques and use reduced separation criteria. The major new technique will be that of delay sharing, adjusting arrival spacing to accommodate departures on an efficient basis. It is estimated that by 1980 there will be substantial capacity improvements from utilizing this equipment and these techniques.

- The Capacities Of the Existing and Improved Airfield Configurations Reflecting Variations in Time Period, Runway Utilization, and Future Air Traffic Control Improvements Are Summarized in Table II-2 On The Following Page

It should be noted that the increase in the annual capacity in the 1975 time period due to the new runway is about eleven percent (11%) when compared to the existing airfield with noise abatement Alternate #1 and on the order of sixteen percent (16%) greater than the existing airport with noise abatement Alternate #2. The difference in delay will be considerably greater, as is shown in the delay discussion.

- Exhibit II-3 Presents Graphically the Relationship Of Airfield Capacity To Projected Traffic Demand

Analysis of the demand/capacity relationship using the planning range total demand indicates that the existing airfield configuration capacity will be exceeded by 1973 and that even with construction of new parallel runway 15L-33R unconstrained demand will exceed capacity by 1975. Failure to immediately begin implementation of the 15L-33R improvement project will result in rapidly increasing delay and congestion levels and the need for relocation of general aviation activity and/or air carrier schedule adjustments by the mid-1970's. With addition of 15L-33R, general aviation relief of a less severe and more achievable nature will also be required. Ramification of banning general aviation activity and schedule adjustments are discussed in Chapter VIII.

In the time period beyond 1975 the capacity deficit between the two plans widens due to the facility limitations which preclude obtaining maximum benefit from the new control techniques and equipment with the facility limitations imposed by the existing airport configuration.

TABLE II-2

Capacity Analysis Summary
Selected Conditions

EXISTING AIRPORT	PANCAP	Peak Hour	PHOCAP Changes For Runway 15-33 VFR	IFR
Condition 1 - 1970, Historic	368,000	91	56	44
Condition 2 - 1975, Maximum Capacity	313,000	73	45	37
Condition 4 - 1975, Noise Abatement Alternate #1	313,000	73	45	37
Condition 5 - 1975, Noise Abatement Alternate #2	300,000	70	45	37
Condition 5A - 1980, Noise Abatement Alternate #2	340,000	80	56	56
IMPROVED AIRPORT				
Condition 6 - 1975, Maximum Noise Abatement	348,000	81	76	53
Condition 6A - 1970, Maximum Capacity	417,000	103	112	60
Condition 6B - 1975, Maximum Capacity	348,000	81	76	53
Condition 6C - 1980, Maximum Noise Abatement	398,000	93	94	82

Note: For a detailed description of capacity analysis see Appendix A.

BOSTON · LOGAN INTERNATIONAL AIRPORT

Demand Versus Capacity

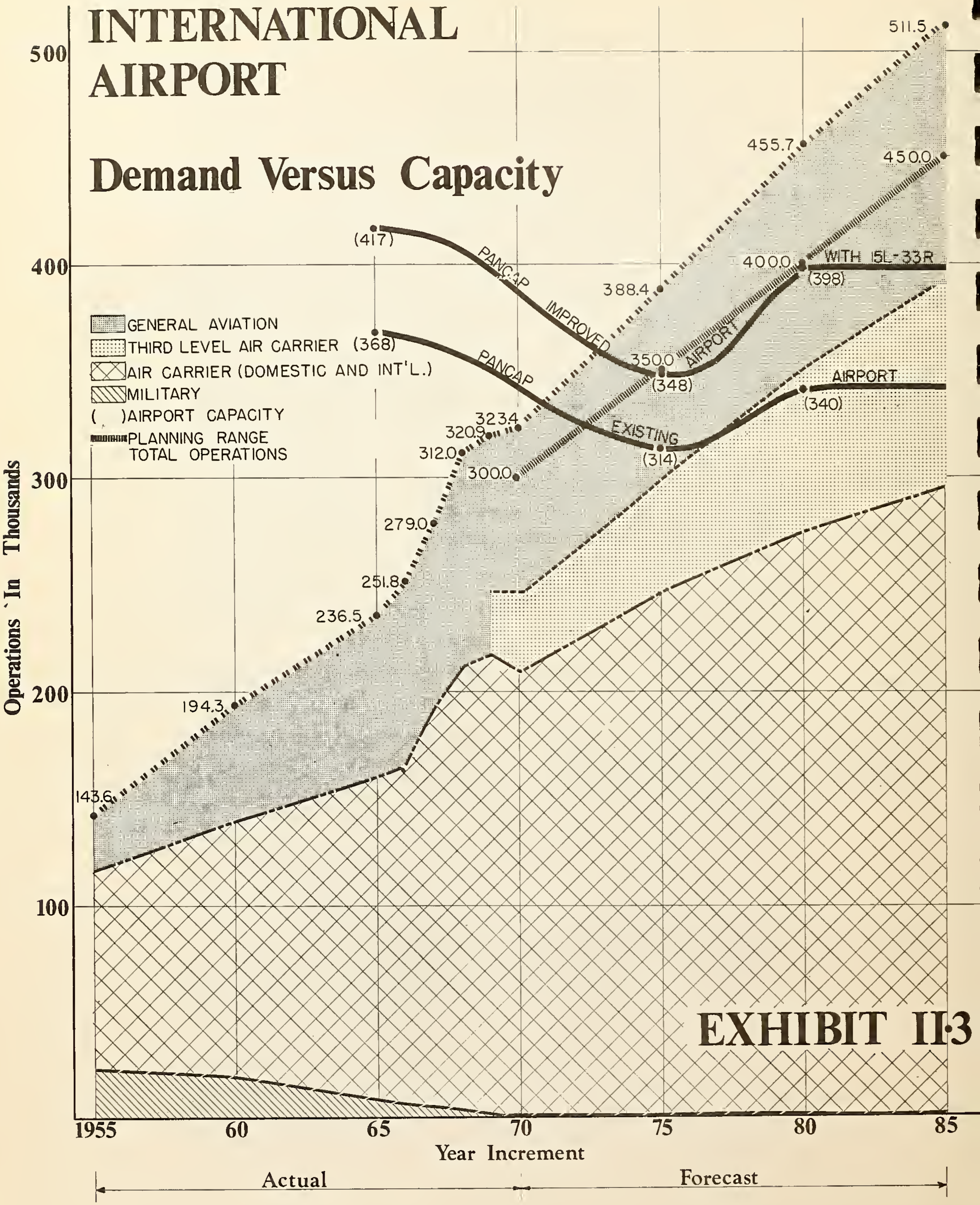


EXHIBIT II·3

(4) Aircraft Delay Illustrates the Penalty the Airport Users Will Pay in Order To Provide Greater Noise Relief and the Positive Benefit Of the New Runway.

The hours of delay in the 1975 time period for the conditions representing variations in runway configuration and utilization patterns are presented in Table II-3. The economic significance of the delay, an indication of the cost of aircraft operations to the aircraft operator is also indicated. The delay levels for conditions 4, 5 and 6, indicated in Table II-3, are of primary importance in the environmental analysis because they represent the delay levels resulting from the runway utilization programs which produce the maximum use of overwater arrivals and departures.

- Condition 4, with 15,480 hours of delay, results from a sixty percent (60%) overwater operation of the existing airport configuration.
- Condition 5, with 20,575 hours of delay, results from a eighty percent (80%) maximum overwater operation of the existing airport.
- Condition 6, with 11,725 hours of delay, results from the operation of the improved airport configuration at eighty percent (80%) overwater.

To provide maximum noise abatement with the improved airfield facility increases annual delay by 2,085 hours over that which occurs with maximum capacity utilization (Condition 6 maximum noise abatement less Condition 6B the maximum capacity use of the same configuration). On the other hand, the delay savings to the airport user by building runway 15L-33R by 1975 will fall in a range between 3,655 and 8,850 hours annually (Condition 4 or 5 less Condition 6). From a practical operating viewpoint the noise relief indicated with the existing airport under operating Condition 4 will result in annual delay closer to the Condition 5 level.

TABLE II-3

Delay Summary

Condition	Description	Annual Hours of Delay*	Annual Cost of Delay
Condition 4	Existing 1975, Noise Abatement Alternate #1	15,480	$4,800,000
Condition 5	Existing 1975, Noise Abatement Alternate #2	20,575	6,160,000
Condition 6	Improved 1975, Maximum Noise Abatement	11,725	3,810,000
Condition 6B	Improved 1975, Maximum Capacity	9,640	3,254,000

* - At the 1975 planning range demand level of 350,000 annual operations.

To summarize the capacity and delay analysis, it is important to the operation of the airport that its capacity be increased in order that it can more satisfactorily handle the increased demand at the airport. The addition of runway 15L-33R will provide a substantially improved service to the air traveler by providing a service at a lower delay level, and therefore, a more reliable operation, and at the same time, permit achieving a greater degree of overwater operations at less cost to the airport users with a significant reduction in noise impact. The significant effect of this delay on air pollution levels is detailed in Chapter IV.

3. <u>THE TERMINAL FACILITY IMPROVEMENT PROGRAM, AS PLANNED BY THE MASSACHUSETTS PORT AUTHORITY, PRESENTS AN EXCELLENT SOLUTION TO MAJOR TERMINAL DEVELOPMENT WITHIN A SEVERELY RESTRICTED LAND AREA.</u>

Projected growth of enplaned passengers from the present level of approximately 4.5 million to 6.3 million in the year 1975 and 10.0 million by the year 1985 will introduce a need for an increase in terminal building area and supporting parking facilities. Scheduled air carrier operations are forecast to rise from the present level of 196,800 to in excess of 268,000 by the year 1985, resulting in a need for 80 to 90 aircraft gates.

(1) <u>Terminal Complex.</u>

Exhibit II-4 depicts existing and planned terminal facilities. Domestic aircraft gate requirements will be satisfied by expansion of the southwest unit terminal building, increasing its capacity to 18 aircraft parking positions and by

BOSTON · LOGAN INTERNATIONAL AIRPORT

Terminal Area Plan

EXHIBIT II·4

the new South Terminal complex programmed to accommodate 34 to 37 gates depending on aircraft size. This terminal and associated apron, multilevel roadway system and intergral auto parking facility is scheduled for completion by the end of 1974. Construction is completed on the interim South Terminal facilities and demolition of the existing apron and finger pier E will begin shortly. Additionally, the new International Terminal facility is under design and scheduled for construction beginning in 1971 with eight gates sized for 747 aircraft. These planned terminal facility additions result in an ultimate total aircraft gate potential of 85 to 94 depending on aircraft type.

(2) Automobile Parking

Auto parking requirements to satisfy this passenger growth will reach in excess of 9,000 stalls by the year 1975 and escalate to 11,800 stalls by the year 1980. This auto parking demand will be met by expansion of the existing multi-level parking garage and parking garage construction related directly to the new South Terminal complex. Two additional floors on the existing garage structure are now under construction and scheduled for completion in 1971. These facilities will provide a combined total of 10,400 public parking stalls by 1975.

4. AIR CARGO FACILITIES MUST BE DEVELOPED TO SATISFY GROWTH DEMANDS.

Rapid growth is forecast to continue in the area of air cargo and air freight in future years. Domestic enplaned air cargo is forecast to rise from the present level of 55,100 tons to 118,900 tons in 1975 and 249,500 tons by the year 1985. This growth results in the need for additional cargo buildings and apron facilities to accommodate the new generation of wide-body transports.

(1) Cargo Complex Development.

Full development of the landfill in the Bird Island Flats area - see Exhibit II-5 - will provide needed area for airfield and aviation oriented support facility expansion. Dike and drainage construction was essentially completed in 1970. Filling operations began in 1970 and are to be completed in 1973.

5. NO OTHER FACILITY ALTERNATIVES EXPLORED WERE AS PRACTICAL, FEASIBLE OR ENVIRONMENTALLY DESIRABLE AS THE RECOMMENDED PROJECTS.

(1) In the course of the Boston-Logan International Airport master planning studies various alternatives to the 15L-33R parallel runway were analyzed.

- Increased separation between 15-33 parallels - separation of the parallel runways by 5,000 feet would permit independent and simultaneous takeoffs and landings, thus increasing the operating capability and land area available for development. However this alternative would result in a substantial land taking and dramatically increased environmental impact on the airport's neighbors.

- Other spacing of less than 1,200 feet centerline Runway 15R-33L to centerline Runway 15L-33R will not meet the FAA Runway-Taxiway Spacing Standard. This Standard requires 600 feet centerline runway to centerline taxiway. Thus, the taxiway-runway as shown on Exhibit II-5 is the minimum standard.

- 15-33 parallel runway spacing of greater than 1,200 feet centerline to centerline was considered. Spacing of 3,500 feet centerline to centerline is required to permit independent landings on one runway simultaneous with an independent takeoff on the parallel runway. This operational capability substantially increases aircraft operations. Increasing the spacing of the 15-33 parallel runways from the proposed 1,200 feet any dimension less than 3,500 feet centerline to centerline has little advantage for capacity and operation. A spacing of 3,500 feet would cause extreme environmental impact on the airport neighbors and substantial land taking.

- Another alternative of shifting a parallel 9-27 runway to the East was studied. Such a shift improves the relationship of the 9 runway for arrivals and departures from and to the east. However, such a solution isolates Deer Island, virtually eliminates Point Shirley, creates major impact on harbor circulation and requires substantial land taking.

(2) Another alternative studied extensively in Landrum and Brown's 1968 "A Study Of The Air Transportation Potentials and Facility Requirements In The Metropolitan Boston Air Service Area, 1970 through 1990" was the development of a second major airport to relieve the pressure for further improvement of Boston-Logan International Airport. The long-range need for a second air carrier airport is not questioned; however, construction of such an airport would require a ten year planning and construction interval and would not satisfy near term airfield capacity needs. From an environmental standpoint, the development of a major new air carrier airport could create significantly greater overall environmental effects than the proposed improvement program.

Further complicating the second airport matter is the fact that the Governor of Massachusetts has taken a position that there will not be another airport for Boston as long as he is in office. This means a strong opposition from the Governor's office until 1974 at best estimate.

In addition the program for a second airport as proposed in 1969 and 1970 was vigorously opposed by the factions located in areas of suggested airport siting. This opposition is similar to that experienced in other cities.

The question of a second major airport is discussed further in Chapter VIII and Appendix D.

6. A PARALLEL 9-27 RUNWAY AND EXTENSION OF EXISTING RUNWAY END 27 WILL BE DELETED FROM THE AIRPORT LAYOUT PLAN.

These additional airport improvement projects, previously included in the Airport Layout Plan as long-range improvements to be considered for construction, have been removed from consideration for the following reason:

(1) These Projects Would Not Add To Operational Flexibility and Might Have a Retarding Effect On Airport Capacity When Operated To Maximize Noise Abatement.

The location of a parallel 9-27 runway as shown on the previous airport layout plan is subject to operating limitations imposed by the harbor channel and high-rise building construction in the downtown Boston area. Additionally it would not increase the degree of overwater operation achievable with the proposed improvement program. Intersection takeoffs would be required when used with the preferred 33 operation presenting controllers with additional management problems.

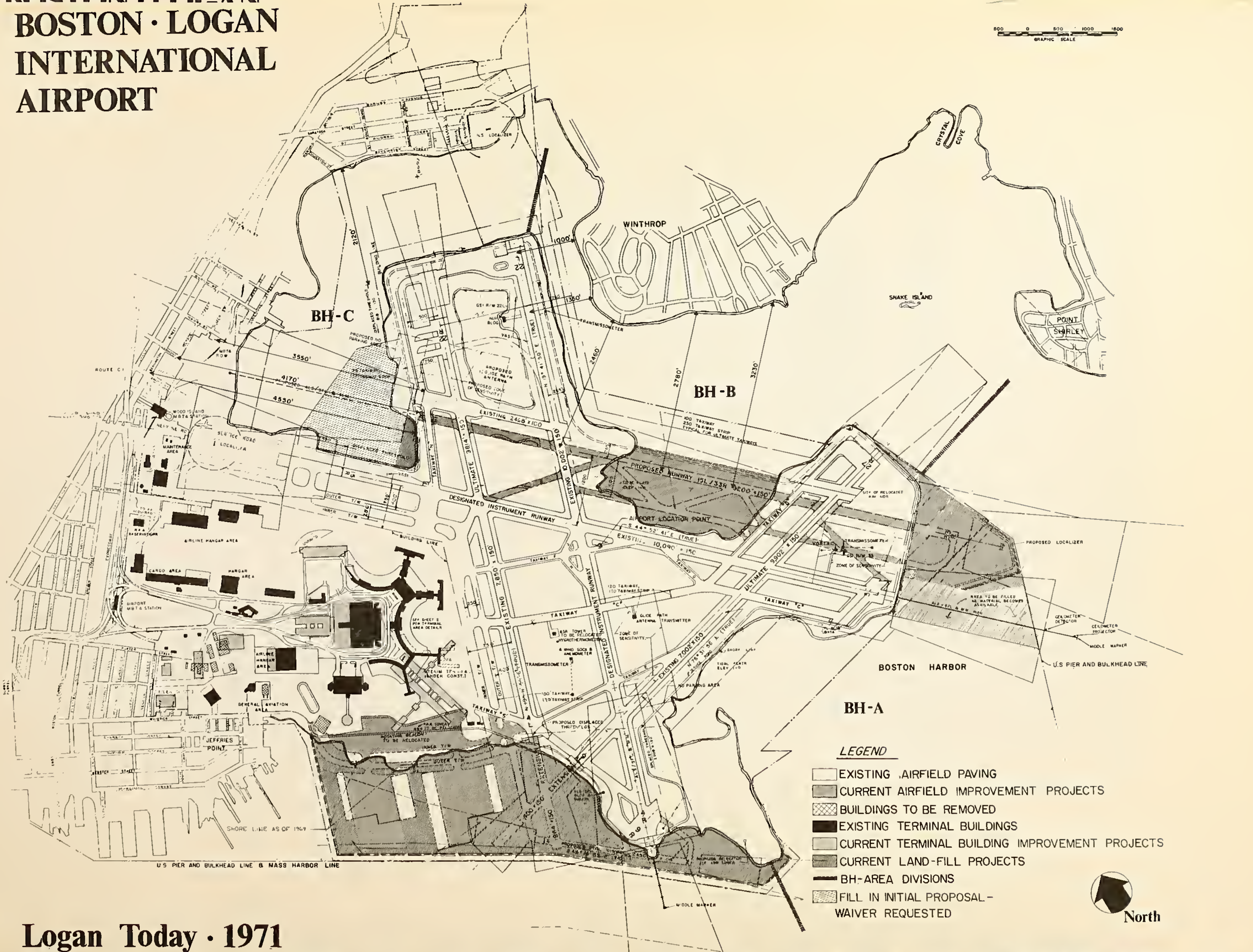
7. COMPLETION OF THE PROPOSED IMPROVEMENT PROGRAM IS URGENTLY NEEDED IF BOSTON-LOGAN INTERNATIONAL AIRPORT IS TO SERVE THE EXPANDING AIR TRANSPORTATION REQUIREMENTS OF THE BOSTON REGION ADEQUATELY.

The proposed improvement program is comprised of construction of a close parallel to the existing 15R-33L runway, extension of runways 9 and 4L and provision STOL runway 15-33. Exhibit II-5 depicts the existing airport with the proposed airfield improvements by 1975.

(1) Runway 15L-33R Is the Highest Priority Project in the Present Development Program.

The project of primary importance in the present improvement program involves construction of a 9,200 foot long parallel to existing runway 15R-33L, spaced at 1,200 feet center to center. The development proposed includes dikes, intercepter drains, fill, surcharge, riprap shore protection, drainage, etc. As was pointed out in the capacity analysis that this runway is urgently needed to increase airfield capacity to meet the near term demands. This runway will be the first major airfield project, since the late 1950 period, to add significant capacity at Boston-Logan International Airport by increasing runway acceptance rates. This increase in capacity will also reduce aircraft delay with its attendent air pollution problems. Instrumentation of this new runway end on 15L will provide significant additional all weather capability, as this runway heading provides excellent coverage during weather conditions of less than 200 foot ceiling/1-1/2 mile visibility to 100 foot ceiling/1/4 mile visibility at Boston-Logan International Airport. Due to current limitations on capability under low ceiling and visibility conditions with instrumentation on runways 33L and 4R, runway 15L provides a realistic solution.

BOSTON · LOGAN INTERNATIONAL AIRPORT



Logan Today · 1971

Logan Tomorrow · 1975

EXHIBIT II-5

Environmentally, in addition to reducing aircraft delays, parallel runway 15L-33R will provide the capability for runway utilization to maximize noise abatement. From a physical standpoint, the approach to runway 15L, which will be primarily a landing runway is better than that to 15R as now extended. Not only is there sufficient land for full ILS and ALS systems, but the approach to 15L is over an area containing fewer close-in residences. In fact, whereas now the closest residence on the extended centerline of existing runway 15R from its physical end is approximately 1,870 feet and with threshold displacement for landing 2,750 feet, the closest residence on the extended centerline of new runway 15L-33R will be approximately 4,170 to 4,550 feet. The closest residence to the physical end of the new runway, off the centerline is approximately 3,550 feet. The existing runway, the longer of the two runways, will normally be used for departures.

The new runway has also been positioned to provide maximum distance from Winthrop and yet maintain adequate separation from existing runway 15R-33L to preserve capacity and safety. This runway is not anticipated to increase the degree of existing lateral noise levels in the Winthrop area as the departure lateral noise levels on 15R will still "overshadow" the lateral noise levels from landing aircraft on 15L. The 2,460 foot distance from the nearest residences in Winthrop to the new 15L-33R is more than double the existing 1,000 feet from these same residential areas to existing runway 4R-22L.

As initially proposed this runway construction would require landfill directly north and on the northwest and southeast ends of the runway. The fill areas at either end were planned primarily to meet new FAA criteria requiring 1,000 feet safety overruns for new runways. For reasons described in Chapter IV of this report the Massachusetts Port Authority intends to request a waiver of this requirement by the FAA as related to the 15L overrun area. Based upon reviews by the Massachusetts Port Authority with the FAA it is reasonable to assume that sufficient extenuating circumstances exist to warrant the granting of such a waiver. Exhibit II-5 indicates the area now intended to be filled as contrasted with the initial proposal.

Construction of runway 15L-33R should start as soon as possible and is the highest priority item of Boston-Logan International Airport's airfield development.

(2) <u>Extension of Runways 9 and 4L.</u>

Extension of existing runways 9 and 4L will provide an increased safety margin for air carrier aircraft operations and assist in reducing the noise impact on surrounding residential areas. The extension of runway 9 will result in a reduction of noise levels in existing residential areas under its departure path by allowing departing aircraft to be at higher altitude when passing over the area, a subject discussed further in Chapter III. The lateral noise effects of landing aircraft will be reduced, inasmuch as longer runways reduce the need for aircraft to apply full thrust reversal. It is necessary to use runway 9 as a departure runway in conjunction with a 4L and 4R operation. The associated taxiways including the dual south bypass, are required to facilitate and expedite traffic movement and improve traffic handling capabilities to and from the terminal area.

(3) New STOL Runway 15-33.

Boston-Logan International Airport was one of the first airports to provide a STOL runway system, one that was used in the Eastern Airlines STOL demonstration that provided the adequacy of Boston-Logan International Airport as a suitable STOL site. This runway continues in use today. The planned STOL runway 15-33 on the southerly side of the airport in the Bird Island Flats areas offers an excellent opportunity to increase airfield flexibility without detriment to the existing airfield operation. The possible timing and impact of full STOL operations are discussed in greater detail in Chapter VIII.

8. A SET OF BALANCED AIRPORT FACILITIES IS NECESSARY TO SERVE THE TRAVELING PUBLIC PROPERLY.

The improvements to the airfield facilities are needed to balance with the demands of the air vehicle traffic. In turn the terminal complex and support facilities must be improved to balance the demands of passenger and commodity traffic. Certain highlights of such balancing are noted below.

(1) The air vehicle and commodities are inanimate. This is not so for the passengers and visitors. The latter creates difficulties if he is mishandled or given substandard accommodations in the processing facilities. A poor image given by a city's air gateway can create a poor image of the city for a non-resident.

(2) The mix of aircraft is forecast to involve a continuing higher percentage of larger aircraft seating increased numbers of passengers per aircraft. In turn, the larger aircraft and larger passenger loads will require larger aprons and terminals to accommodate the added numbers and to balance the terminal and service complexes with the airfield facilities.

(3) It would be poor planning and management if the balancing of the functions were not given a high priority position in the decision making process.

BOSTON · LOGAN

CHAPTER III

ANALYSIS OF NOISE AND ITS IMPACT ON SURROUNDING COMMUNITIES

I. INTRODUCTION

1. PURPOSE

This study evaluated noise levels associated with current aircraft operations at Boston-Logan International Airport and measured the effect of potential changes associated with anticipated modes of operation in 1975. In order to make this review and projection it was necessary to determine the significance of current noise measurement methodology and to consider impending improvements in aircraft noise abatement technology.

2. APPROACH

The following series of analyses were made.

(1) Development and analysis of Noise Exposure Forecast (NEF) contours for several different operating patterns and runway utilizations which consisted of two separate steps.

- A set of comparative and relative NEF analyses were made to show the differences between the improved and existing airport using the same traffic mix and type of airplane. This was intended to measure only the effect of the new runway and therefore used only B-727 aircraft and did not include new quieter aircraft which will be included in the 1975 traffic mix. The results of this study showed the relative number of dwelling units affected and pointed toward the need for a more complete analysis described below.

- A set of NEF analyses compared alternative and preferential runway usage with the aircraft fleet in 1975 which will include many of the newer and quieter aircraft. The object of the study was to determine the differences with respect to NEF contours between the alternative operating patterns. These differences were measured in terms of land areas, residents, dwelling units, schools and hospitals within each contour. The entire analysis was conducted by the firm of Bolt, Beranek and Newman, Inc.

(2) A detailed review of the technological progress of the various programs for noise abatement which included a review of research and development expenditures as a measure of the total effort on this subject and a review of progress on the NASA "quiet engine" program.

(3) A series of discussions with engine manufacturers, aircraft manufacturers, government officials and officials of the Air Transport Association to determine the progress that each is making in noise abatement, which included analysis of major reports on the subject of aircraft noise.

(4) An analysis of the several different principal methods which have been developed to measure the impact of noise on airport neighbors. The object was to make a judgment on the confidence level that can be assigned to individual annoyance as predicted by the NEF methodology.

Conclusions were drawn from analysis of the results with proper consideration for the various interrelationships in the rapidly evolving art of measuring and estimating the effect of noise and its annoyance factors on residents living near the airport. The services of two nationally known firms, Tracor Inc. and Bolt, Beranek and Newman, Inc., were used as consultants. The Bolt, Beranek and Newman, Inc. report is appended in total as Appendix B to this document.

II. SUMMARY

The Noise Exposure Forecast known as the NEF methodology was used to evaluate the impact of noise on the community on a relative basis only. This resulted in comparisons which assessed the effect of alternative runway configurations and operating patterns. The NEF methodology is helpful as a planning tool only and does not accurately predict individual response to aircraft noise and is not currently endorsed as a land value planning tool by the Federal Aviation Administration or other governmental agencies.

The calculations show that the airport improvement provided by the addition of the new parallel runway 15L-33R will result in fewer numbers of residents within the NEF 30 and NEF 40 contours than within these same contours during operations in 1970 with the existing airport. When operations are planned for maximum noise abatement for the improved airport with the expected 1975 traffic mix, forty percent (40%) fewer people reside within the NEF 30 and sixty-four percent (64%) fewer people within the NEF 40 contours than are currently living within those same contours with today's airport and 1970 actual traffic. This reduction will be achieved by introduction of wide-body aircraft which have lower inherent noise levels and implementation of an improved preferential system using the new runway for noise abatement. Realistic implementation of noise abatement procedures will be possible only with construction of the 15L-33R parallel runway.

This new runway is the only reasonable alternative to providing noise relief to the Boston-Logan International Airport neighbors for the short-term. The improved airport will provide even greater noise relief for the long-term because of the additional flexibility for preferential runway use with the new larger aircraft. As aircraft size increases, the relative number of flights will decrease and the inherent noise levels will be lower. The result will be that more flights will be overwater. This, added to the lower noise levels, will reduce the relative size of the NEF contours.

III. CONCLUSIONS

1. THE RESULTS OF THE CALCULATIONS PERFORMED BY BOLT, BERANEK AND NEWMAN, INC. SHOW THAT THE CONSTRUCTION OF THE NEW RUNWAY AND INTRODUCTION OF NEW AIRCRAFT WILL REDUCE THE NUMBER OF RESIDENTS WITHIN THE NEF 30 AND NEF 40 CONTOURS BY FORTY PERCENT (40%) AND SIXTY-FOUR PERCENT (64%) RESPECTIVELY IN 1975 AS COMPARED TO CONDITIONS EXISTING IN 1970.

Condition	1	2	3	4	5	6
Airport Configuration	Existing	Existing	Existing	Existing	Existing	Improved
Traffic Projections	Actual 1970	1975	1975	1975	1975	1975
Runway Utilization	Historic	Maximum Capacity	Historic	Noise Abatement Alt. No.1	Noise Abatement Alt. No.2	Maximum Noise Abatement
NEF 30						
Acres (1000's)	12.1	14.7	13.2	8.3	10.4	8.8
Population (1000's)	121.4	139.9	127.3	71.6	92.7	72.8
NEF 40						
Acres (1000's)	3.1	2.8	3.1	2.5	2.7	2.1
Population (1000's)	24.4	17.0	23.8	11.4	14.2	8.9

2. THE EXISTING AIRPORT OPERATED FOR MAXIMUM NOISE ABATEMENT IN 1975 RESULTS IN AN INCREASE OF TWENTY-EIGHT PERCENT (28%) IN THE NUMBER OF RESIDENTS WITHIN THE NEF 40 CONTOUR AS COMPARED TO THE IMPROVED AIRPORT.

3. REDUCTIONS OF TWENTY PERCENT (20%) IN TERMS OF NUMBERS OF DWELLING UNITS WITHIN THE NEF 40 CONTOUR RESULTED FROM CALCULATIONS MADE ON A RELATIVE BASIS ONLY WHERE THE SAME AIRCRAFT (B-727) AND THE SAME NUMBER OF MOVEMENTS WERE COMPARED WITH AND WITHOUT THE IMPROVED AIRPORT FOR 1975 TRAFFIC.

4. SIGNIFICANT NOISE REDUCTIONS SHOULD RESULT FROM RESEARCH ON NOISE REDUCTION EQUIPMENT AS A RESULT OF EXPENDITURES BY THE INDUSTRY OF $350,000,000 DURING THE LAST FIVE YEARS AND BY THE FEDERAL GOVERNMENT'S ANNUAL EXPENDITURE OF APPROXIMATELY $40,000,000.

5. SUBJECTIVE PERCEIVED NOISE LEVELS ON THE NEWER ENGINES WHICH INCLUDE THOSE ON THE NEW WIDE-BODY AIRCRAFT ARE ONE-FOURTH TO ONE-HALF THOSE THAT WOULD BE PERCEIVED BY AN OBSERVER ON PRESENT FOUR ENGINE VEHICLES SUCH AS THE B-707.

6. THE NASA "QUIET ENGINE" WILL PRODUCE LESS NOISE THAN ANY ENGINE NOW IN PRODUCTION. BUT THIS NEW ENGINE IS PROBABLY TEN TO FIFTEEN YEARS AWAY FROM PRODUCTION.

7. CONTINUED IMPLEMENTATION OF THE BOSTON-LOGAN INTERNATIONAL AIRPORT NOISE ABATEMENT PROGRAM TOGETHER WITH THE FEDERAL AVIATION ADMINISTRATION'S NOISE REGULATIONS WILL PROVIDE ADDITIONAL FUTURE IMPROVEMENTS.

8. THE NEF METHODOLOGY PERMITS ONLY A RELATIVE MEASURE OF AIRCRAFT NOISE IMPACT UNDER VARIOUS OPERATING MODES. IT CANNOT BE USED AS AN ABSOLUTE MEASURE. IT HAS AN INDIVIDUAL ANNOYANCE CORRELATION COEFFICIENT OF ABOUT 0.35 AND IS THEREFORE NOT USEFUL FOR PREDICTING INDIVIDUAL ANNOYANCE.

9. GREATER SIDELINE DISTANCE WILL REDUCE THE NOISE IN WINTHROP. THE 15L-33R RUNWAY SIDELINE DISTANCES WILL BE ABOUT 2,500 FEET FROM WINTHROP AS COMPARED TO THE 1,000 FEET FOR THE END OF THE EXISTING RUNWAY 22. THIS INCREASE IN PHYSICAL DISTANCE WILL PROVIDE SOME RELIEF FROM NOISE. IN ADDITION, THE NEW RUNWAY WILL PERMIT GREATER PERCENTAGES OF OVERWATER OPERATION. THESE ESTIMATES ARE REFLECTED IN THE NEF CALCULATIONS.

10. THE PROJECTED NOISE REDUCTIONS CAN BE ACHIEVED ONLY BY RIGID ENFORCEMENT OF THE RECOMMENDED PRACTICES AND PREFERENTIAL USE OF RUNWAYS AND WILL REQUIRE COOPERATION OF THE ENTIRE AVIATION COMMUNITY.

IV. DISCUSSION

1. NOISE AS PERCEIVED BY AN INDIVIDUAL IS SUBJECTIVE AND DEPENDS ON THE PARTICULAR RESPONSE AND ATTITUDE OF THE OBSERVER.

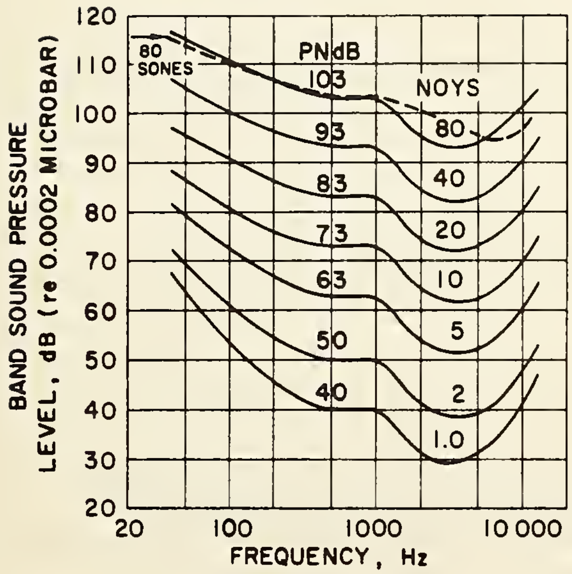
Before discussing the factors which will affect noise levels around Boston-Logan International Airport in the 1975-80 time span, it is important to define what is meant by the term "noise." Noise is undesirable sound. It is, by nature, a subjective quantity. Measurements of noise must include both measurements of sound pressure levels plus weighting factors to account for the response of the human ear.

Perceived Noise Level (PNL) is a measurement of the relative noise perceived by humans. It includes both a sound intensity measurement and a spectrum shape factor. Sounds of equal Perceived Noise Levels will be judged equally noisy under controlled subjective testing. The PNL scale, like the decibal scale for sound, is logarithmic and the units are PNdB. An increase of 10 PNdB will be perceived as a doubling of the noise (10). The relation between PNdB and sound pressure level is shown in Exhibit III-1.

Another term frequently used in aircraft noise measurement is Effective Perceived Noise Level measured in EPNdB. EPNL measurements are a modification of PNL measurements including subjective correction factors to account for pure tone components and duration of noise exposure. Sounds with significant pure tone components are judged subjectively louder than sounds of the same intensity without sound pure tones. Similarly, as the duration of the sound increases, the judged noisiness will increase.

EXHIBIT III-1
Perceived Noise as a Function of Frequency

NOISINESS OF BANDS OF SOUND



Source: NASA SP-189, Paper 34, Kryter, K. D., "Prediction of Effects of Noise on Man."

Several basic methods for measurement of annoyance factors have been developed. The two principal methods are:

(1) "CNR" which stands for composite noise ratio. This has been cited in a recent report (18) by Tracor to be slightly more accurate in measuring individual annoyance than any other methodology. However, it does not accurately predict individual annoyance as shown in the report.

(2) "NEF" which stands for Noise Exposure Forecast is the most widely used methodology today. This method is a relative measure and does not describe a single individual's response. The purpose of the NEF is described in the Federal Aviation Administration Draft Order (19) which states that it is designed to:

> "accommodate governmental, public bodies or individual needs for a more exacting descriptor of aircraft noise exposure; one which would relate noise exposure to compatible land use planning guidelines rather than community complaint and annoyance exceptions; and one which would also serve as an analytical tool for assessing the effectiveness of proposed noise abatement strategies"

Both of the above methods will be discussed in detail later in this report. However, it is well to point out here that the Tracor report (18) referenced above shows:

- That there is a very low coefficient of correlation between individual noise exposure and annoyance. Thus, people react in a manner that may vary greatly between individuals.

- That noise annoyance is to a large degree psychological and depends on attitudes and other subjective factors.

The data developed by Tracor Inc. in this comprehensive study will be presented later in this discussion.

2. NOISE LEVELS FROM AIRCRAFT WILL BE IMPROVED AS A RESULT OF SPECIFIC PROGRAMS NOW UNDER WAY.

(1) Significant Sums Of Money Have Been Spent by Both the Commercial Aviation Industry and the Federal Government To Solve the Aircraft Noise Problem.

- Expenditures by the aviation industry for research and noise reduction equipment totaled $200,000,000 through 1965. Since that time, an additional $350,000,000 has been invested.
- Government spending on aircraft noise reduction totaled about $40,000,000 per year for 1969 and 1970.
- These expenditures should result in significant noise reductions in the next two decades.

(2) Future Community Noise Levels in Areas Adjacent To Airports Will Be Improved by a Number Of Factors, Including:

- Technological advances in aircraft design.
- Federal noise abatement programs.
- Noise abatement procedures will be followed by aircraft operators.
- Acoustical design improvements on new constructions near airports.

In addition, increased application of effective land use planning methods should be employed to reduce the total number of people exposed to aircraft noise. Some of the major programs to reduce the noise from aircraft will be discussed in greater detail in the next paragraph.

3. <u>SEVENTY-FIVE PERCENT (75%) REDUCTION IN RELATIVE PERCEIVED SUBJECTIVE NOISE LEVELS ARE EXPECTED FOR FUTURE COMMERCIAL AIRCRAFT COMPARED TO THE EARLY FOUR ENGINE TURBOJET AIRCRAFT.</u>

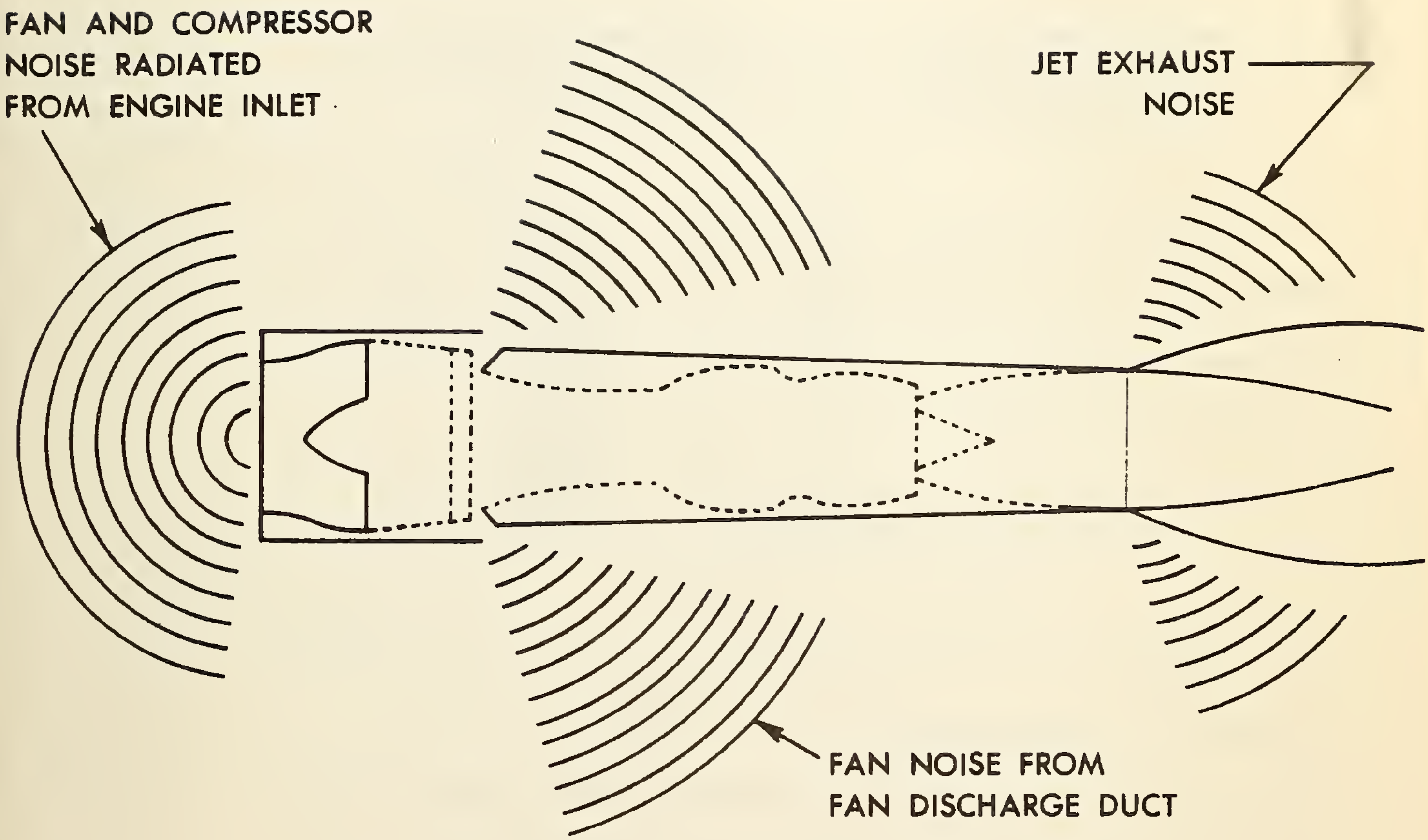
The earliest commercial jet aircraft were powered by turbojet engines. These aircraft produce perceived noise levels of about 120 PNdB at takeoff. The noise of turbojet engines comes primarily from the high velocity jet exhaust itself as it mixes with ambient air and to some degree is a result of inlet duct sources.

(1) <u>Jet Exhaust Noise Was Reduced Because Of the Development Of the Turbofan Or Fanjet Engine.</u>

- By adding an auxiliary fan to the turbojet engine, aircraft engineers created the turbofan engine. Doing this, they were able to cut total engine noise levels by 5 PNdB. This is equivalent to about a thirty percent (30%) reduction in the perceived sound level. The general configuration of a turbofan engine and its noise sources are shown in Exhibit III-2.

- The fan engines have been installed on the majority of the jet aircraft now in service. The data as of September 30, 1970, show that the Boeing Company has delivered 238 turbojets and 1,742 turbofan powered aircraft in the 707, 720,727 and 737 Series (4). The McDonnell-Douglas data, up to September 1, 1970, indicate deliveries of 151 turbojet and 935 turbofan powered aircraft in the DC-8, DC-9 Series (5).

- Fanjet noise reductions result from interactions between the jet exhaust, the fan exhaust, and the atmosphere. The fan exhaust, in effect, serves as a buffer zone between the high velocity jet exhaust and the surrounding air. Also, since the fan itself provides thrust, less high speed flow is required through the jet for a given total thrust.



TURBOFAN ENGINE NOISE SOURCES

Source: First Federal Aircraft Noise Abatement Plan FY 1969-70.

Note: The size of radii is not an indication of noise levels. (BA&H) Comments)

- Fanjet noises are somewhat different in character from turbojet noises, as well as being lower in overall noisiness. Exhibit III-3 shows the types of noises produced by fanjets. Fanjet noise is composed of fan noise and jet noise. Fan noise is emitted from the inlet and the fan discharge duct. Jet noise is emitted from the primary jet and the fan discharge duct.

(2) <u>Additional Noise Reductions Of One-Half Present Levels Appear Feasible and Are Under Active Development by Government Agencies and Private Industries.</u>

Additional noise reductions of fanjet engines are projected for future engines. The potential noise reduction is related to the relative amounts of air channeled through the fan and jet portions of the engine. This relationship is expressed in terms of a by-pass ratio where:

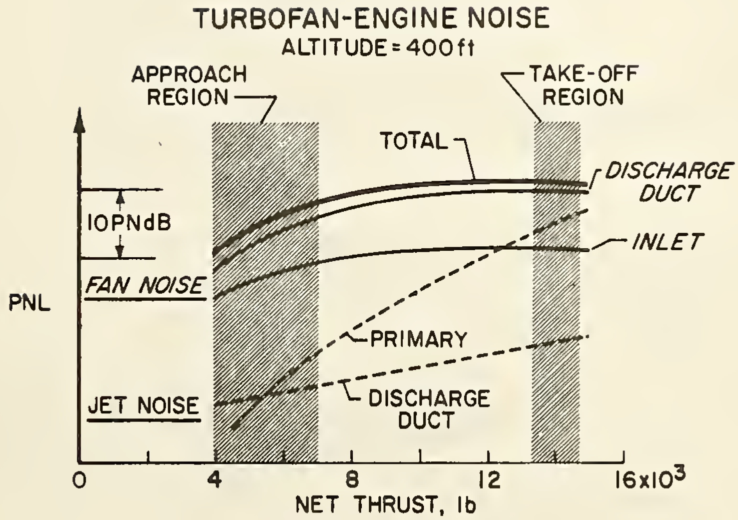
$$\text{By-pass ratio} = \frac{\text{Flow through fan}}{\text{Flow through jet}}$$

Noise levels of the proposed engines are compared with current fanjets and the earlier turbojets in Exhibit III-4. The 20 PNdB noise reduction projected by high by-pass ratio engines represents seventy-five percent (75 %) reduction in subjective noise relative to first-generation jet engines.

- <u>Several Research Programs Were Initiated by the Federal Government To Find Short-Term Solutions To the Aircraft Noise Problem.</u>

  On July 21, 1968, Congress enacted Public Law 90-411. This law amended the Federal Aviation Act of 1958 to require noise abatement regulation. The purpose of the amendment is to provide statutory authority for the control

EXHIBIT III-3
Noise Components in a Turbofan Engine
As a Function of Thrust



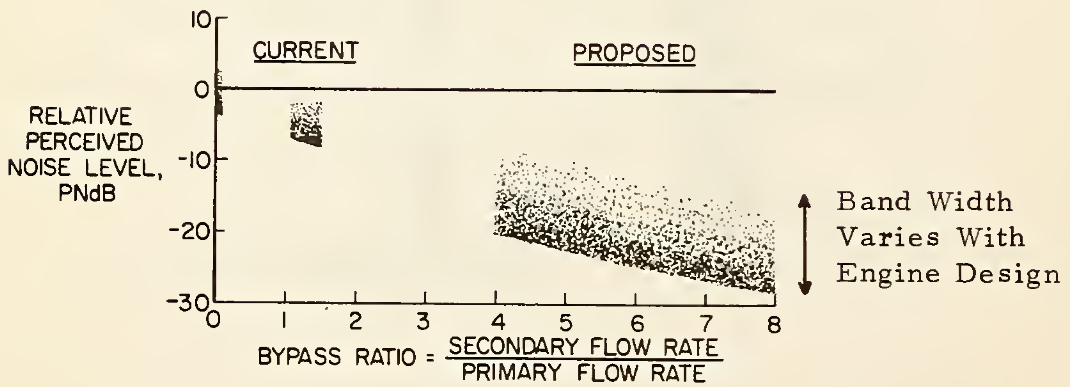
Source: NASA SP-189, Paper 8, Norton, H. T., "Introductory Remarks on Nacelle Acoustic Treatment Application"

Note: Primary refers to the jet noise. Discharge duct noise refers to the flow of air coming out of the fan. (BA&H Comments)

EXHIBIT III-4

Noise Reduction Potential for Fanjet Engines

SIDELINE NOISE LEVELS FOR CONSTANT THRUST



Note: Lower Bound Determined by Jet Mixing Noise

Source: NASA SP-189, Paper 3, Hubbard, H. H., "Conference Scope and Noise Concepts"

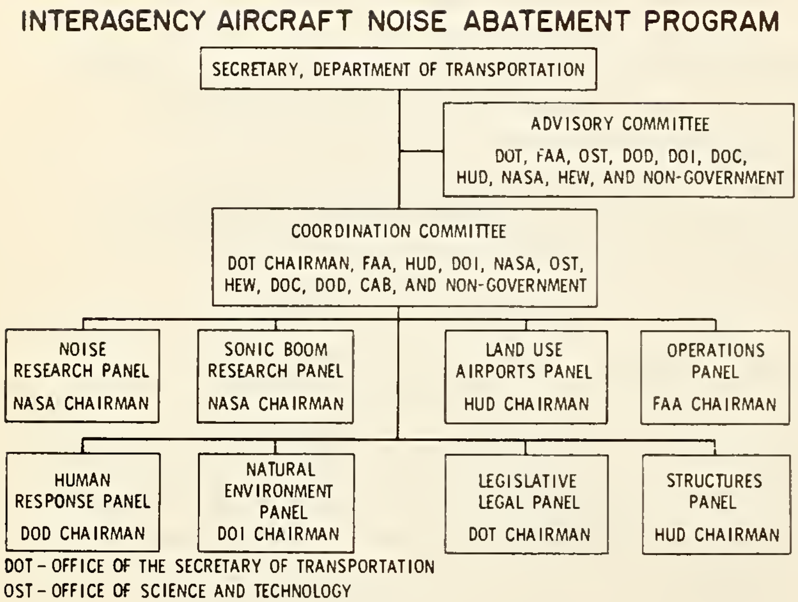
The reference level is set at 0 for the first generation of turbojets with a bypass ratio of 0. (BA&H Comments) and abatement of aircraft noise and sonic boom. It directs the Administrator of the Federal Aviation Administration in consultation with the Secretary of Transportation to prescribe and amend standards for the measurement of aircraft noise and sonic boom. The amendment also includes the application of such standards, rules and regulations in the issuance or revocation of any certification authorized by Title VI of the Federal Aviation Act (6).

The federal government set up an Interagency Aircraft Noise Abatement Program. The structure and composition of the various panels are shown in Exhibit III-5. The level of expenditures by the federal government to support this noise abatement program reached $43 million in FY'69. The results of this program are discussed briefly in the following text.

- The major effort was undertaken by NASA. The program was aimed at reducing the noise level generated by existing large aircraft of the B-707 and DC-8 type powered by the JT3D fanjet engine. The program included flight tests of modified nacelles by Boeing and McDonnell-Douglas. The modifications in the nacelles were aimed at the reduction of the fan noise. The fan noise predominates in turbofan engines. The noise is propagated both forward and aft from the fan discharge ducts. The forward radiated noise can be reduced by installing acoustic linings in the inlet. The aft radiated fan noise can be reduced by installing acoustic linings in the fan discharge ducts. NASA Langley Research Center contracted with Boeing and McDonnell-Douglas for study and development of turbofan nacelle modifications to minimize fan noise on the 707 and DC-8 aircraft.

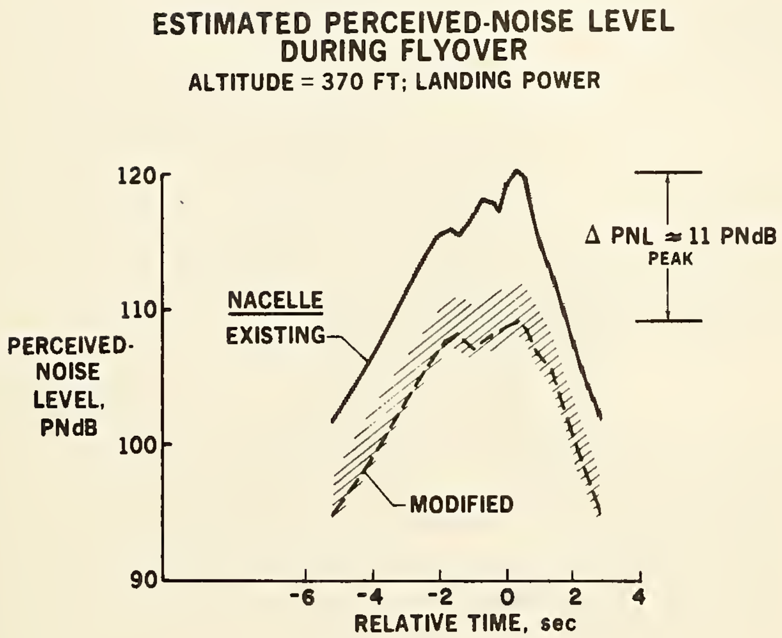
- McDonnell-Douglas completed flight tests of a DC-8 with one-ring treated inlets and treated fan discharge ducts in March 1969, and obtained a noise reduction during flyover of 11 PNdB. The reductions are shown graphically in Exhibit III-6 which shows the estimated flyover perceived noise levels on approach for a DC-8 with JT3D engines.

EXHIBIT III-5
Structure of Interagency Aircraft Noise Abatement Program



Source: NASA SP-189

EXHIBIT III-6
Estimated Perceived Noise Level for Flyover
At Landing Power for a DC-8 With Modified Nacelles



Source: NASA SP-189, Paper 12, Pendley, R. E., Marsh, A. H., "Noise Predictions and Economic Effects of Nacelle Modifications to McDonnell-Douglas DC-8 Airplanes"

- Boeing completed flight tests on a 707 equipped with two-ring treated inlets and long treated fan discharge ducts in June 1969 and obtained noise reductions of 16 PNdB during flyover (6). The reductions are shown graphically in Exhibit III-7 which shows the flyover perceived noise levels on approach for a 707 with JT3D-3B engines.

- NASA has also initiated a "quiet engine" research program to reduce the noise levels generated in the fan in a turbofan jet engine. The program involves a cooperative effort with engine manufacturers.

- The aim of the program is to achieve a propulsion system that could generate no more than 100 PNdB on fan-engine aircraft for ground observers at the three mile point during takeoff and at the one mile point during landing. The major emphasis is on the configuration of the fan in order to reduce the noise tones (7).

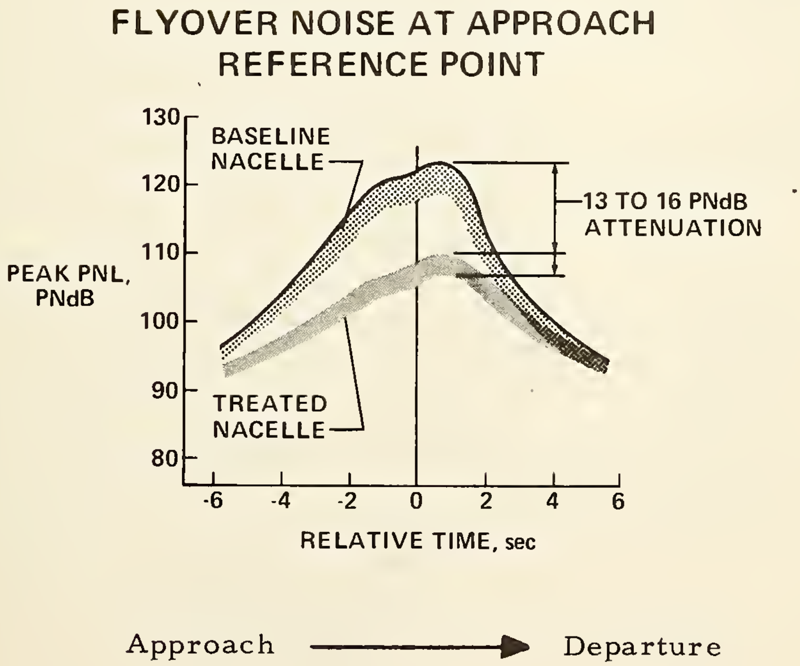
- A test engine is to be delivered to NASA by September 1972. Interviews with the project personnel at NASA showed that, based on the progress to date, the goals that were set up by NASA will be achieved. See Exhibit III-9 and the table on the following page.

- In addition, a program to develop a mobile noise suppressor that could be rolled up to the stationary aircraft is under way. It is expected that this noise suppressor will decrease the noise emissions due to engine run-ups. At this time, we cannot say when this will be available for general use.

- DOT and HUD sponsored research to define the magnitude of the transportation noise problem and its abatement. This research was further supported by work performed by the USAF laboratories. Their work, executed in the Aero Propulsion Flight Dynamics, and Aerospace Medical Research Laboratories, examined quiet propellers, VTOL aircraft, for the effects of noise exposure. The Department of HEW supported research in the field of classroom acoustics and other studies related to noise problems.

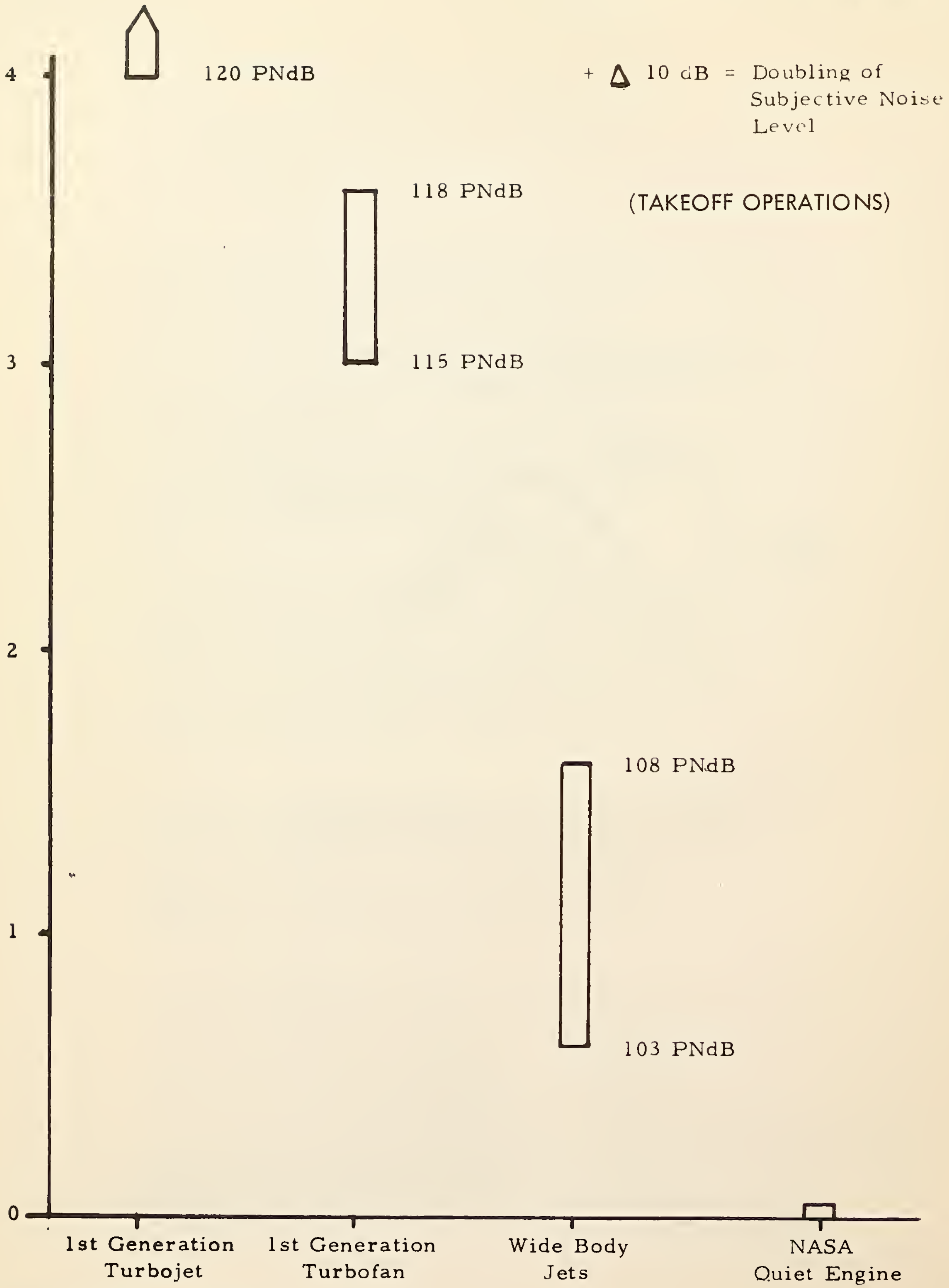
EXHIBIT III-7

Perceived Noise Level for a Flyover
At Landing Power for a 707 With Modified Nacelles



Source: NASA SP-189, Paper 16, Nordstrom, D. C. and Miller D. S., "Noise Predictions and Economic Effects of Boeing Nacelle Modifications"

EXHIBIT III-9
Relative Subjective Noise Levels



Source: NASA SP-189

. **The Aviation Industry Is Also Making Considerable Efforts To Reduce Aircraft Noise To Cut the Perceived Noise by One-Half.**

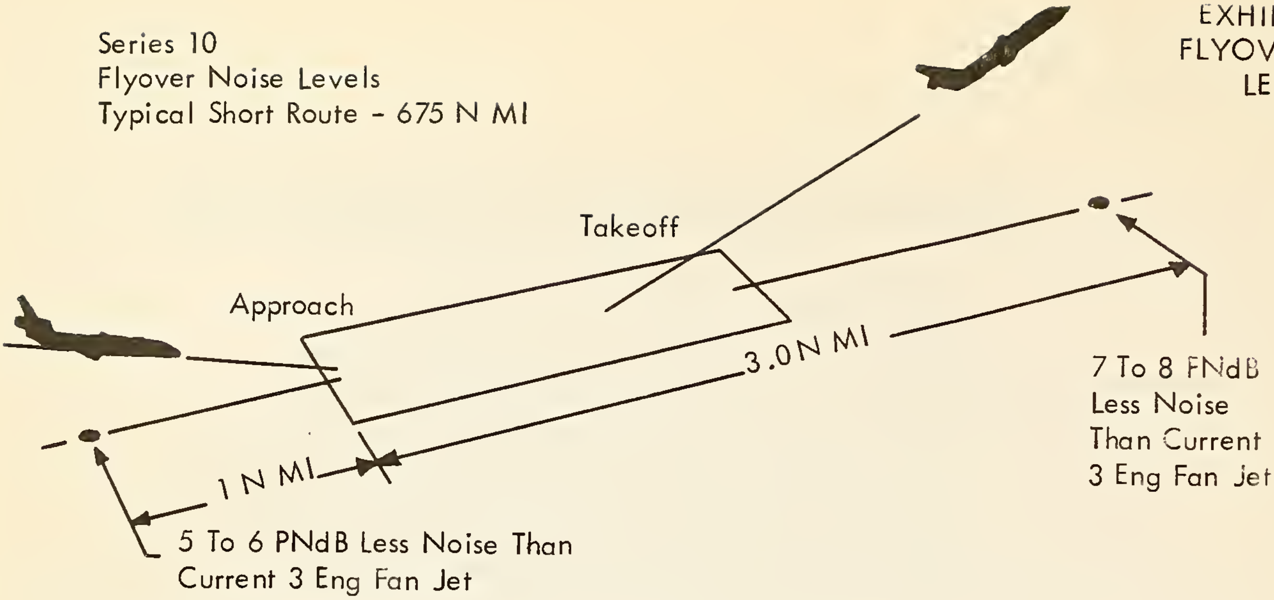
- The major engine manufacturers include General Electric, General Motors, and Pratt & Whitney. These three companies collaborated with the major airframe manufacturers to produce quieter second-generation aircraft. The new, wide-body aircraft are built by Boeing (B-747), Lockheed (L-1011), and McDonnell-Douglas (DC-10). The results of this extensive noise reduction program are shown below and explained graphically in Exhibit III-10 for the DC-10.

Engine Type	Aircraft Type	Noise Emitted	Relative Subjective Noise Levels
Turbojet	Early 707 Early DC-8	120 PNdB	4
Turbofan	707 DC-8 727 DC-9 737	115-118 PNdB	3-3.6
Turbofan	DC-10 747 L-1011	103-108 PNdB	0.7-1.8
Turbofan (NASA Quiet Engine Program)		100 PNdB	0.1
Turboprop	Brequet 911	93-95 PNdB	-2.0

- This indicates that the new wide-body jets are significantly less noisy (10-12 PNdB) than the earlier first-generation turbofans, even though their engines have roughly twice as much thrust as the first-generation aircraft. It should be pointed out that, on the average, an increase in the intensity of 10 PNdB results in the doubling in the subjective noisiness (10). The effect of changing the noise emissions to 103-108 PNdB is shown in Exhibit III-9.

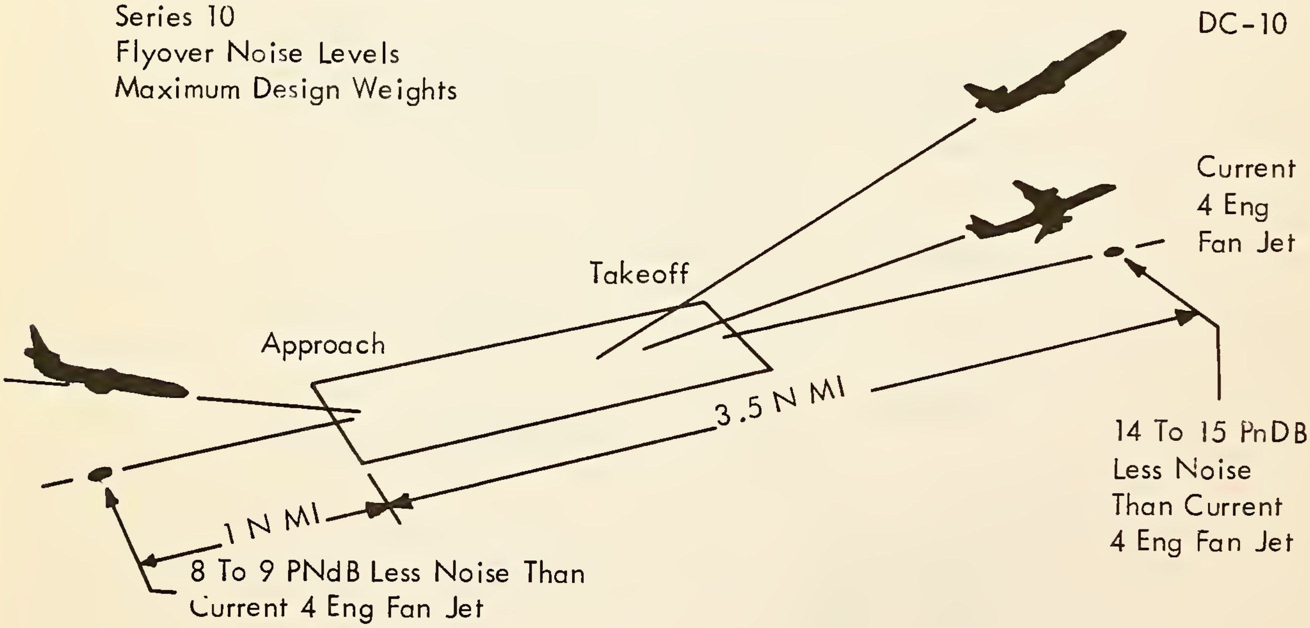
EXHIBIT III-10
FLYOVER NOISE
LEVEL

Series 10
Flyover Noise Levels
Typical Short Route - 675 N MI



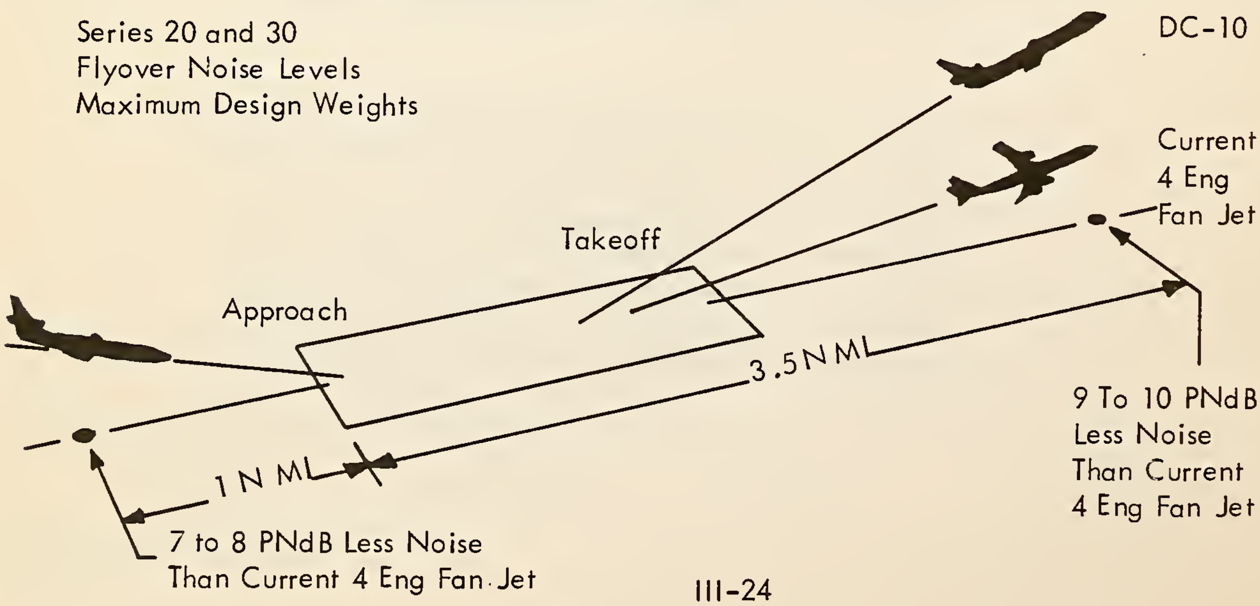
Series 10
Flyover Noise Levels
Maximum Design Weights

DC-10



Series 20 and 30
Flyover Noise Levels
Maximum Design Weights

DC-10



- Exhibit III-9 shows how an individual would perceive the noise levels and shows that major progress is under way. The perception of the noise is measured at a distance of 0.35 miles from the sideline of the runway according to government standards. The table below shows comparisons with other noise sources as follows: (20)

120 db	115 db	110 db
- Pneumatic chipping hammer - Subways	- Auto horn	- Blaring radio - Centrifugal ventilating fan (13,000 CFM)

100 db	90 db	80 db
- Loud street - Wood saw	- Voice/ shouting - Vaneaxial ventilating fan (1,500 CFM)	- Noisy office - Normal radio

- The new engines have actually made more progress than indicated in Exhibit III-9 and the many research programs should help to lower the levels shown.

- Boeing recently announced that their advanced B727-200 has passed noise certification tests which resulted in noise levels that will be significantly reduced. They have not yet made certification tests. The Federal Aviation Administration has not received the exact amount of reduction that is promised by Boeing, but expect that it will meet FAR-36.

4. FEDERAL AVIATION ADMINISTRATION REGULATIONS NOW UNDER CONSIDERATION WILL BRING ABOUT A REDUCTION IN NOISE LEVELS FROM AIRCRAFT AND WILL ALSO LOWER THE NOISE ANNOYANCE FROM AIRCRAFT OPERATIONS.

The Federal Aviation Administration, in consonance with Public Law 90-411, promulgated FAR-36 which governs the noise emissions of subsonic aircraft (9).

(1) Rule FAR-36 Governs New Aircraft Noise Emissions.

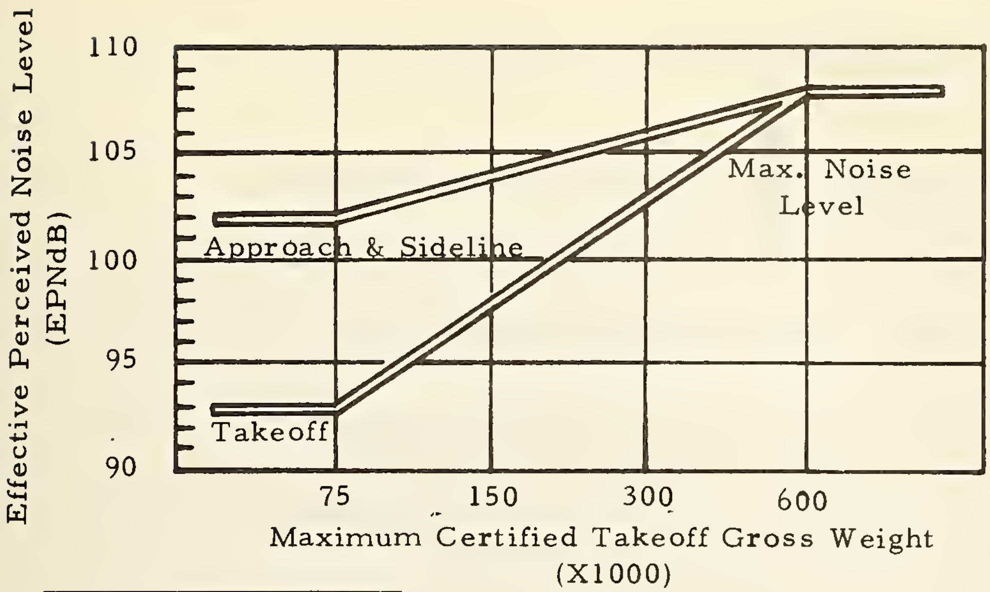
The Federal Aviation Administration has promulgated rules governing the maximum amount of noise that can be generated by large subsonic aircraft. The rule applies only to aircraft that have engines with a by-pass ratio of two or more and for which the original application for certification was made on or after January 1, 1967. This rule (FAR-36) then applies to the new generation of wide-body jet aircraft such as the B-747, DC-10, and L-1011. This will be achieved on the B-747 after December 1971 as discussed later. The general requirements are shown in Exhibit III-11.

The allowable noise limits are based on the aircraft's certificated gross takeoff weight, which for a maximum 600,000 lbs. aircraft is 108 EPNdB. The B-747, DC-10 and L-1011 will meet FAR-36. Aircraft having a gross takeoff weight of up to 75,000 lbs. are limited to takeoff noise of 93 EPNdB and approach and sideline noise of 102 EPNdB.

Exhibit III-11 shows the graphical relationship between Effective Perceived Noise Level (EPNdB) versus maximum certificated aircraft gross takeoff weight, together with the definition of measurement zones.

The noise limits promulgated by the Federal Aviation Administration in FAR-36 will result in a net decrease in noise of 10-15 EPNdB at approach and takeoff and 5 EPNdB on sideline because of the new aircraft of the type of the B-747, DC-10 and L-1011.

EXHIBIT III-11
Allowable Aircraft Noise Vs
Gross Weight & Measurement Location



Source: "Aviation Week & Space Technology," November 17, 1969

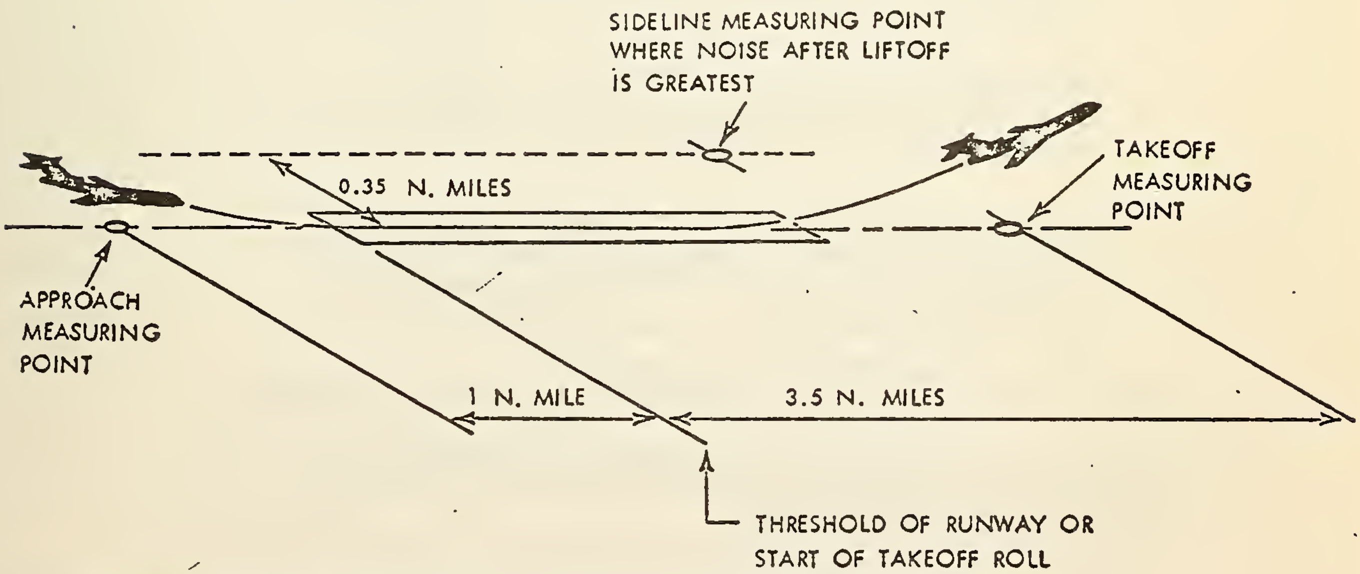


Chart shows approach, sideline and climb-out noise measuring points for aircraft type certification.

Source: "Airport World," January 1970

(2) <u>The Federal Aviation Administration Will Issue Several Other Noise Regulations.</u>

In order to reduce the noise levels emitted by the large jet fleet that is in service but does not meet FAR-36, the Federal Aviation Administration is preparing rules on the following items (12):

- Requirements for retrofitting existing transport aircraft with quieter engines. A final regulation is expected in late 1971. The projected retrofit cost per aircraft ranges from $500,000 to $2,000,000, depending upon the magnitude of the required task (11). The total cost for retrofitting the entire fleet may reach $2 billion.

- Noise criteria for short takeoff and landings (STOL) transport aircraft - an industry conference was held early in 1970 with a notice of proposed rule-making to follow. It is expected that the noise criteria will be set at 95 PNdB for the sideline noise at takeoff. The point of measurement is expected to be 500 feet away from the centerline of the runway. If adopted this will represent a considerable noise decrease.

- Operating regulations for subsonic turbojet at 500 feet and transport aircraft - a notice of proposed rule-making is scheduled to be issued in 1971. The proposed rule-making is expected to set up operational procedures for aircraft to minimize noise emission.

(3) <u>The Federal "Keep-'Em-High" Program Can Provide Immediate Reduction in Noise Annoyance.</u>

This program, not yet used in Boston, has been started by the Federal Aviation Administration and consists of the following:

- On landing, the aircraft will approach the airport at significantly higher altitudes, thus exposing fewer people for a shorter period of time to high noise levels.

- On departure, the aircraft climb at a higher rate and speed to achieve a result similar to the above.

5. RECENT TEST RESULTS SHOW THAT THE NEW WIDE-BODY AIRCRAFT WILL MEET OR EXCEED THE REQUIRED NOISE LEVEL REDUCTIONS.

(1) A recent report by Boeing states that the B-747 airplane will meet the requirements of FAR-36 by December of 1971 (25). Preliminary indications are that it will exceed the requirements.

(2) Similarly, tests on the McDonnell-Douglas DC-10 show that they will meet FAR-36. A recent report by the General Electric Company, which makes the engine for the DC-10, reported the following, (21) which indicates that it will exceed FAR-36.

- For takeoff, at a point 3.5 nautical miles from the start of takeoff roll-on, the extended centerline of the runway - 105.6 EPNdB.
- For approach, at a point one nautical mile from the threshold on the extended centerline of the runway - 107 EPNdB.
- For the sideline, at the point on a line parallel to and 0.25 nautical miles from the extended centerline of the runway where the noise after liftoff is the greatest - 107 EPNdB.

(3) No definitive reports are yet available for the L-1011 aircraft since an aircraft which meets final power specifications has not yet been available for testing. However, it must meet FAR-36 requirements for certification prior to use for commercial flight.

6. ADDITIONAL REDUCTIONS OF COMMUNITY NOISE PROBLEMS ARE POSSIBLE THROUGH ANALYSIS AND MODIFICATION OF AIRCRAFT OPERATIONS WHICH CAN BE PROVIDED BY THE IMPROVED AIRPORT.

(1) Direct reduction of aircraft engine noise levels is only one approach to an effective overall noise abatement program and should be supplemented with other measures to reduce the community impact.

(2) An effective method of noise abatement is modification of airport configuration or operational procedures to keep the aircraft away from populated areas. This second approach reduces community exposure by directing traffic along flight paths overflying sparsely populated areas.

(3) This is the result that will be achieved by the improved airport. The measurements made during this study which clearly demonstrate this will be discussed later.

7. THE FACTORS WHICH HAVE BEEN DEVELOPED TO MEASURE NOISE ANNOYANCE FROM AIRCRAFT ARE RELATIVE MEASUREMENTS AND DO NOT ACCURATELY PREDICT INDIVIDUAL RESPONSE. THEY SHOULD BE USED FOR PLANNING PURPOSES ONLY TO COMPARE DIFFERENT OPERATIONAL PROCEDURES BUT NOT AS FINITE MEASUREMENTS.

(1) The Meaning Of Effective Perceived Noise Levels EPNL.

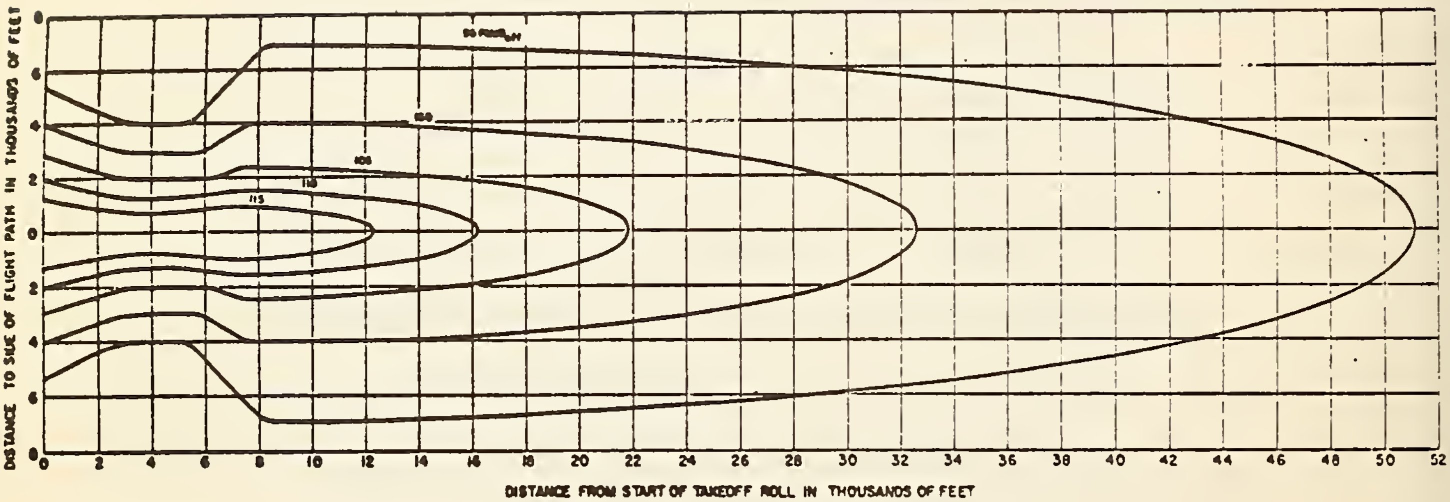
The EPNL at any point is a mathematical estimate of the noisiness of an aircraft as perceived by an individual on the ground.

EPNL = Measured Sound Pressure Level + Spectrum Shape Factor + Tone Factor + Duration Factor

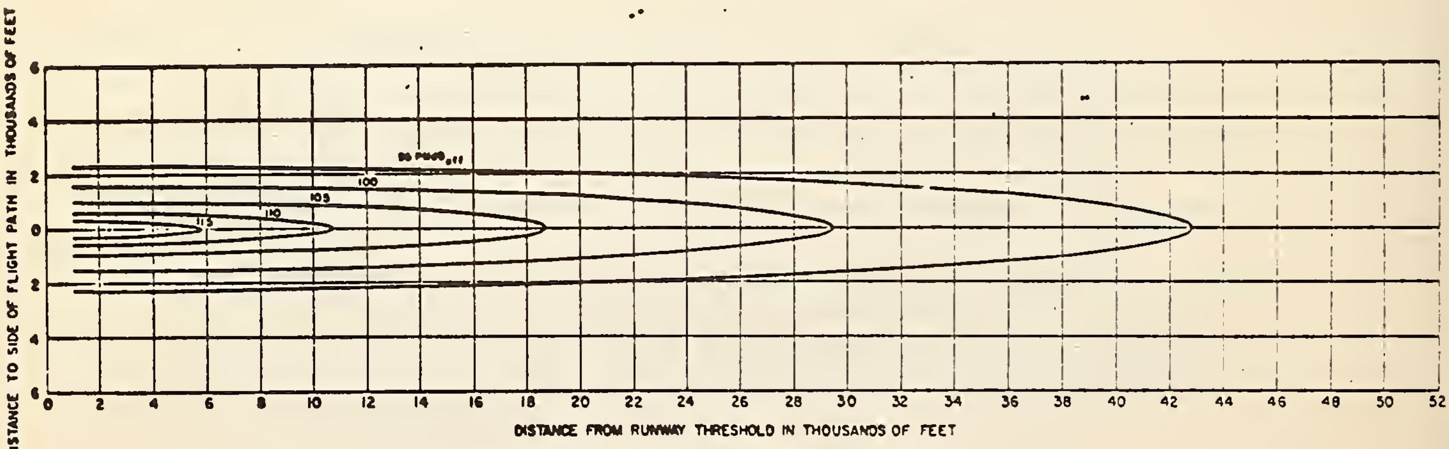
The EPNL will, of course, vary with the position of the observer relative to the runway. Thus, it is possible to produce EPNL contours for a given aircraft under takeoff and landing conditions. Contours for a large turbojet are shown as Exhibit III-12.

For each aircraft type in use at the airport, sound pressure level measurements are made at 1,000 foot distances for takeoff, approach and sideline noise. The sound pressure level (SPL) measurements are then combined with spectrum shape factors related to the response of the human ear to determine the perceived noise level or PNL.

EXHIBIT III-12
Effective Perceived Noise Level
Contours for Large Turbojet



A. TAKEOFFS-TRIP LENGTHS LESS THAN 2000 MILES



B. INSTRUMENT LANDINGS

Source: BBN Report FA-67-WA-170T, "Procedures for Developing Noise Exposure Forecast Areas for Aircraft Flight Operation."

The data is further modified by tone factors and duration factors to develop Effective Perceived Noise Levels (EPNL). The tone factors are a measure of the relative annoyance produced by pure tones compared to broad-band noise. The duration factor relates to the relative acceptability of noise bursts of differing lengths. On takeoff, duration factors will vary with rate of climb, plane speed, etc.

(2) Combined Noise Ratio - CNR.

This method of computation is perhaps the easiest method to calculate and was recently reported by Tracor Inc. (18) to be more accurate than some other methods. A quote from the latter report states that:

> "As measures of aircraft noise exposure in communities, the composite noise rating (CNR), Noise and Number Index, (NNI, as defined in this report), and Noise Exposure Forecast (NEF) are practically interchangeable, although CNR is slightly superior for predicting annoyance."

The CNR method uses the highest values of the perceived noise level at the point of observation or measurement. It does not include corrections for duration of the noise or for different frequency levels. The calculation for CNR at a discrete point is made with the following equation:

$$CNR_p = PNL + 10LOG(N_{D_p} + 20N_{N_p}) - 12$$

Where CNR_p = Flyovers which produce a particular characteristic at Point P.

PNL = Perceived noise level at the point in question.

N_{D_p} = Number of occurrences during the day hours.

N_{N_p} = Number of occurrences during the night hours.

And where the assignment of day and night hours is arbitrary but usually night hours are from 2200 to 0700 hours. The total (t) exposure at the site (p) can be calculated from the equation:

$$CNR_{tp} = 10LOG \sum_p ANTILOG (CNR_p / 10)$$

Thus, in order to use this technique it is necessary to measure the perceived noise level at the point in question for each flyover and to calculate the CNR_{tp} from the above equation.

(3) <u>Noise and Number Index NNI.</u>

This method is described in other reports, (18), (28) but is calculated from the equation:

Where PNL_A is the average of maximum flyover noise levels for the period of consideration.

$$NNI = PNL_A + 15 LOG N - 80$$

and applies to some period of time selected for analysis. Tracor Inc. (18) modified the NNI' to compensate for day and night aircraft operations by using the equation:

$$NNI' = 10 \, LOG \left(ANTILOG \frac{NNI_D}{10} + ANTILOG \frac{NNI_N + 17}{10} \right)$$

Where NNI_D and NNI_N are for day and night operations respectively.

(4) <u>Noise Exposure Forecast - NEF.</u>

NEF values are not directly indicative of community annoyance or disturbance, a fact which has been clearly demonstrated in recent studies, (18), (27).

The NEF concept is simply a technical procedure for combining the important factors contributing to noise exposure into a form suitable for use:

- By airport and community planners as an aid in planning land use and building construction in the vicinity of airports.
- For determining the relative merits of aircraft and engine design, aircraft operating procedures and runway utilization in reducing aircraft noise exposure.
- As part of a coordinated program of aircraft noise control and airport and community planning to limit the total noise exposure.

However, the Federal Aviation Administration has issued the following specific statement with respect to its use in their Draft Order (19):

> "This presentation was prepared by the Federal Aviation Administration solely for planning purposes with respect to future land uses. The Federal Aviation Administration has no expertise as to the effect of aircraft noise on the evaluation of property. Accordingly, this presentation is not intended to, and does not, reflect the view of the Federal Aviation Administration in relationship, if any, between aircraft noise and the evaluation of such property as may be comprehended by the presentation."

> "It is the interpretations associated with NEF contours that sometimes result in controversy, particularly those that are so simplified as to leave the erroneous impressions that the contours represent a sharp division between more or less noise critical zones. In addition, interpretations based upon predicted human response are sometimes accused of being too suggestive in the sense that people often tend to respond in the manner they believe they are supposed to respond."

The Federal Government, in a position paper for the ICAO Special Meeting on Aircraft Noise, November 1969 (Noise 1969-WP/60) emphasized the following:

> "It must be recognized that because of the generalized information upon which noise exposure estimates are made, the computation can be assumed to be accurate only with $\pm$ 5dB."

The NEF value at a given location is the logarithmic sum of "partial NEF's," represented by the symbol NEF_p, each of which corresponds to the noise exposure contribution of a particular aircraft type and flight trajectory.

The total NEF is given by the expression:

$$NEF = 10 \, LOG_{10} \sum_{p} ANTILOG \, (NEF_p / 10)$$

and each partial NEF by:

$$NEF_p = EPNL_p + 10 \, LOG_{10} \, (N_{D_p} + 50/3 \, N_{N_p}) - 88$$

where $EPNL_p$ is the Effective Perceived Noise Level (including discrete frequency and duration corrections) of the particular aircraft type and flight path at a particular point and N_D and N_N are the numbers of occurrences in day and night respectively. The day period is customarily taken to be 0700 to 2200 hours and the night, 2200 to 0700 hours.

To obtain contours of equal NEF values, the above computation is made for a large number of appropriately selected points. Specific contours are passed among these points by a process of interpolation and extrapolation. This process is normally computerized but can be performed by hand. The computer approach permits efficient treatment of complex situations involving large amounts of input data. Hand computation is time-consuming but permits continuous detailed consideration and comprehensions of the effects of various aircraft operations. To obtain a relative measure of the community impact of two different noise exposure conditions as represented by their respective NEF contours, one can determine the population lying within a particular contour, such as the NEF-40 contour.

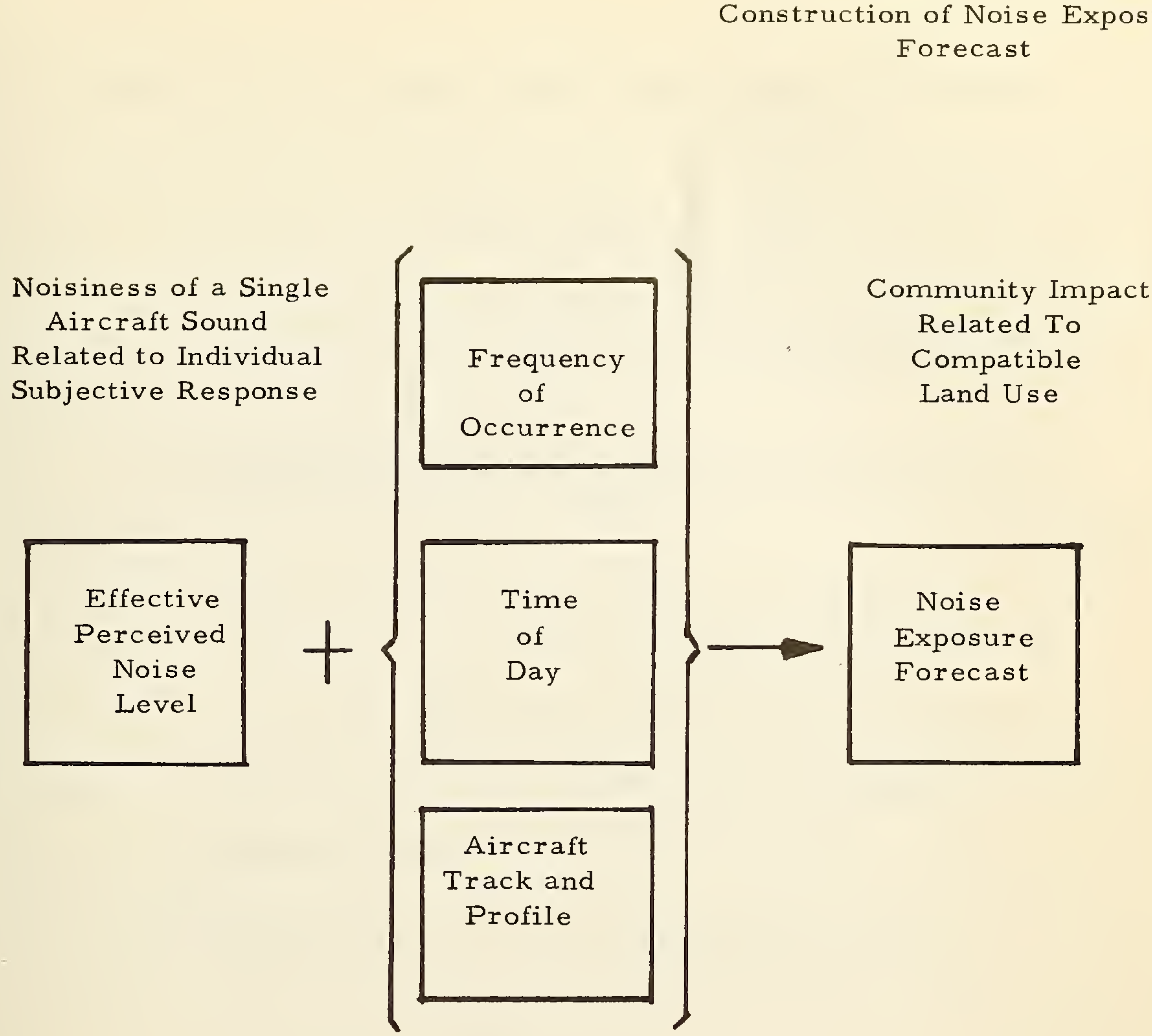
This methodology has been programmed to develop contours for any desired noise level connected with a particular set of noise development sources. This was the method used by Tracor and Bolt, Beranek and Newman, Inc. as subcontractors during this study.

The NEF methodology combines aircraft operational data with EPNL data to estimate the total exposure produced by daily aircraft operations.

To do this, operational data, such as runway utilization, flight paths, types of aircraft, total traffic levels, and hourly traffic distributions must be forecasted for future operations. The methodology is shown schematically in Exhibit III-13.

The results of an NEF analysis are presented as contours of various NEF levels. Bolt, Beranek and Newman, Inc. has suggested that the areas in the contours may be helpful in evaluating land use compatibility (15). However, in light of the low coefficient of correlation with individual annoyance, they may be useful as general tools only. This review indicates that they could be helpful in planning new airports but that would not be precise enough to plan for an already existing community located close to a major existing airport.

EXHIBIT III-13
Construction of Noise Exposure Forecast



Source: BBN Report DOT/HUD, IANAP-70-1, "Aircraft Noise and Airport Neighbors, a Study of Logan International Airports"

In general, factors such as airport capacity, demand for aircraft services, safety considerations, and weather limitations, which are not directly included in the NEF formulas, will limit the operational alternatives for the airport. These factors must also be considered when evaluating alternate techniques for noise abatement by the NEF method.

All in all, the most important operational variables in developing NEF contours are:

- The total number of operations per day
- The ratio of daytime flights to nighttime flights
- The projected runway utilization
- Assumed aircraft mix including aircraft types and stage lengths
- Aircraft operating procedures
- Aircraft noise levels

The total number of operations per day must be estimated from the available projections of future demand for aircraft services. Since both CNR and NEF methodologies are weighted to reflect the number of daily flights, errors in these estimates will be reflected in disproportionately large or small contours.

NEF methods weigh nighttime flights more heavily than daytime flights. For NEF calculations, 12 nighttime flights are equivalent to 200 daytime flights. Thus, over - or underestimating the "mix" of day to night operations can greatly affect the NEF contours. NEF contours can be no more accurate than the basic data used in construction of them. The following factors are those that may not have been considered in the general analysis.

- Failure to allow for varying turn radii for aircraft of the same or different types and weights and the different climb rates making turns after takeoff.
- Failure to consider power and flap management schedule after takeoff and before landing.
- Failure to account for diverging flight paths at distances beyond about three miles from airport. (Departing aircraft often take many different headings depending on local traffic conditions or destination. Arriving aircraft converge from many routes to the outer marker for ILS approaches or to closer points on noninstrument approaches. With the increased use of area navigation more use of multiple flight paths for arrivals and departures will occur.)
- Failure to account for atmospheric conditions (e.g., temperature, humidity, wind velocity) and surrounding terrain characteristics and field elevation.
- Failure to consider Federal "Keep 'em high" programs.
- Failure to consider the effect of seasonal variations on predominant aircraft flight paths.
- Failure to include military operations.

Thus, it is evident that the foregoing factors introduce errors of such magnitude that little value can be attached to contours a significant distance from the airport.

Directing the noise away from the people is a prime method of reducing community annoyance caused by aircraft noise. Utilization of runways directed towards unpopulated areas to the maximum extent allowed by safety and weather conditions can greatly reduce annoyance. Potential runway utilization patterns can be derived from available weather statistics after allowable crosswind and tailwind components have been determined.

A valuable application of the NEF methodology is in comparing the effects of aircraft operational alternatives on overall community exposure levels.

Shifts in airport operations from one runway to another, or from one flight path to another, can often produce significant reductions in the numbers of persons affected by the aircraft noise.

The NEF methodology presents a graphical display of the relative exposure levels produced under assumed operating conditions. Changes in operational procedures, such as shifting flights from one runway to another, or altering flight paths, are reflected in shifts in the NEF contours. Before and after contours for each proposed change are then estimated to determine the net effect on land areas and people residing below the flight paths.

The interpretation of NEF contours should be made with the understanding that:

- The Noise Exposure Forecast (NEF) is a methodology for estimating a single number rating of the cumulative aircraft noise around airport communities. NEF contours result from estimates and generalizations of aircraft categories, mix of aircraft, runway utilizations, number of operations, flight paths, noise levels in EPNdB, and wind direction.

- Considering the nature of this data, the contours must be considered to have a $\pm$ 5NEF margin of uncertainty. In other words, if the contours are plotted at $\pm$ 5NEF intervals, the outer limit for any one contour blends gradually into the adjacent contour. Thus, NEF contours must not be accepted as linear demarkations but rather as a graduated noise spectrum.

- NEF contours, as provided by the proposed Federal Aviation Administration computer program, are suitable for general planning by persons knowledgeable of the limitations of the planning tool. All Federal Aviation Administration/HUD land use recommendations are based upon judgmental factors without regard to specific variations in construction (such as air conditioning and building insulation) or on other physical conditions (such as the terrain, the atmosphere and the background noise levels). These features and others involving social, economic and political conditions must be considered in recommending individual use and density construction combinations in specific locations.

- Major factors to consider in adjusting or selecting a specific NEF boundary between interpretations are the following:

  - Previous community experience. One may utilize past experience in selection of boundaries, taking into consideration known response or complaint history in previously developed areas which are exposed to similar NEF values.

- Local building construction, particularly as influenced by climate considerations. In northern portions of the country, wall and roof constructions may be slightly heavier and houses are likely to be more tightly constructed, thus reducing the amount of noise leakage paths. In addition, windows would typically be kept closed for a larger portion of the year.

- Existing noise environment due to other urban or transportation noise sources. Introduction of aircraft noise in a rural or semi-rural area where existing background noise levels are very low may produce a much more apparent change in the noise environment and more pronounced reactions from residents than would aircraft noise introduced in a dense urban area long exposed to traffic noise. Such considerations may make adjustments of the noise compatibility interpretation boundaries appropriate in specific local situations.

- Time period of land use activities. The basic NEF values as developed by the equations of Appendix A of Federal Aviation Administration-NO-70-9 consider both daytime and nighttime operations with a weighting factor for nighttime operations. This procedure is particularly appropriate for residential land use considerations, but may lead to overestimation of NEF values for work activities or land use which are confined to daytime hours only.

(5) Other Noise Annoyance Measurements.

Other measurements have been used which include:

. Speech interference measures

. Simple weighted sound pressure levels

Tracor Inc. in a recent report (18) concludes that:

"Simple weighted sound pressure level values (dBA and dBN) provide adequate approximations to the more complex measures for the purpose of determining community noise exposure."

(6) A Comparison Of the Methods Used To Measure Aircraft Noise Annoyance Shows That They All Yield Similar Results But None Are Suitable for Predicting Individual Annoyance.

- It is apparent that thus far NEF and the other methods do not accurately predict the exact effects of how an individual may respond. Thus, it is assumed that this is an infant methodology and is yet to be developed into anything that approaches a science. The Tracor Inc. study (18) showed a relatively low correlation coefficient using any of the predictors to actual annoyance. The conclusions from the latter referenced report are herein repeated so that the full context of the conclusions can be absorbed. Items 1 through 15 are direct quotes from the Tracor Inc. report.

"1. Simple weighted sound pressure level values (dBA and dBN) provide adequate approximation to more complex measures for the purpose of determining community noise exposure. (5.1)

2. As measures of aircraft noise exposure in communities, the Composite Noise Rating (CNR), Noise and Number Index (NNI', as defined in this report), and Noise Exposure Forecast (NEF) are practically interchangeable, although CNR is slightly superior for predicting annoyance. (5.3.5, 6.2)

3. Installations for community monitoring of aircraft noise exposure can utilize weighted sound pressure level measurement and should be designed to obtain adequate samples of both flyover noise and ambient noise. (5.1)

4. Estimation of annoyance using noise exposure as the sole predictor is rather poor. (5.4)

5. The inclusion with noise exposure of certain attitudinal or psychological variables affords good prediction of individual annoyance. Prediction is improved by use of a nonlinear model. (6.2)

6. An equation can be written for predicting individual annoyance with good accuracy. (6.3)

7. For a significant reduction in annoyance, a CNR value of 93 or less is required. Above 107 CNR, annoyance increases steadily and above 115 CNR, noise exposure is associated with increased complaint. (6.3, 8.2)

8. Within certain limits, the number of highly annoyed households in a community may be estimated from the number of complainants. (7)

9. Since adjusting for the noise attenuation of the house lowers the correlation between exposure and annoyance, people appear to react to the noise as perceived outdoors rather than indoors. (5.5)

10. An equation for predicting complaints among a random sample, similar to the predictive equation for annoyance, can be written, but its accuracy is not good. (8 .3)

11. There is a substantial difference between predictors of annoyance and predictors of complaint: predictors of annoyance are primarily physical/attitudinal; predictors of complaint are primarily physical/sociological. (6, 8)

12. Complainants are not more sensitive to noise than random respondents. The complainants are less annoyed with typically irritating noises. They are also less annoyed with usual sources of neighborhood noise except for two items -- aircraft and sonic booms. (4.2)

13. On the average, complainants, in comparison to members of the random samples, tend to live nearer the airport, have higher noise exposure, and to be older, more highly educated, and more affluent. They also display a higher awareness of, and negative attitude about, aircraft operations. On the basis of a very limited sample, members of noise protest organizations tend to be simple to complainants in such characteristics. (4)

14. The seven survey cities (Boston, Chicago, Dallas, Denver, Los Angeles, Miami and New York) show consistent patterns for mean noise exposure (CNR), negative attitudes concerning aircraft operations, high annoyance, and percentages of complainants. New York, Boston and Los Angeles generally rate high on these variables; and Dallas, Miami and Denver, low. (4.1)

15. Alleviation of aircraft noise annoyance by "house attenuation" programs and land zoning controls does not appear to be feasible except possibly in special cases. (5.5)"

Note: Numbers in parentheses above reference particular chapters in Tracor Inc. report.

Tracor Inc. (18) shows that the correlation between methods of measurement is fairly good in light of their conclusion that correlation of noise and annoyance is poor by their statement.

> "Since many of the correlation coefficients are substantially higher than the value of 0.35 which is typical for the exposure/annoyance relation, the choice of noise exposure measure is not particularly critical if exposure in a community as a whole is being determined as an estimate of annoyance."

The chart below shows the correlation factors which Tracor Inc. developed as a result of responses from 3,590 respondents.

Annoyance Measure	Exposure Measure		
	CNR	NNI'	NEF
G	0.37	0.34	0.32
V	0.33	0.31	0.30

Note: G – Based on annoyance response interference with nine different activities.
V – Based on annoyance factors G plus three other "conditioning" factors.

- Tracor Inc. makes the following specific quotes:

  - "As a result of the large sample size, confidence intervals are small. For example, the 95 percent confidence interval for G/CNR correlation is 0.335-0.384. CNR is the best predictor of annoyance and there is no significant difference between the other two measures."

  - "In general, however, the value of noise exposure alone as an annoyance predictor is rather poor. This is a typical result of such investigations. In the Heathrow Airport study,[4] a correlation coefficient of 0.46 was obtained between individual annoyance scores and noise exposure. In a study of traffic noise, an examination of "dissatisfaction scores" and a measure called "Traffic Noise Index" produced a correlation coefficient of 0.29[22]."

- Tracor Inc. then presents the following correlation chart which shows that "house attenuation" on insulating residences does not necessarily produce any lower levels of annoyance to those who already live in those houses.

Sample Size	CNR	CNR-NR
3,590	0.37	0.21
-	0.49	0.25

Where CNR is measured outside dwelling
CNR-NR is measured inside same building

Tracor's conclusion is to quote "It may be concluded that, on the whole, respondents reacted to aircraft noise as it would be perceived out of doors rather than indoors."

Thus, the report (18) concluded that if insulation of buildings modifies annoyance factors then correlation should increase. The fact that it decreased proves the point that residential attenuation is not effective.

- The major conclusion from this study was that the existing methods are adequate only for planning tools and do not measure individual annoyance. It is evident that a comprehensive and definitive factor has not yet been developed.

  - The NEF factor and its counterparts embodied in the other methods are totally inadequate measures of annoyance.

  - The correlation factor is so poor that it could not seriously be considered a predictive model of individual annoyance.

- A report by Serendipity Inc. (27) stated that the measurement of individual annoyance is complicated and depends on:

  - The reactions and attitudes of individuals, not only to noise, but to their environment had to be taken into consideration.

  - Noise is only one parameter in an individual environment. For example, attitudes towards the source of the noise can have a significant impact on an individuals reaction to a given noise level.

  - In an experimental environment, as well as a later field study, researchers were able to bias people's reaction to transportation noise by affecting their attitudes towards the transportation mode.

8. SIGNIFICANT REDUCTIONS IN COMMUNITY NOISE EXPOSURE CAN BE ACHIEVED LOCALLY THROUGH CHANGES IN OPERATIONAL PROCEDURE AND GREATER REDUCTIONS CAN BE ACHIEVED THROUGH THE MASSACHUSETTS PORT AUTHORITY'S PROPOSED PROJECTS.

(1) The Boston-Logan International Airport Noise Abatement Committee Has Implemented a Significant Action Plan To Reduce Community Noise Exposure. It Is One Of Two Major Airport Noise Abatement Committees That First Had Community Representatives.

The Boston-Logan International Airport Noise Abatement Committee is composed of representatives of the Federal Aviation Administration, Airline Pilots Association, airlines serving Boston, representatives of nearby communities, Massachusetts Aeronautics Commission, and the Massachusetts Port Authority. The group has investigated airport noise problems over the past three years and has implemented a series of 20 noise abatement procedures as presented in Exhibit III-14. These include:

- Establishment of a preferential runway system
- Limitations on run-ups and other ground operations
- Installation of electronic navigational aids
- Restrictions on nighttime operations
- Efficient use of over-the-sea flight paths

Continued use of these procedures and introduction of new ones as they become available will produce future benefits.

(2) <u>The Location Of the Proposed 15L-33R Runway Provides Greater Separation Between Aircraft and Adjacent Residential Areas.</u>

Environmentally, the approach to runway 15L, which will be primarily a landing runway, is better than the approach to 15R as now extended. The reasons are: Not only is there sufficient land for full ILS and ALS systems, but the approach to 15L is over an area containing fewer close-in residences.

Logan Airport Noise Abatement Committee

MEMBERSHIP: Airline Pilots' Association / Airlines Serving Boston / East Boston Community Representative / Federal Aviation Administration / Massachusetts Aeronautics Commission / Massachusetts Port Authority / Revere Community Representative / South Boston Community Representative/Winthrop Community Representative

Noise Abatement Program at Boston-Logan International Airport

Noise abatement at Boston-Logan International Airport is developed cooperatively through the Logan Airport Noise Abatement Committee. It is composed of representatives of the airlines, Airline Pilots Association, East Boston Community, Federal Aviation Administration, Massachusetts Aeronautics Commission, Revere Community, South Boston Community, Winthrop Community, and the Massachusetts Port Authority.

The Committee, including representatives of East Boston, Revere, South Boston, and Winthrop, meets monthly to analyze current problems and suggest improvements. Subcommittees meet periodically. The following procedures are generally directed toward operations of large turbo-jet aircraft:

1. Logan Airport established the first preferential runway system in the United States. This system influences the use of runways from which takeoffs cause the least community noise.

2. Runups are prohibited between the hours of midnight and 7:00 a.m. A runup is defined as any operation of a stationary aircraft engine above idle power except to overcome inertia to begin taxiing. A night patrol closely monitors this regulation.

3. Prohibition of flights over Boston proper at less than 3,000 feet unless required to do so by Air Traffic Control.

4. Only light planes are permitted to land on Runway 22R, unless safety demands otherwise. Also, a displaced threshold of 800 feet has been established on Runway 22R to require a higher approach slope over the Bayswater Street section of East Boston.

5. A navigational aid five miles north of Runway 22L has been installed to improve approach procedures. A radio beacon permits pilots to remain at 1,500 feet altitude on approach until passing over this point.

6. Aircraft using 22L, cross the Whitman check point at 10,000 feet which is 6,000 feet higher than a previous regulation. This change permits pilots to remain at a high altitude as long as possible before descending, with minimum use of power, to the initial approach altitude of 2,000 feet.

7. Pilots awaiting takeoff on Runways 22R, 22L, 27 and 33L are required to point jet aircraft exhaust away from East Boston and Winthrop homes.

8. Air Controllers have been instructed to assign for takeoffs Runway 15R which points in the direction of the open harbor, whenever safety permits, between the hours of 10:00 p.m. and 6:00 a.m.

9. No training practice is allowed on Logan runways between 11:00 p.m. and 7:00 a.m.

10. Flights using other airports for training will, whenever possible, takeoff from Runway 15R and land on Runway 4R or Runway 33L between 11:00 p.m. and 7:00 a.m. to minimize the noise irritation in residential areas.

11. Between midnight and 6:00 a.m., when atmospheric conditions require approaches from the south, Runway 4R is used for landings, rather than Runway 4L, to avoid residential areas of South Boston.

12. On takeoffs from Runway 22R in the direction of South Boston, pilots are required to turn left toward the sea and remain on a heading of 195 degrees for at least two miles from the end of the runway.

13. The full length of the Runway 15R extension is not used on landings. This helps to maintain a higher approach over Neptune Road, East Boston. The runway threshold for landings is displaced 800 feet.

14. Turbo-jets will normally enter the Terminal Area (radius of 30 miles) at or above 10,000 feet MSL.

15. Pilots cleared for visual approach will remain above 3000 feet as long as practicable.

16. Special controls have been instituted in the General Aviation area near Maverick Street, East Boston to minimize night time noise. These include prohibition of runups, positioning of planes to direct engine exhaust smoke away from homes, and the towing of aircraft in and out of hangars.

17. All operators in the North Apron Area have agreed to tow loaded aircraft through the turn on the apron and align for straight-out taxi. This eliminates the application of high power to accomplish short turns.

18. Between the hours of 7:00 a.m. and midnight, any full power runup must be conducted at the Runway 4R dogleg in order to isolate the noise site.

19. If the Night Noise Monitor considers that wind conditions or other circumstances warrant the discontinuance of idling between midnight and 7:00 a.m., he will issue directions which must be followed immediately.

20. No turns will be made on a pull-up, go-around, or missed approach that will result in low and unnecessary flights over surrounding communities.

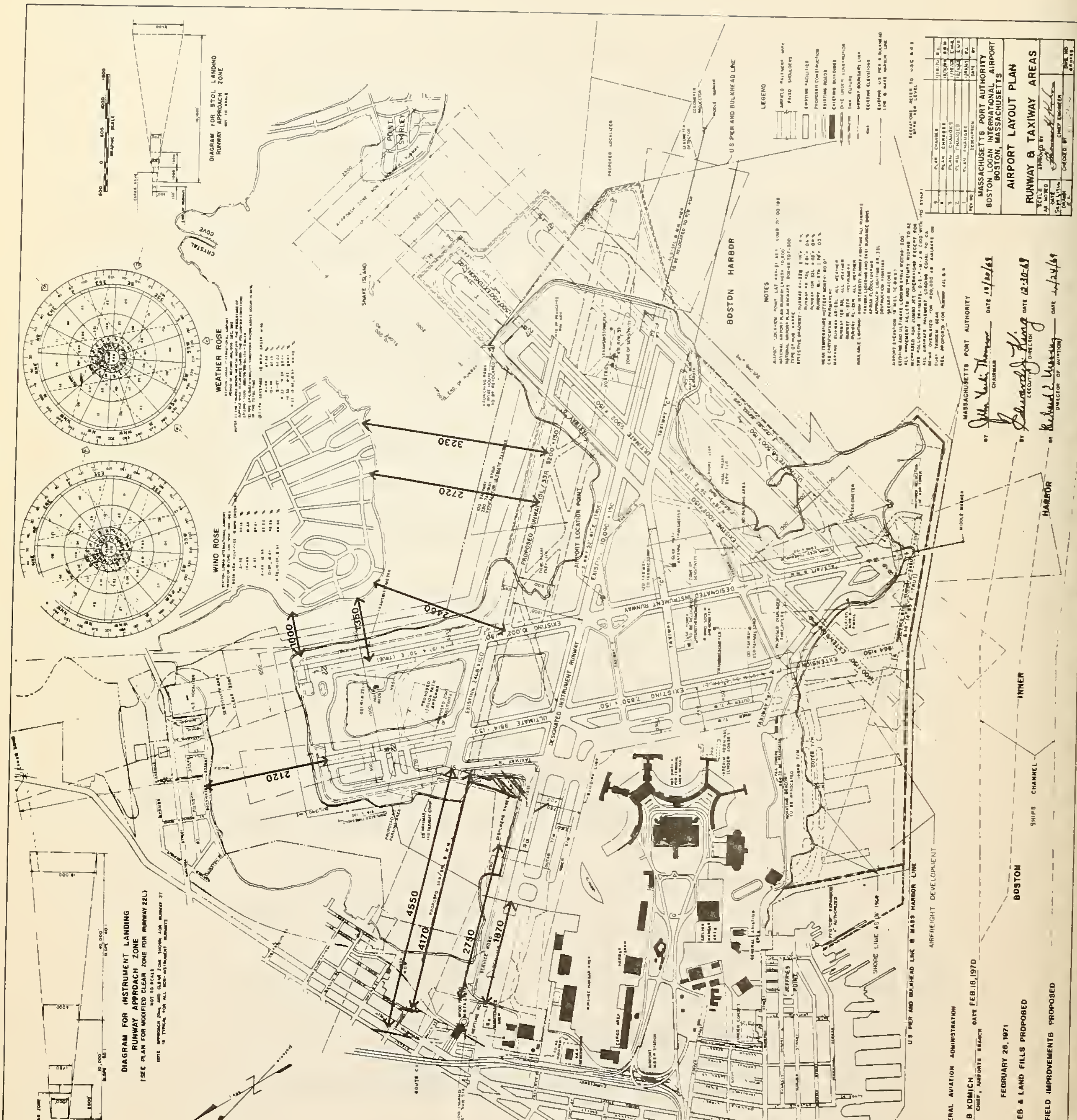
March, 1971

In fact, the distance now between the closest residence on the extended centerline from the physical end of 15R is approximately 1,870 feet, and 2,750 feet with its displaced threshold. The closest residences to the physical end of the proposed runway 15L will be from 3,550 feet (off the extended centerline) to 4,550 feet (on the extended centerline). The sideline distances from the proposed 15R-33L runway and Winthrop range from 2,460 feet to 3,230 feet. The existing runway, the longer of the two, will be used for departures. This is shown in Exhibit III-15.

This new runway has also been positioned to provide maximum distance from Winthrop and yet maintain adequate separation from the existing runway 15R-33L. This runway is not anticipated to increase the degree of existing lateral noise levels in Winthrop. The measured distances from the nearest residences in Winthrop to 15L-33R are 2,460 feet in a lateral direction as compared to 1,000 feet from the end of existing runway end 4L.

Tests were conducted on May 10, 1971 and reported (25) on May 11, 1971 by the Massachusetts Port Authority. These tests were conducted to determine the reduction in sound levels in a location such as Point Shirley, made possible by a 1900 foot westerly displacement of runway 9-27. To accomplish this measurement, tests were taken at Shirley Gut, and 1900 feet directly east simultaneously as planes flew over after takeoff from runway 9. A reduction of three decibels was

EXHIBIT III-15
AIRPORT LAYOUT PLAN



achieved from an average of nine flyovers. This limited experiment indicates that the displacement does make a significant improvement.

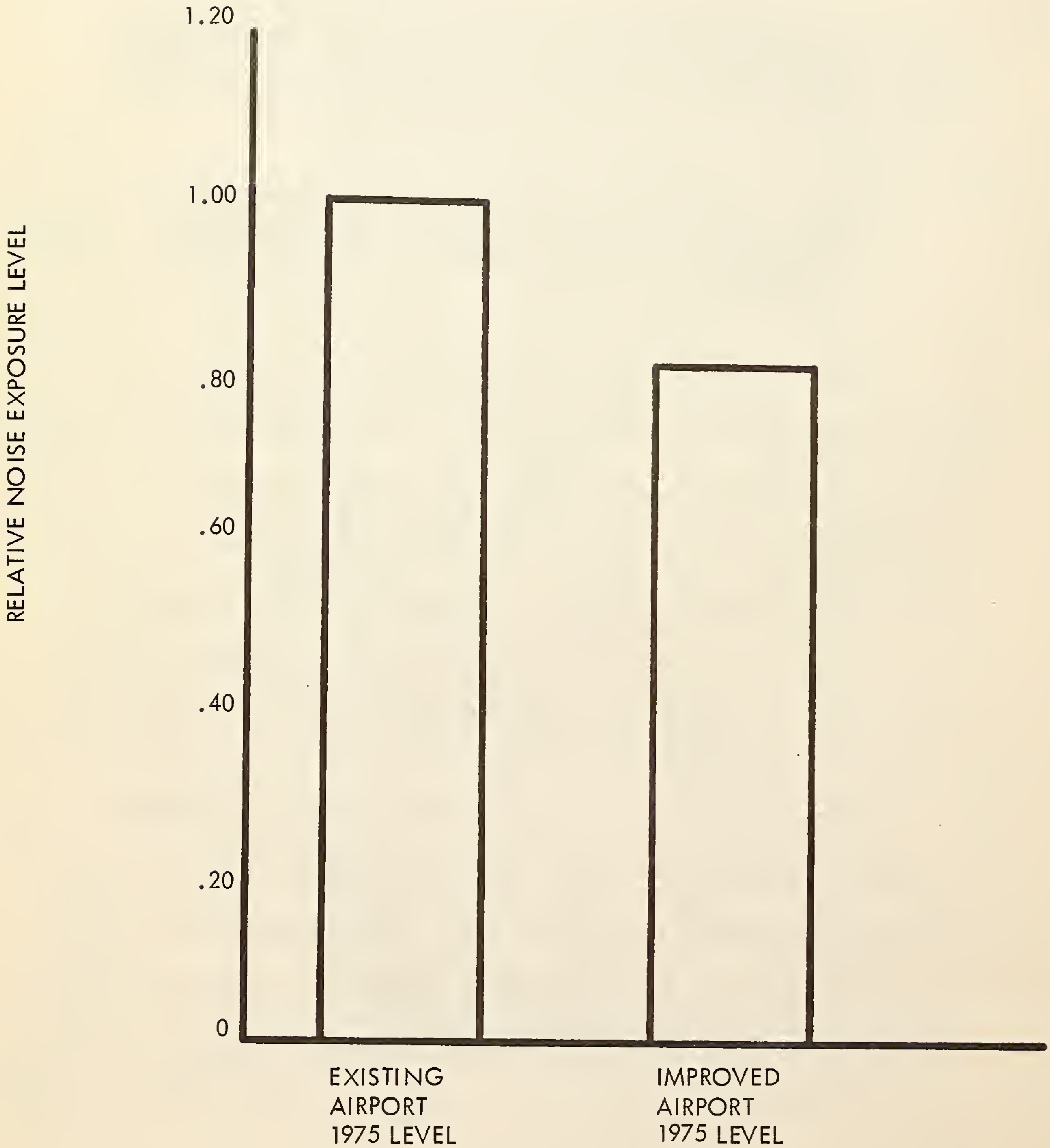
8. <u>NOISE EXPOSURE FORECASTS (NEF) CONTOUR DEVELOPMENT DURING THE COURSE OF THIS STUDY CLEARLY DEMONSTRATES THE NEED FOR AIRPORT IMPROVEMENT BECAUSE IT WILL DECREASE THE AREAS AND THE NUMBER OF PEOPLE WITHIN THE NEF 40 CONTOURS.</u>

(1) <u>The Initial NEF Analysis Showed That On a Relative Basis the Improved Airport Would Result in a Reduction Of Twenty Percent (20%) in Terms Of the Number Of Dwelling Units Within the NEF 40 Contour.</u>

The first NEF contour study was conducted early in this project and the results shown in Table I demonstrated that in terms of numbers of dwelling units the NEF 40 contour for the improved airport included 6,100 dwelling units as compared to 7,700 dwelling units within the NEF 40 contour for the existing airport. This reduction of twenty percent (20%) was possible because of the new runway and preferential runway usage. See Exhibit III-16 on the following page.

The relative NEF contours which were developed clearly showed that it was possible to affect fewer people with the addition of the new runway. Because of the pressures of time and because we intended to use these for only a direct comparison of 1975 traffic levels with the only variable the addition of the new runway only a single type of aircraft was used. This

EXHIBIT III-16
RELATIVE NOISE EXPOSURE LEVELS

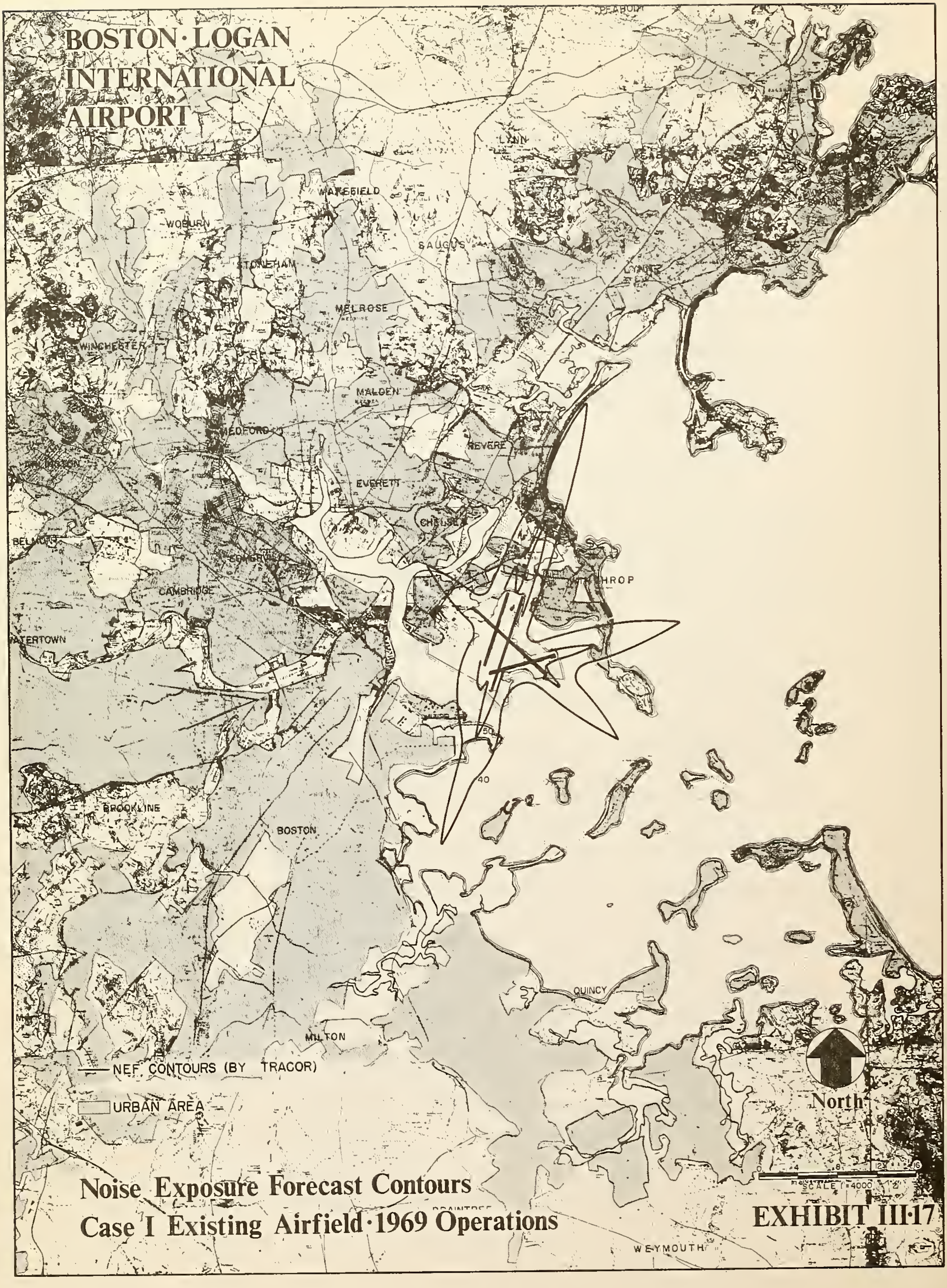


did not take into account the new quieter vehicles but was intended merely to experiment with operational plans to determine whether lower noise contours could be achieved with preferential use of the new 15-33 runway.

In preparing the contours presented herein, NEF values were established by hand computation and EPNL values were based upon a single representative type of aircraft. For this type, a three-engine medium range turbofan aircraft of the Boeing 727 class was chosen.

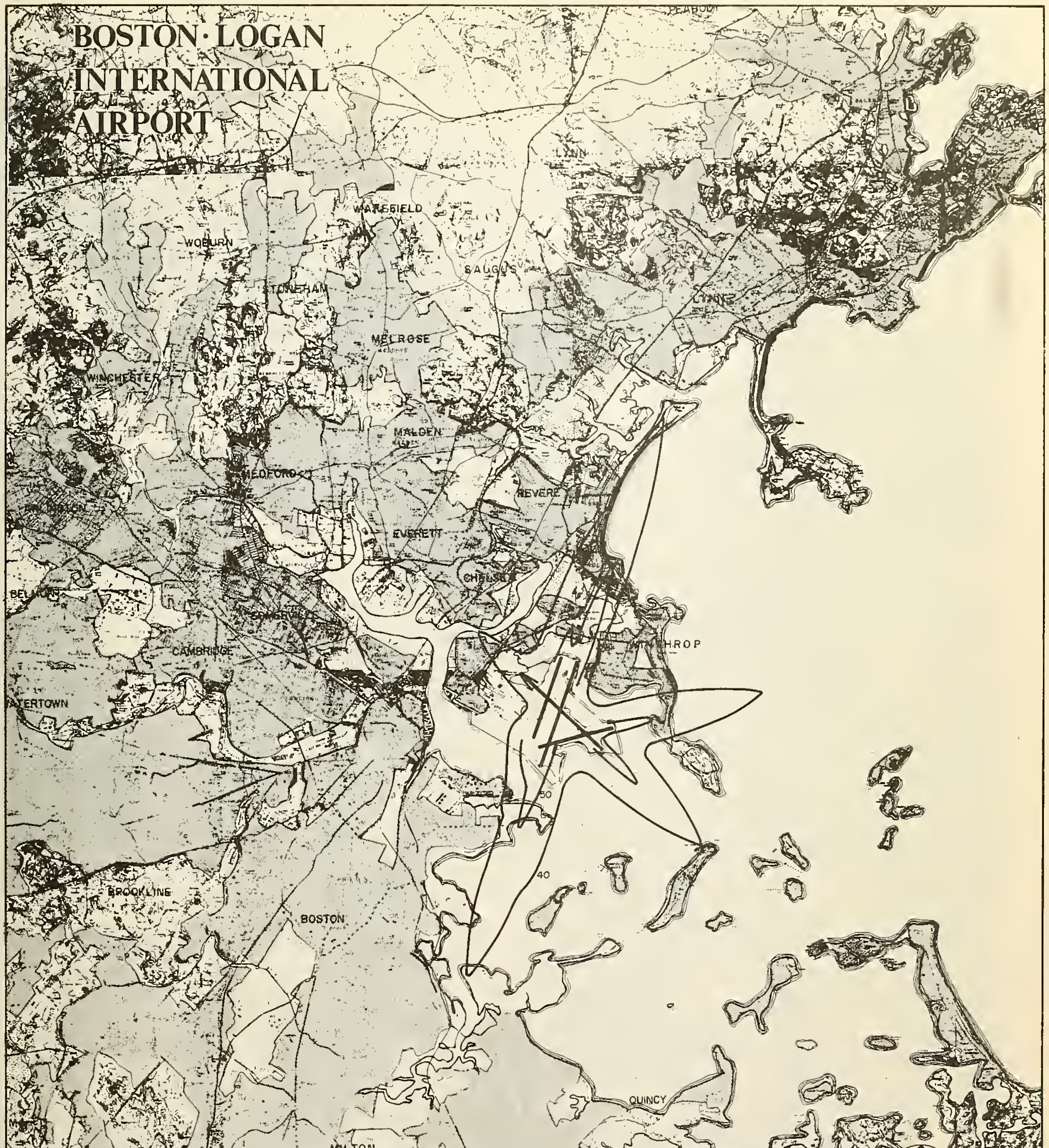
Since these measurements were intended to be relative only, the choice of aircraft was not particularly important. It was intended as discussed earlier to be used for a planning tool only.

Cases I, II and III were analyzed, shown in Exhibits III- 17-18-19, to determine if significant changes would occur in the numbers of dwelling units within NEF 40 noise contours as the result of the proposed new runway. The two cases, II and III, were exactly comparable except for the difference in runway utilization. Thus, the effect of the runway only was measured on a relative basis and was not intended for any other purpose than to determine the advantage, as a percentage of possible change.



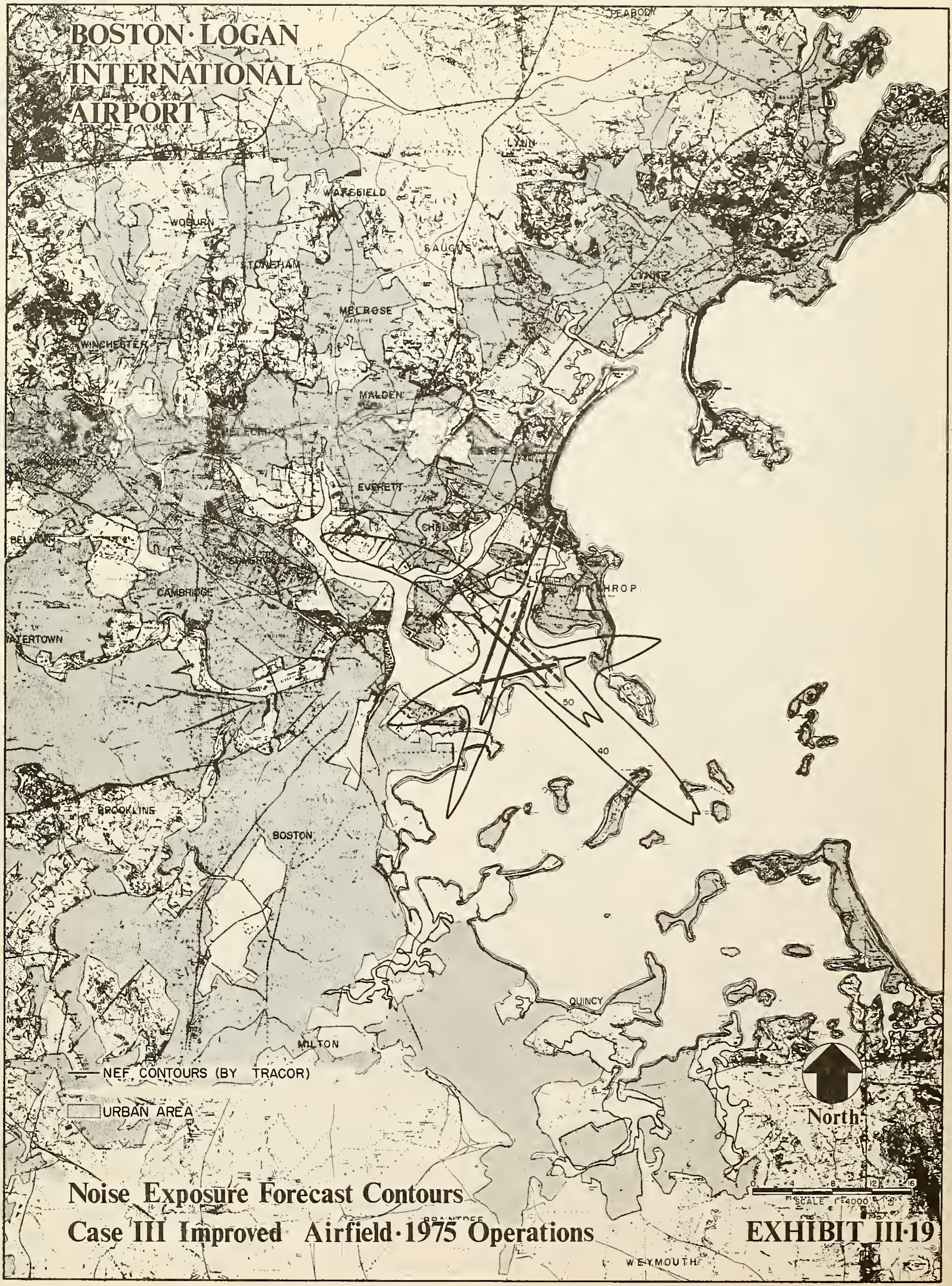
Noise Exposure Forecast Contours
Case I Existing Airfield·1969 Operations

EXHIBIT III·17



Noise Exposure Forecast Contours
Case II Existing Airfield ·1975 Operations

EXHIBIT III·18



Noise Exposure Forecast Contours
Case III Improved Airfield·1975 Operations

EXHIBIT III·19

Population data, by traffic zones, was obtained from the Metropolitan Area Planning Council. The available data consisted of the number of acres and the number of dwelling units in each traffic zone as of 1963. No attempt was made to scale the population figures to 1975 levels since our primary concern was to evaluate the relative effects of operational changes.

Estimates of the dwelling units distribution within each traffic zone were made on the basis of available Geological Survey Maps. The density of the dwelling units was assumed to be constant within each of the traffic zones.

The results of the NEF-40 analysis are presented below:

TABLE I

Operational Pattern	Airport Configuration	Movements/Yr.	Runway Utilization	Number Of Dwelling Units Within NEF 40
CASE I	Existing 1969	320,000	Historic	5,200
CASE II	Existing 1975	388,000	4-22 Primary- Maximum Capacity	7,700
CASE III	Expanded 1975	388,000	15-33 Primary- Maximum Capacity	6,100

The following conclusions can be drawn from the above analysis.

- In general, the improved airport would effect twenty percent (20%) fewer dwelling units with the same operating pattern.
- The same or greater improvement would be obtained for essentially any operating pattern because the new runway allows greater use of overwater movements.

Exhibit III-16 shows how this relative difference in terms of unity for the existing airport and shows the improvement that could be gained by adding the new runway.

(2) A More Complete In-Depth Analysis, Presented in Exhibit III-19 and 20, Of Expected NEF Contours for the Comparison Of the Existing Airport To the Improved Airport Conducted by Bolt, Beranek and Newman Inc. Showed That People Residing Within the NEF-30 and NEF-40 Contours Can Be Reduced by Forty Percent (40%) and Sixty-Four Percent (64%) Respectively by Preferential Use Of the New Runway.

The entire Bolt, Beranek and Newman, Inc. report is in Appendix B. The results of their calculations are shown below.

TABLE 2

Condition	1	2	3	4	5	6
Airport Configuration	Existing	Existing	Existing	Existing	Existing	Improved
Traffic Projections	Actual 1970	1975	1975	1975	1975	1975
Runway Utilization	Historic	Maximum Capacity	Historic	Noise Abatement Alt. No.1	Noise Abatement Alt.No.2	Maximum Noise Abatement
NEF-30						
Acres (1000's)	12.1	14.7	13.2	8.3	10.4	8.8
Population (1000's)	121.4	139.9	127.3	71.6	92.7	72.8
NEF-40						
Acres (1000's)	3.1	2.8	3.1	2.5	2.7	2.1
Population (1000's)	24.4	17.0	23.8	11.4	14.2	8.9

The table shows that the new aircraft in combination with noise abatement operational changes can make possible major reduction in terms of the number of people within the NEF 40 contour. Conditions 4 and 5 also show improvement but are probably not acceptable from an air pollution standpoint as discussed in Chapter V.

(3) The Results Of the Analysis Also Show a Major Reduction in the Number Of Dwelling Units and Schools Within the NEF 40 Contours.

This is shown on Exhibit III-22 and results in a major improvement.

(4) The NEF Contours Developed by Bolt, Beranek and Newman Inc. in March Of 1970, September Of 1970 and for This Program in May Of 1971 Show Different Results Because They Used Different Projections and Different Types Of Aircraft.

The March 1970 report "Aircraft Noise and Airport Neighbors: A Study Of Boston-Logan International Airport" by Bolt, Beranek and Newman, Inc. resulted in differences from the calculations made during this program in May of 1971. These are shown in Exhibit III-20 and the reasons for the differences are explained below.

- Larger contours were developed in the March 1970 report because Bolt, Beranek and Newman, Inc. inadvertently used landing and takeoff cycles (LTO's) as landings only and therefore effectively doubled the number of operations. This resulted in the data shown in Exhibit III-20, column 1.

- A report was issued in September of 1970 (28) which showed different NEF contours but did not explain the detailed reasons for the differences. This report also included data for other airports and showed the results which are included in the revision discussed below.

SUMMARY OF VARIOUS NOISE CONTOURS (NEF) CALCULATIONS MADE AT TIMES NOTED

Bolt, Beranek and Newman, Inc. made the following predictions for the 1975 time period. The reasons for the differences are explained in the footnotes.

	Existing Airport	Existing Airport	Improved Airport
	BB&N Report #DOT/HUD IANAP-70-1 Issued 3/70	Revision of BB&N Report #DOT/HUD IANAP-70-1 Issued 3/71	BB&N Report #2150 Issued 5/71
NEF-30			
· Residents	556,000	340,000	72,800
· Acres	52,000	28,600	8,800
· Annual Operations	562,100 1/	281,050 2/	252,857 3/
· Schools	272	N.A.	46
· Hospitals	23	N.A.	1
· Dwelling Units	160,000	N.A.	25,800
NEF-40			
· Residents	55,200	43,100	8,900
· Acres	7,010	5,200	2,100
· Annual Operations	562,100	281,050	252,857
· Schools	33	N.A.	3
· Hospitals	2	N.A.	0
· Dwelling Units	15,700	N.A.	2,900

1/ BB&N mistakenly used landing and takeoff cycles as landings only and thereby doubled the number.

2/ BB&N discovered the error and corrected by reducing the number of operations by a factor of 2. This number did not reflect "mix" of new aircraft with larger capacities and lower noise levels.

3/ This annual operation projection did include the new higher capacity and quieter engines.

- When the reasons were discovered, a revision dated March 1971 was issued which showed a forty to fifty percent (40% - 50%) reduction in terms of numbers of people and areas affected as shown in column 2 of Exhibit III-20.

- Even the revised report used aircraft movements that are now considered to be excessively high estimates of what is likely to be actually achieved in 1975. As shown in Exhibit III-22, the annual operations were estimated at 281,050 compared to the latest estimate of 252,857. Part of the reason for the reduction is the new larger aircraft which carries more passengers which, of course, results in fewer operations for the number of passengers.

- In addition, the newer wide-body aircraft all have lower noise levels than the earlier vehicles and therefore result in smaller noise contours.

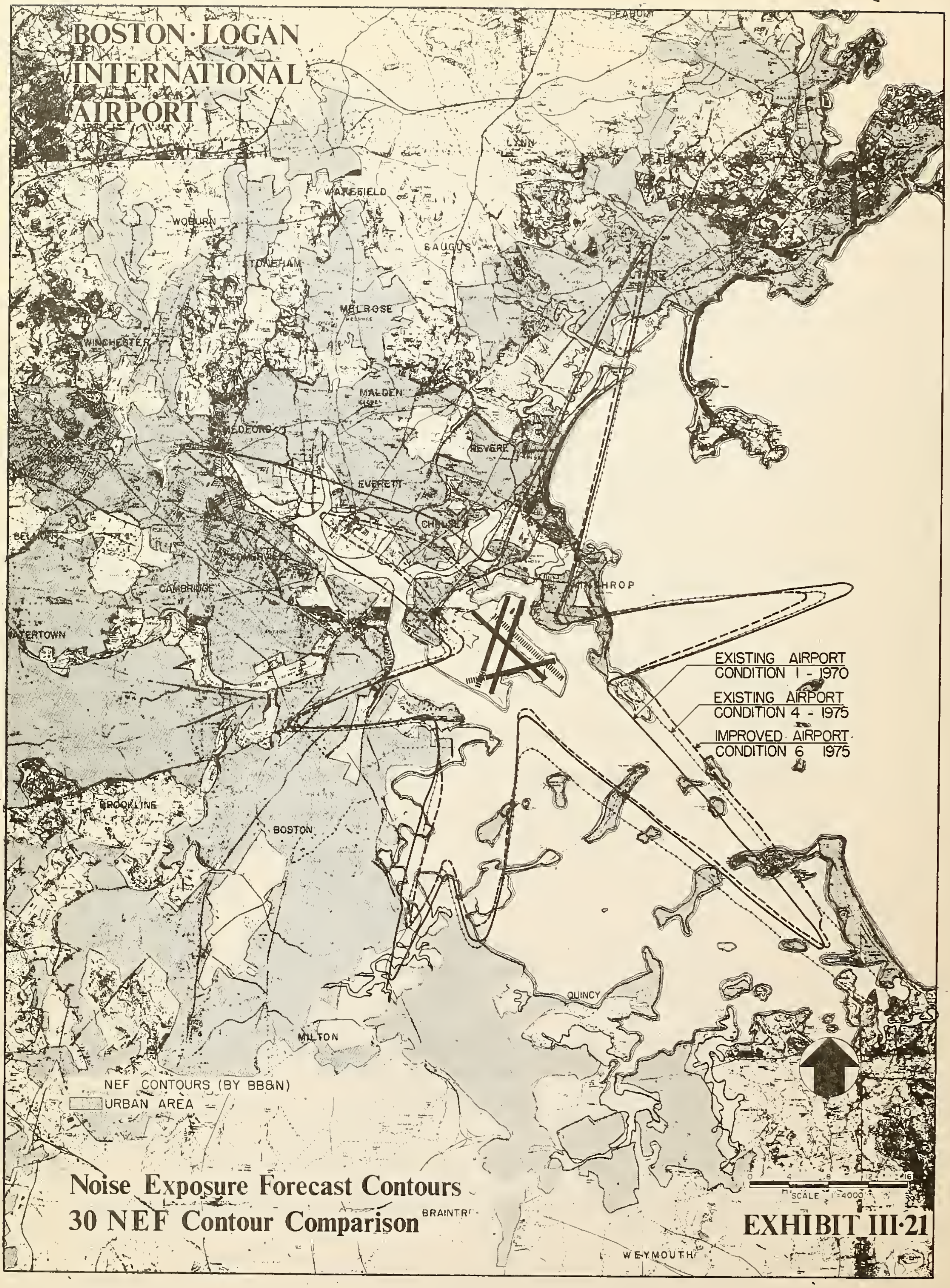
- Finally, the third column of Exhibit III-22 shows the best of six different conditions studied during this project. It includes the use of the new parallel runway 15L-33R which allows preferential overwater use for noise abatement.

In summary, as can be seen on Exhibit III-22, the new runway makes possible major reductions compared to the earlier calculations. These reductions can be summarized as follows in comparison to the corrected report of March 1971.

- The number of people expected to be residing within the NEF 30 contour has been reduced from 340,000 to 72,000 or about eighty percent (80%).

- Similarly, the people expected to be residing within the NEF 40 contour has been reduced from 43,100 to 8,900 or about seventy-nine percent (79%).

Summarizing, the present and improved airport conditions 4 and 6 are shown for both NEF 30 and NEF 40 on Exhibit III-21 and III-21A respectively which demonstrate where the differences in the various conditions exist.


BOSTON · LOGAN
INTERNATIONAL
AIRPORT
PEABODY
LYNN
WAKEFIELD
WOBURN
SAUGUS
STONEHAM
MELROSE
WINCHESTER
MALDEN
MEDFORD
REVERE
EVERETT
CHELSEA
BELMONT
SOMERVILLE
CAMBRIDGE
WINTHROP
WATERTOWN
EXISTING AIRPORT
CONDITION 1 - 1970
EXISTING AIRPORT
CONDITION 4 - 1975
IMPROVED AIRPORT
CONDITION 6 1975
BROOKLINE
BOSTON
QUINCY
MILTON
NEF CONTOURS (BY BB&N)
URBAN AREA
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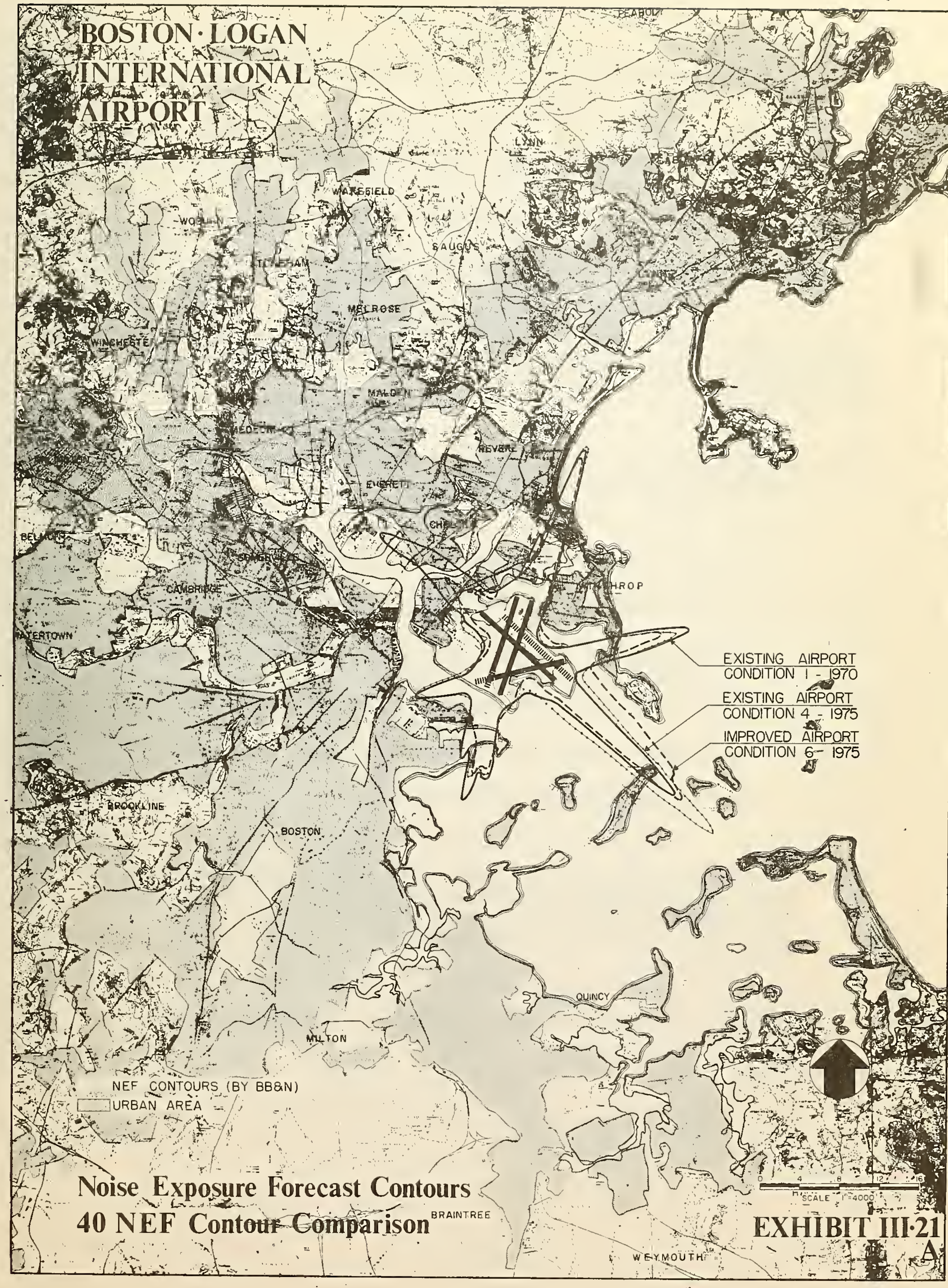
SCALE 1"=4000'
Noise Exposure Forecast Contours
30 NEF Contour Comparison
BRAINTREE
EXHIBIT III·21
WEYMOUTH


BOSTON·LOGAN
INTERNATIONAL
AIRPORT
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WOBURN
SAUGUS
LYNN
STONEHAM
MELROSE
WINCHESTER
MALDEN
REVERE
EVERETT
BELMONT
SOMERVILLE
CAMBRIDGE
WATERTOWN
EXISTING AIRPORT
CONDITION 1 - 1970
EXISTING AIRPORT
CONDITION 4 - 1975
IMPROVED AIRPORT
CONDITION 6 - 1975
BROOKLINE
BOSTON
QUINCY
MILTON
NEF CONTOURS (BY BB&N)
URBAN AREA
Noise Exposure Forecast Contours
40 NEF Contour Comparison
BRAINTREE
WEYMOUTH
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SCALE 1"=4000'
EXHIBIT III·21
A

A study of Exhibit III-22 will show corresponding reductions in schools, hospitals and land areas within the two contours. In conclusion, it shows that the NEF contour is extremely sensitive to the number of operations as well as the noise level of the aircraft and fully explains the differences obtained because of the different input data assumptions.

9. AIRPORT IMPROVEMENT PRESENTS THE BEST ALTERNATIVE FROM THE STANDPOINT OF NOISE ABATEMENT OF THE SIX DIFFERENT ALTERNATIVES CONSIDERED DURING THIS STUDY.

(1) Six Alternatives Were Studied During This Project To Determine the Best Course Of Action for Noise Abatement.

The six conditions are shown on the chart in Section 8 of this report and are described in the Bolt, Beranek and Newman, Inc. report in Appendix B. Two different alternatives were explored to determine the best noise abatement procedure for the existing airport. The latter two approaches attempted to determine the best alternative to achieve maximum noise abatement so that comparison could be made with the improvement plan.

(2) Alternative Conditions 2, 3, 4, 5 and 6 Representing the 1975 Time Period Were Evaluated in Terms Of Environmental Impact Including Both Noise and Air Pollution Since They Are Related in Terms Of Delay Time.

Exhibit III-23 shows the results in summary form. The following conclusions can be drawn.

LAND, RESIDENTS, SCHOOLS, HOSPITALS
DWELLING UNITS WITHIN NEF 30 AND NEF 40 CONTOURS

Condition	1	2	3	4	5	6
Airport Configuration	Existing	Existing	Existing	Existing	Existing	Improved
Traffic Projections	Actual 1970	1975	1975	1975	1975	1975
Runway Utilization	Historic	Maximum Capacity	Historic	Noise Abatement Alt. No. 1	Noise Abatement Alt. No. 2	Maximum Noise Abatement
NEF-30						
. Residents (thousandths)	121.4	139.9	127.3	71.6	92.7	72.8
. Acres (thousandths)	12.1	14.7	13.2	8.3	10.4	8.8
. Annual Opns.	214,987	252,857	252,857	252,857	252,857	252,857
. Schools	70	78	74	*	*	46
. Hospitals	*	*	*	*	*	1
. Dwelling Units (thousandths)	41.5	47.6	42.3	*	*	25.8
NEF-40						
. Residents (thousandths)	24.4	17.0	23.8	11.4	14.2	8.9
. Acres (thousandths)	3.1	2.8	3.1	2.5	2.7	2.1
. Annual Opns.	214,987	252,857	252,857	252,857	252,857	252,857
. Schools	6	5	6	*	*	3
. Hospitals	*	*	*	*	*	0
. Dwelling Units	7.7	6.2	7.5	*	*	2.9

*Not computed.

SUMMARY OF CAPACITY, NOISE EXPOSURE AND AIR POLLUTION ALTERNATIVES

Condition	2	3	4	5	6
Airport Configuration	Existing	Existing	Existing	Existing	Improved
Traffic Projections	1975	1975	1975	1975	1975
Runway Utilization	Maximum Capacity	Historic	Noise Abatement Alt. 1	Noise Abatement Alt. 2	Maximum Noise Abatement
Noise Population NEF-40	17,000	23,800	11,400	14,200	8,900
Air Pollution Tons/Year	13,120	-	17,421	19,787	10,211
Delay Hours/Year	13,120	-	15,480	20,575	11,725
PANCAP Movements/Year	313,000	-	313,000	300,000	348,000

- Condition 2 is unsatisfactory because of 17,000 residents within the NEF 40 contour and because the delay and air pollution is relatively high.

- Condition 3 is the most unsatisfactory from a noise standpoint because the number of residents remains at 23,800 people within the NEF 40 contour which is essentially the same as experienced at the current airport.

- Condition 5 has a higher noise level than condition 4 and has very high delay time and the highest air pollution.

- Conditions 4 and 6 are the principal alternatives for consideration because they represent the maximum noise abatement levels achievable with the existing and improved airports respectively.

(3) Condition 6 Which Represents the Improved Airport Is Recommended From a Standpoint Of Noise and Other Environmental Factors.

- The improved airport permits operations which result in only 8,900 people residing within the NEF 40 contour as compared with 11,400 people with condition 4 which represents an increase of twenty-eight percent (28%).

- The improved airport presents a realistic operating plan since it is reasonable to assume that the increased capacity would permit operation to achieve maximum noise abatement.

- Condition 4 is not realistic since the high delay time would cause reduction of preferential runway use so that maximum noise abatement would not be achieved. The reason for this, of course, is the smaller practical annual capacity.

- Even if condition 4 could be carried out from a traffic management standpoint, the higher air pollution caused by the delay is unwarranted.

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(29) McKennel, A.C., "Aircraft Noise Annoyance Around London Heathrow Airport." S.S. 337 Central Office of Information, April 1963.

VI. ORGANIZATIONS AND INDIVIDUALS CONTACTED

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(2) Department Of Interior

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VII. GLOSSARY OF TERMS

Amplitude - The "strength" or magnitude of a sound wave.

Audible Spectrum - The frequency range normally associated with human hearing. For noise control purposes, this range is usually taken to include frequencies between 20 Hz and 10,000 Hz.

Decibel - A logarithmic "unit" which indicates the ratio between two powers. A ratio of 10 in power corresponds to a difference in 10 decibels. The abbreviation for decibel is dB.

dB - See decibel.

dBA - The sound pressure levels in decibels measured with a frequency weighting network corresponding to the "A-scale" on a standard sound level meter. The A-scale tends to suppress lower frequencies, e.g., below 1000 Hz.

dBC - The sound pressure level in decibels measured with a frequency weighting corresponding to the "C-scale" on a sound level meter. The network provides essentially a uniform response over the audible frequency spectrum.

EPNL - Effective Perceived Noise Level. The value of PNL adjusted for both the presence of discrete frequencies and the time history. (The unit EPNdB is used instead of the unit dB.)

Frequency - The rate of change of a variable such as sound pressure with unit time. The unit of frequency is called the Hertz, abbreviated as "Hz," or the cycle per second.

Frequency Band - An interval of the frequency spectrum defined between an upper and a lower "cut-off" frequency. The band may be described in terms of these two frequencies, or, preferably, by the width of the band and by the geometric mean frequency of the upper and lower cut-off frequencies, e.g., "an octave band centered at 500 Hz."

Hz - The abbreviation for frequency in Hertz.

Source: First Federal Aircraft Noise Abatement Plan, FY 1969-1970.

Inverse First Power - The diminution of sound amplitude due to geometric effects as the observation point increases in distance from an infinite line or cylindrical source. The sound pressure level SPL_1 at distance r_1 is related to the sound pressure level SPL_2 at distance r_2 by the equation:

$$SPL_1 - SPL_2 = 10 \; LOG_{10} \frac{r_2}{r_1}$$

which indicates cylindrical divergence.

Inverse Square - The diminution of sound amplitude due to geometric effects as the observation point increases in distance from a point source. The sound pressure level SPL_1 at distance r_1 is related to the sound pressure level SPL_2 at a second distance r_2 by the equation:

$$SPL_1 - SPL_2 = 10 \; LOG_{10} \frac{r_2^2}{r_1}$$

which indicates spherical divergence.

Level - Used to indicate that the quantity referred to is in the logarithmic notation of decibels, with a standardized reference quantity used as the denominator in the decibel ratio expression.

Loudness - The intensive attribute of an auditory sensation, measured in units of sones. By definition, a pure tone of 1000 Hz, 40 dB above a normal listener's threshold, produces a loudness of 1 sone.

Loudness Level - The loudness level of any sound is defined as the sound pressure level of a 1000 Hz tone that sounds as loud to a listener as the sound in question. Described in units of phons.

Noisiness - Analogous to loudness, but observers judge the "unwantedness" or "unacceptability" of the sound as compared to a reference standard consisting of an octave band of random noise centered at 1000 Hz.

Octave - A frequency ratio of 1:2 e.g., 500 to 1000 Hz. In noise control work, the audible spectrum is often described by a series of contiguous octave frequency bands.

One-Third Octave	-	A frequency ratio of 1:2-1/3. Three contiguous one-third octave bands cover the same frequency range as one octave band.
Perceived Noise Level	-	The level of a sound in terms of "noisiness." Computed from an analysis of the sound pressure levels in octave or one-third octave frequency bands of the noise. The unit of perceived noise level is the "PNdB."
Physical Measure Of Sound	-	Any quantity describing a sound which can be read directly on an electrical instrument, e.g., sound pressure level.
Psychological Measure Of Sound	-	Quantity describing a sound which can be measured by subjected judgments of the sound. Usually computed from some empirically derived rule which uses sound pressure level in frequency bands as input data. Examples are loudness, perceived noise level, etc.
Sone	-	The unit of loudness.
Sound Level	-	A corruption of the term "sound pressure level."
Sound Pressure Level	-	The root-mean-square sound pressure, p, related in decibels to a reference pressure. $$\text{Sound pressure level} = 10 \text{ LOG } \frac{p^2}{p^2_{ref}}$$ where p_{ref} = 0.0002 microbar. Abbreviation: SPL. The value read directly from a sound level meter.
Fan Noise	-	Noise generated within the fan stage of the turbofan engine--includes both discrete frequencies and random noise.
Inlet Noise	-	Fan noise that propagates forward out the inlet.
Fan Discharge Noise	-	Fan noise that propagates out the secondary discharge duct.
Jet Noise	-	Noise generated externally to the engine in the jet wake.
Turbine Noise	-	Noise generated between the burner cans and the primary nozzle, containing discrete frequencies and random noise.

<u>Sonic Boom</u>	-	The acoustic event which is a manifestation, notably on the earth's surface, of the wave system generated by an aircraft flying at a speed greater than the local sound speed.
<u>Cut-Off Line</u>	-	A line that separates a region where sonic booms are experienced from a region where they are not.
Focus Boom (Superboom)	-	A sonic boom that is amplified by focusing effects of aircraft maneuvers or atmospheric anomalies.
<u>N-Wave</u>	-	A pressure signature that resembles the letter N.

CHAPTER IV

IMPACT OF AIRPORT IMPROVEMENTS AND OPERATIONS ON WATER QUALITY

I. INTRODUCTION

1. PURPOSE

This study was undertaken to measure the effects of the proposed fills, aircraft, and airport operations on the quality of the water surrounding the airport. Detailed studies of airport generated solid and liquid wastes were made together with an analysis of airport storm runoff.

2. APPROACH

The approach used to investigate the impact of the airport improvements and operations on water quality included:

(1) Analysis of published literature on the existing water quality in Boston Harbor.

(2) Field measurements of currents, tides, wind directions, and drogue studies in the BH-C embayment area.

(3) Analysis of BH-A and BH-B embayment areas included water and mud samples.

(4) Use of a computer model to predict the effects of the proposed fill in the BH-C embayment.

(5) Extensive water and mud sampling around the perimeter of the airport.

(6) Field interviews and surveys to analyze the origin, consolidation, and final disposal of all solid wastes generated at Boston-Logan International Airport.

(7) Analysis of fuel spills and corrective measures to minimize their effects.

(8) All of the field, experimental and theoretical analyses were conducted within the framework set by available technical literature.

II. SUMMARY

The analysis conducted in this study shows that the water quality in the BH-C embayment is directly dependent upon the frequency and nature of overflows of the City of Boston combined sewer located at Coleridge-Moore Streets. The proposed fills in BH-C will reduce the dilution volumes in that area. The fill will not alter existing diffusion patterns but will tend to cause increases in concentrations of pollutants originating from the City of Boston sewer. The significant recommendation made is to close the sewer which is the cause of pollution in area BH-C.

Solid wastes generated at Boston-Logan International Airport are deposited in sanitary landfills by private cartmen.

The sanitary sewers originating at buildings in the Boston-Logan International Airport complex are connected to the Metropolitan District Commission (MDC) waste treatment plants and therefore discharge through municipally controlled outlets.

Accidental fuel spills occur periodically. Positive corrective steps are already underway by the Massachusetts Port Authority to take short range preventative action and to install permanent corrective equipment.

III. CONCLUSIONS

1. **THE CURRENT WATER QUALITY PROBLEM IN AREA BH-C IS CAUSED BY THE OVERFLOW OF THE COMBINED CITY OF BOSTON SEWER LOCATED AT COLERIDGE AND MOORE STREETS IN EAST BOSTON.**

- The quality of the effluent from the Coleridge-Moore sewer depends on the quantity of rainfall.
  - During light rainfall, the Coleridge-Moore sewer does not overflow and the concentration of pollutants of the effluent is within acceptable limits.
  - Following heavy rainfall, the Coleridge-Moore sewer overflows and the concentration of pollutants of the effluent far exceeds acceptable limits.
- The sewer overflow is apparently the cause of high coliform counts during certain parts of the year.

2. **THE ONLY EFFECTIVE WAY TO IMPROVE THE QUALITY OF THE WATERS IN AREA BH-C IS TO CLOSE THE OVERFLOW FROM THE CITY OF BOSTON SEWER LOCATED AT COLERIDGE AND MOORE STREETS.**

- The proposed fill in BH-C will reduce the volume of water in BH-C by thirty-seven percent (37%).
- The proposed fill in BH-C will not change the current diffusion patterns but will reduce dilution so that existing concentrations of pollutants, originating at the Coleridge-Moore sewer, will be increased by eighteen percent (18%).
- A request will be made to the FAA to waive the requirements for the fills in BH-C until after the sewage overflows have been stopped. At that time, the needs for this fill will be re-examined.

3. **THE PROPOSED FILLS IN BH-C, BH-B, AND BH-A WILL NOT RESULT IN ANY SIGNIFICANT CHANGE IN THE VELOCITY OF CURRENTS IN THE CHANNEL BETWEEN WINTHROP AND RUNWAY 4R-22L.**

- The average velocity will decrease to .42 K/H from 0.5 K/H. This decrease is not significant.

4. INSTALLATION OF COLLECTING AND SKIMMING DEVICES ON DRAINAGE OUTFALLS FOR FUEL SPILL SEPARATION IS RECOMMENDED AND HAS BEEN INITIATED. THESE DECREASE THE EFFECTS OF ACCIDENTAL FUEL SPILLS ON THE WATER QUALITY OF AREA BH-C AND THE AREAS LOCATED ON THE SOUTH SIDE OF THE AIRPORT.

5. THE EFFECTS OF THE PROPOSED FILLS ON THE LOCAL ECOLOGY ARE MINIMAL.

- Existing marine life will not be appreciably affected.
- The design of the dikes has been studied by engineers from Fay, Spofford & Thorndike, Inc. Their analysis shows that the specifications are such that when maintained as planned, the fills will not affect the marine environment.

6. SOLID WASTES COLLECTED OR GENERATED AT BOSTON-LOGAN INTERNATIONAL AIRPORT ARE DISPOSED OF IN SANITARY LANDFILLS. NO CHANGE IS RECOMMENDED OR REQUIRED.

7. SANITARY SEWAGE GENERATED AT BOSTON-LOGAN INTERNATIONAL AIRPORT IS CONNECTED TO MDC SEWAGE TREATMENT PLANT AND DOES NOT CONTRIBUTE TO WATER POLLUTION IN THE INNER BOSTON HARBOR.

IV. DISCUSSION

1. PROPOSED FILLS ARE LOCATED IN BH-A, IN BH-B, AND BH-C.

(1) Landfill Required for Runway 15L-33R.

Construction of Runway 15L-33R will require landfill operations. Exhibit IV-1 shows the areas where land fill is required. These areas are designated as BH-A, BH-B, and BH-C.

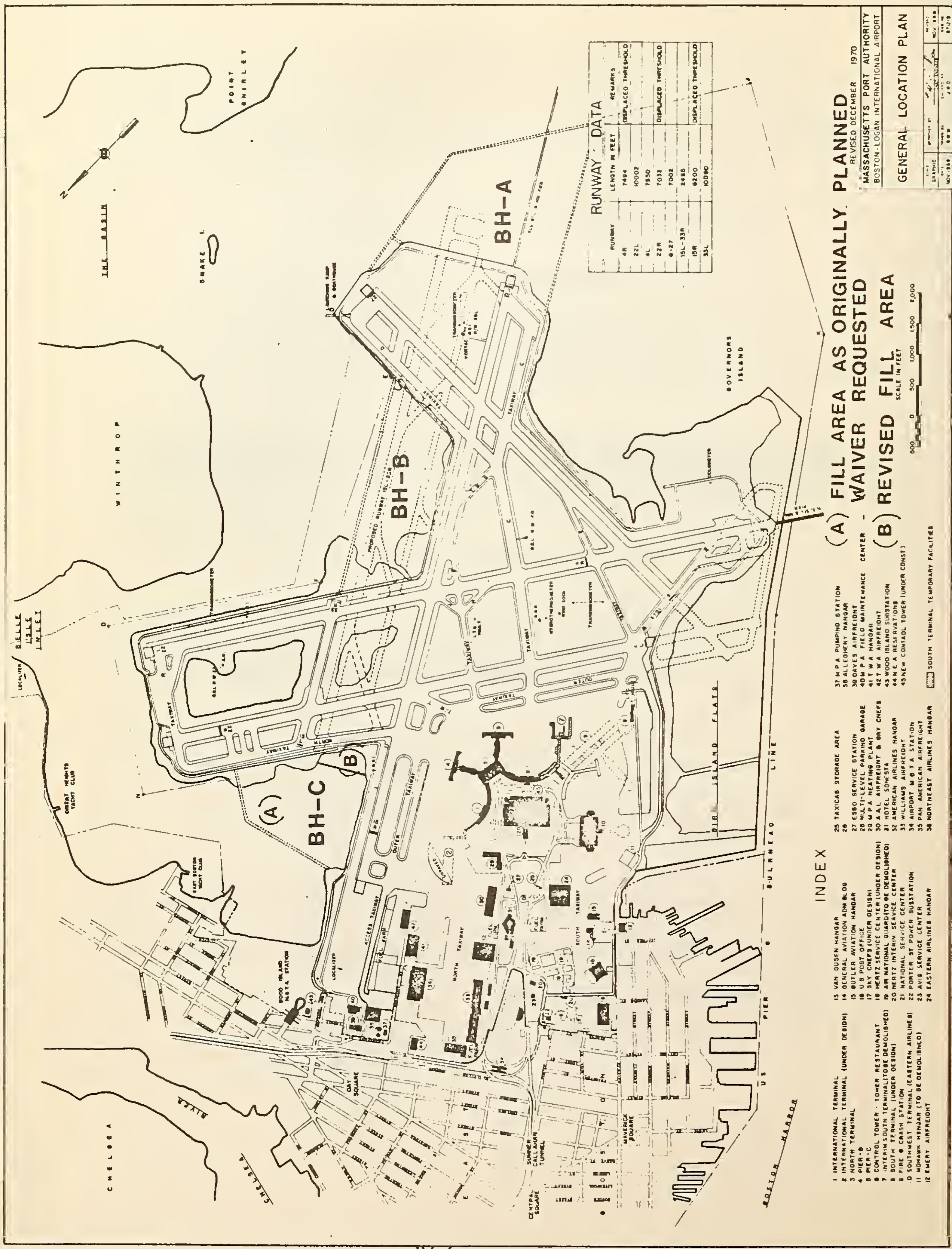
2. FILL AREAS WERE EXAMINED IN A PROGRAM OF FIELD MEASUREMENTS AND THE DATA COLLECTED WAS USED IN A PREDICTIVE COMPUTERIZED MODEL STUDY OF AREA BH-C.

The inner lagoon of area BH-C presented an area of particular interest for the following reasons:

- The area is land locked and presents only a narrow channel to the open sea.
- The City of Boston sewer located at the extension of Coleridge and Moore Streets does discharge raw sewage into the inner lagoon under overflow conditions.
- There has been previous history of sewage contamination of the Orient Heights Beach.

It was therefore decided to concentrate particular attention in the field and computer model studies on the effects of the proposed fills on the inner lagoon of BH-C. A computer model was used to predict the effects of the fill in BH-C.

EXHIBIT IV-1
General View of Projects



The results of the model show that it provided accurate simulation of field conditions.

(1) Current Meters, Tide Meters, and Drogues Were Used to Investigate Existing Conditions in Area BH-C.

- Current and tide meters - In order to be able to predict the probable actions and results of the proposed dike in the inner lagoon of BH-C, it was first necessary to determine through field measurements the existing conditions without the fill. Data required in a computer study of this type includes; the range of tides, the direction and velocity of currents at critical points, surface water movements, usually measured with surface drogues, and a record of wind velocities.

  The field measurements in the inner lagoon of BH-C were undertaken by the Environmental Equipment Division of EG&G International of Waltham, Massachusetts. EG&G used four Model 1102 self-contained digital recording tract meters which were installed on April 9, 1971. The four current meters were located at Mooring A, Mooring B, Mooring E and at the bridge as shown in Exhibit IV-2. These locations were chosen to monitor the current patterns at key points at both areas of the main basin and of the inner lagoon. Mooring A was located to describe the existing flushing in and out of the western tributary tidal basin, also referred to as inner lagoon. Mooring B was located to describe the flow in and out of the main tidal basin. The location of Mooring B was in the vicinity of buoys C9 and N10 at the end of Runway 22L.

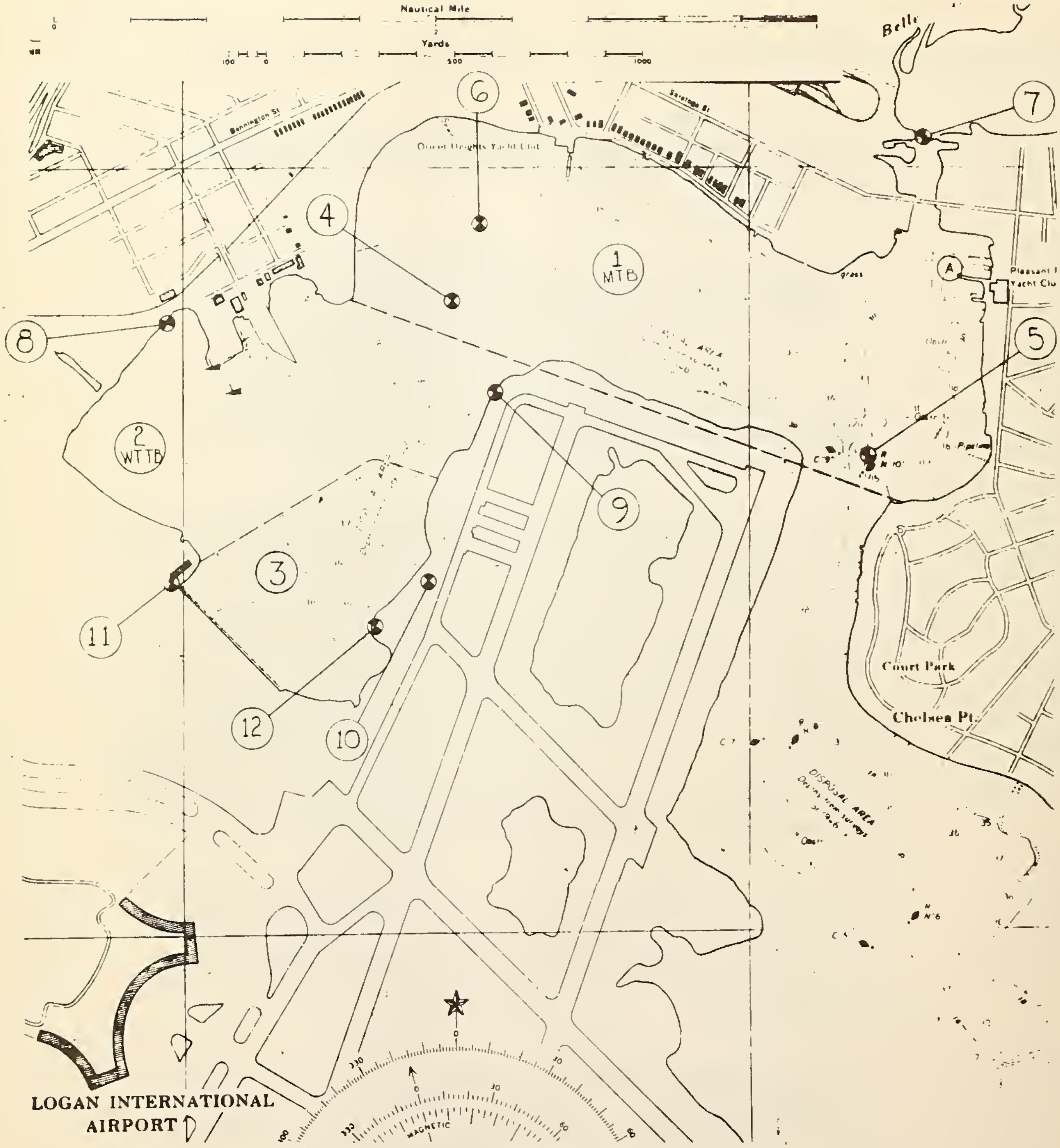
  Mooring E was located to increase the validity of the predictive modeling techniques with respect to potential pollution effects on Orient Heights Beach. The bridge installation on Belle Isle Inlet provided data to calculate the mass balance in the main basin and the inner lagoon.

  The instruments recorded current speed and direction continuously with samplings every five seconds from April 9, 1971 to April 15, 1971. The operation and results of the current meters are described in detail in the attached report by the Environmental Equipment Division of EG&G.

  Tides were measured during the period April 9, 1971 through April 15, 1971. The tide station was located on Airport property in order to monitor ranges of the tides throughout the period of the

EXHIBIT IV-2

Location of Oceanographic Studies



NOTE:

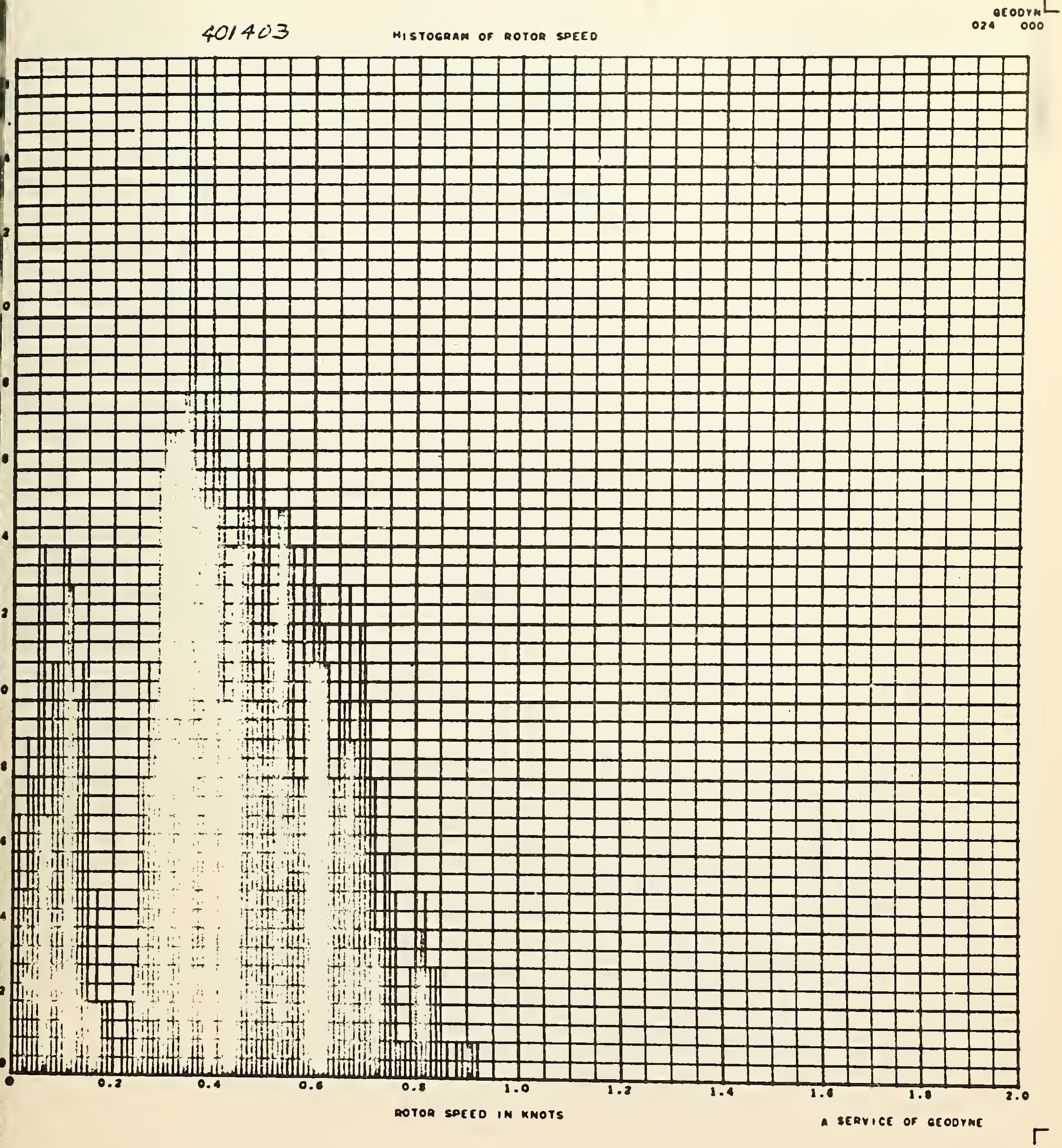
1. PLACE DROGUE TRACKS PLOT (FIG. 10) OVER FIGURE 1 ALIGNING ITEMS 9, 10 & 11, TRIANGULATION STATIONS 1, 2 & 3.

LEGEND

ITEM NO.	DESCRIPTION
1	MAIN TIDAL BASIN
2	WESTERN TRIBUTARY TIDAL BASIN
3	PROPOSED LAND FILL
4	MOORING "A"
5	MOORING "B"
6	MOORING "E"
7	BRIDGE - BELLE ISLE INLET
8	SEWER OUTFALL FOOT OF MOORE ST.
9	TRIANGULATION STATION 1
10	TRIANGULATION STATION 2
11	TRIANGULATION STATION 3
12	TIDE STATION

FIGURE 1

Mooring B
Speed Histogram



survey. The location of the tidal gage is shown on Exhibit IV-2. Knowledge of the tidal prism, that is the quantity of water moving in and out of the embayment due to tidal action, is required for the calculations of mass balance of sea water.

- Current Velocities - The velocities measured at Mooring B averaged 0.3-0.7 knots and did not exceed 0.92K/Hour. The histograms of current velocities are shown in Exhibit IV-3. The velocity will decrease since the quantity of water stored in the embayments will decrease by about fourteen percent (14%). This will translate into a decrease in the average velocity of .08K/H which cannot be considered significant.

- Surface Drogues - Drogues were utilized on April 14 and 15 to describe surface current conditions throughout the tidal cycles in and around the area of the inner lagoon. Of particular interest were the surface currents in the vicinity of the sewer outflow located at the intersections of Coleridge and Moore Streets. The fresher sewer water will tend to remain close to the surface until thoroughly mixed and surface measurements are therefore required. The drogues were set with minimum scope, that is minimum depth, to minimize the effects of the marsh grass as the tide receded. Drogues were tracked with theodolites located at three shore stations on the Airport property as shown in Exhibit IV-2. Positive drogue identification and siting was accomplished using a small boat to follow individual drogues. The drogues were then triangulated with respect to time and plotted graphically. Full description of the testing and data collection procedures utilized in the drogue studies is detailed in the attached EG&G study.

- Winds - Prevailing wind conditions during the period of the drogue survey, April 14 to April 15, 1971, were monitored at the tower at Boston-Logan International Airport and reported every 30 minutes. The detailed listing of wind directions and velocities are shown in the attached EG&G report.

- Depth Soundings - Depth soundings were made at Moorings A, B and E. The data is described in the EGG report attached. The soundings show that depths at Mooring A, and E are about ten feet less than those shown on the chart.

(2) <u>A Computerized Predictive Computer Model Was Used To Assess Changes in Flow Patterns in Area BH-C Caused by the Proposed Dikes and Fills in That Area.</u>

The current, tide, wind, and drogue data was used to calibrate the computer model. Once the computer model was calibrated to reproduce currently existing conditions in BH-C, the proposed dikes were introduced as boundary conditions in the computer model. The computer was then used to calculate the change in the probability of diffusion patterns centered around Mooring E located off shore at Orient Heights Beach.

- <u>Mass Balance</u> - The mass balance of the flow of water in and out of the area was calculated to determine the effects of the tidal prism and to provide information for evaluation of the predictive model results. The areas of the tidal embayments were determined using planimeters and the U. S. Coast Guard and Geodetic survey chart #248. The tidal exchange volume was calculated using an average tidal range of nine feet. The tidal exchange calculations were performed for three locations.

  - Location at Mooring A
  - Location at Mooring B
  - Location at the Bridge

  The results of the tidal exchange calculations are shown in Exhibit IV-4. The results show that in the inner lagoon of BH-C, the proposed fill will reduce the available water in the tidal exchange by approximately thirty-seven percent (37%). If the proposed fills in BH-C are compared to the entire area including the inner lagoon and the main basin the land fill represents approximately a reduction in volume of fourteen percent (14%) of the total area available.

- <u>Predictive Computer Model</u> - The next analytical step consists of the computation of dispersion coefficients using Markov chain models. The basis of this model is based on following the movement of one particle and is performed by computing the probabilities of transitions between a set of 80 possible states. Thus, the pro-

WATER MASS BALANCE

Volume Exchange at Mooring A, the Entrance to the Western Tributary Tidal Basin

Width of Channel	125 yards
Average Depth	7 yards
Cross Section Area	733 m^2
Average Maximum Flow	13.9 cm/sec
Average Maximum Flow x $2/\pi$ = Mean Velocity	8.85 cm/sec
Mean Flow x Area x Tidal Cycle = Volume Exchange	140.8 x 10^4 cubic meters

Volume Exchange at Mooring B

Width of Channel	130 yards
Average Depth	10.7 yards
Cross Section Area	1160 m^2
Average Maximum Flow	38.5 cm/sec
Average Maximum Flow x $2/\pi$ = Mean Velocity	24.5 cm/sec
Mean Flow x Area x Tidal Cycle = Volume Exchange	613.5 x 10^4 cubic meters

Volume Exchange at Belle Isle Inlet

Width of Channel	70 yards
Average Depth	3.5 yards
Cross Section Area	204 m^2
Average Maximum Flow	57.3 cm/sec
Average Maximum Flow x $2/\pi$ = Mean Velocity	36.5 cm/sec
Mean Flow x Area x Tidal Cycle = Volume Exchange	160.9 x 10^4 cubic meters

Summary

Volume Exchange at Mooring B	613.5 x 10^4 cubic meters
Volume Exchange at Belle Isle Inlet	160.9 x 10^4 cubic meters
Volume Exchange for Western Tributary Tidal Basin and Main Tidal Basin	452.6 x 10^4 cubic meters
Main Tidal Basin	202.8 x 10^4 cubic meters
Western Tributary Tidal Basin	171.0 x 10^4 cubic meters
Proposed Fill	57.3 x 10^4 cubic meters

bability of a particular particle path is determined and can be utilized in predicting the dispersion characteristics produced by the computer. This matrix shows the relationship between directions and velocity of transitions. Using this probability matrix, the computer program can be used to determine the most probable path and the characteristics of the motion in the north, south and east and west directions. These characteristics include standard deviation, the average distance travelled, and the weighted standard deviation. The diffusion depends upon the magnitude and velocity of the current. This information can be used to compute the diffusion characteristics in the directions of interest. The diffusion coefficients in the four compass directions are shown in Exhibit IV-5. Exhibit IV-5 shows that the diffusion coefficient in terms of centimeters squared per second are highest towards the west, that is, towards the general area of the beach which indicates that the Orient Heights Beach is currently affected by whatever concentrations of pollutants are available in BH-C.

Making use of the transition probability matrix described earlier, the next step in the analysis builds up successive transition probability matrices for 40 time periods. The times chosen were ten minute increments and the speed ranges were from 0-3 centimeters per second, 3-6 centimeters per second, 6-9 centimeters per second, etc. Each such set of transition probability matrices must be built on the assumption of the initial state vector. Initial states of interest were chosen. Thus, at station A the initial state was assumed to be in a northeasterly direction at 7 1/2 centimeters per second. For station E two initial state ventors were assumed, one in the easterly direction at 4.5 centimeters per second, the other in a northwesterly direction at 4.5 centimeters per second. The initial directions and velocities of these vectors were based on prevailing conditions at the two locations. As an illustration, the initial vectors selected for station E located near Orient Heights Beach describe the condition of initial velocity of water towards and away from the beach. For each probability matrix, computations showing weighted mean distances in all directions of the compass are performed together with the calculation of the probabilities associated with each of these values. Using this information, it is possible to calculate the envelopes of the travel of a given particle as a function of time. The result of these calculations is shown on Exhibit IV-6. Exhibit IV-6 shows the envelopes of particle travel for station E, an assumed initial vector of 4.5 centimeters per second in the northwesterly direction and indicates a peak pointed toward the beach. This implies that if the prevailing current and wind direction are towards the northwest heading the motion of particles originating at station E would be towards the beach.

Exhibits IV-8 and IV-9 show existing conditions at Moorings E and A respectively for various initial conditions.

EXHIBIT IV-5

DIFFUSION COEFFICIENTS AT MOORING E

Diffusion Coefficients in Centimeters^2 Per Second	Direction
3.8×10^3	North
6.9×10^2	South
1.1×10^4	East (away from beach)
7.2×10^2	West (towards beach)

EXHIBIT IV-6

Probable Envelopes of Travel of Particles at Mooring E With An Initial Vector of 7.5 cm/sec NW EXISTING CONDITIONS

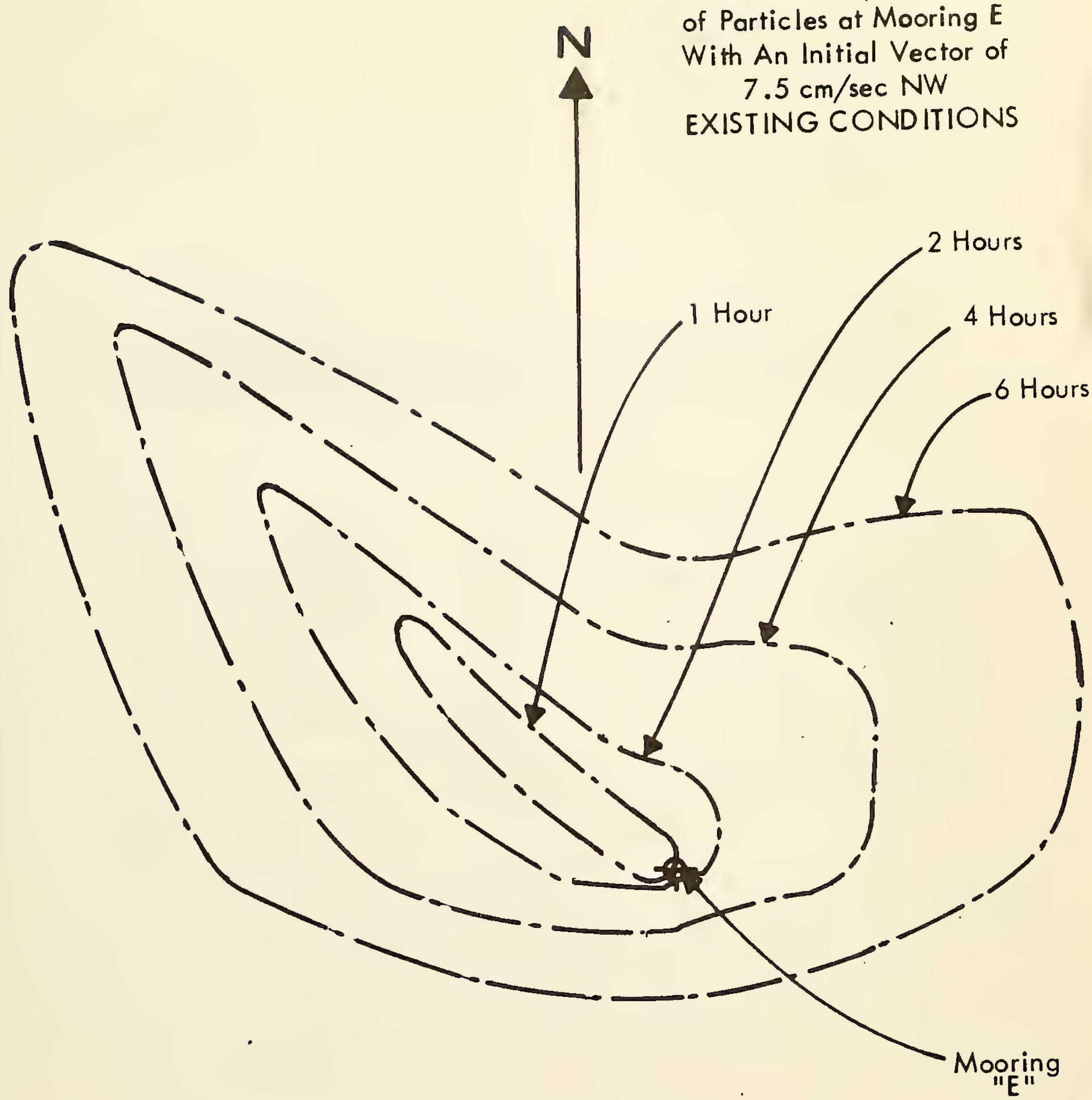


EXHIBIT IV-7

PROBABILITY TABLE SHOWING LOCATION OF PARTICLE WITHIN SELECTED TIMES

The Probability, or the Percentage of the Period of Record, a Particle Will Be Found Within the Envelope, Plotted in Figures 19, 20, and 21

Station	Initial State Vector Average	After One Hour	After Two Hours	After Four Hours	After Six Hours
E	Northwest @ 4.5 cm/sec	14%	23%	33%	40%
E	East @ 4.5 cm/sec	25%	36%	44%	45%
A	Northeast @ 7.5 cm/sec	5%	12%	19%	20%

EXHIBIT IV-8

Probable Envelopes of Travel of Particles at Mooring E With An Initial Vector of 4.5 cm/sec
EXISTING CONDITIONS

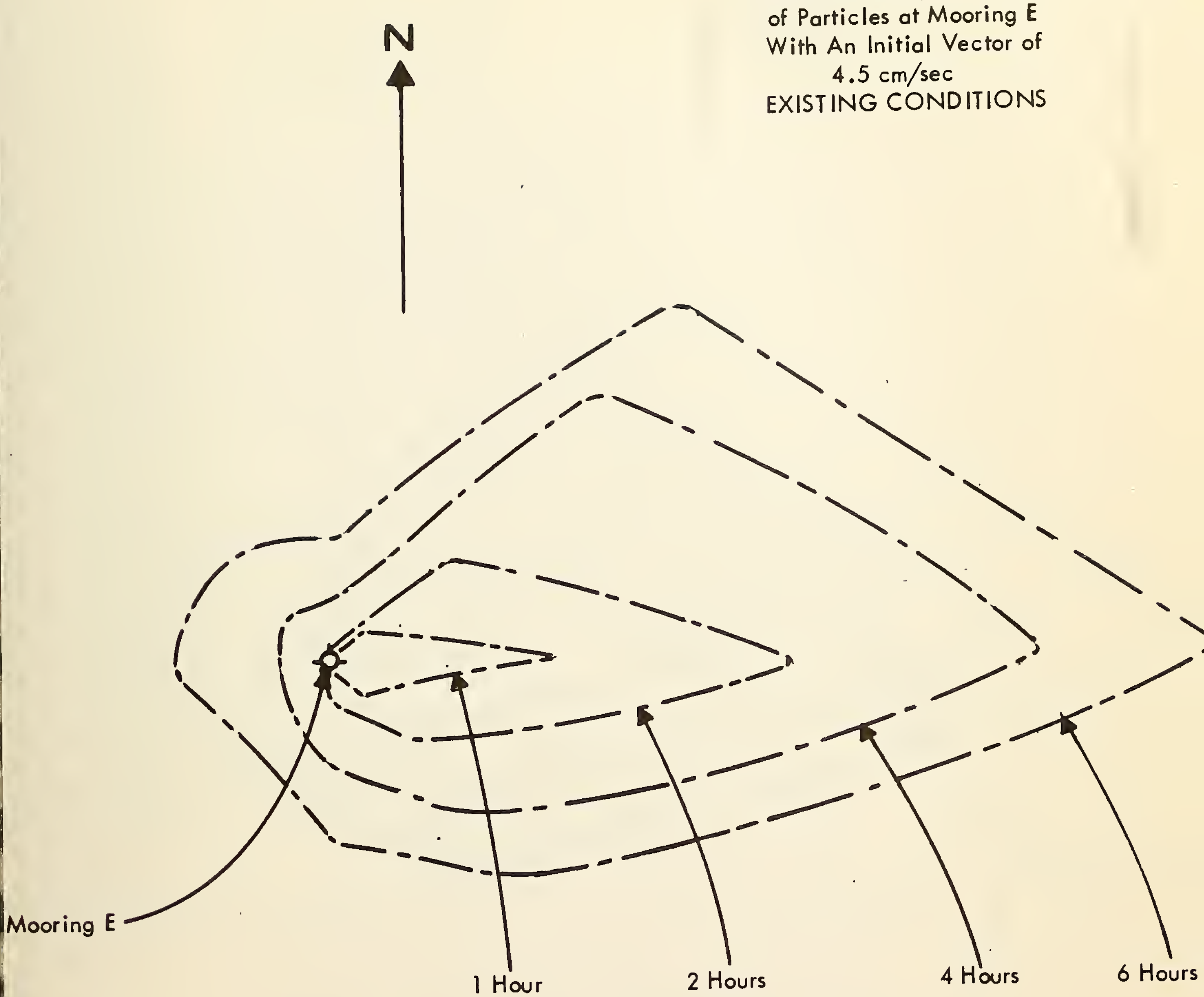


EXHIBIT IV-9

Probable Envelopes of Travel of Particles at Mooring A With An Initial Vector of 7.5 cm/sec NE
EXISTING CONDITIONS

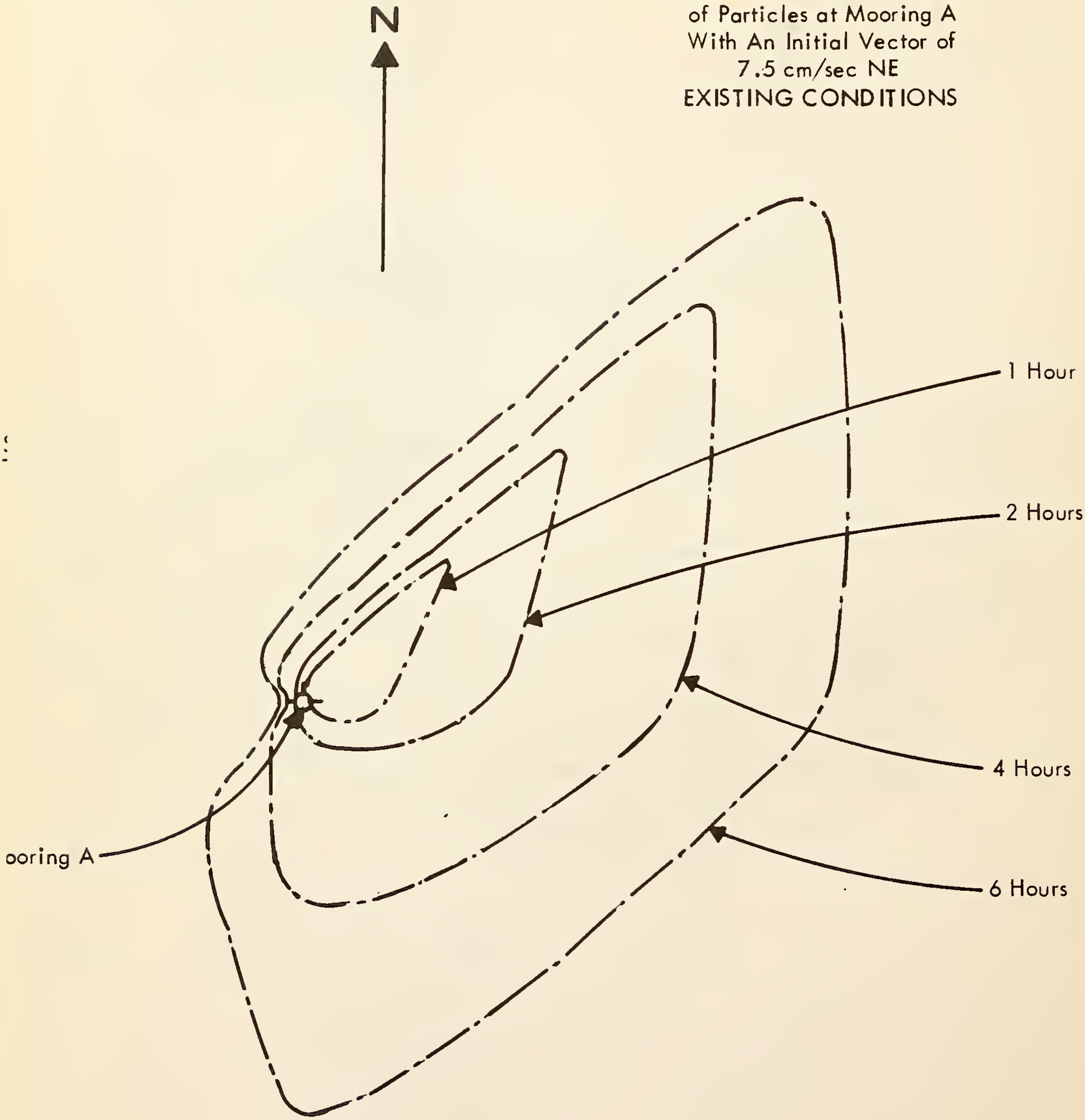


EXHIBIT IV-10

Overlay of Probable Envelopes of Diffusion at Station E With An Initial State Vector of 4.5 cm/sec E

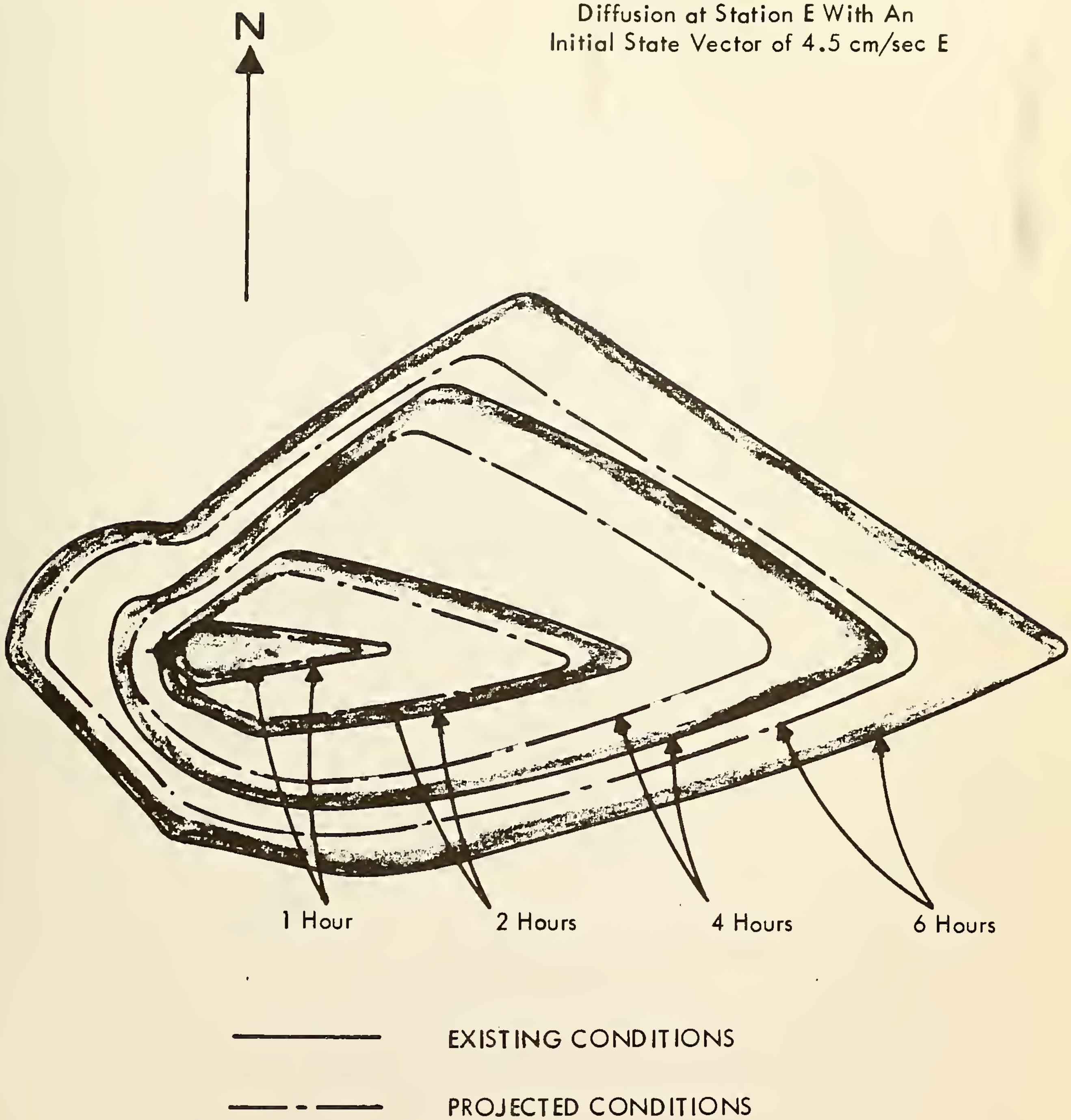
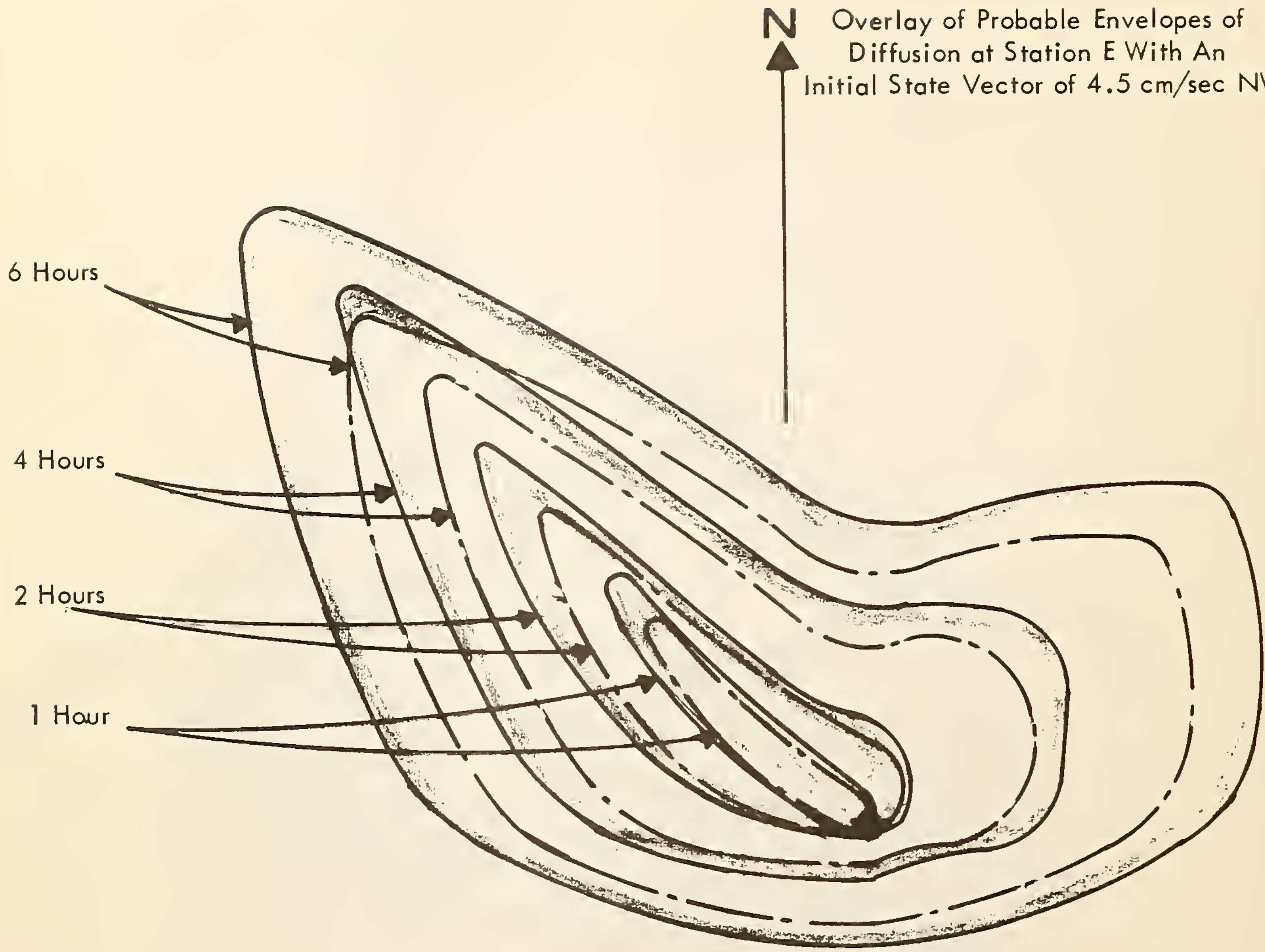


EXHIBIT IV-11

Overlay of Probable Envelopes of Diffusion at Station E With An Initial State Vector of 4.5 cm/sec NW



EXISTING CONDITIONS

PROJECTED CONDITIONS

EXHIBIT IV-12

Overlay of Probable Envelopes of Diffusion at Station A With An Initial State Vector of 7.5 cm/sec NE

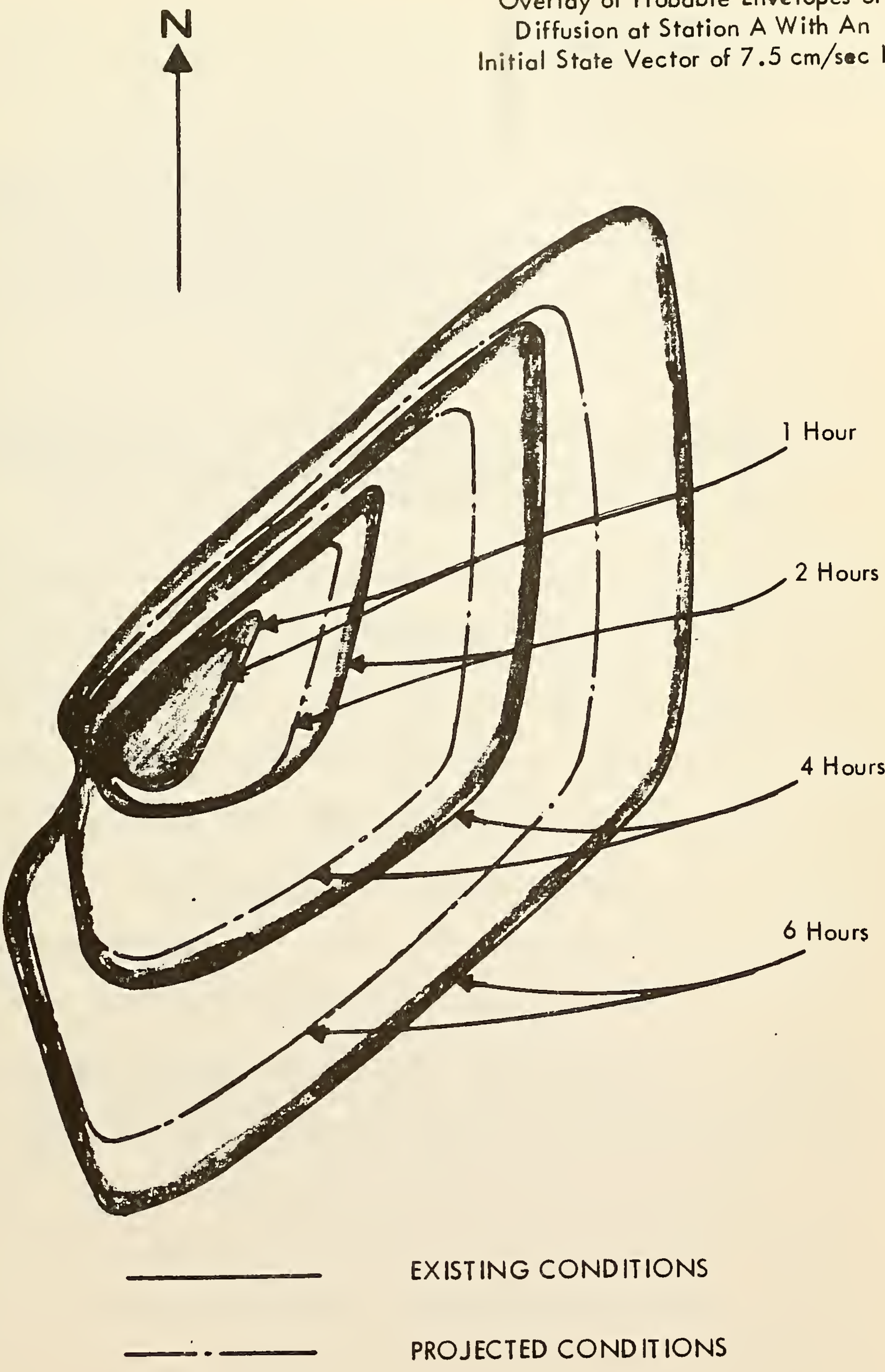


Exhibit IV-7 shows the calculated probability table developed for the three conditions examined. The probability refers to whether or not the original particle will be within the given time contour. The curves of equal concentration have been compared using the predictive model under the assumption of the dikes being in place. The difference in dilution is highlighted by superimposing the contours obtained, from the computer model, for the existing and projected conditions with the dike present. It can be seen that the volume of diffusion in the case of the proposed construction is reduced by approximately eighteen percent (18%) as is shown in Exhibits IV-10, IV-11, IV-12.

(3) <u>The Results of the Computer and Field Study Show that the Water Quality in BH-C is Directly Related to the Discharges from the City of Boston Sewer Located at the Extension of Coleridge and Moore Streets.</u>

Extensive water sampling tests were performed in the inner lagoon of BH-C over the period of three weeks in April of 1971. The tests and their results are shown in Exhibit IV-13 showing the date, location and coliform counts of the sample. The data taken in the inner lagoon of BH-C indicates that as long as the sewer located at Coleridge and Moore Streets does not overflow, the quality of the water in BH-C would meet SA classifications. Specifically, coliform counts are less than ten per hundred milliliters of water. However, from observations made on the 28th, 29th and 30th of April and May 3, after extensive rainfall, the overflow from the same sewer caused high coliform counts in BH-C. Exhibit IV-14 shows recorded rainfall during the test period. Specifically, counts of the order of 6,000 coliform counts per 100 ml.. of water were measured at the sewer mouth after rainfall where counts of less than ten per hundred milimeters were seen during dry weather. The conditions at the beach on Orient Heights are directly related to the quantity and quality of overflows originating at the sewer and thus determine the water quality rating.

EXHIBIT IV-13

WATER SAMPLES COLLECTED ON APRIL 14, 1971

Sample No.	Location	Coliform Count
1	East Boston Yauht Club	1
2	"	0.5
3	Surveyer Station 1	0
4	Winthrop Beach	1
5	Mooring A	1.5
6	Mooring E	3
7	Pleasant Yauht Club	10
8	Mooring at Bridge	2
9	Orient Heights Beach	4.5
10	"	0.5
11	"	1
12	"	8.5
13	City of Boston Sewer at Coleridge & Moore Street	21
14	"	3.5
15	"	4.5
16	"	9.5
17	"	0
18	"	5

Note: Measurements and analysis of samples have been conducted by the Environmental Resources Group of Booz, Allen & Hamilton, Inc. in the laboratories and by the personnel of Foster D. Snell Inc. a chemical and biological subsidiary.

EXHIBIT IV-14

Recorded Rainfall
During Test Period

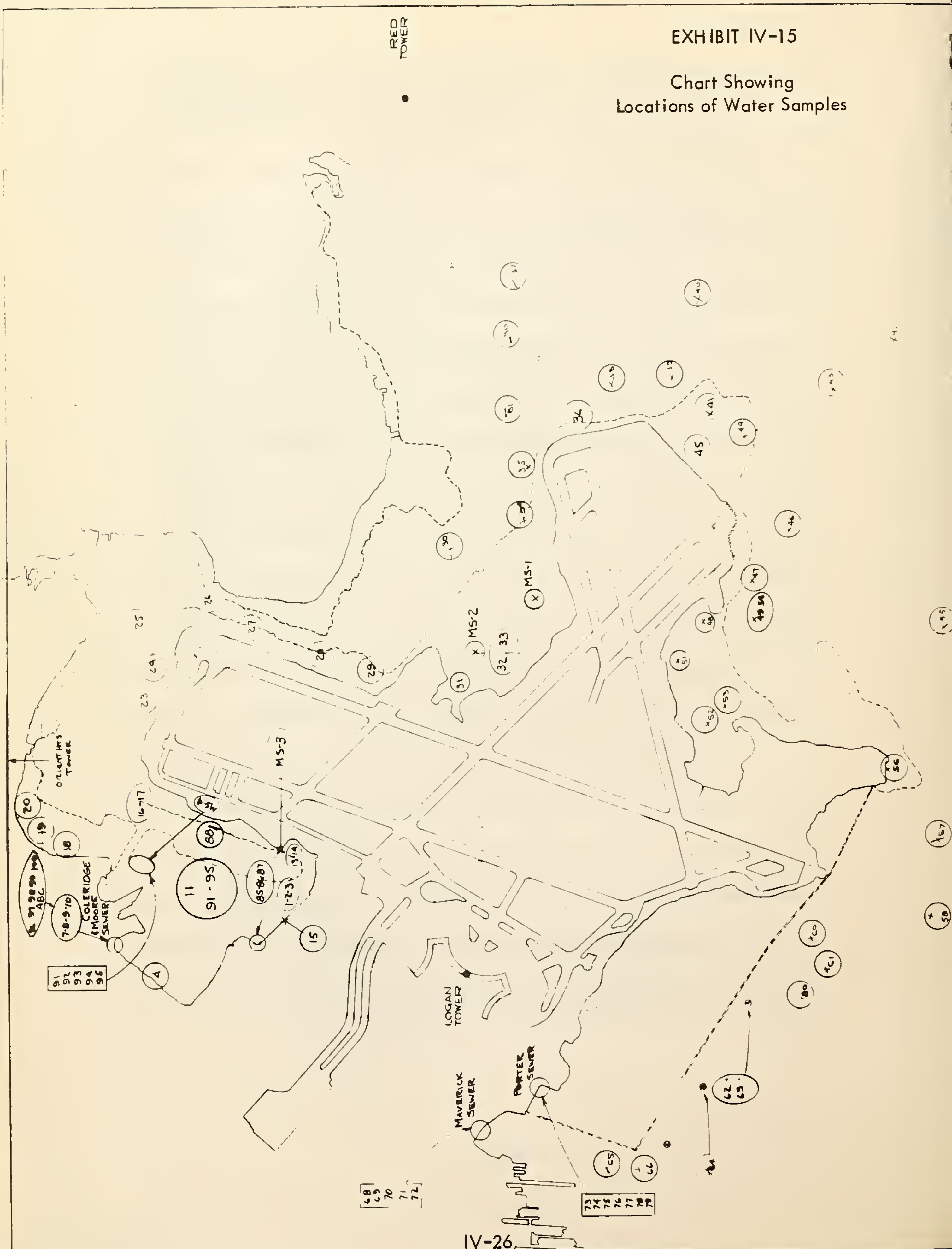
Data	Rainfall "/24 hrs.
4/14	.06
4/15	0
4/16	.08
4/17	-
4/18	.14
4/19	.11
4/20	0
4/21	Traces
4/22	Traces
4/23	0
4/24	.08
4/25	.01
4/26	.12
4/27	.02
4/28	.07
4/29	.70
4/30	Traces
5/1	0
5/2	.13
5/3	.38
5/4	Trace
5/5	Trace
5/6	Trace

(4) <u>An Extensive Water Sampling Program Was Undertaken in Areas BH-A, BH-B, BH-C and to the South of Boston-Logan International Airport.</u>

In order to determine the existing water quality in the Boston Harbor area surrounding Boston-Logan International Airport, extensive water samplings were made both at low and high tide conditions. Exhibit IV-15 shows the location of the samples plotted on a nautical chart of the airport. Samples were taken using a whaler for deep water sampling and a small dingy for shallow water sampling. The location of each sample was triangulated on landmarks located at Winthrop, Orient Heights and Boston-Logan International Airport. Exhibit IV-16 shows the results of analyses of samples collected around the airport. As discussed in a previous section, water samples in area BH-C were considerably more detailed and numerous than in the other areas. This is due to the fact that area BH-C presents particular problems due to the location of a sewer overflow and due to the direct impact of the proposed fills on the dilution of the effluent and its action on Orient Heights Beach. As discussed earlier, the water samples in area BH-C, taken both near the sewer and throughout the inner lagoon, show low coliform counts under no rain or light drizzle conditions. In the case of heavy and sustained rains when the overflow of the sanitary sewer operates, high coliform counts are obtained. Typical values of the order of 6,000 were achieved. <u>This clearly demonstrates the direct correlation between water quality in the area of the inner lagoon of BH-C to the overflows at the City of Boston sewer located at Coleridge and Moore</u> Streets.

EXHIBIT IV-15

Chart Showing
Locations of Water Samples



Date	Sample No.	Coliform Organisms	E-Coli
4/22/71	1	Less than 10	Less than 10
4/22/71	2	Less than 10	Less than 10
4/22/71	3	1	0
4/22/71	4	1	0
4/22/71	5	Less than 10	Less than 10
4/22/71	6	Less than 10	Less than 10
4/22/71	7	1	0
4/22/71	8	2	0
4/22/71	9	Less than 10	Less than 10
4/22/71	10	1	0
4/22/71	11	Less than 10	Less than 10
4/22/71	12	1	0
4/22/71	13	Less than 10	Less than 10
4/22/71	14	Less than 10	Less than 10
4/22/71	15	Less than 10	Less than 10
4/22/71	16	Less than 10	Less than 10
4/22/71	17	Less than 10	Less than 10
4/22/71	19	1	1
4/22/71	20	Less than 10	Less than 10
4/22/71	21	1	0
4/22/71	22	3	0
4/22/71	23	2	2
4/22/71	24	1	0
4/22/71	25	2	0
4/22/71	26	Less than 10	Less than 10
4/22/71	27	Less than 10	Less than 10
4/22/71	28	Less than 10	Less than 10
4/22/71	29	Less than 10	Less than 10
4/22/71	31	Less than 10	Less than 10
4/22/71	32	Less than 10	Less than 10
4/22/71	33	Less than 10	Less than 10
4/22/71	34	Less than 10	Less than 10
4/22/71	35	Less than 10	Less than 10
4/22/71	36	Less than 10	Less than 10
4/22/71	37	15	0
4/22/71	38	Less than 10	Less than 10
4/22/71	39	Less than 10	Less than 10
4/22/71	40	1	0
4/22/71	41	2	2
4/22/71	42	2	0
4/22/71	43	3	0

Date	Sample No.	Coliform Organisms	E-Coli
4/22/71	44	1	0
4/22/71	45	1	0
4/22/71	46	Less than 10	Less than 10
4/22/71	47	2	2
4/22/71	48	Less than 10	Less than 10
4/22/71	49	Less than 10	Less than 10
4/22/71	50	Less than 10	Less than 10
4/22/71	51	1	0
4/22/71	52	10	0
4/22/71	53	Less than 10	Less than 10
4/22/71	54	Less than 10	Less than 10
4/22/71	55	10	0
4/22/71	56	3	0
4/22/71	57	10	0
4/22/71	58	10	5
4/22/71	59	7	0
4/22/71	60	20	0
4/22/71	61	10	5
4/22/71	62	6	0
4/22/71	63	5	0
4/22/71	64	50	0
4/22/71	65	5	0
4/22/71	66	10	0
4/22/71	67	30	0
4/22/71	68	3,000	0
4/22/71	69	2,000	0
4/22/71	70	2,000	0
4/22/71	71	2,000	0
4/22/71	72	2,500	10
4/22/71	73	3,000	0
4/22/71	74	2,000	0
4/22/71	75	3,500	0
4/22/71	76	2,000	0
4/22/71	77	2,000	0
4/22/71	78	Less than 10	Less than 10
4/22/71	79	500	0
4/22/71	83	5	0
4/22/71	84	Less than 10	Less than 10
4/22/71	85	1	0
4/22/71	86	1	1
4/22/71	87	2	2
4/22/71	88	Less than 10	Less than 10
4/22/71	89	10	0

Date	Sample No.	Coliform Organisms	E-Coli
4/22/71	90	40	0
4/22/71	92	2	0
4/22/71	93	3	0
4/22/71	94	11	0
4/22/71	95	10	0
4/27/71	96	10	
4/28/71	97	10	
4/29/71	98	30	
4/30/71	99	6,000	
5/3/71	100		
	A	12,000	4,000
	B	6,600	800
	C	6,000	1,500

Note: Measurements and analysis of samples have been conducted by the Environmental Resources Group of Booz, Allen & Hamilton, Inc. in the laboratories and by the personnel of Foster D. Snell Inc. a chemical and biological subsidiary.

Samples taken in areas BH-B and BH-A indicate good quality levels, that is, coliform counts below 20. Published reports (1), (2), (3), (21) indicate that these areas BH-A, BH-B and BH-C are currently classified SB.

Samples taken to the South of Boston-Logan International Airport indicate progressively deteriorating conditions as the sampling approaches the Inner Harbor. Specifically, samples taken at the combined City of Boston sewers, known as the Maverick and Porter Street sewers, show high coliform counts. The field data gathered during this investigation confirms previously published extensive studies (1), (2), (3), (4). These studies show, that the water quality of the Inner Harbor is controlled by sewage overflows from outfalls operated by the City of Boston. The studies of drawings confirm that Boston-Logan International Airport uses the Maverick and Porter Street outfalls to discharge apron drainage only and thus Boston-Logan International Airport does not contribute to the high coliform counts obtained in this field survey.

(5) Mud Samples Were Taken in Areas BH-B and BH-C.

Exhibit IV-17 shows the results of the coliform counts performed on mud samples. These samples indicate that there was little pollution evident at the time of sampling. The samples showed evidence of the presence of sea worms, clams and fish. Exhibit IV-17 presents the marine fauna detected in the mud.

3. POSITIVE STEPS CAN BE TAKEN TO UPGRADE FURTHER WATER QUALITY CONDITIONS IN BH-C.

The only effective step that can be taken to improve water quality in BH-C is the disuse of the sewer at the end of Coleridge and Moore Streets. It is advisable to postpone

EXHIBIT IV-17

COLIFORM TESTS PERFORMED ON MUD SAMPLES AND MARINE FAUNA DETECTED

Mud Samples	Coliform Organisms	E-Coli
MS 1	Less than 10	Less than 10
MS 2	10	0
MS 3	Less than 10	Less than 10
MS 4	Less than 10	Less than 10

Mud Samples	Marine Fauna Detected
MS 1	Duck Clams, Clam Worms, Tube Worms
MS 2	Duck Clams, Worms
MS 3	Duck Clams, Worms
MS 4	Duck Clams, Worms

Note: The location of the samples is shown in Exhibit IV-15.

Note: Measurements and analysis of samples have been conducted by the Environmental Resources Group of Boox, Allen & Hamilton, Inc. in the laboratories and by the personnel of Foster D. Snell Inc. a chemical and biological subsidiary.

the proposed fills in BH-C until after the sewer is capped off. Until the sewer is capped off this course of events will result in the best environmental solution to the problems connected with the fill in BH-C and will improve the marine environment and the overall ecology of this area.

No alternative to the capping of the sewer will reduce the total organism count.

For this reason, the Massachusetts Port Authority has decided to apply to the FAA for a waiver from the overrun specifications. This waiver can be lifted once the City of Boston stops the overflows of raw sewage from the Coleridge and Moore Streets sewer.

The construction of the proposed runway will initially require limited filling in BH-C. The required fill represents less than ten percent (10%) of the original fill proposal. The affects of this limited fill in BH-C on the concentration of pollutants in BH-C will be very small since the limited fill is located on mud flats. This is caused by the small decrease in the volume of water available in BH-C.

Other alternatives result in conditions that are much less desirable from the environmental standpoint. These include:

- Dredging of bottom material to maintain a constant volume of water available for dilution will not alter the fact that sewage is entering the bay through BH-C.

- Extension of the sewer in pipes beyond the airport such that the mixing occurs in the BH-B area will also result only in movement of the pollutants to new areas.

4. <u>THE IMPACT OF AIRCRAFT, GROUND, AND TERMINAL OPERATIONS ON WATER QUALITY WAS EXAMINED.</u>

Existing and projected operations at the airport were examined as to their impact on the water quality in the waters surrounding the airport. Three major areas of possible impact on water quality include:

- Aircraft Operations
- Ground Operations
- Terminal and other building operations

(1) Aircraft Can Affect Water Quality by Releasing Fuel from Holding Tanks During Takeoffs.

The venting of jet fuel from the engine halding tanks has been highlighted recently. Considerable controversy exists as to the ultimate fate and form of the fuel thus released. Opinions vary as to the ultimate phase of the fuel - liquid or gas (8). However, regardless of the ultimate farm, this fuel represents a form of undesirable pollutian which must be stopped.

Exhibit IV-18 shows the estimates of the daily volumes of fuel released currently into the atmosphere. The dumping of holding tanks is estimated approximately to be 111 gallons af jet fuel per day. The airlines using Boston-Logan International Airport plan to discontinue this practice by the end of 1971 (7). The Massachusetts Port Authority will exert any means within their authority to insure that the venting is curtailed. This step will eliminate a source af water pollution generated by aircraft operations.

(2) Ground Operations Can Affect Water Quality Through the Release of Surface Drainage and Solid Wastes.

The surface drainage of the airpart is collected into conduits which are discharged at two major areas. One area is to the north af the international arrival building discharging into area BH-C which is shown in Exhibit IV-19.

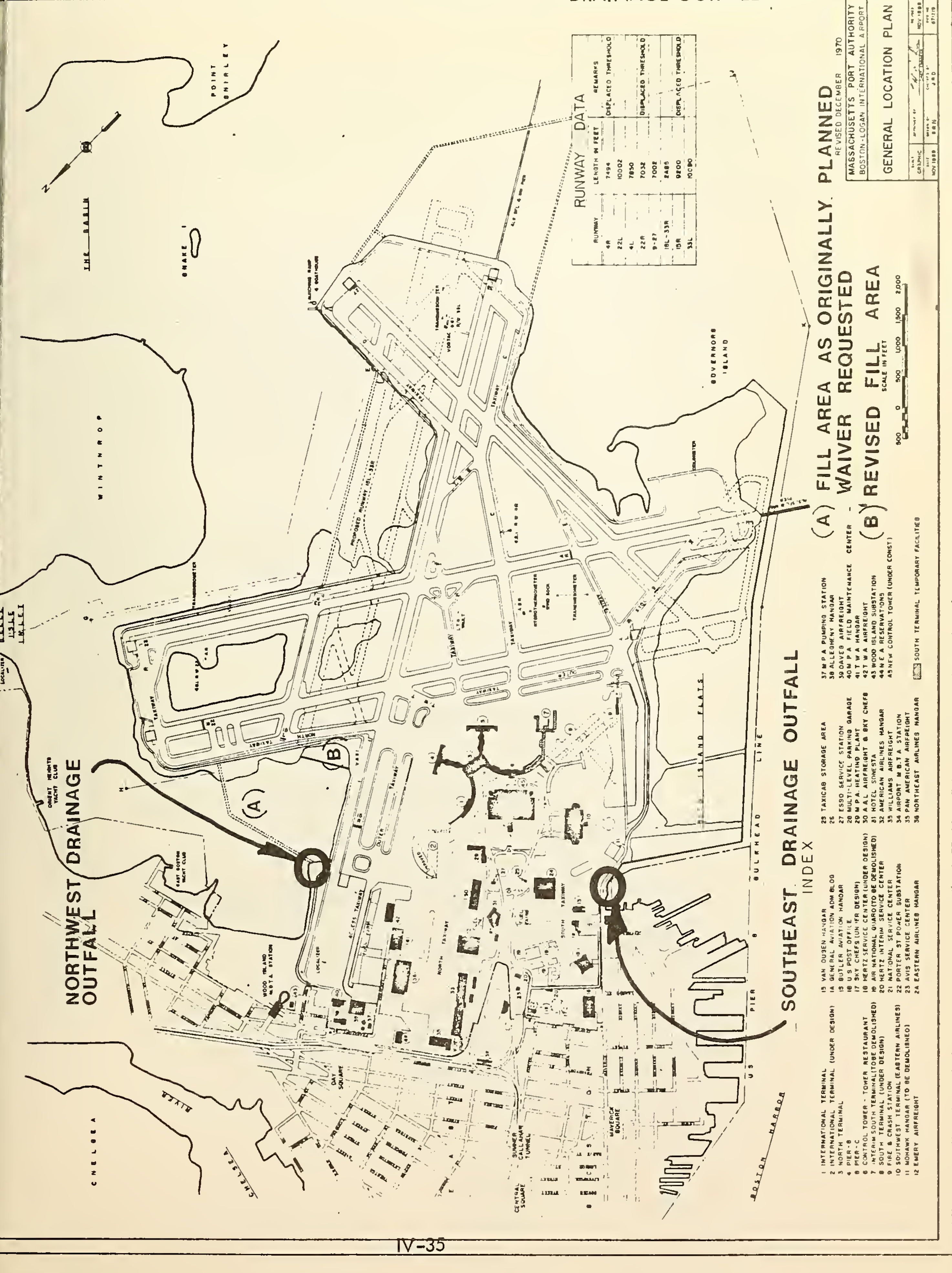
EXHIBIT IV-18

ESTIMATED QUANTITIES
OF FUEL RELEASED FROM
AIRCRAFT HOLDING TANKS

Aircraft	cc/Eng *	Total cc/T/O	T/O 1970	Total Quantities (1970 Year)	
707/DC-8	650	2,650	23,228	61,554 l/y	16,262 g/y
DC-9/737	500	1,000	48,600	48,680 l/y	12,861 g/y
727	500	1,500	28,155	42,732 l/y	11,158 g/y
747	600	2,400	377	905 l/y	239 g/y
					40,520 g/y
		Note: 1 gallon = 3.785 liters			111 gallons/day

* Note: Data from Ref. (8).

LOCATION OF FIELD APRON DRAINAGE OUTFALLS



The other major apron drainage collection area is to the sauth lacated at the Porter and Maverick Street sewers. Field inspection indicates some fuel spillage emanating from these lacatians.

- <u>Fuel Spills</u>

  Exhibit IV-20 shaws the reported fuel spill incidents at Bostan-Lagan International Airport. This Exhibit shows that small fuel spills occur on the average of approximately ance a day. The majority of the fuel spills are flushed down the storm drains. Exhibit IV-20 is based on data accumulated by the Massachusetts Port Authority Fire Department. The impact af fuel spills on water quality is relatively small compared to those other sources af harbor oil pollutian.

  Hawever, the steps taken by the Massachusetts Port Autharity will reduce the danger of pallutian af the Harbar due ta fuel spills. The steps or measures initiated by the Massachusetts Port Authority include:

  - Short-term policing efforts ta be perfarmed by Coastal Services

    - this includes daily inspections of all outfalls and periadic clean up of various fuel and oil traps.

  - Long-term engineering design and construction program ta install surface skimmers at the Northwestern and Southeastern drainage areas.

  Both of these programs are currently under way and represent positive steps initiated by the Massachusetts Port Autharity ta reduce and eventually eliminate the airport's cantribution, althaugh small, to oil pollution in the inner Bostan Harbor.

EXHIBIT IV-20

REPORTED OCCURRENCE OF ACCIDENTAL FUEL SPILLS

Month	Number of Spills in Month
January, 1970	16
February, 1970	23
March, 1970	23
April, 1970	24
May, 1970	23
June, 1970	27
July, 1970	27
August, 1970	32
September, 1970	26
October, 1970	17
November, 1970	12
December, 1970	12

- Deicers

Snow and ice control is affected through the use of applicants as well as mechanical equipment. During the winter of 1970-71 the following quantities of deicing and ice control agents were utilized at Boston-Logan International Airport.

Agents*	Quantity of Tons
Urea	160
Rock Salt	972
Sand	2,297

* Data provided by Massachusetts Port Authority.

The use of rock salt is confined to Boston-Logan International Airport roadways except on overpasses and around the terminal buildings where Urea is preferred. Urea is effective to 26° Fahrenheit and rock salt to 21° Fahrenheit.

Snow removal on the runways and taxiways is accomplished with steel and rubber bladed plows. Deicing of the runway and taxiway surfaces is generally achieved with a three to one mixture of urea with sand. Where ice conditions are extreme, one hundred percent (100%) urea will also be used.

While sand is not soluble it serves to restrict storm drainage flow while urea and rock salt dissolve and are readily dispensed through the draining system.

The results of the use of sand, rock salt, and urea on water quality of the Harbor are negligible. The use of 970 tons of salt spread over a four month winter season will not have any affect whatever on the salinity and the water quality levels of the Harbor. One hundred sixty tons of urea used over a winter season of four months will have no effects on the water quality of the Harbor.

- Solid Wastes Disposal Sites Located on Airport Property.

Extensive field inspections indicate that there are currently several solid wastes disposal areas located on airport property. Most of the materials maintained in the solid waste disposal areas consist of construction rubble and therefore do not contribute appreciably to water pollution. The Massachusetts Port Authority has prepared, and is carrying out, a plan to remove the dumps principally to improve aesthetics of the perimeter of the airport. Some of the materials, such as car bodies, contained in the solid waste disposal areas are used for fire fighting training sessions. In addition, the Massachusetts Port Authority will continue regular and periodic clean up operations of its entire perimeter to dispose of any water borne debris that may be carried to its shores.

(3) Terminals and Other Building Operations Have No Effects on Water Quality.

- Terminal Sanitary Sewage Disposal

All sanitary sewers which handle sewage generating at the terminal buildings and the sewage pumped out of the planes using the tricolater equipment is hooked up to the M.D.C. sanitary sewage system. The sewage is treated in municipal treatment plants and therefore does not contribute to water pollution in the inner Harbor.

- Solid Waste

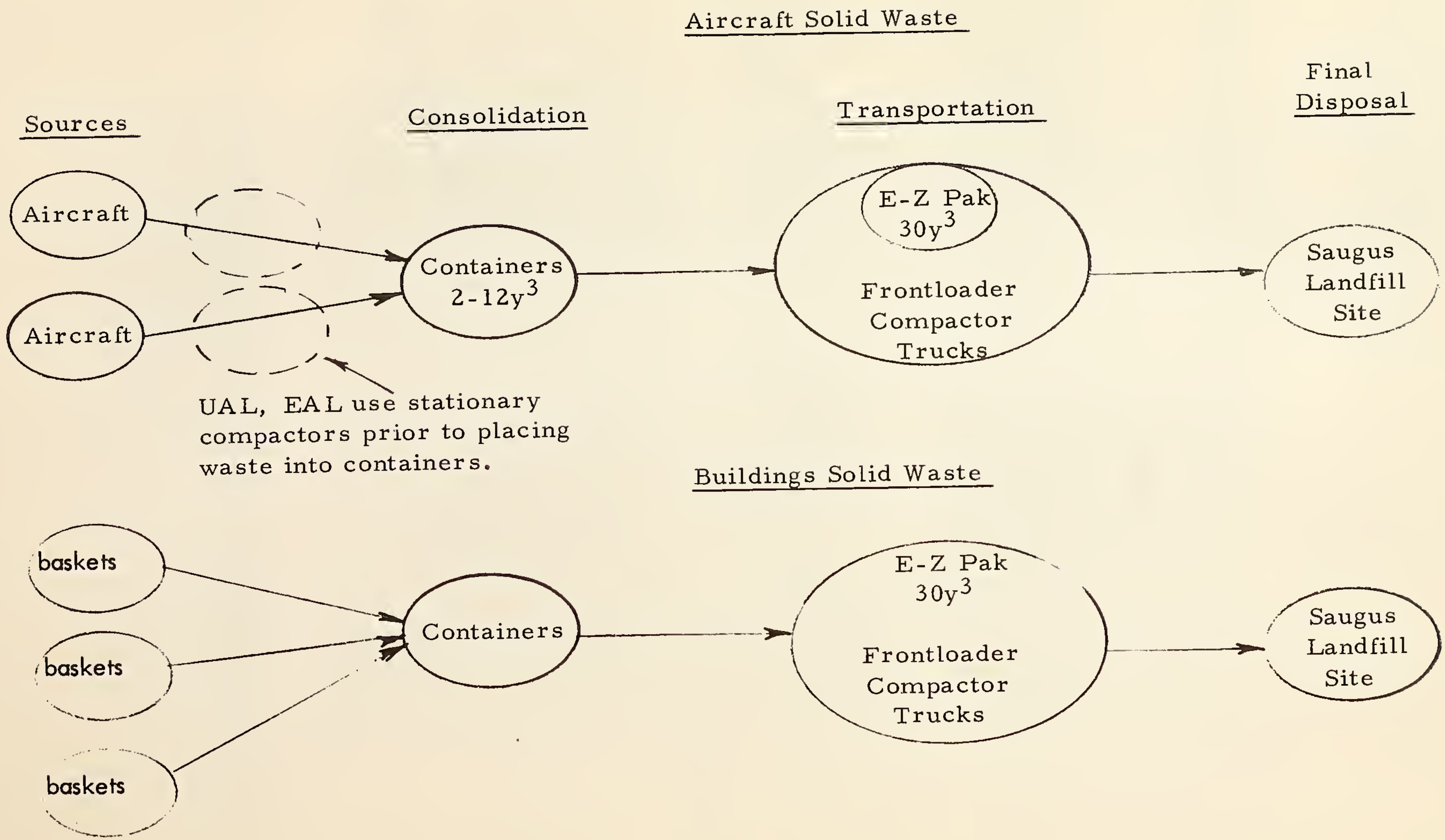
Solid waste generated at Boston-Logan International Airport and in aircraft is containerized and transported by commercial collectors to disposal sites from aircraft and the terminal building. Exhibit IV-21 shows the flow of solid waste.

One commercial collector has ninety percent (90%) of the Boston-Logan business estimates, an average daily collection of 20 tons which is transported by truck to the Saugus landfill site. Dooley Brothers Incorporated has placed an estimated 150 solid waste containers ranging in size from two to twelve cubic yards around the airport. The containers are serviced by an E-Z Pack 30 cubic yard front loaded compactor truck which hauls three loads daily to the Saugus landfill site. Each load weighs six to seven tons. Two airlines process the solid waste with compacting units prior to collection. United Airlines and Eastern Air Lines facilities employ stationary compactor units which compact solid waste into a joint container.

The solid waste generated by Boston-Logan International Airport is disposed of in a fashion which does not affect water quality in Boston Harbor.

EXHIBIT IV-21

Flow of Solid Wastes From
Aircraft and Airport Buildings



5. <u>THE IMPACT OF THE PROPOSED DIKES AND RELATED DREDGING ON WATER QUALITY WAS ANALYZED BY FAY, SPOFFORD AND THORNDIKE, INC.</u>

The firm of Fay, Spofford, and Thorndike, Inc. studied the ecological effects of the materials specified for the construction of the dikes and of the fill behind the dikes (9). There analysis shows that the ecological impact of the proposed dikes is minimal. Their analysis shows that:

- the material to be disposed of at sea is relatively clean,
- the material does not remain in suspension for a long period of time.

The results of the chemical tests on the need to be dredged are compared to the Environmental Protection Agency dredging criteria on Exhibit IV-22.

These analyses show that the ecological impact of the dredging and fill material will be minimal.

The aesthetic aspects of the dikes is discussed in detail in Chapter VII of this report.

6. <u>AIRPORT IMPROVEMENTS WILL HAVE MINIMAL EFFECTS ON WATER QUALITY IN AREAS SURROUNDING BOSTON-LOGAN INTERNATIONAL AIRPORT.</u>

Specific recommendations that will reduce current water pollution hazards include:

(1) The overflows from the City of Boston Coleridge and Moore Streets sewer must be stopped.

EXHIBIT IV-22

CHEMICAL TESTS ON MUD
TO BE DREDGED

Environmental Protection Agency Dredging Criteria

Item	Limit % Dry Weight	% Samples Logan Mud
Volatile Solids	6%	2.93%
Chemical Oxygen Demand (C.O.D.)	5%	4.42%
Total Kjeldahl Nitrogen	0.10%	0.12%
Oil-Grease	0.15%	0.016%
Mercury	0.0001%	0.000077%
Lead	0.005%	0.000053%
Zinc	0.005%	0.000085%

Note: Data provided by Fay, Spofford, and Thorndike, Inc.

- A waiver should be obtained from the FAA to delay fill in BH-C until the sewer overflows have been stopped. At such time, the need for this fill will be re-examined.

(2) The impact of fuel spill pollution is being reduced by the programs initiated by the Massachusetts Port Authority. These programs will continue.

(3) The practice of emptying holding tanks should cease as soon as feasible.

(4) The solid waste dumps located on airport property should be removed and the City of Boston should be encouraged to prevent dumping on properties surrounding the airport to improve existing conditions.

(5) The frequency of shoreline clean up operations will be increased by the Massachusetts Port Authority.

V. BIBLIOGRAPHY

(1) "Biological Aspects of Water Quality Charles River and Boston Harbor, Massachusetts" Technical Advisory and Investigation Branch Federal Water Pollution Control Administration, U. S. Department of the Interior, January 11, 1968.

(2) "Chemical and Physical Aspects of Water Quality Charles River and Boston Harbor, Massachusetts" Technical Advisory and Investigation Branch Federal Water Pollution Control Administration, U. S. Department of the Interior, February, 1968.

(3) "Proceedings Conference on the Pollution of the Navigable Waters of Boston Harbors and its Tributaries" U. S. Department of the Interior, Federal Water Pollution Control Administration, May 20, 1968, Boston, Massachusetts.

(4) "Joint Report on Pollution of the Navigable Waters of Boston Harbor" United States Department of the Interior, Federal Water Pollution Control Administration Northeast Region, New England Basins Office, and Massachusetts Water Resources Commission Department of Natural Resources, Division of Water Pollution Control, April 1, 1969.

(5) "Proceedings of the Conference in the Matter of Pollution of the Navigable Waters Boston Harbor and its Tributaries" U. S. Department of the Interior, Federal Water Pollution Control Administration, April 30, 1969, Boston, Massachusetts.

(6) "Progress Toward Achieving the Water Quality Goals for Boston Harbor" Inland River Basin Commission, Boston Harbor Coordinating Group, October, 1970.

(7) Interviews with ATA Officials," May 5, 1971.

(8) "Gas Turbine Engine Emissions Characteristics and Future Outlook," A. W. Bristol Jr., SAE-DOT Conference on Aircraft and the Environment, February 8-10, 1971, Washington, D.C.

(9) Report by Fay, Spofford and Thorndike, Inc. to Massachusetts Port Authority, May 7, 1971

CHAPTER V

STUDIES OF CURRENT AND PROJECTED LEVELS OF AIRBORNE MATERIALS AT BOSTON-LOGAN INTERNATIONAL AIRPORT

I. INTRODUCTION

1. PURPOSE

This Study was undertaken to determine the potential effects of air pollutants emitted by aircraft operations at Boston-Logan International Airport. Both the hazards and/or annoyance factors of air pollutant concentrations within the airport boundaries and the contribution of aircraft operations to the overall environment of the Boston Metropolitan Area were evaluated. Finally, projections of changes in production of the four major pollutants from 1970 through 1975 were calculated for a number of possible airport configurations and use patterns in order to evaluate the potential effects of introduction of a new parallel runway system.

2. GENERAL

In the calculation of aircraft emissions, the general practice is to include only the ground operation of the vehicles and in-flight operations below 3,000 feet. The emissions at higher altitudes cannot be considered in the same light as those emitted at or near ground level due to major differences in diffusion at higher altitudes and to differences in efficiency of aircraft engine operation. Calculation of emission factors based on operations below 3,000 feet have become accepted practice for use in Congressional investigations pursuant to the Air Quality Act of 1967 (1) as well as in airport planning studies (e.g. Heathrow, Los Angeles County reports (2, 3).

Total emissions below 3,000 feet are estimated on the basis of the landing-takeoff (LTO) cycle which includes approach, landing, taxiing, takeoff and climbout. Taxiing includes all operations from engine start-up to actual takeoff. Though only about twenty percent (20%) of total aircraft fuel is consumed during the LTO cycle, about eighty percent (80%) of all the airborne contaminants are emitted during this phase of aircraft operation (1). The amount of emission in eoch phase of the LTO cycle is dependent on a number of factors such as use of noise abatement procedures, waiting time, length of taxiway, permissible rate of climb, etc.

Gosoline or diesel fuel, if pure hydrocarbons, would be completely combusted to carbon dioxide (CO_2) and water (H_2O) in one hundred percent (100%) efficient engine operation. The production of these moterials is not of interest becouse the levels produced are infinitesimol when compored to the omounts of these moterials normally in the atmosphere. Current engines do not achieve one hundred percent (100%) efficient operation, however, turbine engines are much more efficient users of fuels than the OTTO cycle engines powering automobiles. Due to the presence of impurities in the fuels or due to incomplete combustion which is worse during inefficient phases of engine operotion, five other moteriols which can be produced are of interest as potential pollutants, i.e., carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), hydrocorbons and particulate matter. In generol, sulfur contents of oviotion fuels are negligible. Consequently, this is not usuolly considered in aircroft operotion analyses (1).

However, sulfur dioxide can be produced in the combustion of heating fuels, in the production of electricity, and by other modes of transportation. This, then, must be considered in total airport operations. Hydrocarbons, which are emitted by aircraft operations, are generally at a fixed rate to particulate matter, therefore need not be measured, only calculated (14). In general, studies of air pollution consider the emission and concentration of all five of these chemical species.

Effects of these materials can be estimated by either or both of two routes. The ambient concentration of each of these may be determined and compared to the known data about the effects of these materials. Such publications as the Air Quality Criteria originally published by the U.S. Department of Health, Education and Welfare (4, 5, 6, 7, 8) in response to the Air Quality Act of 1967 and now under review by the Environmental Protection Agency and a wealth of other scientific and medical literature can be used as guidelines for this evaluation. Rather than highlighting the utilization of actual concentrations at any given moment, a second approach involves the calculation of total annual emissions from aircraft and the determination of the contribution of aircraft to the metropolitan area. This technique has been adopted in analysis of such airports as Heathrow London (2), Los Angeles County (3) and, in the past Boston-Logan International Airport (13). To do this, calculations are made of the effects of the LTO cycle on the emission of chemicals. The contribution of these to overall air contamination is then determined. Such a calculation has the value of discounting diurnal, daily and seasonal variations to permit the evaluation of the overall effects of aircraft operations on the surrounding community. Such an approach is useful in assessing the effects of alternate airport configurations rather than in the determination of the air quality within the airport confines.

3. APPROACHES

(1) Current levels of the five materials of interest in the Boston Metropolitan area were determined by analysis of published literature available from the Massachusetts Department of Health, from the U.S. Department of Health, Education and Welfare (4, 5, 6, 7, 8) and from other local studies such as the recent research conducted at Northeastern University (14).

(2) Field measurements of carbon monoxide, oxides of nitrogen, oxides of sulphur, and particulates were made in and around the airport. The sites of measurement are shown in Exhibit V-1. These sites were selected to permit comparison of results from this study with those from the definitive studies of Heathrow and Los Angeles County Airports (2, 3). Comparisons were made of the airports and evaluations of potential effects made by literature analysis. The actual analyses* were made in accordance with methodology described by the American Society of Testing and Materials (ASTM) (15, 16, 17, 18, 19). Samples were always selected at the downwind end of the runway having greatest use. Other studies have shown that this procedure maximizes air concentration data providing conservative or maximized estimates of ambient air concentration (2).

(3) Calculations were made of total 1970 emissions by aircraft of carbon monoxide, oxides of nitrogen, hydrocarbons and particulates during LTO based on the operating characteristics of air carriers and using the actual number of aircraft operations. Projections of such emissions have been made for 1975 under the existing and improved airport configurations using historical and/or noise abatement use patterns. The emission totals were then compared to total chemical emissions within other airports and within Metropolitan Boston.

(4) The literature was reviewed to determine the effects on health and social welfare of the various pollutants considered (9) in this study. Other operations which could lead to air pollution were studied. Analysis was made of the published literature on production of pollutants by aircraft operations and the various publications were gathered into a single bibliography for review. The overall effect of Boston-Logan International Airport aircraft operations on pollution was calculated and related to the general conditon of air environment in 22 metropolitan centers in the United States (4).

(5) A review of the anticipated and mandated changes in aircraft engines was made to determine the effect of these on pollutants. The magnitude of these changes has been studied (25).

* Analysis conducted by the Environmental Resources Group of Booz, Allen & Hamilton Inc. in the laboratories of Foster D. Snell, Inc., the Chemical and Biological subsidiary of BA&H, Inc.

II. SUMMARY

Analyses were made for two weeks during the Spring of 1971 of the actual concentration of the four important air contaminants (Carbon Monoxide, Sulfur Dioxide, Nitrogen Oxides and Particulates) in and around Boston-Logan International Airport. Calculations were also made to estimate total production of the four materials usually emitted by aircraft, using the 1970 and 1975 traffic demands, using both the existing and the improved airport. Comparisons were made between these ambient concentrations and emission levels and those reported for other airports and metropolitan centers in the United States and abroad, as well as those reported for Metropolitan Boston and Boston-Logan International Airport, by other investigators, to validate the findings. With this done, the actual levels and projected emission data were compared to the established standards to evaluate potential hazard and annoyance effects of current and projected operations.

The contribution of Boston-Logan International Airport operations to total airborne materials in the Greater Boston Area is small in comparison to other sources. This will not change significantly by 1975.

Comparison of actual concentrations of airborne chemicals with suggested air quality criteria has shown that current levels will not be health hazards or annoyance factors based on the EPA standards which recently became official. Calculations of effects of increased operations show that concentrations should remain within the prescribed standards.

Anticipated and mandated changes in jet aircraft engine design as well as changes in operational procedures will permit reduction in total emissions by aircraft. However, if other operational changes were implemented for noise abatement purposes, significant increases in air pollution production will result if the airport is not improved.

The greatest single emission abatement factor can be achieved through reduced ground operations of aircraft where inefficient engine operation produces high concentrations of undesirable chemical species.

The evolution of various chemicals into the air will be less in 1975 if the airport is permitted to develop by the introduction of the new 15L-33R parallel runway than would be the case if the anticipated traffic volume is confined to the existing runway configurations. Conservative projections for 1975 traffic demand, utilizing the current airport show that ground operating time will more than double using the existing airport and historical patterns of operation where noise abatement procedures are attempted. Increases will be greater by almost 3-4 times if noise abatement procedures are optimized. Airport improvement will reduce aircraft waiting time which results in the highest emissions due to inefficient engine operations.

In summary, the production of airborne chemicals due to airport operations is small when compared to that from other sources within the Boston Metropolitan area. Although the chemical emissions produced by aircraft do not now constitute any form of recognized hazard with respect to the concentration levels, these should be controlled through the exercise of good practice where possible. These include operations, changes and introduction of new airport runway systems. The latter will permit reduced ground aircraft operation time for aircraft when compared to the aircraft ground operation times without the improvement.

III. CONCLUSIONS

1. FOUR CHEMICAL SPECIES ARE RECOGNIZED AS UNDESIRABLE PRODUCTS OF AIRCRAFT OPERATIONS:

- Carbon Monoxide
- Oxides of Nitrogen
- Particulate Matter
- Hydrocarbons

The first three of these have been detected in the ambient environment of Boston-Logan International Airport during two weeks in the Spring of 1971.

2. A FIFTH MATERIAL, SULFUR DIOXIDE, IS COMMONLY FOUND IN THE ENVIRONMENT OF ANY CITY, INDUSTRIAL OPERATION, ETC. THIS, TOO, HAS BEEN DETECTED AT BOSTON-LOGAN INTERNATIONAL AIRPORT.

3. LEVELS OF THESE POLLUTANTS ARE BELOW EITHER THE PRIMARY OR SECONDARY MAXIMA WHICH HAVE BEEN RECOMMENDED BY THE ADMINISTRATOR OF THE ENVIRONMENTAL PROTECTION AGENCY IN MAY, 1971 (9).

   - No concentration of any of these materials was found which exceeded the levels recommended by the Administrator.

4. THE AVERAGE LEVELS OF THESE MATERIALS WITHIN THE AIRPORT ARE EQUAL TO OR LESS THAN LEVELS OF SIMILAR MATERIALS MEASURED IN THE CITY OF BOSTON OR AT OTHER AIRPORTS SUCH AS HEATHROW (LONDON) OR LOS ANGELES COUNTY WHERE EXTENSIVE STUDIES HAVE BEEN DONE (2, 3).

5. **AIRCRAFT OPERATIONS APPEAR TO CAUSE LESS THAN HALF OF ONE PERCENT (1/2%) OF THE FORMATION OF CARBON MONOXIDE, OXIDES OF NITROGEN, HYDROCARBONS, AND PARTICULATES FOUND IN THE BOSTON METROPOLITAN AREA.**

- Sulfur dioxide praduction is nat usually associated with aircraft operatians because af low cantent af sulfur in aircraft fuels.
- Using data published by the Federal Gavernment for Metrapalitan Boston, 1970 aircraft aperatians at Bostan-Logan Internatianal Airpart have contributed the follawing to tatal levels af pallutants in the Boston Metrapolitan area.
  - 0.54% of carbon monoxide
  - 0.39% of axides af nitrogen
  - 0.57% af hydrocarbons
  - 0.60% of particulate matter
- The predaminant winds at Boston-Logan International Airport favor the mavement of these to sea thereby further minimizing the significance of these values.

6. **AIRCRAFT OPERATING ON THE GROUND APPEAR TO CAUSE ABOUT EIGHTY PERCENT (80%) OF ALL AIRCRAFT EMISSIONS BELOW 3,000 FEET; THIS IS A FUNCTION OF WAITING TIME.**

7. **COMPARISON OF FIVE POSSIBLE MODES OF BOSTON-LOGAN INTERNATIONAL AIRPORT OPERATION REVEALS THAT GROUND WAITING TIME AND TOTAL CHEMICAL EMISSIONS CAN BE CONTROLLED AND MINIMIZED ONLY THROUGH INTRODUCTION OF THE NEW PARALLEL RUNWAY PERMITTING OPTIMIZATION OF NOISE ABATEMENT PROCEDURES WITHOUT INCURRING FURTHER DEPARTURE DELAYS.**

TABLE 1

Condition	1	2	4	5	6
Chemical Species	Current Airport Configuration Output Operation Mode	Current Airport Configuration Maximum Capacity Operation	Current Airport Configuration Noise Abatement Operation Mode Alternative 1	Current Airport Configuration Noise Abatement Operation Mode Alternative 2	Improved Airport Maximum Noise Abatement Mode
	1970	1975	1975	1975	1975
			Tons/Year		
Carbon Monoxide	5,030	10,626	13,479	15,757	7,934
Oxides of Nitrogen	669	768	1,022	1,142	828
Hydrocarbons	394	1,415	1,999	2,095	985
Particulate Matter	498	600	740	893	464

8. THE PROGRAM TO COMPLETE RETROFIT OF EXISTING AIRCRAFT WITH "SMOKELESS" ENGINES MUST CONTINUE IN ORDER TO REDUCE PARTICULATE AND HYDROCARBON EMISSIONS EVEN FURTHER. THIS WILL SIGNIFICANTLY REDUCE PARTICULATE EMISSION PER HOUR OF WAITING TIME.

9. A FURTHER REDUCTION IN HYDROCARBON EMISSIONS CAN BE ACHIEVED THROUGH SPECIFIC CONTROL OF IN-FLIGHT DUMPING OF FUELS ACCUMULATED IN HOLDING TANKS IN AIRCRAFT; THIS RULE MUST BE STRICTLY ENFORCED.

10. THE EFFICIENT USE OF THE BOSTON-LOGAN INTERNATIONAL AIRPORT CAN BE ACHIEVED WITH A PROGRAM TO MAINTAIN MAXIMUM NOISE ABATEMENT AND WITHOUT SIGNIFICANT INCREASE IN AIRBORNE CHEMICAL EMISSIONS FROM AIRCRAFT ONLY IF THE AIRPORT CAPACITY IS INCREASED THROUGH RUNWAY IMPROVEMENT, WITH CONCOMITANT CONTROL OF WAITING TIME.

11. PRELIMINARY ESTIMATES INDICATE THAT AIR QUALITY AT BOSTON-LOGAN INTERNATIONAL AIRPORT WILL BE IMPROVED IN 1975 ONLY IF THE PARALLEL RUNWAY IS CONSTRUCTED.

IV. DISCUSSION

1. THE SPECIFIC LEVELS OF AIR POLLUTANTS AT BOSTON-LOGAN INTERNATIONAL AIRPORT WERE DETERMINED IN FIELD STUDIES

(1) Air Samples Were Taken at Boston-Logan International Airport and in the Surrounding Areas of Boston During Two Weeks in the Spring, 1971.

- Air samples for carbon monoxide, oxides of nitrogen and sulfur dioxide were taken two times each day 100 yards from the end of the downwind end of the most active takeoff runway in use at the time of sample collection.

  - Studies at Heathrow Airport (2) have shown that collection of samples in this manner, i.e. at the downwind end of the most active runway permits determination of maximum ambient levels of those air pollutants produced by aircraft.

  - In these same periods using sulfur dioxide as the parameter since this is not produced (to any significant extent) by air or other vehicle operations, the investigators (2) showed that use of the downwind sampling technique reduced the effect of the surrounding community on the airport permitting determination of airport conditions which are a function of airport operations.

- Continuous (24-hour) particulate sampling was carried out at four selected sites on the airport during the specified period.

- Random samples were also taken in Winthrop, South Boston, Point Shirley, North Terminal and within the Sumner and Callahan Tunnels for examination for all four chemicals.

- The location of the sampling points is shown in Exhibit V-1.

(2) The Results of the Various Determinations Have Been Summarized in Table .

- The average levels in the airport were:

LOCATION OF AIR SAMPLING USING HIGH VOLUME AIR SAMPLER

Stations	High Volume Continuous Air Samplers
1	Near 22L Location
2	Near 33 Location
3	Near Mid-Point of 4L-22R Location
4	Near 15 Location
5	Wiggins Terminal Location
6	Winthrop Location
7	Point Shirley Location

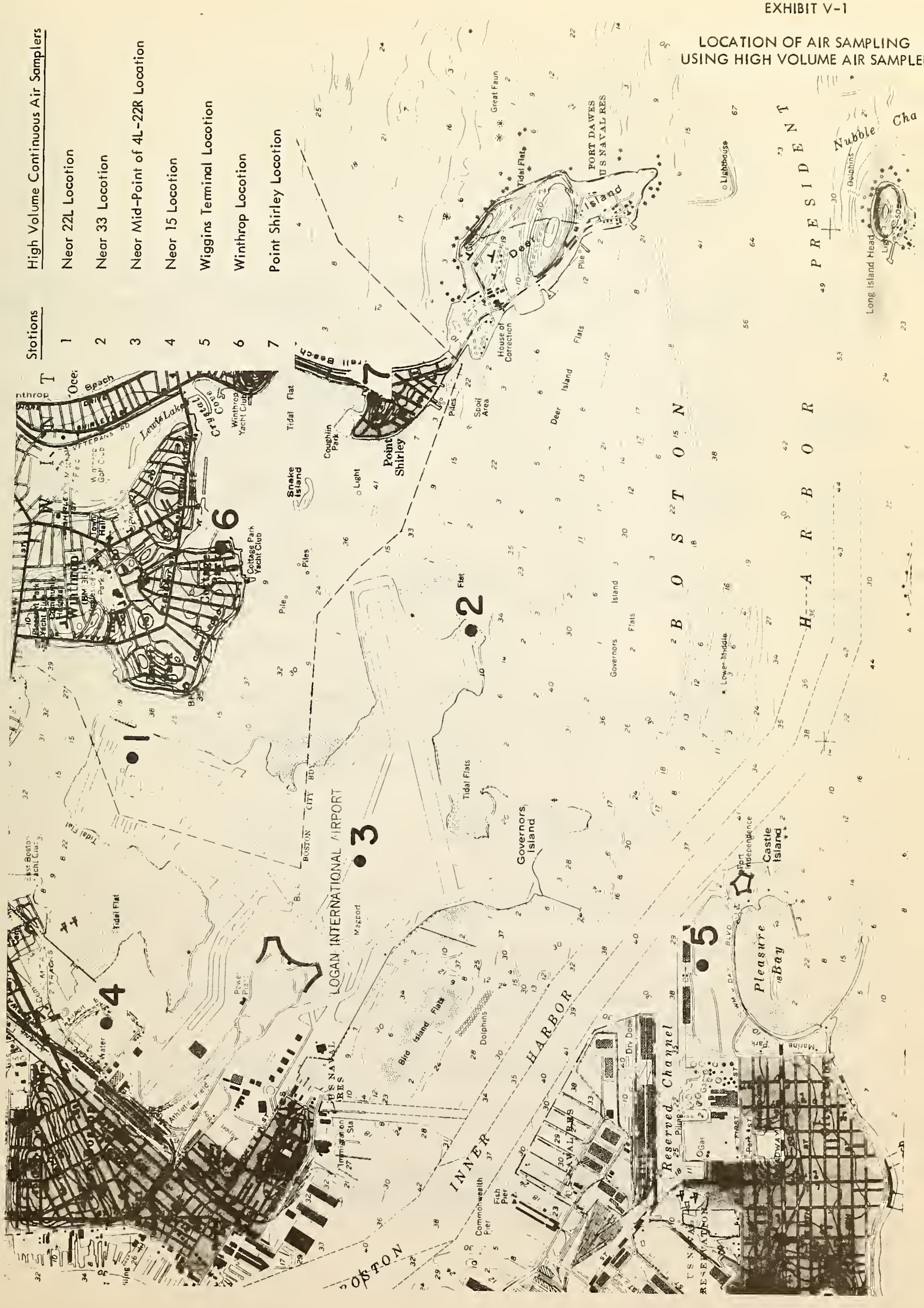


TABLE 1

Ambient Air Levels of Four Pollutants

Chemical Species	Method	Boston-Logan International Airport Average	S.D. 1/	n 2/	Other Location South Boston	Winthrop	Point Shirley
		µg/M³			µg/M³		
Carbon Monoxide (16)	Gas Chronat-agraphy	n.d.	-	20	20 to 26	n.d.	n.d.
Oxides of Nitrogen (17)	ASTM D-1607-69	11	6.31	60	9 to 40	7	11, 14, 16
Particulate Matter (19)	Gravimetric 5/	50	22.48	35	50 to 80	68	48, 50
Sulfur Dioxide (18)	ASTM D.2914-70T	14	11.635	36	0, 7	0	14, 16

1/ Standard Deviation = $\sqrt[2]{\frac{(Xa - X)^2}{n-1}}$

2/ n = no. of determinations

3/ n.d. = none detectable or less than 11.6 µg/M³

4/ In continuous collection at 50 ft.³/Min. on glass fiber filter paper retaining all particles greater than 0.02 milli microns in size.

5/ µg/M³ = micrograms per cubic meters

6/ Measurements taken from April 20 to May 5, 1971.

Note: Field measurements were performed by the Environmental Resources Group of Booz, Allen & Hamilton Inc. with the analysis performed at and by personnel of F. D. Snell, Inc., a chemical and biological subsidiary.

- Carbon Monoxide — non-detectable*
- Oxides of Nitrogen — 11 $\mu g/M^3$**
- Sulfur Dioxide — 14 $\mu g/M^3$
- Particulate matter — 35 $\mu g/M^3$

* non-detectable = less than 11.6 $\mu g/M^3$

** $\mu g/M^3$ = micrograms/cubic meter

. Levels within surrounding areas were measured as follows:

- Carbon Monoxide — non-detectable to 25.5 $\mu g/M^3$
- Oxides of Nitrogen — 9 to 40 $\mu g/M^3$
- Sulfur Dioxide — 0 to 17 $\mu g/M^3$
- Particulate Matter — 48 to 68 $\mu g/M^3$

. The results are summarized in Table 1.

. These results were collected under a wide variety of wind headings and wind speeds which were analyzed and compared to the general conditions prevailing at Boston-Logan International Airport throughout the year.

- Wind conditions on the days during which the study was conducted are given in Table 2.
- During the study period wind blew out to sea (192° to 033°) 66.1 percent of time.
- In a five year study of wind direction (1959-1963) wind blew out to sea 68.2 percent (26).

(3) <u>The Data for Particulate Matter is in General Agreement with Those from the Studies</u>.

. In August, 1969, W. A. Martin of Northeastern University (14) found particulate matter levels to be higher in the City than at the airport.

- Average particulate matter levels at the airport were 64 $\mu g/M^3$ (35 readings).

- Levels in the City of Boston average 150 and 156 $\mu g/M^3$ at each of two sites.

. In studies at Heathrow Airport (2), particulate matter averaged 20 and 30 $\mu g/M^3$ at each of two sites during April, 1970. These values are of the same order of magnitude as the findings in this study which showed average values of 35 $\mu g/M^3$ for Boston-Logan International Airport during two weeks in the Spring of 1971.

(4) <u>In Other Studies (2) the Sulfur Dioxide Data were Considered to Reflect Effects of Surrounding Communities and Industries on the Airport.</u>

. At Heathrow average sulfur oxide values, April through September, varied from 59 to 91 $\mu g/M^3$ while those in the surrounding communities varied from 87 to 117 (2).

- The substantially higher sulfur dioxide levels at Heathrow and in the surrounding communities reflect the continued use of high sulfur coals in the United Kingdom (2).

- The investigation at Heathrow reported the windborne movement of sulfur dioxide from surrounding town to the airport where dilution occurs (2).

. The Boston-Logan International Airport heating and air-conditioning plant currently uses low sulfur (less than 1%) fuel in winter and natural gas during the summer. Thus, its emissions of sulfur dioxide are low.

(5) <u>The Findings of no Detectable Carbon Monoxide Levels at Boston-Logan International Airport are Consistent with Other Airport Studies.</u>

. At Heathrow Airport during more than 715.7 hours of study, carbon monoxide concentration exceeded 11.6 $\mu g/M^3$ for only 36.5 minutes (2).

. At Los Angeles County Airport carbon monoxide concentrations of less than 11.6 $\mu g/M^3$ were noted on most days (3).

TABLE 2

Summary of Wind Conditions
April 20 through May 5, 1971

Wind Headings (Magnetic)	April - May, 1971 Absolute	April - May, 1971 Percent	Jan, 1959 thru Dec. 1963 (20) Percent
349-010	34	9.3	4.29
011-033	14	3.8	3.40
034-055	10	2.7	3.75
056-078	13	3.5	3.99
179-100	25	6.8	4.67
101-122	18	4.9	4.74
123-146	23	6.3	3.38
147-169	17	4.6	2.84
170-191	24	6.6	4.35
192-213	11	3.0	6.89
214-235	14	3.8	8.82
236-258	26	7.4	8.57
259-280	31	8.5	8.65
281-303	46	13.0	10.78
304-326	43	12.2	9.13
326-348	18	5.1	7.73
Total	367	101.5	95.98

- Using a paired sampling study, it was shown that carbon monoxide values in the airport were equivalent to those outside of the airport and in downtown Los Angeles.

. Where significant differences of carbon monoxide levels exist among sites, the higher values are always associated with internal combustion engines, or ground vehicle traffic. The values at new locations are the:

- City of Boston locations support this.

- The data from the Los Angeles Study supports this.

2. THE SPECIFIC LEVELS OF AIR POLLUTANTS AT BOSTON-LOGAN INTERNATIONAL AIRPORT WERE EXAMINED BY COMPARISON TO THE LEVELS WHICH HAVE BEEN PROPOSED BY THE ENVIRONMENTAL PROTECTION AGENCY.

(1) The Administration of EPA Has Published New National Air Quality Standards for Sulfur Oxides, Particulate Matter, Carbon Monoxide, and Nitrogen Oxides (9). The Proposed Standards are Shown in Table 3.

A literature survey of known estimates of the effects of pollutants on health has been performed and is presented as an appendix to this Chapter.

(2) Values for Carbon Monoxide, Oxides of Nitrogen and Sulfur Dioxide Were Always Below the Secondary Chronic Exposure Standards - These Are Considered as Acceptable in Terms of Both Human Health and Annoyance.

Based on the EPA standards, the current conditions will not represent annoyance during human activities including recreation.

(3) Approximately Twenty Percent (20%) of the Particulate Values Exceeded the Recommended Secondary Chronic Exposure Standards:

. Two of 41 values exceeded the primary chronic exposure standards.

. None of the values approaches the secondary single exposure criteria.

- The secondary single exposure standards is 150 $\mu g/M^3$

- The highest recorded value at the airport in this study was 105 $\mu g/M^3$

- Values in the City during the study by W.A. Martin averaged 150 and 156 $\mu g/M^3$ in August 1969.

. Attention must be paid to further development of "smokeless aircraft engines" which emit fewer particulates.

- All airport studies reflect the level of particulates to be the greatest emission annoyance of aircraft operation.

- The program to retrofit JT8D engines to reduce particulates will continue and is expected to be essentially completed by the end of 1972.

3. <u>THE CONTRIBUTION OF AIRBORNE CHEMICALS BY AIRCRAFT OPERATIONS AT BOSTON-LOGAN INTERNATIONAL AIRPORT TO THE BOSTON METROPOLITAN AREA HAVE BEEN CALCULATED FOR 1970.</u>

(1) <u>Combining Estimates of Fuel Alloted the Various Phases to the LTO Cycle with a Knowledge of Performance Characteristics of Each Type of Aircraft Permits Calculation of Aircraft Emission During 1970.</u>

. The calculated emission factors for 1970 are shown in Table 4.

. A greater portion of the carbon monoxide and oxides of nitrogen is produced during in-flight phases of LTO.

- Approximately sixty percent (60%) of carbon monoxide is produced in-flight.

- Approximately seventy-three percent (73%) of oxides of nitrogen are produced in-flight.

. The greater portions of hydrocarbons and particulate matter is emitted during the ground phases of LTO.

- Approximately eighty-four percent (84%) of hydrocarbons is produced during aircraft ground operations.

TABLE 3

Air Quality Standards Proposed by
The Federal Environmental Protection
Agency (9)

Chemical Species	Primary Standards 1/		Secondary Standards 2/		Values at Logan Airport 3/	
	Chronic Exposure 4/	Single Exposure 5/	Chronic Exposure	Single Exposure	Average	Range
	micrograms/M^3					
Carbon Monoxide	10	15	10	15	n.d. 6/	n.d.
Oxides of Nitrogen	100	250	100	250	11	1-28
Particulate Matter	75	260	60	150	35	19-105
Sulfur Oxides	80	365	60	260	14	0-46

1/ Primary standards are designed to protect human health.

2/ Secondary standards are designed to protect against effect on soil, water, vegetation, materials, animals, weather, visibility, personal comfort and well-being.

3/ During April and May, 1971.

4/ Annual arithmetic means.

5/ Maximum 24 hour exposure, not more than once per year.

6/ None-detectable.

- Fifty-two percent (52%) of particulate matter is produced during aircraft ground operations.

(2) <u>Aircraft Exhaust Emissions Generated During Current Ground Operations Were Calculated.</u>

. The average fuel quantities consumed by aircraft at Boston-Logan International Airport are presented below. These quantities represent averages used by airlines for flight planning purposes (27). The quantities are based on current (i.e. airline 1970 data) and have been confirmed using interviews of the staff of operations at Boston-Logan International Airport (28).

• The data presented herein represents the average quantities of fuel consumed by aircraft during normal taxiing and idling conditions as existed during 1970.

- DC-8 1600 lbs.
- Boeing 727 1350 lbs.
- Boeing 737 800 lbs.
- DC-9 500 lbs.
- Boeing 747 2000 lbs.
- DC-10 1500 lbs. (estimate)

Note: The amount of fuel was determined by interviews of airlines operating at Boston-Logan International Airport

The underlying assumptions on which the calculations were based include the following:

- Delays affect departures only since incoming aircraft is usually maintained in a holding mode at altitudes greater than 3,000 feet. Thus it is assumed that arrival delay does not contribute to emissions as defined by the HEW procedure (1).

- Emissions caused by general aviation aircraft larger than 12,500 lbs. have been included with the air carriers.

- Emissions caused by general aviation aircraft smaller than 12,500 lbs. have been excluded from the calculations.

- Traffic data used for the calculations is presented in detail in Chapter I of this report.

TABLE 4

Total Cumulative Emissions
From Aircraft Operations at
Boston-Logan International Airport in 1970 1/

Condition 1

Departure Delay 4,000 Hrs.

Aircraft Type	Phase of LTO Cycle	Carbon Monoxide	Oxides of Nitrogen	Hydrocarbons	Particulate Matter
		Tons/Year			
4-Engine Jet	ground	746.4	36.9	178.1	111.3
	air	1,398.3	249.3	35.8	93.4
3-Engine Jet	ground	635.0	25.6	121.9	76.3
	air	757.4	136.5	19.3	68.6
2-Engine Jet	ground	589.5	24.5	11.7	73.0
	air	866.9	155.1	22.3	57.7
4-Engine 747	ground	19.3	.7	3.7	2.2
	air	17.9	40.9	0.7	15.3
Totals	ground	1,990.2	87.7	315.4	262.8
	air	3,040.5	581.8	78.1	235.0
Grand Total		5,030.7	669.5	393.5	497.8

1/ Calculated from the techniques suggested by the Department of Health, Education and Welfare (1) and the Conference on Aircraft and the Environment (21).

2/ The airborne portion of the operations are analyzed up to and down from an altitude of 3,000 feet.

3/ Ground operations are based on the actual average quantity of fuel consumed by aircraft on the ground.

- As peak waiting times increase from 30 minutes during winter to 45 mintues during the summer tourist season, a commensurate amount of additional fuel will be used.

- These estimates are borne out by the actual measurements made at Heathrow Airport (London) during the period of April through September, 1970 (2).

(3) <u>The Annual Emissions of Airborne Chemicals at Boston-Logan International Airport Represents a Small Percentage of the Total Air Pollutants in the Boston Metropolitan Area.</u>

- Two studies of total air pollutant load in Boston have been published recently.

  - In one (13) prepared for the Metropolitan (Boston) Air Pollution Control District, total Sulfur Dioxide and Particulate Matter Loads were calculated for 1966 by estimating all the sources of pollution.

  - In the second study for the Federal Government under the Air Quality Act, air levels were actually determined on random samples and total emission calculated for 1967-68 (4).

  - The data from the two studies are shown in Table 5.

  - As a base for this study, the data from the 1967-68 study were considered as more accurate since these were actually determined other than estimated only.

- On the basis of the data in the 1967-68 study the contribution of aircraft operations to total pollution in Boston was approximately one-half of one percent in 1970:

  - Carbon Monoxide 0.54%

  - Oxides of Nitrogen 0.39%

  - Hydrocarbons 0.45%

  - Particulate Matter 0.60%

TABLE 5

Summary of Annual Pollutant
Emissions in the
Boston Metropolitan Area

Chemical Species	1966 MAPCD Study (13)	1967-1968 Air Quality Act Study (4)
	------------- Tons/Year-	-------------
Carbon Monoxide	Not determined	921,000
Oxides of Nitrogen	Not determined	168,000
Hydrocarbons	Not determined	87,000
Particulates	40,754	82,000
Total		1,258,000

(4) Weather Conditions at Boston-Logan International Airport Favor Dispersion of Aircraft Emissions Over the Ocean (26).

- Wind movement in the directions of 190° to 032° will move air pollutants toward the ocean.
- The wind movement is in this overall direction 249 days per year.
  - 62 days per year at five to nine mph or
  - 79 days per year at 10 to 14 mph
  - 104 days per year at 15 to 29 mph
  - 4 days per year at 30 mph or greater
- Wind directions at Boston-Logan International Airport are shown in Exhibit V-2.

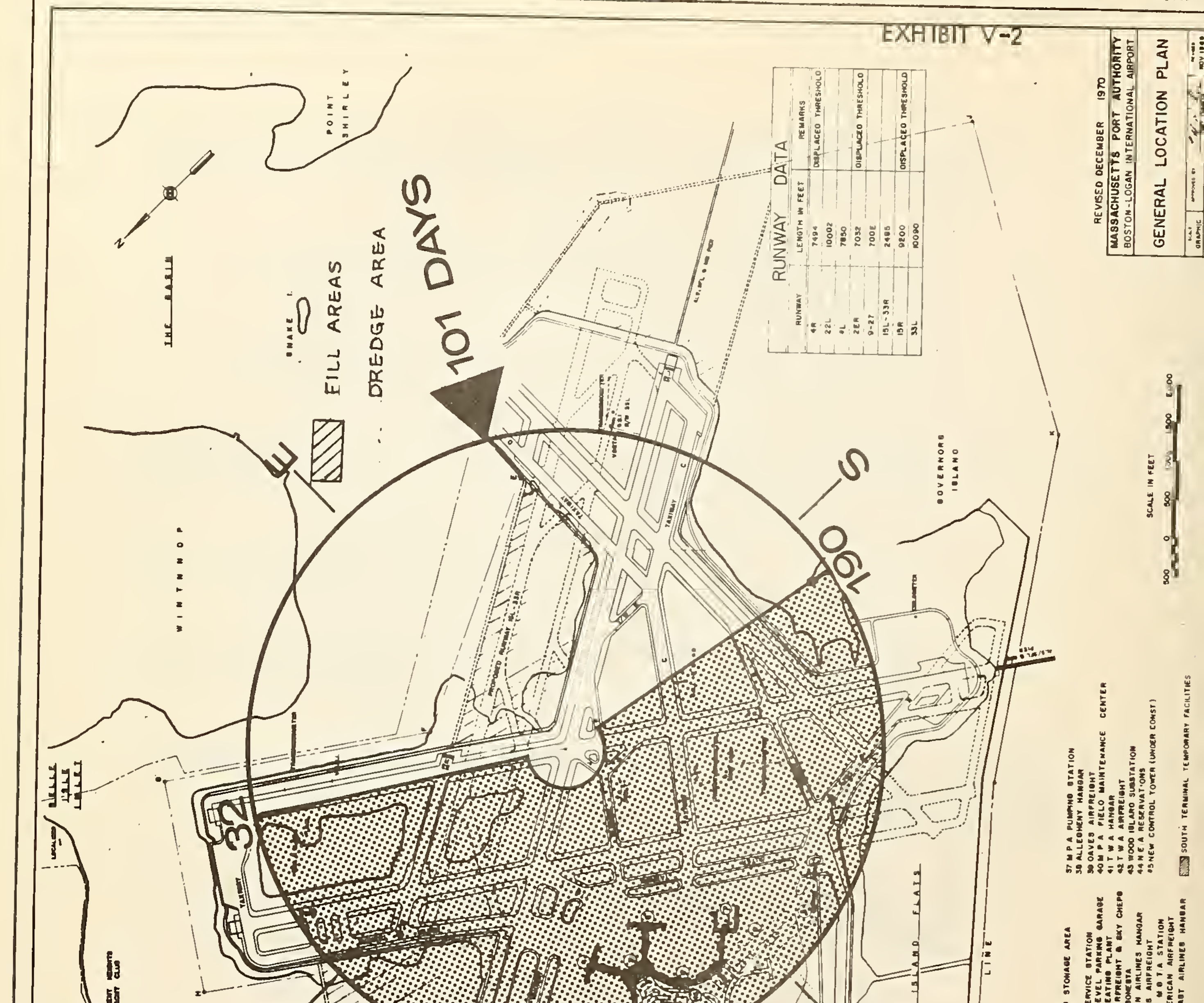
4. POSITIVE STEPS ARE REQUIRED TO MINIMIZE ENGINE EMISSIONS AS AIR TRAFFIC INCREASES.

(1) The Most Significant Reduction and Control Must be Achieved With Particulate Matter.

- Concentrations of particulate matter are high in relation to published primary and secondary standards.
- Particulates are relatively stable materials which do not readily decompose.
- Smoke and particulates have been constantly cited as the key problems of aircraft emissions in studies at Heathrow Airport and in testimony to the United States Congress (1, 2, 3).

(2) New Aircraft Power Plants are Being Installed Which Will Reduce Production of Hydrocarbons and Particulate Matter (24).

EXHIBIT V-2



RUNWAY DATA

RUNWAY	LENGTH IN FEET	REMARKS
4R	7494	DISPLACED THRESHOLD
22L	10002	
4L	7850	
22R	7032	DISPLACED THRESHOLD
9-27	7000	
15L-33R	2495	
15R	9200	DISPLACED THRESHOLD
33L	10090	

- The retrofit programs on DC-9's, 727's, 737's will be substantially completed by the end of 1972.

- The new wide-body jets such as the 747 and DC-10 incorporate "smokeless engines" which will produce significantly less hydrocarbons and particulate matter.

- It is anticipated that installation of these units will reduce specific particulate emission (pounds of particulates formed per 1,000 pounds of fuel) significantly.

  - At idle (during waiting time) particulate emissions will be reduced fifty-nine percent (59%).

  - Under power, as in taxi or in-flight, particulate emissions will be reduced twenty-three percent (23 %)

- If all two and three jet aircraft in 1970 had carried the retrofitted engines particulate annual emissions would have been approximately 339 tons as contrasted with the actual value of 498 tons.

(3) <u>Further Efforts Must be Made to Reduce Ground Waiting Time Since the Majority of Particulates are Formed in that Portion of the LTO Cycle. Such Control Must be Exercised with Anticipated Increases in Airport Traffic.</u>

The traffic demands projected for 1975 at Boston-Logan International Airport could be handled in two major ways. Attempts could be made to operate the airport in its current configuration (i.e. no. 15L-33R parallel). The operational modes could be theoretically tailored to three conditions which are explained fully in Appendix A.

<u>Existing Airport</u>

- <u>Condition 2</u>

  Condition 2 consists in maximizing the capacity of the airport and results in 8,308 hours of annual departure delays.

- Condition 3

  Condition 3 closely approximates Condition 2 and hours have not been re-calculated.

- Condition 4

  Condition 4 consists in noise abatement alternative No. 1 and results in 10,597 hours of annual departure delays.

- Condition 5

  Condition 5 consists in noise abatement alternative No. 2 and results in 15,693 hours of annual departure delays.

From a practical operational standpoint, the noise relief obtainable in Condition 4 cannot be realistically achieved without the delays approaching those developed in Condition 5. The detailed explanations of Conditions 4 and 5 are given in Appendix B. This point is also discussed in Chapters I, II and III.

The increases in departure delay time have been translated into increases in the quantity of fuel consumed by air carrier aircraft during the ground operation phase of the LTO cycle. It has been assumed that for the purposes of the calculations of projected emissions, the fuel to be consumed by various air carrier aircraft in 1975 is proportional to the 1970 fuel consumption and to the 1970 departure delays.

Improved Airport

Aircraft operating conditions resulting in maximum noise abatement due to over the water flights have been considered for the projected 1975 traffic demand using the improved airport (i.e. with 15L-33R runway).

- Condition 6

  Condition 6 consists in maximum noise abatement and results in 6,939 hours of annual departure delay.

(4) <u>Ground Delay Time Will More Than Double Using the Current Runway System and the Historical Pattern of Operations (Condition 2)</u>

- 1970 departure waiting time is approximately 4,000 hours per year during which a total of 2,656 tons of chemical emissions occur.

- Total 1970 emissions from aircraft were calculated to be 6,592 tons as compared to the 1.25 million tons produced in the Boston Metropolitan area.

- At the anticipated level of 1975 operation departure waiting time will increase to 8,300 hours annually with a concurrent increase to double the current emission levels from waiting aircraft.

  - A complete summary of emissions under this mode of operation is shown in Table 6.

  - Total emissions in 1975 under this mode of operations will be 13,409.4 compared to 10,209.7 tons if airport is improved.

  - All emission predictions are conservative allowing for some significant reduction in particulate emission anticipated from engine retrofit. It is possible that the new power plant designs will actually yield a far greater reduction (20).

(5) <u>Ground Delay Time Will be Increased by Approximately Two and a Half to Four Times If the Current Airport Runway System is Used in 1975 with Programs to Further Noise Abatement (Conditions 4 and 5).</u>

- If noise abatement measures are followed at all times except during maximum peak hours, departure waiting times of 10,597 hours are forecast (Condition 4 - noise alternative 1)

- If all possible noise abatement measures are taken and over-the water takeoffs are maximized then 15,693 hours of departure waiting time are forecast (Condition 5 - noise alternative 2).

- Total emissions generated by aircraft under Condition 4 will be approximately 17,239 tons annually as compared to the total emissions of 6,591.5 tons in 1970.

TABLE 6

Total Cumulative Emissions Anticipated From Aircraft Operations
at Boston-Logan International Airport In 1975
Using The Current Runway System and The Maximum Capacity
Noise Abatement Alternative 1

Condition 2

Departure Delay 8,308 Hrs.

Aircraft Type	Phase of LTO Cycle	Carbon Monoxide	Oxides of Nitrogen	Hydrocarbons	Particulate Matter
		Tons/Year			
4-Engine Jet	ground	2,395.5	110.0	223.5	191.7
	air	702.4	127.7	18.0	46.6
3-Engine Jet	ground	2,082.5	83.3	400.5	103.3
	air	623.0	112.8	16.0	20.7
2-Engine Jet	ground	1,404.5	56.5	269.9	72.0
	air	503.9	90.7	14.3	16.7
4-Engine 747	ground	662.9	26.3	126.9	46.1
	air	201.6	36.0	5.1	5.7
3-Engine DC-10	ground	1,737.5	69.5	332.7	88.7
	air	311.7	56.0	7.9	8.8
Totals	ground	8,282.9	345.6	1,353.5	501.8
	air	2,342.6	423.2	61.3	98.5
Grand Total		10,625.5	768.8	1,414.8	600.3

Note 1: Calculated from techniques suggested by Department of Health, Education and Welfare (1).

Note 2: Airborne portion of the operations are analyzed up and down from altitude of 3,000 feet

Note 3: Ground operations are based on projected average quantities of fuel consumed by aircraft on ground as anticipated for 1975.

Condition 5 is a more realistic practical alternative than Condition 4.

- Complete summaries of the calculations of emissions under Conditions 4 and 5 are shown in Tables 7 and 8.

(6) <u>Ground Departure Delay Time Will be Increased Significantly Less With Introduction of the Projected 15L-33R Parallel Runway.</u>

- Despite the larger forecast for operations, total departure delay time in 1975 is anticipated to be about 6,939 hours per year with the introduction of the new runway system and a maximization of noise abatement procedures.

- Such an operation, it is anticipated, will produce a total of about 10,209.7 tons per year as contrasted with current totals of 6,591.5 tons per year from ground operations and potential reduction of 7,029.4 tons per year from operations in Condition 2 or 3,132.2 tons per year from Condition 4 or 9,577.6 tons per year from Condition 6.

  - A tabular comparison of emission production under Conditions 2, 4, 5, 6 is given in Table 10.

- The new runway will also result in similar arrival delays. Aircraft circuling high above the airport generate pollutants. The HEW procedure (1) is limited to altitudes of 3,000 feet above the airfield and thus the pollution generated by aircraft above 3,000 feet has not been calculated. It can be said the new runway will reduce this pollution by reducing arrival delay time.

(7) <u>Selection of the Improved Airport With Maximum Noise Abatement Procedures Will Yield Significantly Lower Amounts of Emissions than Use of Current Runway Systems and Noise Abatement Alternative No. 2. The Reductions That are Possible are Detailed Below.</u>

. Carbon Monoxide	7,823.6 tons/year
. Oxides of Nitrogen	214.1 tons/year
. Hydrocarbons	1,110.6 tons/year
. Particulates	429.3 tons/year

4. <u>THE AIR QUALITY OF BOSTON-LOGAN INTERNATIONAL AIRPORT WILL BE ACCEPTABLE IN 1975 ONLY IF THE NEW RUNWAY SYSTEM IS COMPLETED.</u>

TABLE 7

Total Cumulative Emissions Anticipated From Aircraft Operations
at Boston-Logan International Airport In 1975

Condition 4

Departure Delay 10,597 Hrs.

Aircraft Type	Phase of LTO Cycle	Carbon Monoxide	Oxides of Nitrogen	Hydrocarbons	Particulate Matter
		-Tons/Year-			
4-Engine Jet	ground	2,366.3	94.5	454.4	202.9
	air	1,040.3	186.2	26.6	68.9
3-Engine Jet	ground	2,686.4	107.0	514.7	138.7
	air	921.6	167.2	23.7	30.7
2-Engine Jet	ground	1,783.0	73.0	348.6	93.8
	air	834.0	134.3	21.2	24.8
4-Engine 747	ground	848.6	34.0	162.8	43.8
	air	297.5	53.3	7.7	8.4
3-Engine DC-10	ground	2,239.3	89.4	427.1	115.0
	air	461.7	82.9	11.7	13.1
Totals	ground	9,923.6	397.9	1,907.6	594.2
	air	3,555.1	623.9	90.9	145.9
Grand Total		13,478.7	1,021.8	1,998.5	740.1

Note 1: Calculated from the techniques suggested by the Department of Health, Education and Welfare (1).

Note 2: The airborne portion of the operations are analyzed up to and down from an altitude of 3,000 feet.

Note 3: Ground operations are based on the actual projected average quantity of fuel consumed by aircraft on the ground as anticipated for 1975.

TABLE 8

Total Cumulative Emissions Anticipated From Aircraft Operations
at Boston-Logan International Airport In 1975
Using The Current Runway System and Maximum
Noise Abatement Procedures
Alternative 2

Condition 5

Departure Delay 15,693 Hrs.

Aircraft Type	Phase of LTO Cycle	Carbon Monoxide	Oxides of Nitrogen	Hydrocarbons	Particulate Matter
		Tons/Year			
4-Engine Jet	ground	3,547.8	168.9	331.0	282.9
	air	1,040.3	186.2	26.6	69.0
3-Engine Jet	ground	3,084.3	123.4	593.1	158.0
	air	922.7	167.1	23.7	30.7
2-Engine Jet	ground	2,080.1	83.6	399.7	106.6
	air	746.4	134.3	21.2	24.8
4-Engine 747	ground	981.9	39.0	187.9	68.3
	air	298.6	53.3	7.7	8.4
3-Engine DC-10	ground	2,573.3	102.9	492.8	131.4
	air	461.7	82.9	11.7	13.1
Totals	ground	12,267.4	417.8	2,004.5	747.2
	air	3,469.7	623.8	90.9	146.0
Grand Total		15,757.1	1,141.6	2,095.4	893.2

Note 1: Calculated from the techniques suggested by the Department of Health, Education and Welfare (1).

Note 2: The airborne portion of the operations are analyzed up to and down from an altitude of 3,000 feet.

Note 3: Ground operations are based on the projected average quantity of fuel consumed by aircraft on the ground as anticipated for 1975.

TABLE 9

Total Cumulative Emissions Anticipated From Aircraft Operations
at Boston-Logan International Airport In 1975
Using The Expanded Runway System and Maximum
Noise Abatement Procedures

Condition 6

Departure Delay 6,939 Hrs.

Aircraft Type	Phase of LTO Cycle	Carbon Monoxide	Oxides of Nitrogen	Hydrocarbons	Particulate Matter
		Tons/Year			
4-Engine Jet	ground	1,111.4	44.5	203.7	134.7
	air	1,040.3	186.2	26.6	69.0
3-Engine Jet	ground	1,237.4	49.6	237.3	57.3
	air	921.6	167.2	23.7	30.7
2-Engine Jet	ground	930.8	37.2	179.6	48.2
	air	835.1	149.7	21.5	27.4
4-Engine 747	ground	57.7	15.7	75.9	20.4
	air	297.5	53.3	7.7	8.4
3-Engine DC-10	ground	1,040.0	41.2	197.1	54.7
	air	461.7	82.9	11.7	13.1
Total	ground	4,377.3	188.2	893.6	315.3
	air	3,556.2	639.3	91.2	143.6
Grand Total		7,933.5	827.5	984.8	463.9

Note 1: Calculated from the techniques suggested by the Department of Health, Education and Welfare (1).

Note 2: The airborne portion of the operations are analyzed up to and down from an altitude of 3,000 feet.

Note 3: Ground operations are based on the projected average quantity of fuel consumed by aircraft on the ground as anticipated for 1975.

(1) The Calculations on Emissions Were Made Very Conservatively, i.e., at a Maximum Since All Predicted Factors for New "Smokeless" Engines are not Yet Fully Evaluated.

(2) Based on These Conservative Estimates and on the Observed Concentrations of Air Pollutants During April-May, 1971 Projections of Pollutants Concentration Can be Made for 1975.

- A simple ratio comparing current (1970) annual production of pollutants with anticipated 1975 production can be extended to estimate concentrations in 1975.

- The simplicity of the calculation is based on three assumptions:

  - The wind conditions factors in 1975 will be approximately equal to those in April-May of 1971.

  - The level of air pollutants measured in this study is representative of the prevailing conditions throughout the year.

  - Since the great majority of the air pollutants generated at Boston-Logan International Airport are due to aircraft, changes in aircraft activity will reflect changes in projected concentrations of pollutants.

- The estimated concentrations for the four modes of operation are compared to 1971 air quality standards in Table 11.

- The particulate values exceed standards for good air quality in Condition 2, Condition 4, Condition 5 but not for Condition 6.

  - Conservative allowances for lower particulate emissions by new power plant designs permit the following estimates. These estimates project that there will be a net decrease in the tons of particulate emissions for Condition 6 only.

Traffic Demand	Tons/Year of Total Particulate Emissions
1970 - Actual	497.8
1975 Condition 2	600.3
1975 Condition 4	740.1
1975 Condition 5	893.2
1975 Condition 6	463.9

(3) <u>Strict Enforcement of a Rule Against Dumping of Fuel Holding Tanks Must be Made in Order to Realize Further Control of Pollutants.</u>

- About 111 gallons of fuel was dumped daily from all aircraft in 1970.
- Reduction of this dumping will reduce hydrocarbon pollution by more than 40,520 gallons per year.
- Action to control this practice is beyond the power of the Massachusetts Port Authority. Corrective action must be voluntary on the part of the air carriers or be directed by Federal Authority.

(4) <u>Calculations to Project the Anticipated Concentration of Air Pollutants Expectedat Boston-Logan International Airport Have Been Made for 1975.</u>

- The data is presented in Table 11.

(5) <u>The Graphical Comparisons, Illustrating the Conditions at the Airport, With the Conditions in the Metropolitan Area are Shown in Exhibit V-3.</u>

TABLE 10

Comparison of Anticipated Emissions
In 1975 Under Various Operating Modes

Chemical Species	Condition 2 1/	Condition 4 2/	Condition 5 3/	Condition 6 4/
Carbon Monoxide	10,625.6	12,478.7	15,757.1	7,933.5
Oxides of Nitrogen	768.8	1,021.8	1,041.6	827.5
Hydrocarbons	1,414.8	1,998.5	2,095.4	984.5
Particulate Matter	600.3	740.1	893.2	463.9

Note 1: Using current runway system maximum capacity

Note 2: Using current runway system for noise abatement alternative 1

Note 3: Using current runway system for noise abatement alternative 2

Note 4: Using improved runway system for maximum noise abatement

TABLE 11

Anticipated Concentrotions of Air Pollutants at
Boston-Logon International Airport in 1975

Chemical Species	Primary Standards		Secondary Standords		Observed 1971 1/		Yellow 1975 Condition 2		Orange 1975 Condition 4		Red 1975 Condition 5		Green 1975 Condition 6	
	Chronic	Acute	Chronic	Acute	Averoge	Moximum Observed Volues	A	B	A	B	A	B	A	B
	ug/M^3													
Carbon Monoxide	10	15	10	15	n.d. 9/	-	-	- 10/	-	-	-	-	-	-
Oxides of Nitrogen	100	250	100	250	11	to 28	16	40	17	44	20	50	12	26
Particulate Matter	75	260	60	150	35	105	33	98	53	158	63	190	32	97
Sulfur Dioxide 6/	80	365	60	260	14	46	22	63	38	123	39	127	20	65

1/ Actuol measurements made from April 20, 1971 through May 5, 1971.

2/ Using calculated number of operotions and the current airpart configuratian for maximum capacity.

3/ Using calculated number of operotians, the current airport configuration for noise abotement Alternative 1.

4/ Using colculoted number of operations, the current airport configuration for noise abatement Alternative 2.

5/ Using calculated number of operations ond the improved airport for maximum noise obatement.

6/ Estimated changes are based on calculated increoses in carbon monoxide productian.

7/ Primary standords are designed to protect human health.

8/ Secondary standards are designed to protect against effect on soil, woter, vegetation, materials, animals, weather, visibility, personal camfort and well-being.

9/ None-detected.

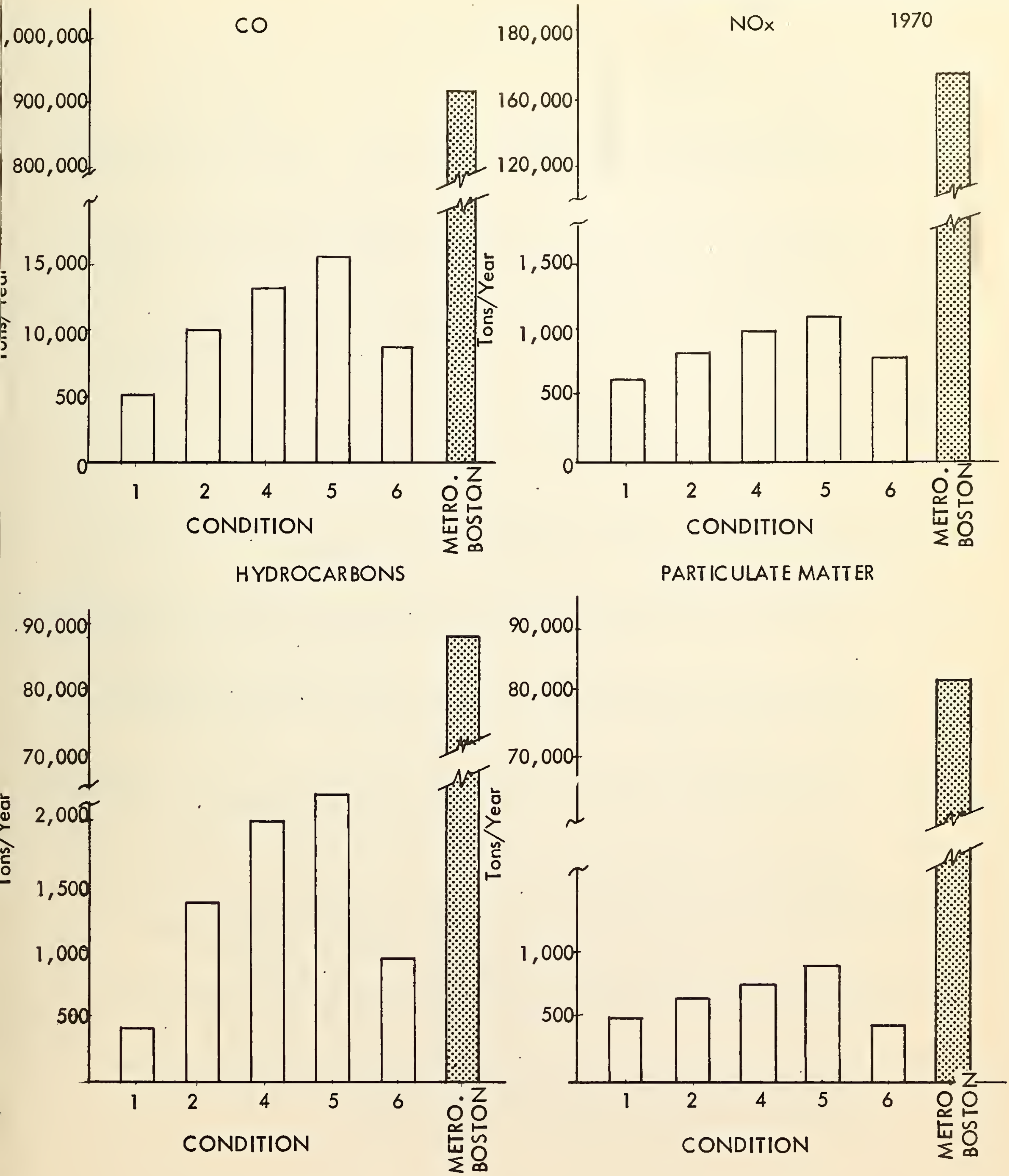
10/ No extrapolation was mode, since little or no corbon monoxide was found in 1971.

A. Predicted Averoge

B. Predicted Maximum Average

EXHIBIT V-3

COMPARISON OF TOTAL POLLUTANTS



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Appendix to

Report on Hazardous, Nuisance Causing and

Safe Levels of Certain Air Pollutants

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APPENDIX V-I

REPORT ON

HAZARDOUS, NUISANCE CAUSING AND SAFE LEVELS

OF CERTAIN AIR POLLUTANTS

TABLE OF CONTENTS

I. INTRODUCTION

I. INTRODUCTION

This report is an estimation of safe, nuisance causing and hazardous levels of the following air pollutants.

- SO_2
- CO
- NO_x
- Hydrocarbons
- Particulates

II. BACKGROUND

II. BACKGROUND

The National Air Pollution Control Administration has from time to time set guidelines for acceptable levels of the air pollutants discussed in this report. Most recently (1/30/71) the Environmental Protection Agency has proposed national air quality criteria for various pollutants. A copy of an article describing the proposed new standards is appended.

There is a substantial body of literature concerning the effect of varying quantities of the pollutants in question, particularly as related to human exposure in industry. Threshold limits as suggested for industrial installations in the past have tended to be on the high side although more recent threshold limits approved by the American Conference of Governmental and Industrial Hygienists (ACGIH) have been more realistic.

III. NOMENCLATURE

III. NOMENCLATURE

Present practice is to express levels of various pollutants in air as micrograms per cubic meter abbreviated as ug/m^3, or in some cases such as CO as milligrams per cubic meter, abbreviated as mg/m^3.

Milligrams per cubic meter implies a weight to volume relationship. In many literature references quantities of pollutants are expressed as parts per million (ppm). In the case of gaseous substances this almost invariably refers to parts of the gas by volume rather than by weight. Since such nomenclature is now outdated it is necessary to convert from a volume to volume basis to a weight to volume basis. The following equations may be used.

To convert ppm to milligrams per liter:

$$\text{ppm} \times \frac{\text{molecular weight}}{24450} = \text{milligrams per liter.}$$

For SO_2, CO and NO_x the following may be used:

SO_2	MW64,	ppm x .00262	=	mg/liter
CO	MW28,	ppm x .001145	=	mg/liter
$NO_{1.5}$	MW38,	ppm x .001554	=	mg/liter

IV. SAFE LEVELS

To convert mg/liter to ug/m^3, multiply by 1,000,000. Therefore the conversion of ppm to ug/m^3 can be expressed as follows for different pollutants.

SO_2, ppm x 2620 = ug/m^3

CO, ppm x 1145 = ug/m^3

$NO_{1.5}$, ppm x 1554 = ug/m^3

As an example the accepted ACGIH threshold level for SO_2 of 5 ppm becomes 13,100 ug/m^3.

IV. SAFE LEVELS

As previsouly mentioned, the Environmental Protection Agency has proposed air quality criteria fro six common classes of air pollutants. In brief, the safe levels proposed are as follows:

Pollutant	ug/m^3
SO_2	80
Nitrogen oxides	100
Hydrocarbons	125
Particulate matter	75
Photochemical oxidants	125

Pollutant	mg/m^3
CO	10

These levels are annual mean figures designed to protect human health. The same report describes secondary standards, designed to protect against effects on soil, water, vegetation, materials, animals, weather, visibility, personal comfort and well-being. These levels are as follows:

Pollutants	ug/m^3
SO_2	60
Nitrogen oxides	100
Hydrocarbons	125
Particulate matter	60
Photochemical oxidants	125

Pollutants	mg/m^3
CO	15

The report also defines levels which are allowable for certain periods of time, not be exceeded more than once per year.

V. NUISANCE LEVELS

V. NUISANCE LEVELS

It is difficult to exactly define what would constitute a nuisance level of a pollutant. The safe levels described in the previous section are beyond the capacity of human beings to recognize. We could, therefore, define nuisance levels roughly as being levels wherein the pollutant is:

- Directly discernible by humans through the senses of taste, smell or vision.
- Discernible by being the cause of phenomena such as haze or fog recognizable by humans.

Such levels could be delineated as follows:

Pollutants	ug/m^3	Evidence of presence
SO_2	786-2620	Can be tasted
CO	see note 3	None
NO_x	155	Recognizable odor
Hydrocarbon	see note 1	Recognizable odor
Particulate	see note 2	Reduction of visibility

Note 1

Most hydrocarbons which are products of combustion possess a distinctive and recognizable odor. The threshold of recognition of such odors is not available at this writing.

Note 2

The levels at which particulates manifest themselves is dependent on many factors such as particle size and color for instance. However, in the presence of SO_2, a reaction between particulates and SO_2 yields substances which cause reduction of visibility at low levels and physical irritation at higher levels. The level of SO_2 at which reaction with particulates becomes evident is about 285 ug/m^3. The corresponding level of particulates may be as low as 80 - 100 ug/m^3. See discussion in section 7.

Note 3

CO is colorless, tasteless and odorless and does not manifest itself at any level. However, it is known the carboxy hemoglobin appears in blood at a detectable level when breathing in an atmosphere containing 77 mg/m^3 of CO.

VI. HEALTH HAZARD LEVELS

VI. HEALTH HAZARD LEVELS

The following table delineates figures from current literature for harmful and lethal levels of pollutants. Hydrocarbons and particulates are not intrinscially lethal but by interaction with nitrogen oxides and ozone in the case of hydrocarbons, and with sulfur dioxide in the case of particulates, can yield harmful reaction products. This is briefly discussed in section VII.

Pollutant	Harmful mg/m^3	Lethal mg/m^3
SO_2	15-30	1310
CO	1145	4588
NO_x	1550	3100
Hydrocarbon	see section VII	
Particulates	see section VII	

VII. INDIVIDUAL POLLUTANTS

VII. INDIVIDUAL POLLUTANTS

SO_2

The bulk of the SO_2 in the atmosphere is derived from the burning of coal and a smaller quantity from combustion of sulfur-containing oil. It is prevalent in the atmosphere of certain cities as the following table shows.

City	SO_2, ug/m^3 (average annual)
San Francisco	26
Chicago	471
New York	445
Kansas City	5

It is noteworthy that levels of SO_2 of no appreciable toxicity can yield very significant toxic results in the presence of particulate matter.

CO

Produced by incomplete burning of coal, fuel oil, gasoline, etc. In comparison with other pollutants CO is much less toxic. It does react with blood hemoglobin to produce carboxyhemoglobin although this reaction is reversible to some extent. The safe limit for CO is 10 mg/m^3 but continuous exposure to such levels can produce detectable amounts of carboxyhemoglobin in blood.

The allowable threshold limit (ACGIH) is 115 mg/m^3 which can produce significant carboxyhemoglobin levels in blood.

NO_x

Nitrogen oxides originate in high-temperature combustion of petroleum fuels and coal. They are not only harmful in their own right but they also can react with hydrocarbons to form photochemical oxidants which are irritating to the mucous membranes.

Hydrocarbons

Hydrocarbons derive mainly from use of petroleum products. Other than the nuisance of their aroma, hydrocarbons are not highly toxic materials but in the presence of nitrogen oxides can yield photochemical oxidants which are irritating and harmful.

Particulates

Rather obviously the nature of particulate matter could vary enormously from area to area yet annual averages from different cities do not vary by any large factor indicating that smoke from coal and petroleum fuels is the principal contributor.

Particulates of themselves are not noticeably harmful although in certain dimensions (the so-called "respirable" air particles of 0.5 to 3 microns in diameter) they can cause damage to lung and bronchial tissues.

It has been found that levels of SO_2 of themselves certainly not toxic, can cause significant health effects in the presence of particulate matter. It has been claimed that levels of 250-500 ug/m^3 of SO_2 can produce significant harmful effects in the presence of 80-100 ug/m^3 of particulate matter.

APPENDIX TO

REPORT ON HAZARDOUS, NUISANCE CAUSING AND

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Air Quality Criteria for Hydrocarbons.
Washington, Department of Health, Education, and Welfare, 1970.
ca 100 pp.

Environmental Protection Agency Proposes National Air Quality Standards

Administrator William D. Ruckelshaus of the Environmental Protection Agency has proposed National air quality standards for six common classes of air pollution: sulfur oxides, particulate matter, carbon monoxide, photochemical oxidants, nitrogen oxides, and hydrocarbons. As published in the Federal Register on January 30, the standards are designed to protect public health and welfare by setting limits on levels of pollution in the air. They apply to all areas of the United States.

Ruckelshaus also announced publication on January 30 of an advance notice of proposed rule making reflecting the agency's intention of proposing regulations affecting use of lead additives in gasoline. He explained that the anticipated regulations would ultimately result in the elimination of lead additives from gasoline.

The Environmental Protection Agency has authority to regulate fuel additives under amendments to the clean air act signed by President Nixon last month. The amendments also call upon EPA to set National primary and secondary air quality standards for those air pollutants for which air quality criteria are published. Primary standards are designed to protect human health. Secondary standards are designed to protect against effects on soil, water, vegetation, materials, animals, weather, visibility, personal comfort, and well-being. The criteria describe the relationship between levels of pollution and the associated effects on health and welfare. Criteria for sulfur oxides, particulate matter, carbon monoxide, oxidants, and hydrocarbons were published by the Federal Government under previous amendments to the law. Criteria for nitrogen oxides were published simultaneously with the proposed National standards.

With each set of criteria, the Federal Government has published a summary of what is known of methods to control each pollutant.

The primary and secondary standards for the six classes of pollution follow:

Sulfur oxides primary standards
- 80 micrograms per cubic meter—annual arithmetic mean
- 365 micrograms per cubic meter—maximum 24 hour concentration not to be exceeded more than once per year.

Sulfur oxides secondary standards
- 60 micrograms per cubic meter—annual arithmetic mean
- 260 micrograms per cubic meter—maximum 24 hour concentration not to be exceeded more than once per year.

Sulfur oxides in the air come primarily from the combustion of sulfur-containing fossil fuels. Their presence has been associated with increased incidence of respiratory diseases, increased death rates and property damage.

Particulate matter primary standards
- 75 micrograms per cubic meter—annual geometric mean
- 260 micrograms per cubic meter—maximum 24 hour concentration not to be exceeded more than once per year.

Particulate matter secondary standards
- 60 micrograms per cubic meter—annual geometric mean
- 150 micrograms per cubic meter—maximum 24 hour concentration not to be exceeded more than once per year.

Particulate matter, solid or liquid, may originate in nature or as a result of industrial processes and other human activities. By itself or in association with other pollutants, it may injure the lungs or cause adverse effects elsewhere in the body. Particulates also reduce visibility and contribute to property damage and soiling.

Carbon monoxide primary and secondary standards
- 10 milligrams per cubic meter—maximum 8 hour concentration not to be exceeded more than once per year.
- 15 milligrams per cubic meter—maximum 8 hour concentration not to be exceeded more than once per year.

Carbon monoxide is a product of incomplete burning of carbon containing fuels, and of some industrial processes. It decreases the oxygen-carrying ability of the blood and, at levels often found in city air, may impair mental processes.

Photochemical oxidants primary and secondary standards
- 125 micrograms per cubic meter—maximum 1 hour concentration not to be exceeded more than once per year.

Photochemical oxidants are produced in the atmosphere when reactive organic substances, chiefly hydrocarbons, and nitrogen oxides are exposed to sunlight. They irritate mucous membranes, reduce resistance to respiratory infection, damage plants, and contribute to deterioration of materials.

Nitrogen oxides primary and secondary standards
- 100 micrograms per cubic meter—annual arithmetic mean
- 250 micrograms per cubic meter—24 hour concentration not to be exceeded more than once per year.

Nitrogen oxides usually originate in high-temperature combustion processes. The presence of nitrogen dioxide in ambient air has been associated with a variety of respiratory diseases. Nitrogen dioxide is essential to the production of photochemical smog.

Hydrocarbons primary and secondary standards
- 125 micrograms per cubic meter—maximum 3 hour concentration (6 to 9 A.M.) not to be exceeded more than once per year.

Hydrocarbons come mainly from the processing, marketing and use of petroleum products. Some of the hydrocarbons combine with nitrogen oxides in the air to form photochemical oxidant.

Under the 1970 amendments, the Environmental Protection Agency will review comments on the proposed standards, and within 90 days publish final standards. The states will then have nine months to submit plans for controlling the sources of pollution to meet the standards. EPA may allow a State up to 27 months to submit plans for achieving secondary standards.

CHAPTER VI

PERIPHERAL FACTORS CONNECTED WITH AIRPORT OPERATIONS

I. INTRODUCTION

1. PURPOSE

This chapter is to present a discussion of two factors, which while peripheral to the airport itself, will be affected by improvement program decisions. One such factor is the impact of glide path separation of aircraft and vessels in the President Roads Anchorage, and the Boston Harbor Main Ship Channel. The other is the relationship of air traffic growth upon access modes to Boston-Logan International Airport.

2. APPROACH

Analysis of the airport geometry and its relationship to Boston Harbor shipping was performed by the consulting team. Additional details are contained in correspondence, dated May 10, 1971, from the Federal Aviation Administration to the Corps of Engineers, included for reference in Appendix D.

Study of access to Boston-Logan International Airport was undertaken by the Massachusetts Port Authority staff. The staff study material is reviewed herein and presented fully in Appendix D.

II. SUMMARY

The analysis conducted in this study shows that the airport improvement program will have a limited effect on peripheral factors. The proposed 15L-33R runway will not represent a hazard to vessels in the harbor ship channel or the President Roads Anchorage although the larger ships anchored near the northern boundary of the anchorage will penetrate the 50:1 approach surface representing a potential obstruction. There will be no change in the airport glide path to runway 4L and 9 as the landing thresholds will remain in their current positions.

Vehicular traffic to and from Boston-Logan International Airport will continue to increase whether or not the improvement program is undertaken. Boston-Logan International Airport generated access trips do contribute to the peak hour congestion problems in the Boston roadway network; however, Logan is only one segment of a total system which requires improvement and expansion. The Massachusetts Port Authority in conjunction with other agencies having direct responsibility for off-airport access are actively seeking solutions to this problem.

III. CONCLUSIONS

1. THE 15L-33R RUNWAY WILL NOT REPRESENT A HAZARD TO VESSELS IN THE HARBOR SHIP CHANNEL OR THE PRESIDENT ROADS ANCHORAGE.

2. EXTENSION OF RUNWAY ENDS 9 AND 4L WILL HAVE NO EFFECT ON SHIPPING.

3. VEHICULAR TRAFFIC TO AND FROM BOSTON-LOGAN INTERNATIONAL AIRPORT WILL INCREASE WHETHER OR NOT THE IMPROVEMENT PROGRAM IS UNDERTAKEN.

4. BOSTON-LOGAN INTERNATIONAL AIRPORT GENERATED ACCESS TRIPS DO CONTRIBUTE TO THE PEAK HOUR CONGESTION PROBLEMS IN THE BOSTON ROADWAY NETWORK. HOWEVER, LOGAN IS BUT ONE SEGMENT OF A METROPOLITAN ROADWAY AND TRANSIT SYSTEM WHICH REQUIRES IMPROVEMENT AND EXPANSION.

5. SHIFTS IN BOSTON-LOGAN INTERNATIONAL AIRPORT'S PASSENGER DEMAND TO ALTERNATE TRANSPORTATION MODES WILL NOT REDUCE PEAK HOUR CONGESTION PROBLEMS IN THE BOSTON ROADWAY NETWORK, BUT MERELY REDISTRIBUTE THIS TRAFFIC FROM ONE AREA TO ANOTHER.

IV. DISCUSSION

Discriptive and analytical material concerning the effect of the airport improvements on water navigation and land areas to the airport is considered in the following discussion.

1. EFFECT ON SHIPPING

(1) The 15L-33R Runway Will Not Represent A Hazard To The Harbor Ship Channel or the President Roads Anchorage.

- The extended center line of the 15L-33R runway intersects the edge of the President Roads Anchorage 6,700 feet from the 33R proposed threshold. At this distance, with latest air navigation aids an aircraft would be 314 feet above mean sea level at the edge of the anchorage. This dimension increases to 375 feet at the center of the anchorage masts for major ships at heights of less than 130 feet above mean sea level will be safely and adequately cleared. The altitudes over the anchorage on the 3 degree glide slope are depicted on Exhibit VI-1. The geometric relationship is similar to that on existing 33L.

- Projection of the 50:1 approach surface to its intersection with the President Roads Anchorage indicates that ships with mast heights of 130 feet will be considered obstructions, as defined in the FAA PART 77 criteria, when anchored near the northern boundary of the anchorage. This condition exists in the shaded area depicted on Exhibit VI-2. The FAA has stated that this condition is not considered a hazard to aircraft or ship operations and it will not affect operating minimums or procedures.

- The main shipping channel is farther from the runway threshold than the anchorage. Thus, there is no question of safety from aircraft relative to the main channel.

(2) The Improvements To Runway Ends 9 and 4L Will Have No Effect on Shipping.

The landing thresholds for these runways are to remain unchanged. Thus, the relationship of the aircraft using these runways to shipping will remain unchanged.

EXHIBIT VI-1

3° Glide Slope
Runway 33R

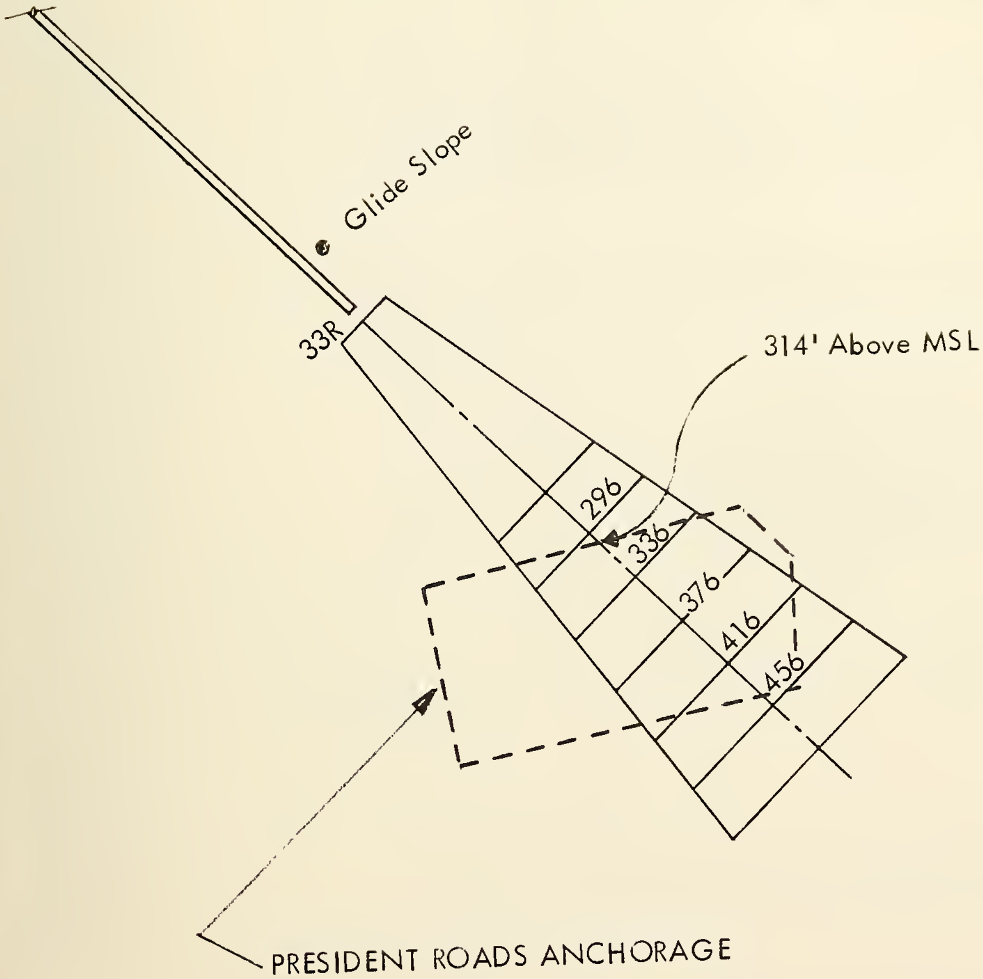
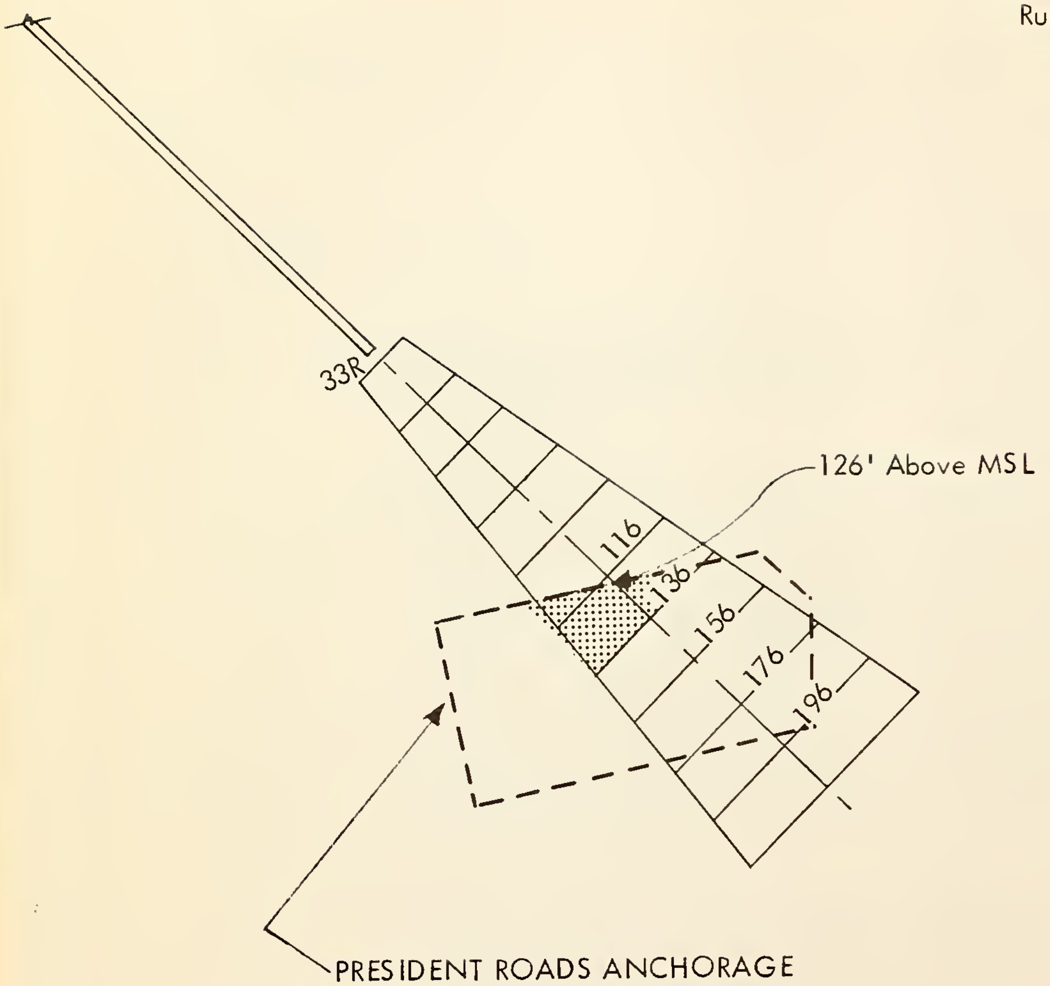


EXHIBIT VI-2

50:1 Approach Surface
Runway 33R



130' Mast penetrates 50:1 approach surface.

2. EFFECT ON AIRPORT ACCESS

(1) Vehicular Traffic To and From Boston-Logan International Airport Will Increase Whether or Not the Improvement Program Is Undertaken.

Whether improvements are made to the airport or not, vehicular traffic is expected to increase. Improvements at the airport will not create a new traffic problem.

(2) Boston-Logan International Airport Is Not the Only Contributor to Highway Access Problems.

The vehicular traffic to and from the airport contributes only a share of the total number of daily and peak hour movements. Consequently, the airport traffic contributes to the total problem and the future problem in the same manner. Technical detail concerning this is in Appendix D.

(3) Mass Transit Is A Potential Alternative Method of Reducing Traffic Volumes.

At the present time public transit services are not heavily used by Boston-Logan International Airport air passengers, employees or visitors. Improvements in service and methods to increase use of this service are under study. See Appendix D for technical detail.

(4) The Total Ground Traffic Situation, of Which Boston-Logan International Airport and Its Operations Are A Part, Will Require Improvements To Ground Access Facilities.

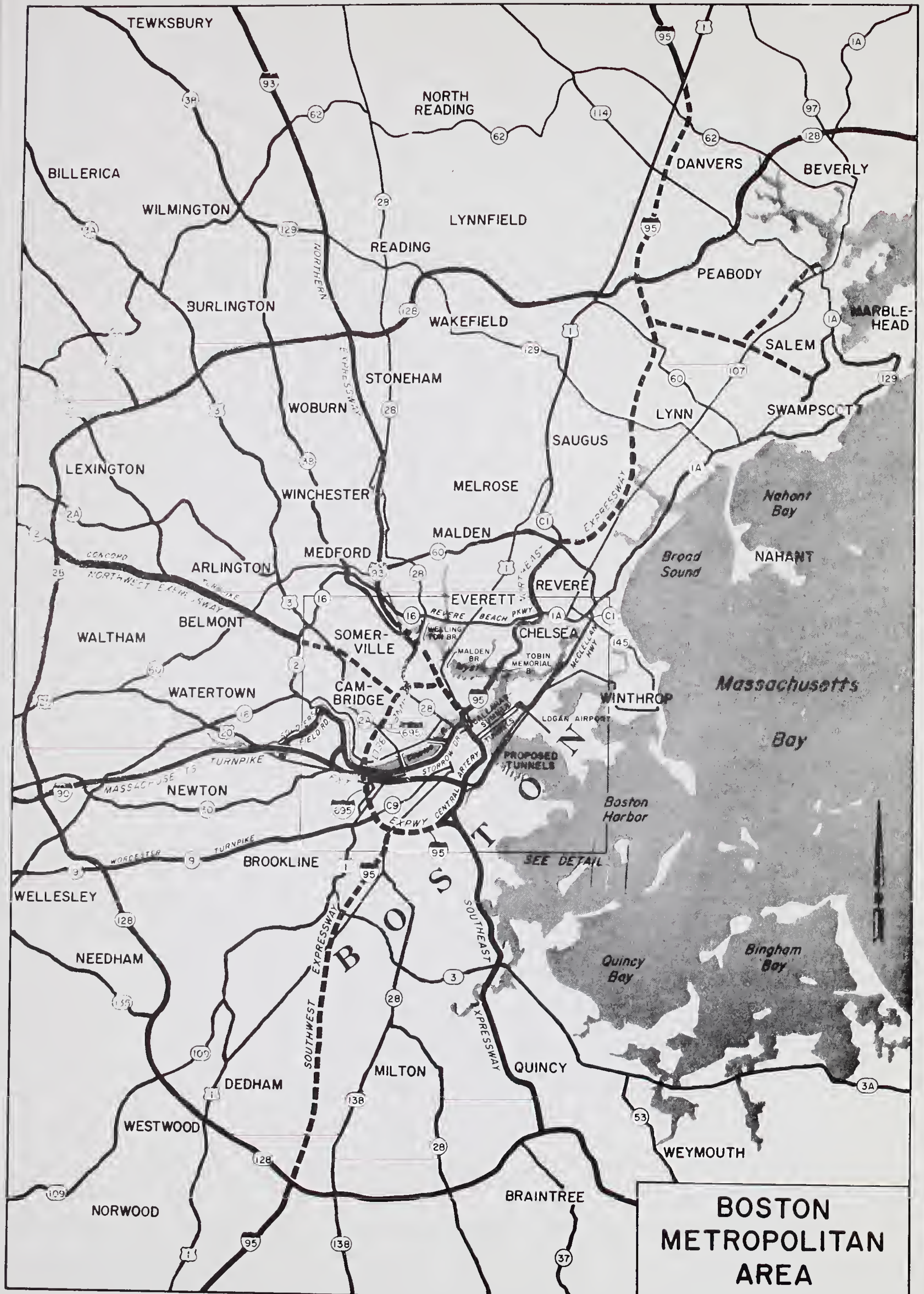
Alternate solutions to improving ground access facilities are under study by the Massachusetts Port Authority in conjunction with other agencies having the direct responsibility. See Appendix D for further information regarding these items.

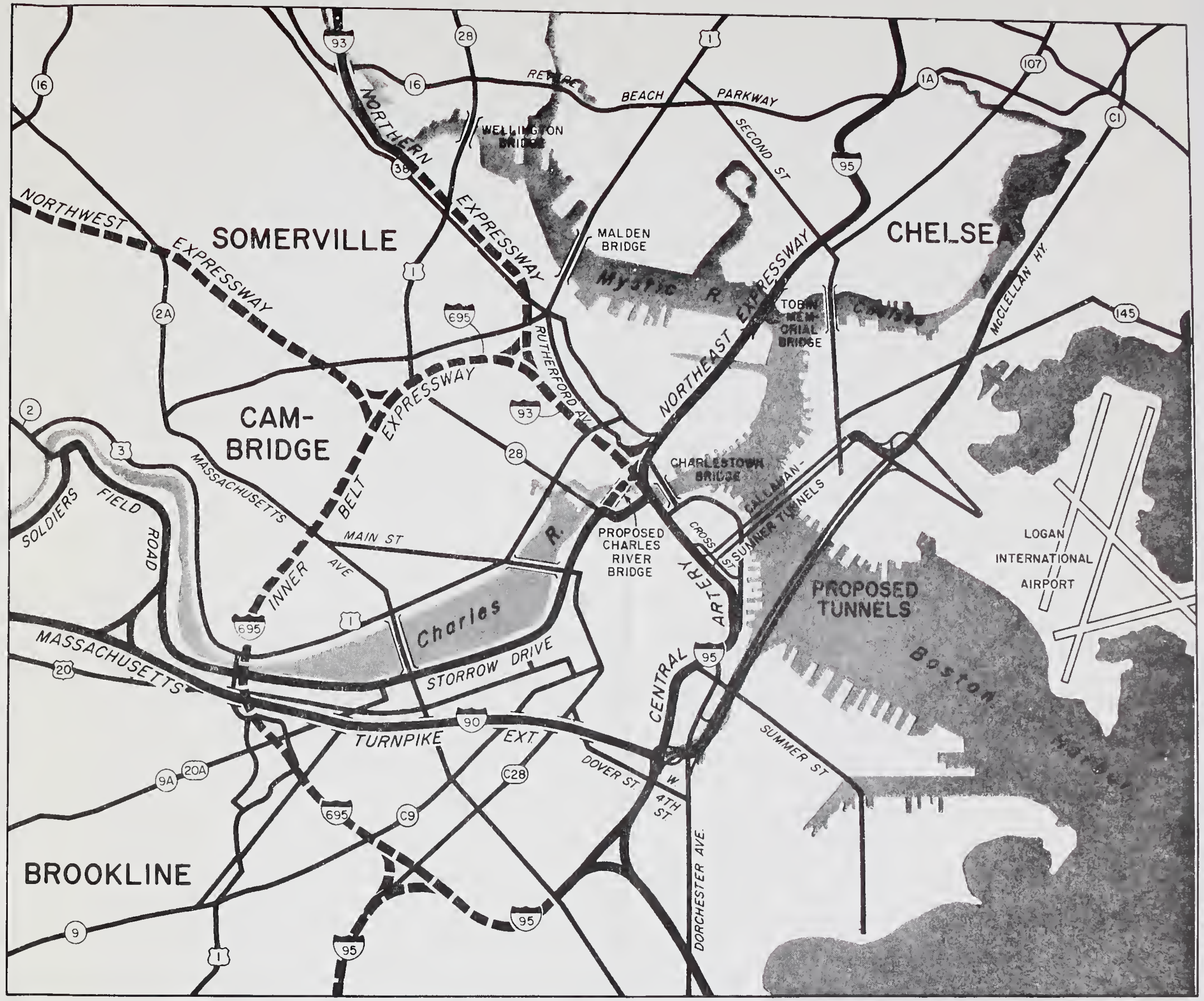
(5) High Speed Overwater Access May Prove to be A Partial Alternative To Reducing Highway Traffic Volumes.

Today there are no overwater commuter services in the Metropolitan Boston area. Various tests and experiments are under way using high speed air cushion waterborne vehicles. It is conceivable that this may provide a partial potential answer to moving people between the airport and selected points in the future.

EXHIBIT VI-3

BOSTON METROPOLITAN ROADWAY NETWORK





LOCATION OF

PROPOSED TUNNELS

IN RELATIONSHIP TO
EXISTING AND PROPOSED ROUTES, EXPRESSWAYS AND BRIDGES
IN THE

BOSTON METROPOLITAN AREA

EXISTING — PROPOSED — OTHER MAJOR ROUTES

EXHIBIT VI-3

CHAPTER VII

ANALYSIS OF IMPACT OF AIRPORT IMPROVEMENTS ON CIVIC AND RECREATIONAL ACTIVITIES

I.. INTRODUCTION

1. PURPOSE

This study was undertaken to assess the recreational impact of the proposed airport improvements.

2. APPROACH

The approach used in the analysis of the subject of the proposed airport improvements included the following studies:

(1) Review of existing civic and recreational progroms orgonized ond supported by the Massachusetts Port Authority.

(2) Review of existing and future recreational programs organized by various municipal and state agencies.

(3) Review and analysis of available literature.

(4) Detailed plans for the relocation of existing clam beds to cleaner and safer areas.

(5) Study of bird habitats that will be affected by the proposed fills.

(6) Navigation of small craft near Boston-Logan International Airport.

(7) Aesthetic aspects of airport perimeter.

(8) Further recreational facilities considered by Massachusetts Port Authority.

(9) Review of future recreational programs planned for Boston Harbor Islands by the Metropolitan Area Planning Council.

II. SUMMARY

The analysis conducted in this study shows that the present and future recreational uses of areas surrounding Boston-Logan International Airport will not be adversely affected by the proposed airport improvements.

The landfills proposed for the improvements will require the removal of existing clam beds which at times are considered unsafe for use, to areas which will result in rehabilitation.

The reduction in bird habitats will result in greater margin of safety for aircraft operations.

The aesthetic appearance of the perimeter at Boston-Logan International Airport will be further improved by eliminating solid waste disposal areas on airport property and by providing regular perimeter clean up.

III. CONCLUSIONS

1. MASSACHUSETTS PORT AUTHORITY CURRENTLY SUPPORTS SEVERAL CIVIC AND RECREATIONAL PROGRAMS BENEFITING THE COMMUNITY.

2. THE IMPROVEMENTS PROPOSED FOR BOSTON-LOGAN INTERNATIONAL AIRPORT WILL HAVE NO ADVERSE IMPACT ON THE RECREATIONAL USES OF THE AREAS SURROUNDING THE AIRPORT.

3. THE PROPOSED FILLS WILL DISPLACE CLAM BEDS IN AREAS BH-A, BH-B. HOWEVER, MASSACHUSETTS PORT AUTHORITY IS COMMITTED TO WORK WITH THE MASSACHUSETTS DEPARTMENT OF NATURAL RESOURCES IN A CLAM BED RELOCATION PROGRAM AND WILL DEFRAY THE COSTS OF SUCH RELOCATION.

4. MASSACHUSETTS PORT AUTHORITY WILL INCREASE THE FREQUENCY OF ITS CLEAN-UP OPERATION TO FURTHER IMPROVE THE APPEARANCE OF THE AIRPORT PERIMETER.

5. MASSACHUSETTS PORT AUTHORITY INTENDS TO COOPERATE WITH THOSE RESPONSIBLE COMMUNITY REPRESENTATIVES FOR THE CONTINUED IMPROVEMENT AND ASSIST IN THE FURTHER DEVELOPMENT OF RECREATIONAL FACILITIES IN THE COMMUNITY AT AN ACCELERATED LEVEL.

IV. DISCUSSION

1. CURRENT CIVIC INVOLVEMENT CONNECTED WITH BOSTON-LOGAN INTERNATIONAL AIRPORT INCLUDES AIRPORT TOURS, COURTESY FLIGHTS, VISITS, JOB TRAINING PROGRAMS, LAW ENFORCEMENT, FIRE PROTECTION AND RECREATION.

(1) More Than 90,000 People Took Part in Free Guided Tours Of Boston-Logan International Airport in 1970. (1)

Massachusetts Port Authority provides guides and buses to support a program of free tours of the airport complex.

Exhibit VII-1 presents a list of communities from which members participated in touring Boston-Logan International Airport in 1970. Exhibit VII-2 shows the number of people taking the tours.

The tours allow interested groups to acquaint themselves with the operations of a modern international air carrier airport.

(2) Boston-Logan International Airport's Observation Decks Are Used by Many Visitors. (1)

The observation decks at Boston-Logan International Airport were used by 294,916 people in 1970. Exhibit VII-3 shows the attendance of the observation deck for the years from 1960 to 1970.

EXHIBIT VII-1

LIST OF CITIES & TOWNS WHOSE GROUPS TOOK PART IN TOURS DURING 1970

Acton
Arlington
Ashland
Attleboro
Bellingham
Berkeley
Beverly
Boston
Bridgewater
Brighton
Brockton
Brookline
Burlington
Cambridge
Charlestown
Chelmsford
Chelsea
Chestnut Hill
Cohasset
Danvers
Dedham
Dorchester
Dracut
East Boston
E. Braintree
Everett
Foxboro
Gloucester
Groveland
Harwich
Haverhill
Hingham
Hyannis
Ipswich
Lawrence
Lexington
Lowell
Lynfield
Lynn
Marblehead
Marshfield
Melrose
Merrimac, N.H.
Methuen
Middleboro
Nashua, N.H.
Natick
Needham
Newton
N. Scituate
Norwood
Quincy
Randolph
Rochester, N.H.
Rockland
Roxbury
Salem
Saugus
Scituate
Somerville
South Boston
S. Weymouth
Southboro
Stoneham
Swampscott
Tewksbury
Upton
Wakefield
Watertown
Wayland
Wellesley
W. Peabody
W. Roxbury
Westboro
Westford
Weston
Wilmington
Winchester
Winthrop

Note: Data provided by Massachusetts Port Authority.

TOTAL NUMBER OF PEOPLE BY YEAR TAKING GUIDED TOURS

1966		5,950
1967		6,891
1968		13,796
1969		32,030
1970		33,569
	TOTAL	91,470

Note: Data provided by Massachusetts Port Authority.

EXHIBIT VII-3

OBSERVATION DECK
ATTENDANCE

Year	Total Enplaned Passengers	Observation Deck Attendance	Attendance As A Percentage Of Total Enplaned Passengers
1960	1,451,360	874,398	60
1965	2,746,360	571,817	21
1966	3,090,798	519,031	18
1967	3,892,691	422,182	11
1968	4,378,679	538,398	12
1969	4,604,668	496,628	11
1970	4,449,589	294,916	7

* Note 1: The decline in attendance on the observation decks is attributable to construction activities and the fact that the new terminal buildings (present and future) provide excellent viewing of aircraft apron activity from within.

Note 2: Data provided by Massachusetts Port Authority.

(3) The Massachusetts Port Authority and Airlines Provide Courtesy Flights for Civic Groups.(1)

Boston-Logan International Airport's neighbors - East Boston, Winthrop residents, business and civic leaders have taken courtesy flights. Thus far, approximately 2,500 people have been Massachusetts Port Authority's guests on these flights which will continue to operate.

The proceeds of some of these flights go to local charities. An example of this is the Jimmy Fund airlift flights which involve patrons paying for the flights. The aircraft fuel, crews, etc., are provided free of charge by the airlines, fuel suppliers, etc.

(4) Massachusetts Port Authority Participated in Job Clinics During 1970.(1)

Massachusetts Port Authority participated in two job clinic programs this year. One was held at Suffolk Downs and consisted of providing information and, where appropriate, interviews for candidates qualified for a variety of openings at Massachusetts Port Authority facilities. A similar job clinic was conducted at Raymond's Department store in downtown Boston.

Massachusetts Port Authority was also a participant in an Action for Boston Community Development project. This unique program provided six economically underprivileged teenagers with the opportunity to work "on the job" at Massachusetts Port Authority for a period of six weeks.

(5) Massachusetts Port Authority Law Enforcement and Fire Protection Activities That Benefit the Community.(1)

- State Police Assistance

  Troop F of the Massachusetts State Police is based at Boston-Logan International Airport. The salaries of the men and all of their equipment are paid for by Massachusetts Port Authority -- at no cost to the taxpayer.

  The magnitude of activities and responsibilities of this Troop are similar to those of a police force of many metropolitan areas for Boston-Logan International Airport is, after all, comparable in many ways to a city. The scope of security duties of Troop F includes patrol of Massachusetts Port Authority owned or operated Port facilities as well.

  In addition to their involvements with crimes which range from felonies to misdemeanors, Troop F personnel also render emergency medical assistance and transportation to the Massachusetts General Hospital and Medical Aid Station at Boston-Logan International Airport and provide emergency assistance to communities in the vicinity of Boston-Logan International Airport.

- Fire Department Assistance

  One of the country's most modern and effective airport fire departments is located at Boston-Logan International Airport. It is specially equipped and trained to fight chemical and fuel fires that might occur within the airport. However, it also conducts training sessions for community fire departments in these specialized areas of fire fighting. To date, 941 fire department personnel from eleven community fire departments have received this valuable training from Boston-Logan International Airport's personnel at no cost to the community departments or to any taxpayer. The training sessions are conducted using materials located in solid waste disposal areas on the Airport's property.

  Because of its specialized talents and equipment, the Boston-Logan International Airport Fire Department has been called in to extinguish major chemical and fuel conflagrations off the airport. The most serious of these included the Chelsea fuel tank farm fire which would have almost certainly developed into a fire of much greater proportions, threatening lives and property, had it not been for the successful efforts of the Boston-Logan International Airport Fire Department.

Among its other emergency assistance activities, the Fire Department was called to extinguish a blaze that had been caused by an overturned fuel truck on Route 1 in Saugus when local fire department equipment could not extinguish the fire.

(6) Massachusetts Port Authority Is Already Engaged in Sponsoring Recreational Facilities Benefiting the Community.(1)

Massachusetts Port Authority constructed and maintains, on an annual basis, a regulation-size lighted Little League Field in East Boston. The original cost of this field was approximately $22,000 with an annual maintenance contribution of $2,000. Another $15,000 has been spent for the construction of a clean, modern play area for East Boston children which is maintained by the Authority.

One of Massachusetts Port Authority's major efforts to improve the recreational activities and facilities in the East Boston area was the rehabilitation of the Dominic Savio School athletic field, located on Massachusetts Port Authority property, for both school and community use at a cost of $40,000. Costs for annual maintenance and sponsorship of a summer recreation program for East Boston and Winthrop youth at the school exceeds $6,100.

Various East Boston High School athletic programs have been assisted by Massachusetts Port Authority. Jackets and sweaters, an "Athletics Banquet," awards and trophies and scholarships have been provided under Massachusetts Port Authority's sponsorship at a cost exceeding $7,000 annually. Massachusetts Port Authority also contributes over $500 annually to the East Boston Jets hockey team as well as to other teenage hockey teams.

Through the cooperation of the airlines and of Massachusetts Port Authority, school children from surrounding communities can participate in aircraft cleaning sessions. One such session involved the washing of a B-707, which yielded about $150. The children are paid for these services and the proceeds are used to improve recreational facilities at their schools.

(7) <u>Massachusetts Port Authority Participates in Anti-Pollution Efforts.(1)</u>

To help restore Boston Harbor to its once unpolluted state and to help prevent additional pollution, Massachusetts Port Authority is a major participant on two committees charged with the safeguarding of the waters of this historic and vital body of water. The Port Emergency Planning Committee this year conducted the most extensive fire/oil spill exercise carried out on the East Coast. The project demonstrated and tested the effectiveness of procedures and facilities which would be used in the event of an actual disaster.

In addition to supporting legislation calling for the clean up of the Bay State's harbors, streams and lakes, Massachusetts Port Authority was active as a member of the Harbor Pollution Committee which sponsored a clean up campaign and which resulted in the collection of more than 300 tons of debris on the shores of Long Island in Boston Harbor.

Massachusetts Port Authority also carried on a summer shoreline clean up program in the area of Bayswater Street in East Boston.

2. THE AREAS IN THE IMMEDIATE VICINITY OF BOSTON-LOGAN INTERNATIONAL AIRPORT ARE USED IN SEVERAL RECREATIONAL ACTIVITIES.

(1) Area Surrounding Boston-Logan International Airport Is Used for Boating, Fishing, Swimming and Picnicking.

The major recreational uses in the near vicinity of Boston-Logan International Airport are centered about the East Boston Yacht Club, the Orient Heights Yacht Club and the Belle Isle Yacht Club. Additional boating facilities are located in Winthrop. Orient Heights Beach in East Boston provides public swimming facilities owned and maintained by the MDC.

Water front parks that are currently developed are centered around Castle Island in South Boston. Recreational fishing can take the form of fishing from land and boats. Land based fishing appears to be confined principally to the pier that was recently constructed on the Castle Island facility. Fishing from boats does not appear to be extensive in the immediate area surrounding the harbor. Commercial fisheries are limited to the exploitation of the shellfish beds located in areas BH-B and BH-A.

(2) <u>Although the Proposed Landfills Will Reduce Available Marine Habitats, Immediate Safety and Long-Range Environment Improvements Will Result.</u>

Available marshes, adjacent rocky shoreline and tidal flats currently provide suitable habitat areas for a limited population of water fowl, shoreline birds and shellfish. Proposed landfill required for the airport improvement programs will partially eliminate these areas.

. <u>Birds</u>

Tidal flat areas which border the airport have historically been a year-round as well as seasonal habitat for various species of birds. Among these are: (2)

- All year
    - Herring Gulls
    - Black Back Gulls
    - Least Terns
- During migratory seasons
    - Sandpipers
    - Black Bellied Plovers
    - Yellowlegs
    - Ducks (Black and Scaup also winter in significant numbers)

Seagull feeding populations greatly increase on the mud flats during periods when clams are being harvested. The presence of birds in the immediate landing and takeoff areas of the airport presents a potentially serious hazard to the safe operation of aircraft and, of course, to the birds themselves. The Massachusetts Port Authority has, for this reason, maintained a substantial bird control program for many years to minimize the risk of bird strikes on aircraft and their injestion by jet engines.

. Lobsters

There are no known lobster colonies in the harbor waters surrounding the airport with the exception of a newly created colony along the rock dike recently constructed by the Massachusetts Port Authority around the Bird Island Flats area.

. Fin Fish

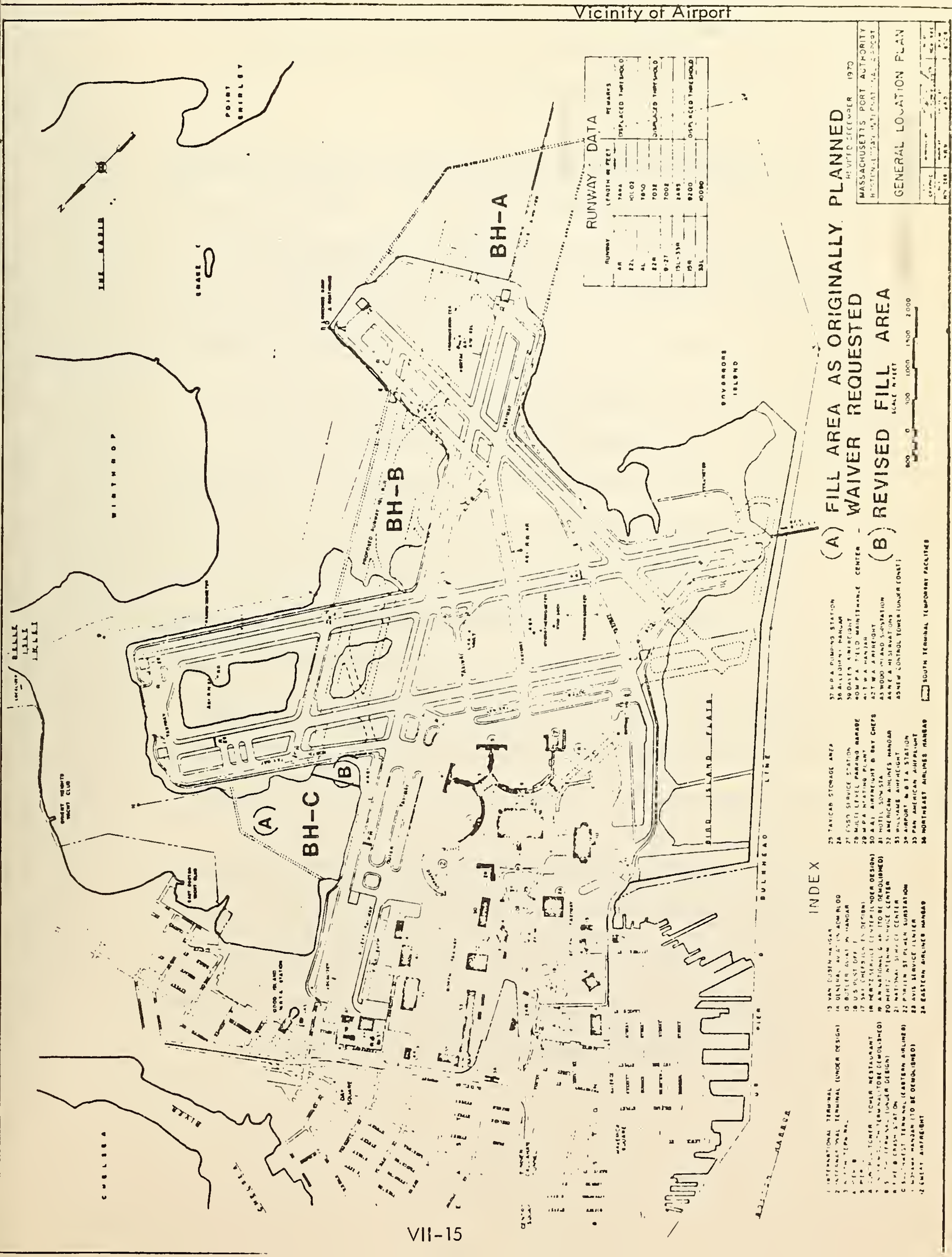
The harbor waters surrounding the airport support a limited population of flounder, striped bass and smelt and may serve as a spawning grounds for winter flounder.

3. THE WATERS ADJACENT TO BOSTON-LOGAN INTERNATIONAL AIRPORT CONTAIN SHELLFISH BEDS.

A 1968 survey of the Boston Harbor revealed 2,397 acres of shellfish which may be legally harvested (3). It is estimated that the required landfills will eliminate 150 acres or about eight percent (8%) of the total area. The location of the shellfish beds in the vicinity of the airport is shown on Exhibit VII-4.

One area known as BH-C, that is the waters and flats of the northwest shoreline of the airport extending to the extremity of runway 22R, has been closed to the taking of shellfish for food purposes since 1968 because the shellfish were considered unsafe for human consumption. Closing was caused by the discharge of raw sewage from the overflow of the combined City of Boston sewer located at the end of Coleridge and Moore Streets in East Boston. Other shellfish areas adjacent to the airport are under regular sanitary surveillance by the Department of Public Health of the Commonwealth of Massachusetts

EXHIBIT VII-4
Location of Shellfish Beds in Vicinity of Airport



and have been closed periodically in the past because of pollution not caused by the operation of the airport.

More specifically, areas BH-B and BH-A are currently restricted to clamming operations by master clam diggers only. Master clam diggers are licensed operators with the State Department of Natural Resources. Their permits, issued by the City of Boston allow them or allow their employees under their supervision, to conduct shellfish operations. The shellfish so harvested must be depurified in the Newbury Port purification plant before they can be legally consumed. A survey conducted by the Massachusetts Department of Natural Resources on June 25, 1970 indicates that the procedure of area BH-A covers approximately 19.9 acres and has an estimated population of 1,408 bushels of legal sized clams. In Massachusetts a legal size clam is one that has at least one dimension equal to or greater than two inches. The same survey conducted in area BH-B indicates that the productive area covers 22.9 acres (3) and that the estimated legal size clam fish population is 2,993 bushels. The combined affected areas in BH-A and BH-B represent 14.8% of the total areas of BH-A and BH-B.

Although presently restricted, the clam beds located in areas BH-A and BH-B represent a potential for further development if their habitats could be improved. For this and other reasons, the Massachusetts Port Authority volunteered to pay for the relocation of the affected clams in BH-A and BH-B to cleaner and safer areas.

The relocation program will be executed in close cooperation with the Massachusetts Department of Natural Resources.

4. A DETAILED OUTLINE OF THE PROGRAM REQUIRED TO RELOCATE THE CURRENTLY RESTRICTED CLAM BEDS IN AREA BH-A AND BH-B HAS BEEN PREPARED.

Relocations of clams and oysters have been performed previously (4, 5, 6). The successful relocation program should result in a high survival percentage of the relocated shellfish.

In order to maximize the survival rate a systematic relocation plan must be followed. Such a plan is described in detail herein. The plan includes the following major steps:

- Search for new locations
- Shellfish harvesting and relocation
- Follow-up program

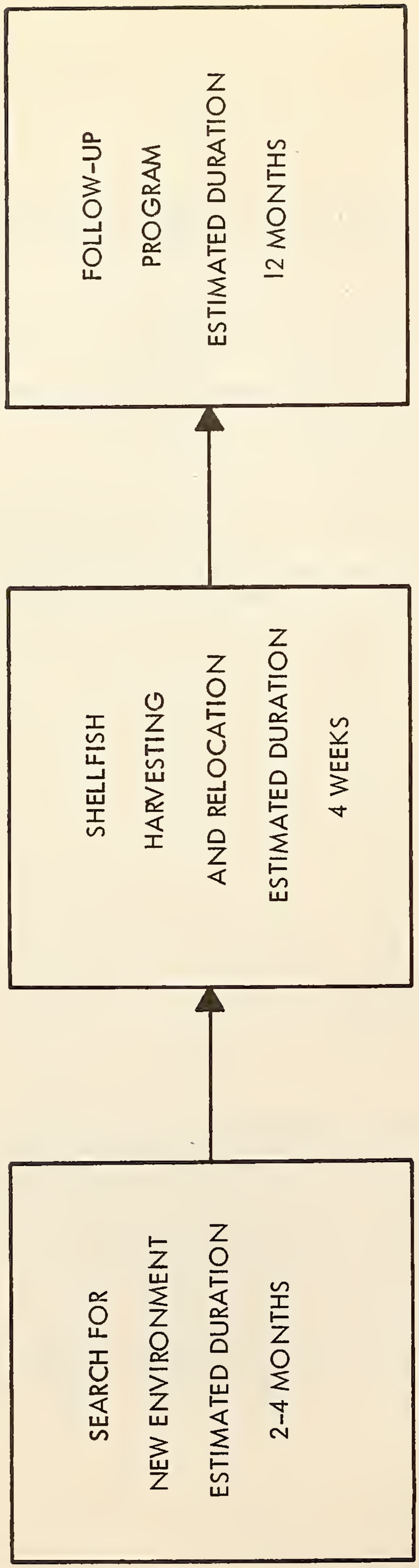
The plan is presented in graphical form in Exhibit VII-5. Each step is detailed further in Exhibit VII-6.

- Search for new locations. The new locations must satisfy several criteria. These include environmental requirements and the ease of access to the new beds. The environmental requirements will insure that the new habitat proposed for the relocation will be compatible with the shellfish and thus allow the relocated shellfish to prosper.

  The access requirements will insure that the clam diggers will be able to exploit the beds in their new locations. The access must provide safe boating conditions.

EXHIBIT VII-5

SHELLFISH RELOCATION PLAN



DETAILED CONSIDERATIONS IN SHELLFISH RELOCATION PLAN

SEARCH FOR NEW LOCATIONS

- Environment
  - Quality of water
  - Salinity
  - Temperatures
  - Depth
  - Current velocities
  - Wave action
  - Nutrients
  - Bottom conditions
  - Predators
- Access
  - Distance from current boat anchorage
  - Nature of waters - open, sheltered
  - Wind conditions
  - Safety of boating

SHELLFISH HARVESTING AND RELOCATION

- Timing
  - Spawning season
  - Salinity
  - Temperatures

DETAILED CONSIDERATIONS
IN SHELLFISH RELOCATION PLAN

- Method
  - Hand harvesting
  - Water jet - Maryland float
  - Storage on boat

- Relocation
  - Discharge overboard

FOLLOW-UP PROGRAM

- Testing Of Shellfish
  - Mortality rate
  - Spawning
  - Estimate population
  - Biological testing of harvested shellfish

Discussions (7) with staff members of the Massachusetts Department of Natural Resources have identified several possible candidate sites in Boston Harbor. These include:

- Spectacle Island
- Ransford Island
- Long Island

These possible sites and others will be studied using the detailed relocation plan described herein and a final site can be selected only after the detailed plan has been followed to identify the best area.

- Shellfish harvesting and relocation. The harvesting must not result in damage to excessive numbers of the clams. Successful relocations (6) have used the hydraulic clam digger utilized extensively in Maryland. This method of harvesting is suggested here provided proper clearance is obtained from the appropriate authorities.

  The use of the hydraulic clam digger results in lower relocation costs since it replaces manual operations. It provides an added advantage in that the entire relocation program can be speeded up to take advantage of the relatively short times during which relocation can take place (6).

  The relocation involves the movement of the harvested clams to their new location. Once the vessel has arrived over the new area, the clams are simply spread overboard. The spreading operations should be such as to result in uniform densities of clams on the bottom.

- Follow-up program. The relocation program cannot terminate immediately after the shellfish have been physically moved to their new location. The relocation must be combined with a thorough follow-up program which includes periodic inspections of the new beds to determine the extent of clam survival. In addition, the clams themselves should be sampled periodically and checked for wholesomeness. Since the average growth of the shellfish to maturity ranges from two to four years, the follow-up program should be carried out for at least one year.

Previous work has shown (6) that survival rates ranging from ten to ninety percent (10 - 90%) of the relocated clams can be expected. With the knowledge acquired in previous studies (6) a conservative estimate of the survival rate can be made at fifty percent (50%).

The cost of the relocation based on previous work was $2.50/bushel (6). The estimate of the population of clams in BH-A, BH-B was made by the Massachusetts Department of Natural Resources (3) and is shown below in Table I.

TABLE I

	BH-A* Bushels	BH-B* Bushels
Legal Greater than 2"	1408	2993
Intermediates Lesser than 2"	1706	2554
TOTALS	3114	5547

Total of legal and intermediate clams
8661 Bushels

* Data provided by the Department of Natural Resources of the Commonwealth of Massachusetts (3).

Assuming that all intermediate and legal clams are moved the cost of the relocation is estimated at ($8,660 x 2.50) $21,650. Additional expenditures related to the search for new sites and to the follow-up program are estimated at between $5,000-$10,000 and the total program cost is estimated at approximately $30,000-$35,000.

- Economics. Assuming a fifty percent (50%) rate of survival, the 8661 bushels will represent a potential harvest of 4330 bushels. The market value of this harvest is estimated at $10/bushel yielding $43,000. This economic return should continue indefinitely if the beds are harvested keeping within sound conservation guidelines. The relocation program, if properly conducted, will result in a cleaner and safer habitat for the shellfish than now exists. In addition, the relocation program will allow unrestricted harvesting of the shellfish, thereby yielding significant economic benefits.

5. THE PROPOSED AIRPORT IMPROVEMENTS WILL HAVE NO ADVERSE EFFECT ON OTHER MARINE LIFE.

Conversations with the Massachusetts Department of Natural Resources indicate that the areas BH-A and BH-B may sustain some finfish population. The proposed fills will tend to decrease the amount of nutrients available for this type of marine life. The reduction resulting from the proposed fills will not have a significant effect on the quantity of nutrients available in Boston Harbor.

6. OPERATIONS OF AIRCRAFT AT THE AIRPORT DO NOT PRESENT A HAZARD TO NAVIGATION OF SMALL CRAFT PROVIDED THAT THEY ARE MAINTAINED WITHIN NAVIGABLE CHANNELS.

Navigation of small craft, both power and sail, can continue to be safely conducted near the vicinity of the airport provided the craft are kept within the marked channels as indicated on Chart 248 of the U. S. Coast and Geodetic Survey.

The proposed airport improvements will have no effects on the safety of the navigation of small craft near Boston-Logan International Airport.

7. THE AESTHETIC APPEARANCE OF THE PERIMETER AT BOSTON-LOGAN INTERNATIONAL AIRPORT IS CURRENTLY SUPERIOR TO THAT EXISTING ON PROPERTIES SURROUNDING THE AIRPORT IN AREA BH-C.

Typical visual appearance of the airport perimeter as it would be seen from Winthrop or from a small boat is shown in a photograph in Exhibit VII-7. Typical appearances of the land shore located in East Boston in area BH-C is shown in a photograph in Exhibit VII-8. The stone dikes surrounding the airport perimeter show an uncluttered and clean condition. This has been confirmed by more than 100 photographs taken during this study. A study of the rock dikes was performed by Fay, Spofford and Thorndike, Inc. (8). The major findings of this study are reported below.

(1) Several Factors Influence the Aesthetics Of Rock Embankments. (8)

Aesthetics is one of many things that is normally considered in the design of any structure exposed to public view. There must be a balance between aesthetics, economy of construction, economy of maintenance and the ability of the structure to perform its functions with efficiency with the least adverse effect on its surroundings. The possible structures that could be used to retain the fill material are as follows:

- A timber bulkhead
- A steel sheet pile bulkhead
- A structural concrete retaining wall
- A stone riprap face on an earth or stone fill

For a waterfront structure which does not require a vertical face for the docking of vessels and where space permits, we consider a sloping surface to be desirable. A sloping face permits waves and the wash from

PHOTOGRAPHS OF AIRPORT PERIMETER

1. VIEW OF AIRPORT PERIMETER NEAR RUNWAY 33 LOOKING WEST

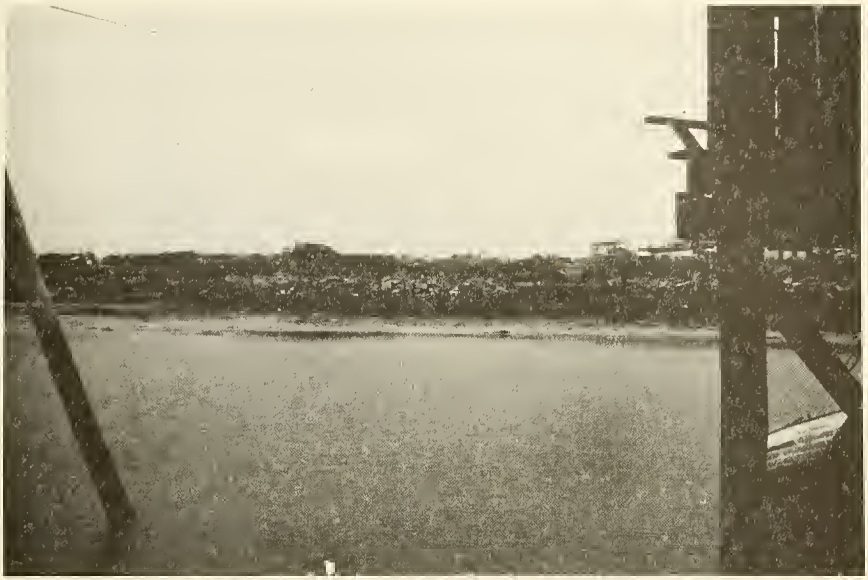
2. VIEW OF AIRPORT PERIMETER END OF RUNWAY 22L

PHOTOGRAPHS OF AIRPORT PERIMETER

3. VIEW OF AIRPORT PERIMETER NEAR RUNWAY 22L LOOKING WEST

4. VIEW OF AIRPORT PERIMETER NEAR RUNWAY 22L LOOKING NORTH-WEST

PHOTOGRAPHS OF SHORELINES
IN AREA BH-C
BOSTON HARBOR



1. VIEW OF E. BOSTON LOOKING SOUTH

2. VIEW OF AREA NEAR COLERIDGE STREET LOOKING NORTH

PHOTOGRAPHS OF SHORELINES
IN AREA BH-C
BOSTON HARBOR

3. VIEW OF AREA NEAR COLERIDGE AND MOORE STREET LOOKING NORTH

4. VIEW OF COLERIDGE STREET LOOKING WEST

boats and ships to dissipate without causing a counter wave. Vertical surfaces reflect waves and the wash from boats operating in the area which can be dangerous to the operation of small boats. It also provides an access to land for swimmers who might capsize in small boats in the area.

Timber bulkheads have a limited life, require constant maintenance and ultimate replacement. Timber bulkheads originally constructed at the airport had to be protected with stone riprap to prevent their total collapse.

Steel sheet pile bulkheads require maintenance often including electronic protection, are not inexpensive and present a poor appearance.

Concrete retaining walls are expensive and the life of concrete exposed to tidal action is limited. In addition, a review of concrete structures in the area indicates staining from the contaminated water which detracts from their appearance.

The New England area is no stranger to rock outcrops facing the ocean. A rock dike or a rock protected earth fill is no more expensive to construct than any of the other types; maintenance is nominal and there are instances of such installations in the area which are older than living memory. By blending with the New England shoreline scene, rock dikes will present a pleasing appearance. Because they appear to satisfy all criteria, they were chosen for this project.

(2) <u>The Dikes Will Not Provide Nutrients For Rats. (8)</u>

It has been stated that stone riprap protected slopes are an invitation to infestation by rats. Experience with rat control indicates that where there is no food supply there are no rats. If there are rats currently living in the area in which the stone structure will be constructed, they undoubtedly will take up living in the interstices in the stone. The stone offers no food supply so that the rat population should not increase. Adequate rat control programs are available and, if rats should become a problem, they can be controlled. To maintain the uncluttered conditions of the perimeter of the airport, Massachusetts Port Authority will further accelerate the regular clean up operations to remove water carried debris that may clutter the perimeter from time to time.

8. ADDITIONAL COMMUNITY RECREATIONAL OPPORTUNITIES WILL BE STUDIED BY THE MASSACHUSETTS PORT AUTHORITY.

The Massachusetts Port Authority intends to cooperate with these responsible community representatives for the continued improvement and assist in the further development of recreational facilities in the community at an accelerated level.

8. BOSTON HARBOR ISLANDS STUDY

The Metropolitan Area Planning Council (MAPC) has been charged with the primary responsibility of preparing a detailed development program involving all the islands in Boston Harbor, Quincy, and Hingham Bays for conservation and recreational purposes. The MAPC has been contracted by Massachusetts Department of Natural Resources to perform this work.

A key to the success of this program is a transportation support system to provide access to and from these islands from selected mainland points. In this regard, the Authority is prepared to assist and work with the MAPC to insure the success of this worthwhile program. Preliminary discussions have already been held with the MAPC (9).

It is recognized that there are and will continue to be aircraft overflights involving some of these islands and their planned activities. Although the degree of resulting aircraft noise impact upon some planned activities is not quantifiable, the MAPC intends to design their program in such a manner as to minimize noise impact in affected areas. It should be noted, however, that inasmuch as the Boston Harbor Area is a highly active and exciting environment that overflights could be considered to be a part of the total recreational experience.

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CHAPTER VIII

ALTERNATIVES TO BOSTON-LOGAN INTERNATIONAL AIRPORT IMPROVEMENT

I. INTRODUCTION

1. PURPOSE

This chapter presents an assessment of alternatives to the recommended improvement program. Their feasibility and effectiveness as solutions in lieu of the proposed Boston-Logan International Airport facility improvement program is explored.

2. APPROACH

Several distinct types of alternatives to the proposed improvement program were examined as follows:

- A moratorium on airfield and terminal improvements,
- Capacity, noise exposure and air pollution considerations,
- Operational alternatives to reduce total aviation demand,
- Development of a second major airport,
- Diversion of Boston-Logan International Airport demand to alternate transportation modes,
- Noise reduction alternates,
- Boston-Logan International Airport facility alternatives.

The findings and conclusions related to alternatives from the specific study areas are recapitulated herein along with discussion of operational alternatives which attempt to reduce the future level of air traffic demand to that which can be accommodated by the existing airport.

II. SUMMARY

Each of the alternatives presented were considered to be a potential means of reducing the environmental impact of Boston-Logan International Airport operations on the communities surrounding the airport. Fundamental to an understanding of possible alternative implications must be the realization that as long as demand for air service in Boston continues to increase and no viable alternative exists, the air carrier segment of the Boston-Logan International Airport activity will continue to grow, but at a declining rate due to increased use of larger aircraft.

It is this air carrier activity which largely defines the environmental impact of a facility such as Boston-Logan International Airport. This study has sought to define the most environmentally acceptable means of satisfying this natural and economically beneficial growth of demand in the time period when Boston-Logan International Airport is the only available solution. Of all the alternatives considered for reducing environmental impact, the recommended improvement program offers the greatest potential for substantially reducing environmental impact while satisfying the beneficial growth of aviation demand.

III. CONCLUSIONS

NONE OF THE ALTERNATIVES EXPLORED WERE AS PRACTICAL, FEASIBLE OR ENVIRONMENTALLY DESIRABLE AS THE PROPOSED IMPROVEMENT PROGRAM CONSISTING OF PARALLEL RUNWAY 15L-33R, EXTENSION OF RUNWAYS 9 AND 4L, AND STOL RUNWAY 15-33.

1. ANY MORATORIUM ON AIRFIELD AND TERMINAL IMPROVEMENTS WOULD HAVE ADVERSE LEGAL, FINANCIAL, AND ECONOMIC IMPACTS ON THE BOSTON METROPOLITAN REGION.

2. FROM THE STANDPOINTS OF CAPACITY, NOISE EXPOSURE AND AIR POLLUTION, THE PROPOSED IMPROVEMENT PROGRAM REPRESENTS THE MOST ADVANTAGEOUS ALTERNATIVE.

   (1) Condition 6, the Improved Airport Is the Only Condition Which Satisfies Projected 1975 Aviation Demand.

   (2) Condition 6 Which Represents the Improved Airport Is Superior From a Standpoint of Noise and Air Pollution.

3. OPERATIONAL ALTERNATIVES CANNOT PRACTICALLY BE USED TO REDUCE TOTAL AVIATION DEMAND TO WITHIN THE CONSTRAINTS IMPOSED BY THE EXISTING AIRFIELD FACILITY CAPACITY WITHOUT A DEROGATORY EFFECT ON SERVICE.

   (1) Restriction Of General Aviation Traffic As Required To Reduce Congestion and Eliminating the Need For Increased Capacity Will Not Noticeably Reduce Boston-Logan International Airport's Environmental Impact.

   (2) Reducing and Consolidating Schedules and Increasing Aircraft Load Factors Will Not Eliminate the Need for Increased Capacity.

   (3) The Establishment Of Landing Fee and Fare Differentials To Discourage Peak Hour Use Will Have Limited Effect During the Daylight Hours Of Heavy Demand and Could Shift Additional Operations Into the More Noise Critical Nighttime Hours.

4. POLITICAL AND ENVIRONMENTAL OBJECTIONS TO A SECOND AIR CARRIER AIRPORT MUST BE OVERCOME BEFORE PLANNING, DESIGN, AND CONSTRUCTION CAN BE UNDERTAKEN. SUCH CONSIDERATIONS HAVE PLACED A SECOND AIR CARRIER AIRPORT BEYOND THE TIME REQUIREMENT FOR BOSTON-LOGAN INTERNATIONAL AIRPORT IMPROVEMENT TO MEET THE DEMANDS PLACED UPON IT BY THE BOSTON AREA.

(1) Powerful Forces Both Political and Environmental Must Be Overcome Before Specific Development Can Begin On Another Major Airport.

(2) The Site Selection, Planning, Design, Financing and Construction Of a Major Airport Can Be Expected To Consume a Period Of Ten Years Or More.

5. FROM A PRACTICAL AND TECHNOLOGICAL VIEWPOINT, THE DIVERSION OF THE SHORT-HAUL PASSENGER MARKET TO ALTERNATE TRANSPORTATION MODES MUST BE CONSIDERED AS A POSSIBLE LONG-RANGE FACTOR, WHICH COULD ULTIMATELY DECELERATE THE RATE OF INCREASE IN THE DEMAND FOR SHORT-HAUL SERVICE FROM BOSTON-LOGAN INTERNATIONAL AIRPORT.

(1) The Practical Application Of a Competitive High-Speed Rail System Operating in the Northeast Corridor Doesn't Appear Probable Until at Least 1980.

(2) It Is Highly Probable That Competitive V/STOL System In the Northeast Corridor Will Not Be Realized Until 1980.

6. OF ALL THE ALTERNATIVES CONSIDERED FOR REDUCING NOISE EXPOSURE, WITH THE EXCEPTION OF NOISE REDUCTION AT THE SOURCE, THE IMPLEMENTATION OF A RIGID AND COMPREHENSIVE PREFERENTIAL RUNWAY USE SYSTEM OFFERS THE GREATEST POTENTIAL FOR SUBSTANTIAL NOISE ABATEMENT WITHOUT PRODUCING UNREALISTIC PENALTIES ON THE AIRPORT USER.

(1) Banning Of 4-Engine Jets Would Make a Minor Improvement in Overall Noise Exposure, However, the Effects On the Air Transportation Industry Negate the Small Benefit Derived.

(2) Locally Established Maximum Noise Level Restrictions Are Legally Questionable and Would Create Chaos in the Aviation Industry Due To Lack of Conformity From Area To Area.

(3) Surcharges For Noisier Aircraft Including Night Differentials Would Not Provide Sufficient Economic Leverage To Induce Changes in Equipment Types Or Schedules.

7. NO OTHER FACILITY ALTERNATIVES EXPLORED WERE AS PRACTICAL, FEASIBLE OR ENVIRONMENTALLY DESIRABLE AS THE RECOMMENDED PROJECTS.

IV. DISCUSSION

1. ANY MORATORIUM ON AIRFIELD AND TERMINAL IMPROVEMENTS WOULD HAVE ADVERSE LEGAL, FINANCIAL, AND ECONOMIC IMPACTS ON THE BOSTON METROPOLITAN REGION.

A complete moratorium on all construction at Boston-Logan International Airport has been proposed. The duration of such a moratorium would extend until all of the alternatives to the future transportation needs of the Boston area have been thoroughly explored and the best solution has been determined.

(1) A Self Imposed Moratorium Would Violate Provisions of the Authority's Enabling Act.

The Enabling Act charges the Authority with the responsibility to:

- extend
- enlarge
- improve
- rehabilitate
- operate

all projects under the Authority's control. The Authority is also bound by a Trust Agreement constituting a contract between the Authority and its trustee. Any legislative action to impose a moratorium would constitute legislative interference with a private contract and is considered unconstitutional by the legal staff of the Massachusetts Port Authority.

(2) A Moratorium On All Improvements at Boston-Logan International Would Result in Involuntary Contract Abridgments.

If a moratorium were to be imposed on all improvements at Boston-Logan International Airport, the Massachusetts Port Authority would involuntarily abridge contracts and agreements totaling approximately 120 million dollars. The result would be a loss of 25 million dollars in investments. This is presented in more detail in Appendix D.

(3) Adverse Economic Affects Of a Moratorium Would Develop in the Metropolitan Boston Area.

The economic impact of deferred or cancelled construction is examined in Chapter IX. The short-term economic impact would include:

- direct loss of investment,
- loss of promotional investment to further air service,

The long-term economic impact would include:

- reduction in air transportation service,
- increases in costly delays to passengers and freight shipments,
- reduction in airport employment
  - at the airport
  - in the shipping industry
  - in the construction industry

2. FROM THE STANDPOINTS OF CAPACITY, NOISE EXPOSURE AND AIR POLLUTION, THE PROPOSED IMPROVEMENT PROGRAM REPRESENTS THE MOST ADVANTAGEOUS ALTERNATIVE.

(1) <u>Alternative Conditions 2, 3, 4, 5 and 6 Representing the 1975 Time Period Were Evaluated in Terms Of Capacity and Environmental Impact Including Both Noise and Air Pollution Since They Are Related in Terms Of Delay Time.</u>

Exhibit VIII-1 presents in summary form the findings of the capacity, noise and air pollution studies described in Chapters II, III and IV. The following conclusions can be drawn:

- Condition 2 is unsatisfactory because there are 17,000 residents within the NEF-40 contour and because the delay and air pollution is relatively high.
- Condition 3 is the most unsatisfactory from a noise standpoint because the number of residents remains at 23,800 people within the NEF-40 contour which is essentially the same as experienced today with the current airport.
- Condition 5 yields the lowest capacity and an extremely high delay level which creates the highest air pollution volumes and would be difficult to achieve operationally.
- Condition 5 has a higher noise level than Condition 4.
- Conditions 4 and 6 are the principle alternatives for consideration because they represent the maximum noise abatement levels achievable with the existing and improved airports respectively.

(2) <u>Condition 6, the Improved Airport Is the Only Condition Which Satisfies Projected 1975 Aviation Demand.</u>

The increase in operating capacity offered by the improved airport configuration is substantially higher than that achievable with the existing airport facility. The Condition 6 capacity of 348,000 operations annually equates with the 1975 planning range demand of 350,000 total aircraft operations.

EXHIBIT VIII-1

SUMMARY OF CAPACITY,
NOISE EXPOSURE AND
AIR POLLUTION ALTERNATIVES

Condition	2	3	4	5	6
Airport Configuration	Existing	Existing	Existing	Existing	Improved
Traffic Projections	1975	1975	1975	1975	1975
Runway Utilization	Maximum Capacity	Historic	Noise Abatement Alt. 1	Noise Abatement Alt. 2	Maximum Noise Abatement
Noise Population NEF-40	17,000	23,800	11,400	14,200	8,900
Air Pollution Tons/Year	13,120	-	17,421	19,787	10,211
Delay Hours/Year	13,120	-	15,480	20,575	11,725
PANCAP Movements/Year	313,000	-	313,000	300,000	348,000

(3) Condition 6 Which Represents the Improved Airport Is Superior From a Standpoint Of Noise and Air Pollution.

- The improved airport permits operations which result in only 8,900 people residing within the NEF-40 contour as compared with 11,400 people with Condition 4 which represents an increase of twenty-eight percent (28%).

- The improved airport presents a realistic operating plan since it is reasonable to assume that the increased capacity would permit operation to achieve maximum noise abatement.

- Condition 4 is not practical since the high delay time developed would preclude actually achieving the noise reduction indicated.

- Even if Condition 4 could be carried out from a traffic management standpoint, the higher air pollution caused by the delay is unwarranted.

3. OPERATIONAL ALTERNATIVES CANNOT PRACTICALLY BE USED TO REDUCE TOTAL AVIATION DEMAND TO WITHIN THE CONSTRAINTS IMPOSED BY THE EXISTING AIRFIELD FACILITY CAPACITY WITHOUT A DEROGATORY EFFECT ON SERVICE.

A review of the air traffic demand forecasts presented in Chapter I and their relationship to airfield capacity, as presented in Chapter II, gives an indication of three possible operational alternatives which if feasible or practicable could reduce total demand to the point where the recommended airfield improvement program would not be required. These three conditions are discussed in the paragraphs below. These alternatives are unproven as to their effect either individually or collectively. It is very questionable that they would make the existing facility tolerable.

(1) Restriction of General Aviation Traffic As Required To Reduce Congestion and Eliminating the Need For Increased Capacity Will Not Noticeably Reduce Boston-Logan International Airport's Environmental Impact.

Analysis of demand versus capacity indicates that by 1975 forecast operations at Boston-Logan International Airport will exceed the capacity levels of each of the airfield conditions examined. Three conditions where this problem would exist are:

- The existing airfield operated as it has been historically.
- The existing airfield operated with maximum noise abatement utilization to minimize residential flyover.
- The improved airfield with new runway 15L-33R operated with maximum noise abatement utilization.

The capacity of the existing airport is 313,000 when operated in the historical manner, 300,000 movements annually when operated using the maximum noise abatement utilization and 348,000 operations annually with the added 15L-33R parallel runway operated with maximum noise abatement utilization. Each of these is less than the 1975 total operations forecast of 388,400 and the planning range demand of 350,000 operations annually.

Operating at demand levels in excess of airfield capacity results in increasing delay in congestion levels with attendant noise and pollution problems discussed elsewhere in this report. It is assumed for the purposes of this analysis, that certain operations would have to be eliminated in order to meet the capacity levels for the three cases specified above. It is conceivable that each category of airport user presently operating at Boston-Logan International Airport would experience a proportional decrease. However, if the entire reduction were to occur in general aviation operations, only 13,600 general aviation operations could be accommodated by the existing airfield operating under maximized capacity conditions. This would reduce to 600 operations for the existing airfield with preferential runway use. It is clearly evident that with the improved airfield facilities, general aviation operations could be reasonably satisfied until 1975, while without improvement of existing airfield facilities, general aviation would, for all intents and purposes, cease to operate at Boston-Logan International Airport.

- Banning of general aviation aircraft from Boston-Logan International Airport will not reduce appreciably the noise impact caused by aircraft operations.

It should be emphasized that the general aviation aircraft in large part are small (less than 12,500 pounds) single and multi-engine piston aircraft whose pollution contribution is insignificant when compared with the larger air carrier jet aircraft.

(2) <u>Reducing and Consolidating Schedules and Increasing Aircraft Load Factors Will Not Eliminate the Need for Increased Capacity.</u>

Increases in aircraft load factors would not alleviate traffic congestion or the need for airfield improvement at Boston-Logan International Airport.

The load factor forecast at Boston-Logan International Airport for 1975 is fifty percent (50%), which when related to the forecast of enplaning passengers and average aircraft seating capacity produces the domestic scheduled operations forecast of 206,000. If Boston-Logan should realize an average load factor increase to fifty four percent (54%) by 1975, using the same forecast for domestic enplaned passengers and average seating capacities, the domestic scheduled operations would amount to 191,000 or eight percent (8%) less than the original forecast. The eight percent (8%) reduction in operations is considered minimal (15,000 operations of the 1975 total operation forecast of 388,400).

It appears that some consolidation and reduction in scheduled air carrier operations will occur as a result of current economic downturn.

The magnitude of these reductions would represent only a minor segment of total demand and would not be a realistic alternative to increasing airfield capacity.

(3) The Establishment of Landing Fee and Fare Differentials To Discourage Peak Hour Use Will Have Limited Effect During the Daylight Hours of Heavy Demand and Could Shift Additional Operations Into the More Noise Critical Nighttime Hours.

> The institution of general aviation peak hour differential landing fees have had less appreciable effect than FAA instituted restrictions on operations at other major airports.

A broad and general analysis was made of the number of recorded general aviation operations for Chicago-O'Hare, Washington National, John F. Kennedy and LaGuardia Airports to ascertain the effect of peak hour general aviation landing fee differentials. These major airports are representative of operations with and without such landing fee differentials and are also all subject to FAA instituted restrictions on hourly aircraft movements.

Results indicate that the institution of general aviation peak hour differential landing fees had little if any effect on general aviation operations at J.F. Kennedy and LaGuardia. The overall trend in general aviation operations at the four major airports under consideration after the institution of FAA regulations was downward. Even with the presence of peak hour landing fees at Kennedy and LaGuardia their decline was less than that of Chicago-O'Hare, which has no peak hour general aviation landing fee.

The relationship of peak hour to daily demand tends to naturally flatten as air traffic load increases.

That is to say that the peak hour percentage as a total of daily volume can be expected to decrease as the number of aircraft operations at the Boston-Logan International Airport increases. The capacity analyses, detailed in Appendix A, indicate that by 1975 the Boston-Logan International Airport operation will remain relatively constant or slightly below peak hour demand for a 12 hour period beginning at 8:00 a.m. during the days of peak facility usage, (see Appendix A, Exhibit A-5.) It is conceivable that landing fee differentials could force peak hour operations to fill in the few remaining valleys in the otherwise constant demand situation. It is likely, however, that these operations would be forced to occur in substantially off-peak hours, such as those prior to 7:00 a.m., and in the evening, perhaps after 10:00 p.m. If so, the shift of activity from daytime to nighttime hours will have a substantial impact on the noise exposure forecast contours and adversely effect the environmental impact. The effect produced is similar to that which will occur if the new parallel 15L-33R is not constructed and the existing airfield configuration becomes heavily overloaded.

Fare differentials to accomplish peak flattening could have a similar effect as that discussed in the preceding paragraph.

It should be pointed out that domestic air carrier fares are set by the Civil Aeronautics Board and any change affecting Boston must be achieved within the context of the national system. The amount of such fare differentials would have to be high in order to offset the potential loss of revenue during off-peak travel demand times. Peaks in airport demand are in large part dictated by the desires of the traveling public.

4. POLITICAL AND ENVIRONMENTAL OBJECTIONS TO A SECOND AIR CARRIER AIRPORT MUST BE OVERCOME BEFORE SITE SELECTION, PLANNING, DESIGN AND CONSTRUCTION CAN BE UNDERTAKEN. SUCH CONSIDERATIONS PLACE A SECOND AIR CARRIER AIRPORT BEYOND THE TIME REQUIREMENT FOR BOSTON-LOGAN INTERNATIONAL AIRPORT IMPROVEMENT TO MEET THE DEMANDS PLACED UPON IT BY THE BOSTON AREA.

(1) Powerful Forces Both Political and Environmental Must Be Overcome Before Specific Development Can Begin On Another Major Airport.

The present Governor of the State of Massachusetts has publicly announced that there will be no new airport as long as he is in office.

In addition to this powerful force, strong protests and opposition on environmental grounds has been voiced by the populace of areas of airport sitings proposed in 1969 and 1970.

Further, cities other than Boston have been experiencing resistance to development of new airports. Legislative approval is necessary before development of a second air carrier airport can be undertaken in the Boston region.

(2) The Site Selection For a Major Airport Is a Difficult and Time Consuming Task.

A balance must be struck between the various basic site selection criteria which tend to counter oppose one another. These factors include:

- Accessibility to market demand
- Land availability
- Compatibility of land use

A balancing of market accessibility with available compatible land of sufficient size to accommodate a major airport will take time. A site satisfying these fundamental criteria and not causing major adverse environmental impact may be impossible to locate.

The market potential aspects of a second airport and the effect of given sites on Boston-Logan International Airport's potential demand was detailed in Landrum & Brown's 1968 study and referenced in Appendix D.

(3) The Site Selection, Planning, Design, Financing and Construction Of a Major Airport Can Be Expected To Consume a Period Of Ten Years Or More.

The time frame of ten or more years for development of a new major airport was spelled out in the 1961 "Project Horizon" ten year aviation forecast directed by President John F. Kennedy. The environmental issues have become much more pronounced since 1961. Consequently the 1971 time frame requirement can be expected to exceed that of 1961.

(4) Further Data Related To Various Sitings and Solutions For a Second Airport Are Set Forth in Appendix D.

5. <u>FROM A PRACTICAL AND TECHNOLOGICAL VIEWPOINT, THE DIVERSION OF THE SHORT-HAUL PASSENGER MARKET TO ALTERNATE TRANSPORTATION MODES MUST BE CONSIDERED AS A POSSIBLE LONG-RANGE FACTOR, WHICH COULD ULTIMATELY DECELERATE THE RATE OF INCREASE IN THE DEMAND FOR SHORT-HAUL SERVICE FROM BOSTON-LOGAN INTERNATIONAL AIRPORT.</u>

Two modal transfer alternatives could ultimately displace segments of Boston-Logan International Airport's passenger market. These two are:

- High speed rail
- V/STOL

(1) <u>The Practical Application Of a Competitive High-Speed Rail System Operating in the Northeast Corridor Doesn't Appear Probable Until at Least 1980.</u>

It is recognized that approximately fifty percent (50%) of the Boston air travel market lies in the Northeast Corridor and that if competitive transportation modes were available the impact on Boston-Logan International Airport could be significant.

Studies indicate that if a viable high-speed rail system is fully realized in the 1980's it will only decelerate the rate of increase in demand for service from Boston-Logan International Airport. Technical data related to this question is contained in Appendix D.

(2) <u>It is Highly Probable That Competitive V/STOL System In the Northeast Corridor Will Not Be Realized Until 1980.</u>

Today there is not an existing economically viable aircraft or system of STOL ports and navigational facilities to support such a system. STOL runway 15-33 is included in the recommended improvement program to encourage V/STOL development.

The development of V/STOL facilities on existing airports should pose no real problem as their noise and operational requirements are well within the envelope of CTOL equipment requirements.

However, the installation of new V/STOL facilities in preferred market areas (urban centers) can be expected to meet environmental opposition of much the same nature as that experienced at CTOL facilities.

6. OF ALL THE ALTERNATIVES CONSIDERED FOR REDUCING NOISE EXPOSURE WITH THE EXCEPTION OF NOISE REDUCTION AT THE SOURCE, THE IMPLEMENTATION OF A RIGID AND COMPREHENSIVE PREFERENTIAL RUNWAY USE SYSTEM OFFERS THE GREATEST POTENTIAL FOR SUBSTANTIAL NOISE ABATEMENT WITHOUT PRODUCING UNREASONABLE PENALTIES ON THE AIRPORT USER.

(1) Banning Of 4-Engine Jets Would Make a Minor Improvement In Overall Noise Exposure; However, The Effects On the Air Transportation Industry Negate the Small Benefit Derived.

Four engine jet operations account for approximately twenty-five percent (25%) of total air carrier movements at Boston-Logan International Airport today. Of these, less than half are the earlier turbojets which generate the greatest noise levels. It is these aircraft that are scheduled for earliest retirement to be replaced by quieter new technology aircraft as described in Chapter I. Imposition of such a ban would pose serious operational problems for the airlines whose fleets have large numbers of these aircraft. Current three engine jet aircraft have operating ranges insufficient to serve many of the nonstop long-range markets, particularly the transatlantic and transcontinental service.

(2) Locally Established Maximum Noise Level Restrictions Are Legally Questionable and Would Create Chaos in the Aviation Industry Due To Lack Of Conformity From Area To Area.

See Appendix D for a discussion of noise level restrictions.

(3) Surcharges For Noisier Aircraft Including Night Differentials Would Not Provide Sufficient Economic Leverage To Induce Changes In Equipment Types Or Schedules.

This subject is discussed further in Appendix D.

(4) The Application Of Preferential Runway Use Procedures Represent the Greatest Potential For Substantial Noise Abatement Without Producing Unreasonable Penalties On the Airport User.

The benefits of an improved concept of preferential runway utilization are described in detail in Chapter III of this report.

7. NO OTHER FACILITY ALTERNATIVES EXPLORED WERE AS PRACTICAL, FEASIBLE OR ENVIRONMENTALLY DESIRABLE AS THE RECOMMENDED PROJECTS.

In the course of the Boston-Logan International Airport master planning studies various alternatives to the 15L-33R parallel runway were analyzed.

(1) Increased Separation Between 15-33 Parallels Would Result in a Substantial Land Taking and Dramatically Increased Environmental Impact on the Airport's Neighbors.

Separation of the parallel runways by 5,000 feet would permit independent and simultaneous takeoffs and landings, thus increasing the operating capability and land area available for development.

(2) Other Spacing Of Less Than 1,200 Feet Centerline Runway 15R-33L To Centerline Runway 15L-33R Will Not Meet the FAA Runway-Taxiway Spacing Standard.

This standard requires 600 feet centerline runway to centerline taxiway. Thus, the taxiway-runway as shown on Exhibit II-5 is the minimum standard.

(3) 15-33 Parallel Runway Spacing Of Greater Than 1,200 Feet Centerline To Centerline Was Considered, But Such Spacing Would Cause Extreme Environmental Impact On the Airport Neighbors and Substantial Land Taking.

Spacing of 3,500 feet centerline to centerline is required to permit independent landings on one runway simultaneous with an independent takeoff on the parallel runway. This operational capability substantially increases aircraft operations. Increasing the spacing of the 15-33 parallel runways from the proposed 1,200 feet to less than 3,500 feet centerline to centerline has little advantage for capacity and operation.

(4) Concentration Of Development in the 9-27 Direction Was Considered, However It Is Not Possible To Make This a Primary Operating Direction.

Runway 9-27 is subject to obstruction by high-rise building construction taking place in downtown Boston and by harbor activity.

(5) Another Alternative Of Shifting a Parallel 9-27 Runway To the East Was Studied, But It Creates Major Environmental Disruption.

Such a shift improves the relationship of the 9 runway for arrivals and departures from and to the east. However, such a solution isolates Deer Island, virtually eliminates Point Shirley, creates major impact on harbor circulation and requires substantial land taking. This subject is discussed further in Chapter II.

CHAPTER IX

ECONOMIC ASPECTS OF AIRPORT AND AIRPORT IMPROVEMENT PROGRAM

I. INTRODUCTION

1. PURPOSE

Boston-Logan International Airport is undertaking a $211 million improvement program. The reason for undertaking this program is based upon many factors -- economics is only one consideration among others. This chapter is concerned with reporting the necessary research and analysis that was conducted to evaluate the following two major subjects:

- The economic contribution of Boston-Logan International Airport today and in 1975
- The cost of reducing jet noise impact under alternative methods

2. APPROACH

During the course of this assignment, primary emphasis and reliance was placed upon original research. Secondary data (published materials) were thoroughly searched, inventoried and reviewed to insure that duplication would not be made of work already performed or significant information was not overlooked.

The research efforts included the following:

- In depth interviews with Authority staff, co-consultants of the study team and others.
- Review of literature published on subjects relevant to the study and a survey of other sources having private "in house" information.

- Pre-testing and survey of the largest, selected, businesses dependent upon air freight transportation. A survey was conducted for the purpose of determining the impact of a night curfew on their operations.

- Survey of airlines with flights scheduled during the hours of 10:00 p.m. and 7:00 a.m.

- Field inspection of properties adjacent to Boston-Logan International Airport and properties shown to lie in the general area of the airport. The purpose of this task was to gain an understanding of construction types and development patterns.

- Interviews with realtors and developers in the above-mentioned areas and several large industrial and commercial realtor/developers were contacted to gather data on values and demand for various land uses.

- Use of existing secondary data determined to be relevant to the study. These materials included prior surveys, studies, etc., as well as census data.

- Several studies have been conducted by the consultant for other airports and enterprises which are relevant and useful to this assignment. Examples of such prior assignments include the following:

  - Locational alternatives for major airline's headquarters and maintenance facilities.

  - Development impact of the relocation of an international airport upon surrounding land area

  - Route selection study for inter-state airline

  - Industrial site location studies for major corporation's production and office facilities

  - Benefit-cost analysis of public works projects including airport improvements, rapid transit systems and various land use developments.

Pertinent results of these studies were utilized in this assignment.

II. SUMMARY

The analysis contained in this chapter shows that the Boston Metropolitan economy receives a significant portion of its income as a result of the payrolls and purchases of businesses located at Boston-Logan International Airport. Furthermore, the economy will not realize the full potential gain resulting from the growth in the demand for airport service if Boston-Logan International Airport's improvement program is not completed. Finally, the economic loss resulting from a night curfew is analyzed and the impact of the loss in airport employment is quantified.

If all the economic elements are considered in one framework the following is an indication of the magnitude of the annual economic impact of Boston-Logan International Airport on the Boston Metropolitan area's economy in 1975:

Payroll and Purchases Impact	$1,274 Million
Construction Impact	$ 192 Million
Visitors Impact	$ 494 Million
Total	$1,960 Million

This annual impact is of major significance. It is inconceivable that an enterprise of this magnitude can be treated other than with a most profound respect. It must be noted that the estimates shown above are conservative as they do not include the airport independent businesses other than transient services.

A restraint of this growth could have a potentially disastrous impact on the Boston area's economy.

III. CONCLUSIONS

1. BOSTON-LOGAN INTERNATIONAL AIRPORT MAKES A SIGNIFICANT ECONOMIC CONTRIBUTION TO THE BOSTON METROPOLITAN AREA, A CONTRIBUTION THAT WILL BE ENHANCED BY THE PROPOSED IMPROVEMENT PROGRAM.

(1) The Impact Upon the Income of the Economy of the Boston Metropolitan Area Created By the Direct Payrolls and Purchases of Boston-Logan International Airport Was $728 Million in 1970. With the Improved Airport This Impact is Expected To Grow To $1,274 Million ($1.27 Billion) In 1975. All of This $546 Million Increase In Impact Will Not Occur If the Number of Operations At the Airport In 1975 Is Restricted.

(2) If the Existing Airport Were Operated In 1975 On the Same Basis As Is Projected For the Improved Airport In 1975 (Same Delay Levels and Noise Abatement Procedures) To Approach the Reduced Levels of Air and Noise Pollution Made Possible By the Improved Airport, An Estimated 21,600 Scheduled Air Carrier Operations With 1,200,000 Passengers Or 600,000 Trips Would Be Lost. This Reduction In the Level of Air Transportation Services In 1975 Would Create A Loss To The Economy Of $116 Million Per Year By 1975.

(3) The Present Average Level of Construction Expenditures (1967-1970) At Boston-Logan International Airport Creates a Total Impact Upon the Boston Metropolitan Economy of $76.3 Million Per Year With An Estimated 900 Construction Jobs. The Increase In the Economy Created By the Proposed Improvement Program Will Average $191.9 Million Per Year With 1,900 Jobs Over The Period 1971-1974.

(4) The Cost To the Boston Metropolitan Area Resulting Only From the Loss Of Airport Employment Caused By a Curfew Imposed On Night Jet Flights Between 10:00 p.m. And 7:00 a.m. Is Estimated To Be $18 To $28 Million Per Year In 1971. In Addition, Such A Curfew Will Cause Increases In Transportation Costs And Competitive Disadvantages For Selected Firms In the Boston Metropolitan Area Whose Operations Are Highly Sensitive To Transportation Delays.

IV. ECONOMIC ANALYSES

1. WHAT THE BOSTON-LOGAN INTERNATIONAL AIRPORT MEANS TO THE BOSTON METROPOLITAN AREA TODAY.

The dependence of a modern metropolitan economy upon the proper functioning of a major air carrier airport is undisputed. An airport not only serves as a vital link in the complex intraregional transportation network but, also, as a vital element within the local economy's "export" sector.

Just as a nation's material wealth is often dependent upon the value of its exports, a metropolitan area is also reliant upon the value of goods and services it can supply to other areas. The demand for export goods and services creates jobs and payrolls that would not otherwise exist in the local economy.

The creation of one "export" related job begins a chain of events which is explained by the employment multiplier effect and the income multiplier effect. The total economic impact resulting from the single export-related job-payroll is many times greater than the value of that initial job.

(1) Employment Multiplier.

For each direct "export" related job, additional demands are created within the local economy to support it. Examples of local support jobs include the grocer, the carpenter, personal service personnel, etc. Based upon prior studies, (22) it is estimated that in an area the size of the Boston Metropolitan area, for each direct "export" job created there is simultaneously created a demand for 1.3 added indirect or support jobs.

(2) Income Multiplier.

When a dollar from outside the area enters the income stream within the local economy, the person who receives it has a predictable propensity to save part of it and spend the balance. This expenditure becomes "new" income to the recipient who likewise saves some of it and spends the remainder. Consequently, the impact of these successive "rounds" of spending creates a total income within the local economy greater than the amount of the initial dollar. For areas the size of the Boston Metropolitan area it is estimated by the economic consultant that total income as a result of this chain of events is 2-3 times the size of the initial amount entering the local economy from the "outside."

(3) Total Economic Impact of Export Enterprises.

The income and employment multipliers taken together have an amplifying effect upon the income and jobs created by the export enterprise. Because the average salary paid by airport enterprises ($9,600) closely approximates the present average salary level in the Boston Metropolitan area, the direct and indirect payrolls can be taken together for purposes of analysis. For example, one direct job plus the 1.3 jobs created by it equals 2.3 jobs. These jobs represent a combined average payroll of $23,000 (assuming a $10,000 average wage). This $23,000 payroll means the total income to the local economy (at 2-3 times the "initial" payroll income) is approximately $46,000-$69,000 annually. The one export job has, in other words, an ultimate impact of 4.5-7.0 times its own value (or an average of 5.75).

For example, Table IX-1 shows the impact of the total 1970 direct employment of 10,000 employees. Assume an increase in Boston-Logan International Airport activity required the addition of only one new employee at, say, "Acme Rent-A-Car". This one direct employee would receive an average wage of $9,600 in 1970 and would spend this income on food, clothing, shelter, etc. This spending would create an additional demand for the aforementioned goods and services. This demand is estimated to cause an additional 1.3 support jobs. For example, the garage service which repairs "Acme's" autos may hire a new mechanic. The impact of the 2.3 jobs (one direct and 1.3 support) creates a total identifiable payroll of (2.3 x $9,600), $22,080. The impact of this payroll is amplified because the money spent for food, clothing and shelter becomes "new income" to the grocer, clothing store and landlord or builder, etc. These service persons in turn spend for their own purposes -- new merchandise, salaries, etc. This effect of spending - income - spending, etc. is estimated to increase total income in the economy by a factor of 2-3 before it has run its course (because a certain amount is saved and not "re-spent").

It is important to note that the process or chain of events created by the one export job also works in reverse as well. If the one export job is lost, the contraction in the local income is 4.5-7.0 times the payroll of the one job.

(4) The Economic Impact of Boston-Logan International Airport Employment.

The business directly associated with Boston-Logan International Airport includes the airlines, Massachusetts Port Authority airport employees and

TABLE IX-1

Economic Impact of Airport Employment In 1970

Number of Direct Airport Employees	10,000	
Number of Support Jobs Per Direct Job	1.3	
Total Number of Support Jobs	13,000	
Total Number of Support and Direct Jobs	23,000	
Average Payroll Per Employee	$9,600	
Total Payroll of Support and Direct Jobs	$220,800,000	($23,000 x $9,600/job)
Factor of Expansion in Income From Payrolls	2-3	
Total Impact Upon Income in Economy	$440-$660 million	
Midpoint in Range	$550 million	

employees of other airport-located businesses. All totaled, these enterprises employ nearly 10,000 persons. (23) Total wages paid to these employees in 1970 equaled $96,000,000. According to the methodology outlined above, this payroll creates a net increase (4.5-7.0 times) of $440-660 million in the local economy's income. (Table IX-1)

Based upon the projected number of flights in 1975 for the improved airport, it is estimated that the total impact resulting from Boston-Logan International Airport payrolls will grow from its present level of $550 million (mid-point of range expressed above) to $878 million. (Table IX-2)

This assumes the improved airport will be operated to accommodate 348,000 aircraft operations with a calculated delay of 11,752 hours per year to maximize noise reduction considerations.

If the improvements are not realized and 1975 operations are restricted in order to equate:

(1) The level (hours) of aircraft delay, and

(2) The levels of air and noise pollution reduction

to those levels achieved by the improved facility, aircraft operations and passenger trips will have to be cut.

In order to estimate the consequences of the loss resulting from such a restriction it was assumed that:

TABLE IX-2

ECONOMIC IMPACT OF EMPLOYMENT AND PURCHASES BY AIRPORT - LOCATED ENTERPRISES IN 1965 AND 1970 AND IN 1975 ASSUMING TWO ALTERNATIVE OPERATION CONDITIONS [A]

	1965 Actual	1970 Actual	1975 Projected [A] [E] Condition X	1975 Projected [A] [E] Condition Y	Income or Employment Multiplier	Total Annual Income: 1970 [E] Estimated	Total Annual Income: 1975 Projected [A] [E] Condition X	Total Annual Income: 1975 Projected [A] [E] Condition Y	Increase In Condition X over Condition Y
						- - - - - - Mid Point of Range	- - - - - -		
Total Operations Scheduled Air Carrier [B]	150,452	209,379	246,300	224,700	-	n.a.	-	-	-
Total Enplaned Passengers [B]	2,746,360	4,449,000	6,335,000	5,735,000	-	n.a.	-	-	-
Value of Purchases of Goods and Services	$20,800,000 [C]	$71,100,000 [C]	$158,375,000	$148,375,000	2-3X	$178 million	$ 396 million	$ 358 million	$ 38 million
Value of Employee Payroll	$37,800,000 [C]	$95,900,000 [C]	$152,700,000	$139,314,000	4.5-7.0X	$550 million	$ 878 million	$ 801 million	$ 78 million
Total Impact of Payrolls and Purchases						$728 million	$1,274 million	$1,159 million	$116 million
Value of Payroll Per Operation	$251	$458	$620 [D]	$620 [D]	-	n.a.	-	-	-
Value of Purchases Per Passenger	$7.57	$16.16	$25.00 [D]	$25.00 [D]	-	n.a.	-	-	-

A Condition X assumes the improved airport with 1975 operations and maximum noise abatement procedures. Condition Y assumes the existing airport and operations restricted in 1975 as described in the text.

B Actual and projected figures from Landrum and Brown.

C Results of annual survey conducted by Massachusetts Port Authority.

D Projection based upon the percentage change in value of payroll per operation as a function of the percentage change in the number of operations; and the percentage change in value of purchases per passenger as a function of the percentage change in the number of passengers.

E Projected by Development Research Associates.

Source: Massachusetts Port Authority
Landrum and Brown, Inc.
Development Research Associates

- There would be a proportionate reduction in all types of aircraft activity projected for 1975 based upon the pro rata share of that type of aircraft activity. In other words, scheduled air carrier operations received the same percentage reduction as did general aviation.

- Passengers per aircraft was held constant for the reduced level of operations as well as the level of operations with airport improvements.

Based upon the foregoing assumptions, an estimated 21,600 scheduled aircraft operations and 1,200,000 passengers or 600,000 trips will be lost. The effect of this potential loss in operations is to reduce the projected impact from payrolls in 1975 from $878 million to $801 million or a loss of a potential $77 million per year in 1975. (Table IX-2)

(5) <u>Purchases of Goods and Services by Enterprises Located at Boston-Logan International Airport.</u>

In addition to payrolls related to Boston-Logan International Airport, the enterprises located at the airport spent an estimated $71,000,000 in 1970 [(23)] for goods and services in the Boston Metropolitan Area. This expenditure increased income within the Boston Metropolitan Area economy by a factor of 2-3 times, or a total impact of $140-$210 million with a midpoint of $178 million. (Table IX-2)

By 1975, with the improved airport, the impact resulting from purchases by these enterprises is estimated to be $396 million. (Table IX-2) If the improvements are not made, and the level of operations is limited in 1975 as described in the discussion of payrolls above, this impact will be restricted to an estimated $358 million, or $38 million less than could be realized with the improvements. (Table IX-2)

(6) <u>The Economic Impact of Boston-Logan International Airport Improvements Program.</u>

The ongoing program at Boston-Logan International Airport has, over the years, accounted for millions of dollars in expenditures for payrolls and purchases. In the four year period 1967-1970, over $77 million (24) was expended for improvements -- an average expenditure of $19 million per year. (Table IX-3) When the appropriate multipliers are applied to the portions of this expenditure for labor (payrolls) and material purchases, the total impact upon the Boston Metropolitan economy is estimated at over $76 million per year from 1967 to 1970. (Table IX-3) This is partly produced by the more than 900 construction employees involved in these projects.

The 1971 improvements program will cause a directe expenditure of approximately $211 million. (24) The number of construction jobs will grow from the 900 average 1967-1970 period to an estimated 1,900 in the period 1971-1974. (Table IX-3) The total dollar impact upon the Boston Metropolitan economy is estimated to be on the order of $192 million per year in the years 1971-1974, or an increase of $115 million per year above present levels (Table IX-3)

TABLE IX-3

ECONOMIC IMPACT OF IMPROVEMENT PROGRAMS FOR THE PERIODS 1967-1970 AND 1970-1975

	1967-1970	1971-1974	Increase
Total Construction Expenditures [A]	$77,029,000	$211,000,000	$134,000,000
Average Expenditure Per Year	$19,257,000	$ 52,750,000	$ 33,493,000
Percent Labor/Payrolls [A]	45%	35%	-
Expenditure for Payrolls	$ 8,666,000	$18,463,000	$ 9,797,000
Expenditure for Materials	$10,591,000	$ 34,287,000	$ 23,696,000
Multiplier for Payrolls	5.75	5.75	-
Multiplier for Purchases (Midpoint of Range)	2.5	2.5	-
Total Impact of Payrolls (Midpoint of Range)	$49,830,000	$106,160,000	$ 56,330,000
Total Impact of Purchases	$26,500,000	$ 85,700,000	$ 59,200,000
Total Impact	$76,330,000	$191,860,000	$115,530,000
Average Construction Wage 1970-71 [B]	$ 9,600	$ 9,600	-
Estimated Number of Jobs Generated by Payrolls	900	1,900	1,000

A Data supplied by Massachusetts Port Authority.

B Bureau of Labor Statistics average weekly earnings for construction workers.

Source: Massachusetts Port Authority,
Bureau of Labor Statistics
Development Research Associates

(7) <u>The Total Economic Contribution of Boston-Logan International Airport.</u>

The impact upon the Boston Metropolitan economy resulting from payrolls and purchases generated by airport-dependent businesses is substantial. These enterprises include service and manufacturing industries. For example, headquarters offices of insurance companies are dependent upon the airport to transport their employees. Also, millions of dollars are spent each year by visitors to the Boston area. Whether they are businessmen, tourists or convention/seminar attendees, they support a substantial portion of transient service businesses such as hotels, restaurants, gift shops and the like. Based upon broad and general studies of visitor expenditures, it has been estimated that non-residents arriving in Boston via the Boston-Logan International Airport spent approximately $350 million in the Boston Metropolitan Area in 1970. This estimate is based upon normal expenditures for taxis, hotels, meals, entertainment and miscellaneous items by the non-resident air traveler. Based upon the estimated increase in air passengers these expenditures are estimated to reach almost $500 million by 1975 ($494,100,000).

Another type of airport dependent business is the air-freight shipper. As subsequently discussed in the curfew section of this chapter, hundreds of businesses in the Boston Metropolitan Area depend upon air freight to ship goods on a regular and emergency basis to their customers.

There are several conceptual approaches that could be taken to attempt t a measurement of the airport's total contribution to the Boston Metropolitan Area's economy. Posed in the form of questions these approaches could be expressed as follows:

- What is the total value of the businesses that have located here because the area is served by a major international air carrier airport?

- What is the value of the sales and payrolls that would be lost to the Boston Metropolitan economy if the airport ceased operating?

Obviously, such an exercise would be predicated upon absurd assumptions to begin with. Few businesses today would consider locating in an area without good air transportation services. A modern metropolitan economy that was deprived of such a vital service would gradually decay to a fraction of its present size. Clearly, a major segment of the total regional economy's income would be lost if it were not serviced by a modern air carrier airport. It follows that a decline in the level of air transportation services would also restrict the development of the area it serves.

2. ECONOMIC EVALUATION OF ALTERNATIVE METHODS OF REDUCING THE NOISE IMPACT OF AIRCRAFT OPERATIONS.

Several measures have been utilized in other areas in attempting to reduce the impact of jet noise upon communities adjacent to airports. (1, 2, 25) In this section three of these methods will be considered:

- Soundproofing
- Curfew on night flights
- Property acquisition/re-use

Each one of these methods has different levels of cost, different degrees of noise reduction and will be discussed for different analytical purposes.

(1) Soundproofing of Private and Public Structures.

Although the cost of soundproofing structures within a noise impact area can be calculated,[14] based upon prior research the cost of such a program is presently beyond the financial capacity or legal responsibility of the Massachusetts Port Authority entity today.[26] More importantly, as stated in Chapter III there is no correlation between individual annoyance and NEF contours. Additionally, many structures are of such construction, or condition that it is either:

- More feasible to construct a new house than soundproof the one one, or
- More expensive to soundproof than the property is worth.

However, the cost of soundproofing can provide a means of measuring relative conditions and allow an evaluation of alternative airport improvements from a cost/benefit standpoint. Alternatively, if areas now in need of soundproofing can be made relatively more quiet by other means (preferential runway use) so that they are no longer in need of soundproofing then this "need reduction" can be regarded as a benefit.

(2) <u>Property Acquisition and Possible Re-Use.</u>

As with the applicability of soundproofing cost estimates discussed previously, this alternative is more useful in illustrating cost differentials than it is indicative of a practical solution to reducing the noise impact upon the airport environs at the present time.

Of the "noise incompatible" residential land use lying within the critical areas, it is reasonable to assume that certain sections will not lend themselves to conversion to "noise compatible" land uses due to such reasons as; the new use would be incompatible with surrounding uses, the area acquired would be too small to assemble sufficient acreage, the acquired land lies in an area exhibiting poor access for any land use but residential, etc.

Also, in certain areas where non-residential uses would be incompatible, recreation and other open space would be a suitable, indeed desirable, re-use. However, since this type of use is in most instances not "marketable," no attempt is usually made to establish a value upon sale for re-use for these parcels.

(3) Economic Cost of Imposing a Curfew on Night Flights.

The equation utilized for calculating the Noise Exposure Forecast areas gives approximately ten times as much weight to a jet flight at night (10 p.m.- 7 a.m.) as is given to the same operation between the hours 7 a.m.-10 p.m. The equation thus recognizes that a jet operation at night is much more perceptible by the ear when the ambient noise level is minimal. Consequently, if only one-tenth as many flights operated during the curfew period as operates outside this period they would be given equal importance of "weight" with day/flights in the calculation.

The curtailment in nighttime jet flight activity will cause certain economic losses to the local economy. These losses can be categorized by losses in direct airline employment, increases in transportation costs to business shipping goods during this period and sales losses to business because of their extreme sensitivity to transportation time requirements.

. Losses in Direct Airport Employment

In order to ascertain the impact a nighttime curfew would have upon airline operations, interviews were conducted with the following:

- Airline Station Managers
- Airport Official at Washington National Airport
- Airline Regional Managers
- Massachusetts Port Authority Executive Staff
- Air Freight Forwarders

It is concluded from these interviews that the following factors determine the ultimate impact of a nighttime curfew:

- If the airlines were restricted from landings or takeoffs between the hours of 11 p.m. and 7 a.m. they would not schedule any flights after 10 p.m. in order to avoid not being able to land a plane that was scheduled to arrive between 10 p.m. and 11 p.m. but was delayed at its origin or enroute.

- A very small percentage of total passengers depart between the hours of 10 p.m. and 7 a.m. However the major portion of air freight shipments go out at night during the proposed curfew period.

- If the nighttime curfew were enforced, the cancelled flights would not be rescheduled because of the need to have that equipment (airplane) at its scheduled destination (another city) for another scheduled flight. Also, Boston-Logan International Airport is a terminating or turnaround point. Consequently, the maintenance that would have to be performed on that equipment at night would have to be done at another location. Hence, another airport would handle this job.

- Most air freight is picked up at the point of origin between the hours of 9 a.m. and 5 p.m. It arrives via the freight forwarder all during the day and into the early evening hours. It is assembled and some freight is containerized then put aboard planes scheduled for night departures or put aboard planes that arrive after 10 p.m. scheduled for early morning departures. Inasmuch as air freight is the most expensive mode of transportation, shippers pay the extra cost because of extremely short delivery schedules - i.e., 24 hours. If they cannot expect their freight (shipped via Boston-Logan International Airport) to arrive the next day they will ship via another airport or another mode of transportation.

- Most airlines have a night shift responsible for attending to arrivals and departures during that period. If those flights are cancelled (since they cannot be scheduled for the next day) most of these employees would be eliminated from the airline payrolls.

A total of 15 scheduled air carriers have operations scheduled between the hours of 10 p.m. and 7 a.m. Interviews with the local management of these airlines indicates a total of approximately 400 jobs would be lost if a curfew were enforced (Table IX-4).

The average payroll for these employees is about $10,000 per year. This average payroll is slightly higher than the $9,600 for all airport employees because of shift premium differentials and in many instances certain white collar employees (such as salesmen) would be eliminated if the air cargo operation were to be cut back or relocated. The total impact of this employment loss to the Boston Metropolitan Area is estimated to be $18 million to $28 million annually. This estimate is derived as follows:

Total Jobs Lost (approximate)	-- 400
Average Salary per Job	-- $10,000
Total Direct Payroll Lost	-- $4,000,000
Payroll Multiplier	-- 1.3
Total Indirect Payroll Lost	-- $5,200,000
Total Payroll Lost	-- $9,200,000
Income Multiplier	-- 2-3
Total Income Lost (rounded)	-- $18-$28 million

. Losses to Businesses

In 1965 Landrum & Brown conducted a survey of over 3,000 businesses and large institutions in the Boston Metropolitan Area. Of the more than 500 replies to this survey, over 100

TABLE IX-4

Scheduled Air Carrier's[a] Reduction In Employment Resulting From Enforcement Of A Curfew On All Night Jet Flights

Airline Code Number	Number of Employees Cut From Payroll
Domestic:	
1	3
2	100
3	10
4	50
5	32
6	65
7	-
8	-
Subtotal Domestic	260
International:	
9	5
10	30
11	75
12	-
13	-
Subtotal International	110
Air Freight:	
14	9
15	25
Subtotal Air Freight	34
Grand Total Air Carriers	404

(a) Those air carriers who have scheduled flights during the hours of 10 p.m. and 7 a.m. (March 1971).

spent $10,000 or more on air transportation services in 1965. In addition, a major airline compiled a list of its largest air freight customers as did another air freight related enterprise. These lists were used in the survey as further described below.

During the course of the analysis, the co-efficient of specialization for industry groups within the Boston Standard Metropolitan Statistical Area (the counties of Essex, Middlesex, Norfolk and Suffolk) was measured. Those industries most specialized in this region had the highest relative concentrations of employment in proportion to the distribution of employment in that Standard Industrial Classification (4 digit SIC #'s) in the nation. These key industries were regarded as most important to the regional economy in terms of generating "export" income (See Table IX-5). This reasoning is based upon the fact that if an area has many times the nation's average share of employees in any one industry category it must be serving "extra-regional" needs, or, exporting their larger-than-average output.

Therefore, by selecting from the lists of business names available (from the aforementioned survey and listings) those companies which were most likely to be "export" industries and those with largest air freight expenditures, interviews were conducted with those businesses most sensitive to inter-regional competition and most valuable to the Boston Metropolitan Area.

During the survey period approximately 70 selected businesses were interviewed after having received formal notification that they would be contacted and requesting their cooperation.

In most cases the persons interviewed at each business included the plant manager or operations manager, and traffic manager. They were asked such preliminary questions as:

- Their scale and types of activities in the Boston Metropolitan Area.

- Their use of air freight mode of shipment.

- Their market areas (east or west of Chicago, etc.)

- Their competition from other regions.

TABLE IX-5

ANALYSIS OF EMPLOYMENT
SELECTED THREE & FOUR DIGIT SIC CODE
FOUR COUNTY AREA - BOSTON SMSA

SIC Code	Selected Industrial Categories	United States Employment		Boston SMSA Employment		% Boston SMSA ÷ % of U.S.	Distribution of Highly Specialized Categories			
		Total	% of Total	Total	% of Total	(Percent)	1-1.5X	1.5-5X	5-10X	Over 10X
	GRAND TOTAL	56,348,479		1,224,926	2.17%					
273	Books	97,749	0.173%	3,643	0.297	171.7%		X		
2731	Book Publishing	52,280	0.093	1,703	0.139	149.5	X			
2732	Book Printing	45,372	0.081	1,940	0.158	195.1		X		
306	Fabricated Rubber Pdct., N.E.C.	150,192	0.267	3,748	0.306	114.6	X			
307	Misc. Plastic Pdcts.	278,144	0.494	7,437	0.607	122.9	X			
311	Leather Tanning & Finishing	29,905	0.053	5,428	0.443	836.8			X	
313	Footwear Cut Stock	14,494	0.026	3,257	0.265	101.2				X
314	Footwear Except Rubber	212,816	0.378	17,414	1.422	376.2		X		
3141	Shoes, Except Rubber	200,969	0.357	14,561	1.189	333.1		X		
3142	House Slippers	11,629	0.021	846	0.069	328.6		X		

SIC Code	Selected Industrial Categories	United States Employment		Boston SMSA Employment		% Boston SMSA ÷ % of U.S.	Distribution of Highly Specialized Categories			
		Total	% of Total	Total	% of Total	(Percent)	1-1.5X	1.5-5X	5-10X	Over 10X
3171	Women's Handbags & Purses	25,023	0.044	216	0.017	38.6				
3172	Personal Leather Goods	12,271	0.022	346	0.028	127.3	X			
361	Electric Test & Distributing Equip.	187,275	0.332	4,224	0.345	103.9	X			
3611	Electric Measuring Instruments	64,803	0.115	2,330	0.190	165.2		X		
3613	Switchgear & Switchboard Apparatus	70,959	0.126	1,247	0.102	81.0				
362	Electrical Industrial Apparatus	211,777	0.376	1,424	1.116	30.1				
3622	Industrial Controls	51,719	0.092	962	0.079	85.9				
363	Household Appliances	172,396	0.306	655	0.053	17.3				
364	Electric & Wiring Equip.	173,715	0.308	6,146	0.502	163.0		X		
3641	Electric Lamps	32,854	0.058	2,205	0.180	310.3		X		
3642	Lighting Fixtures	68,304	0.121	542	0.044	36.4				
3643	Current Carrying Wiring Devices	48,962	0.087	1,144	0.093	107.0	X			
365	Radio & TV Receiving Equip.	134,935	0.239	2,791	0.228	95.9				
3651	Radio & TV Receiving Sets	117,258	0.208	2,791	0.228	109.6	X			

SIC Code	Selected Industrial Categories	United States Employment		Boston SMSA Employment		% Boston SMSA ÷ % of U.S. (Percent)	Distribution of Highly Specialized Categories			
		Total	% of Total	Total	% of Total		1-1.5X	1.5-5X	5-10X	Over 10X
366	Communication Equipment	523,988	0.930	16,918	1.381	148.5	X			
367	Electronic Components & Accessories	410,893	0.729	20,240	1.652	226.6		X		
3674	Semiconductors	93,792	0.166	4,683	0.382	230.1		X		
3679	Electronic Components, N.E.C.	254,373	0.451	8,057	0.658	145.9	X			
369	Misc. Electrical Equip. & Supplies	111,386	0.198	2,664	0.217	109.6	X			
3693	X-Ray Apparatus & Tubes	9,472	0.017	684	0.056	329.4		X		
3694	Engine Electrical Equip.	54,157	0.096	1,305	0.107	111.5	X			
471	Freight Forwarding	32,892	0.058	554	0.045	77.6				
472	Arrangement of Transportation	53,421	0.095	1,665	0.136	143.2	X			
631	Life Insurance	502,277	0.891	20,290	1,656	185.9		X		
632	Accident & Health Insurance	68,124	0.121	2,837	0.232	192.3		X		
633	Fire, Marine & Casualty Insurance	350,466	0.622	14,413	1.178	189.4		X		
671	Holding Companies	13,327	0.024	146	0.012	50.0				

SIC Code	Selected Industrial Categories	United States Employment		Boston SMSA Employment		% Boston SMSA ÷ % of U.S. (Percent)	Distribution of Highly Specialized Categories			
		Total	% of Total	Total	% of Total		1-1.5X	1.5-5X	5-10X	Over 10X
672	Investment Companies	9,587	0.017	703	0.057	335.3		X		
6799	Investing Institutions, N.E.C.	3,579	.006	16	0.001	16.7				
7391	Research & Development Labs.	77,610	0.138	5,444	0.444	321.7		X		
7392	Business Consulting Services	238,662	0.424	7,259	0.593	139.9	X			
7397	Commercial Testing Tabs	14,807	0.026	145	0.012	46.2				
7399	Business Services, N.E.C.	216,742	0.385	4,243	0.346	89.9				

Source: U.S. Department of Commerce, County Business Patterns 1969. Development Research Associates.

Although they were asked for information regarding their size of payroll, sales, value of plant and equipment and employment, most firms refused to divulge this information.

Lastly, they were asked to estimate the impact upon their operations, sales, etc. if they were not able to ship by air freight during curfew hours.

A categorization was made of the economic impact of a curfew upon those firms interviewed. The categories used to classify the impact have been defined as follows:

- No impact - Firms either don't use Boston-Logan International Airport during the curfew hours or could reschedule air cargo shipments to day flights at little or no cost.

- Low impact - Firm would lose sales to competitors for emergency shipments amounting to less than five percent (5%) of gross sales; corresponding loss of customer goodwill would also be realized.

- Medium impact - Loss of 5-10 percent gross sales from emergency shipments and inability to provide reliable continuous service.

- High impact - Loss of 10 to 100 percent of sales from their firm's operation in Boston Metropolitan Area.

Based upon the information gathered from the interview program, it is evident that hundreds of businesses in the Boston Metropolitan Area are dependent upon the air cargo service (that would be curtailed by a night curfew) for transporting their goods. They use air cargo transportation for both regular and emergency shipments. Utilizing another, more distant, airport or another mode of transportation would either increase their cost of shipment or cause significant delays in the arrival of their product to its destination, or both. The impact of these consequences of a night curfew would be loss of sales and customer goodwill. As discussed previously, these export businesses are vital to the prosperity of the Boston Metropolitan Area and placing them at a competitive disadvantage to businesses in other areas would result in a decline in that prosperity.

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