AN AIRPORT PROGRAM
FOR THE LOWELL-LAWRENCE-HAVERHILL AREA IN MASSACHUSETTS
WITH A MASTER PLAN
FOR THE DEVELOPMENT OF AN AIRPORT FOR LOWELL

By

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Dear Professor Adams:

I hereby submit this thesis entitled An Airport Program for Lowell-Lawrence-Haverhill Area in Massachusetts, with a Master Plan for the Development of an Airport for Lowell, in fulfillment of the final requirement for the degree of Master in City Planning.

Respectfully yours,

William B. S. Leong

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CHAPTER 1

INTRODUCTION

A. AIRPORT PLANNING - A REGIONAL PROBLEM

Until recent years airport development has not been guided by any systmematic planning. The only guide has been the general desire to advance aerial transportation. Although many splendid airports have been provided for communities simply because they are needed, or simply because the communities can well afford them without any far-sighted and comprehansive planning, there is grave danger that initial development may later be found to be improperly located, incapable of expansion, conflicting in purpose, and in the end, perhaps very costly mistakes. For example, the mixed operations for scheduled and non-scheduled commerical air services, military (coast guards), and personal flying at the Logan International Airports, Boston, is considered to be most hazardous and unsatisfactory. The situation is even more unfortunate when no sities are available for personal flying within the 10 miles radius from Boston. This aggravating condition could have been eliminated or made less serious if there was a comprehensive plan for the Airport development in the Boston area.

There are several reasons for an airport development plan to be considered on a comprehensive regional basis. Municipal boundaires including town, city, and even county do not usually delineate separate areas for planning

purposes. The need for public facilities, and most efficient way to provide them, often overlap these political boundaries, and make joint solutions to their mutual problems highly advisable. This is especially true in airport planning.

It is felt that in the interest of smaller cities, towns and communities, which cannot finance or support airports of their own, although there are definite needs in aviation, it becomes necessary that an airport program be intelligently worked out as a regional program. Furthermore, flying to-day consists of many types. When not one but all types of flying are taken into consideration, the fact there is a joint interest and responsibility is even more obvious. What is needed then is not a solution for a special and local problem, but a co-ordinated solution for the region.

This regional concept has been recognized in the planning of water supply, sewerage, transportation and other public utilities. Great progress has been made both in preparing and in effecturating such comprehensive regional plans. Because of the rapidly growing needs of aviation, the need for co-orindated and comprehensive planning for airport development appears to be more urgent than ever before.

This study contains an analysis of present and future aviation needs, and airport requirements in the Lowell-Lawrence-Haverhill area for the next ten years, and recommends general locations for airports to be developed within the same period. It is not considered advisable at this time to predict future needs beyond 1958 because of the

rapid advance of technical improvements in aeronautical science which are constantly changing the requirements for ground facilities, and makes such predictions impractical. Any forecast beyond the next ten years is considered rather speculative. To bring this plan up to date with current needs and technological requirements it is necessary that this plan should be revised from time to time.

B. THE GROWTH OF AVIATION IN MASSACHUSETTS

A year after the Congress had passed the Civil Aeronautics Act in 1938, the Massachusetts Aeronautics Commission came into being with functions of fostering and regulating and aeronautical activities in the State. Before the Massachusetts Aeronautics Commission was established, all pilots and aircraft in Massachusetts were registered with the Motor Vehicles Department, Department Public Works. No uniform methods had been used for registration. Therefore, it is difficult to know the exact picture of growth of aviation in Massachusetts. However, from the sketchy entries of the early years and the recently organized records of the Massachusetts Aeronautics Commission, one begins to realize the rapidity with which aviation has grown from infancy to manhood in the brief thirty years.

In 1914 there were only five planes registered with the Department of Public Works and a handful of pilots mostly military personnel. The record of August 1, 1948 shows that there are 4462 registered pilots and 1586 registered aircraft in the State.

The following table is taken from record at office of the Inspectors, Massachusetts Aeronautics Commission.

TABLE 1

CURRENT INCREASES OF REGISTERED PILOTS AND AIRCRAFT IN MASSACHUSETTS

Date	No. of Registered Aircraft	No. of Registered Pilots
1947 Oct.	1149	3971
Nov.	1181	3216
Dec.	1250	3316
1948 Jan.	1225	3424
Feb.	1256	3505
Mar.	1267	3604
Apr.	1292	3776
May	1330	3951
June	1461	4094
July	1565	4292
Aug.	1586	4462

The increase in registration does not necessarily mean the actual increase of pilots and aircraft. An Explanation herein is necessary. When the Massachusetts Aeronautics Commission was appointed in 1938, efforts were made to have all pilots operating ~~in~~, and owners of planes based in Massachusetts to register with the Commission, regardless whether they had previously registered with the Civil Aeronautics Commission for interstate flying, and therefore had not been necessary to register with the state. Nothing was done about this during the war. In 1946 pilots and plane owners were notified to register, and to report the conditions and uses of their aircraft. Airport managers and fixed base operators cooperated to serve notices to pilots and plane-owners

to bring about speedy action. Many registrations were entered in 1946 and early 1947, but since October 1947 the increase of registrations have become more or less constant, giving rise to the belief that the current increases of registrations may represent a true increase of the number of pilots and aircraft in the State. However, one thing is apparent: the number of registered pilots and the number of registered aircraft are maintaining a constant ratio of 3 to 1.

In 1945 the unpublished data* of the Civil Aeronautics Administration show that in 1945 there was in Massachusetts 3,324 certificated pilots, of which 53 were airline pilots, 489 commerical pilots and 2,782 private pilots. If these proportions hold true to-day Massachusetts has 71 airline pilots 655 commerical and 3736 private pilots.

In the Lowell-Lawrence-Haverhill area the number of registered aircraft is 104, representing 4.6% of the total number of registered aircraft in the State, and 206 registered pilots, representing 9.1% of the total number of registered pilots in the State. These pilots in the area are either commerical or private pilots.

The area is fairly well supplied with airports for personal flying at present, but plans must be made now to provide for the anticipated increase of personal

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* Modley Rudolf (Editor), Aviation Facts and Figures, 1945, McGraw-Hill, New York and London, 1945, p.74.

flying activities and scheduled and non-scheduled air services.

C. CITY PLANNERS AND AIRPORT PLANNING

It is an established fact that air transportation has tremendous effects upon the growing pattern of communities. When business and industry begin to make full use of the speed offered by this new form of transportation, their operating and transacting methods will be different, and offices and factories desirous of obtaining the benefit of transportation will be located near commerical and industrial airports. Many large organizations having offices throughout the country are maintaining their own fleet of commerical aircraft. Industries depending on air transportation will be different ~~type~~ from one that is dependent on rail or motor transportation. Vast areas for airports together clear approaches will be needed. Accordingly zoning ordinances protecting the areas surrounding airports against future obstructions will become necessary. In some cases housing developments may be expected around the airports. Thus, the influence of air transportation on the economic and social activities has given rise to a new physical planning pattern. Unfortunately, airport planning has been drastically neglected by city planners. The urgent need exists for every one concerned with city planning to acquire the greatest possible amount of knowledge concerning air transportation, air traffic patterns, airway and airport traffic control, plane types and airport requirements, airport financing and

management, and finally airport zoning and legislation. These elements must be studied and must become the necessary working tools of city planners so the subject of airport development can be intelligently treated, and included as part of comprehensive master plan. This phrase of planning may be probably more inspiring and encouraging than others because for several reasons. The needs for air transportation can be more readily felt. The utility concept of airport easily understood, and the results of the war has increased the public interest in aviation. Aeronautics has shown wonderful progress in the past, and its future is bright.

D. DEVELOPMENT OF AIRPORTS

One of the most serious factors responsible for the slow development of airports even in communities where aeronautics needs are urgent is the expenses involved in airport construction. Many a community erroneously conceives of the idea that then the plans for an airport is prepared, elaborate funds should be appropriated for construction of the airport to the final details of the class specified. It does not, however, understands that although there is a definite need for an airport in a community, aviation activities do not come to the airport the moment the construction is completed in as large a volume as 10 years after the construction. Aviation activities must grow. The rate of growth not only will depend on the potential factors such as industries and

commerce which must be considered in planning of an airport, but will also depend on the planning and management of the airport. An airport must also grow with the immediate aeronautics activities. It is not necessary to have, at the outset, sufficient funds for airport construction to meet the needs anticipated in 10 years.

Therefore, an orderly and systemmatic process by which an airport site is transformed from its orginal undeveloped condition to a completely developed airport must be devised. In this process, development is carried out by stages.

The first stage of development is the grading and turfing of a portion of the site chosen, the size of which depends on the immediate needs. Successive stages will depend on the ultimate increase in the need for expansion. The number of stages will vary according to the special requirements of each individual case. The responsibilities rest on the shoulders of a planner with full understanding of the objective of the master plan for airport development, and also on the shoulders of competent designing engineers.

The stage development of airports should consist of the construction of a smooth, well-drained turf surfaces or landing areas, with the order of construction of pavements or other surfacings to be aprons, initial taxiways, and possible one runway in the direction of the prevailing wind, and finally the construction of the remaining runways and taxiways required for a fully developed airport.

In each stage buildings may be added according to the immediate needs of the airport.

The reason for this order of construction of pavements or surfacing is to protect the areas which will receive the greatest amount of wear. Although it is quite obvious that small aircraft do not exert sufficient pressure on a good turf surface to cause ruts, nor do they take off and land exactly on the same area each time, the apron areas are apt to receive excessive wear due to repeated parking and servicing of planes, and the operations of servicing trucks, automobiles and tractors. Therefore it is logical that the aprons are the first areas to be hard-surfaced.

Even if the finance of a community permits the construction for the ultimate development of airport immediately, it is still a wise policy to keep the cost down to cover only the requirements of the present or the very near future. The cost of maintenance and operation must not be overlooked. Revenues which may come from the users of an airport will never pay for the cost of maintenance and operation of an oversized airport. However, when a site is chosen it is adviaable that the land necessary be required for the ultimate development for an airport, thus eliminating future complications which may arise in connection with land acquistion.

Part 2 of this study presents the Master Plan for the development of an airport for Lowell by stages.

CHAPTER 2

BASIC SURVEY DATA

A. AREA:

The Lowell-Lawrence-Haverhill area proposed for airport development is located in the northeastern portion of the state of Massachusetts. It does not cover the entire Planning Board Region No. 4 of the State Planning Board, but includes all territory designated in the U.S. Census as the Lowell-Lawrence-Haverhill District, and the town of Salisbury and Westford. The area consists of four cities (Lowell, Lawrence, Haverhill and Newburyport) and sixteen towns in two counties, namely Middlesex and Essex, with a land area of 375.25 square miles, and an aggregate of land and water of 389.72 square miles. These cities and towns in two counties are listed below with their land areas and population figures:

City or Town	County	Land Area (Sq. Mi.)	Population
Amesbury	Essex	12.65	10,824
Andover	Essex	31.10	11,902
Billerica	Middlesex	25.46	8,504
Chelmsford	Middlesex	22.54	8,726
Dracut	Middlesex	20.84	7,434
Georgetown	Essex	13.10	1,978
Groveland	Essex	8,90	2,150
HAVERHILL	Essex	33,11	46,162
LAWRENCE	Essex	6.75	85,603
LOWELL	Middlesex	13.38	101,229
Merrimac	Essex	8.66	2,384
Methuen	Essex	22.41	23,160
Newbury	Essex	23.97	1,636
NEWBURYPORT	Essex	8.30	14,079
North Andover	Essex	26.63	7,936
Salisbury	Essex	15.74	2,622
Tewksbury	Middlesex	20.70	5,949
Tyngsborough	Middlesex	16.86	1,495
West Newbury	Essex	13.90	1,503
Westford	Middlesex	30.25	3,815

This area is so chosen for planning study because it is an integrated area with common economic, social and administrative interests.

B. POPULATION:

The population growth of the Lowell-Lawrence-Haverhill area from 1900 to 1945 is as follows:

1900	265,438
1910	315,137
1920	346,450
1930	341,205
1940	344,577
1945	348,091

The total population has increased from 265.438 in 1900 to 349,091 in 1945, attaining an increase of 31.5% in 45 years.

Reliable forecasts of population trends and shifts are difficult to make. While all forecasts of future population must be based on rates of growth which have occured in the past. The past trends cannot be projected blindly into the future without considering the factors which will influence the trends in the future. Many factors influencing the population trends in large areas become more prominent in small communities. Since 1920 the populations of the Lowell, Lawrence and Haverhill exhabit general downward trends. Nevertheless, it is still possible for new industries to locate in these large urban aggromerations. If this will be the case, the distribution population in the area may be altered or increased considerably. Such circumstances cannot forecast. Another complication in the forecast of population is the population shifts within the area such as the gradual decentralizing movements

towards the suburban areas. Forecast for the next decade or so must also take into consideration the anticipated building boom in all areas.

In forty years the trends indiciate an increase of only 5000 population for Lowell and Lawrence. Inasmuch as there are few desirable housing sites within the limits of these two cities, continous movements to the suburbs by the inhabitans may cause a drain in the next few years from the Lowell and Lawrence population. However, this increase may be upset in part by new housing developments. The population of Haverhill may be expected to increase since there are considerable undeveloped lands in the city. The trends of decentralization, though present, will be, unlike in Lowell and Lawrence, mostly towards the outer areas still within the city limits. Suburban towns such as Chelmsford, Westford, Tyngsborough, Tewksbury and Billerica may be expected to experience moderate gains in population at the expense of Lowell. Similarly, the populations of Methuen, Andover and North Andover will gain at the expense of Lawrence. The populations of Groveland, Georgetown, West Newbury, Merrimac, Amesbury, Newbury, and Newburyport will also show slight increases ~~of population~~, with Newburyport, exhabiting perhaps a greater and more steady growth in the future because of the combination of small year-around diversified industries and summer attractions.

The following figures shows population trends with forecasts to 1970:

Figure 1 is for the entire area;

Figure 2 for Lowell, Lawrence and Haverhill;

Figure 3 for North Andover, Chelmsford, Dracut Billerica and Tewksbury;

Figure 4 for Salisbury, Merrimac, Groveland, Newbury, Tyngsborough, West Newbury and Westford; and

Figure 5 for Newburyport, Methuen, Amesbury, Andover and Georgetown.

The reason for not including Boxford in the Lowell-Lawrence-Haverhill area while West Boxford is definitely economically related to Haverhill is the small population concerned. Boxford has a population of 811, and half of it in the eastern portion is economically dependent on another urban center of Ipswich, which is situated about two miles to the east.

The populations of the nearby towns in New Hampshire which may be affected by this proposed airport program are as follows:

Atkinson	434
Newton	900
Pelham	979
Plaistow	1414
Salem	3267
Seabrook	1782
S. Hampton	294
Hampton	2137
	11207

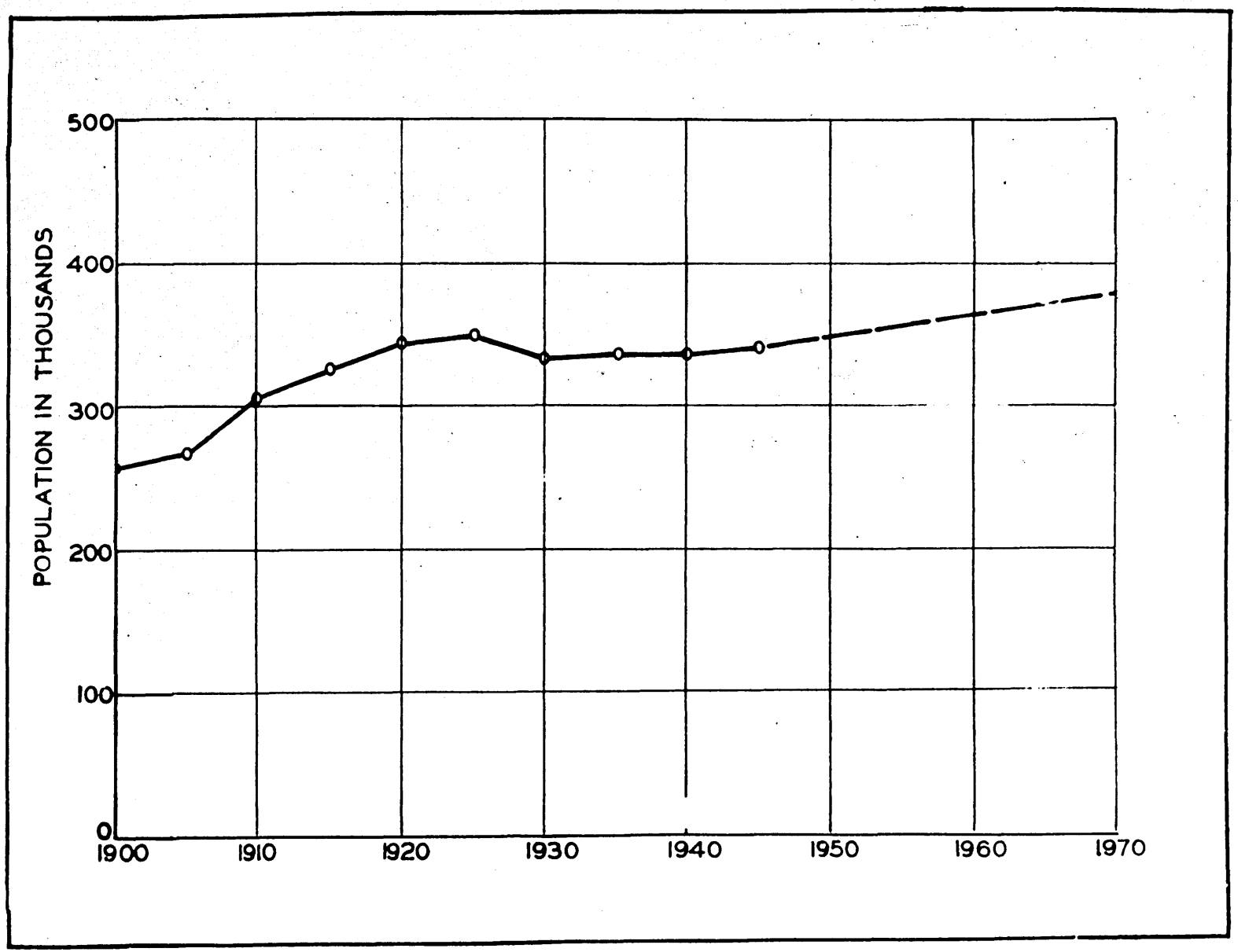

FIG. 1. POPULATION TRENDS FOR THE ENTIRE AREA

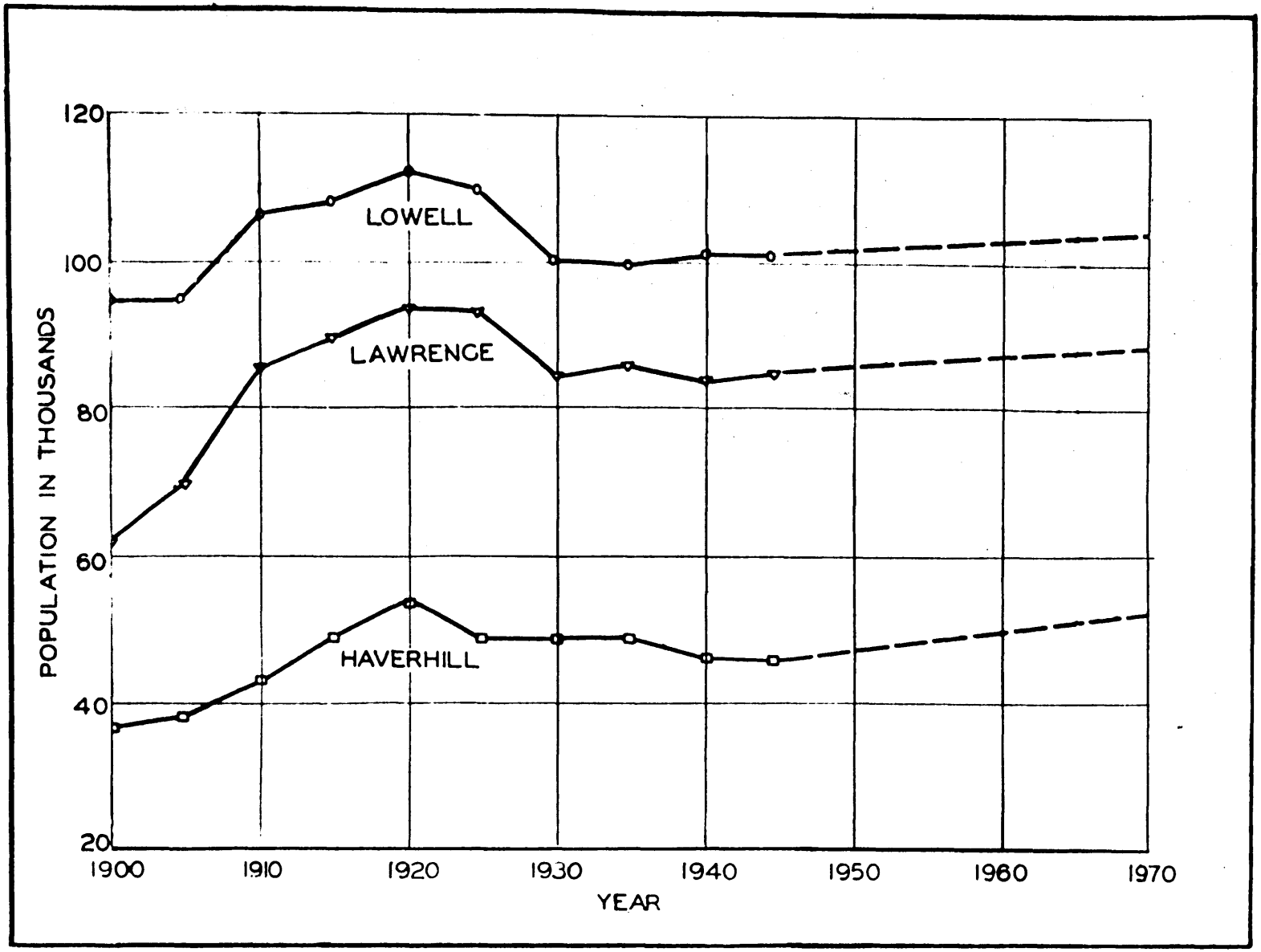

FIG. 2. POPULATION TRENDS FOR LOWELL, LAWRENCE AND HAVERHILL

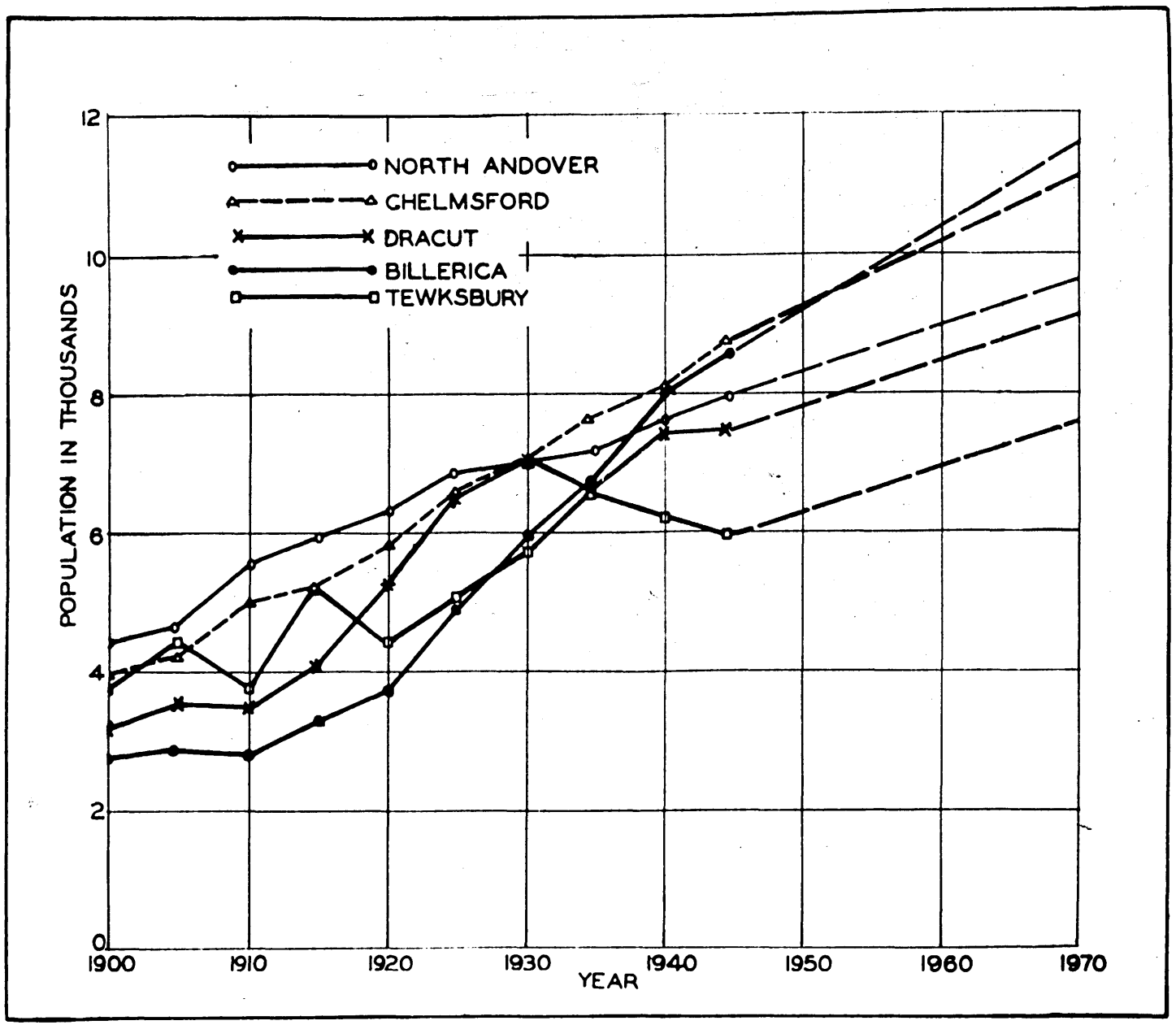

FIG. 3. POPULATION TRENDS

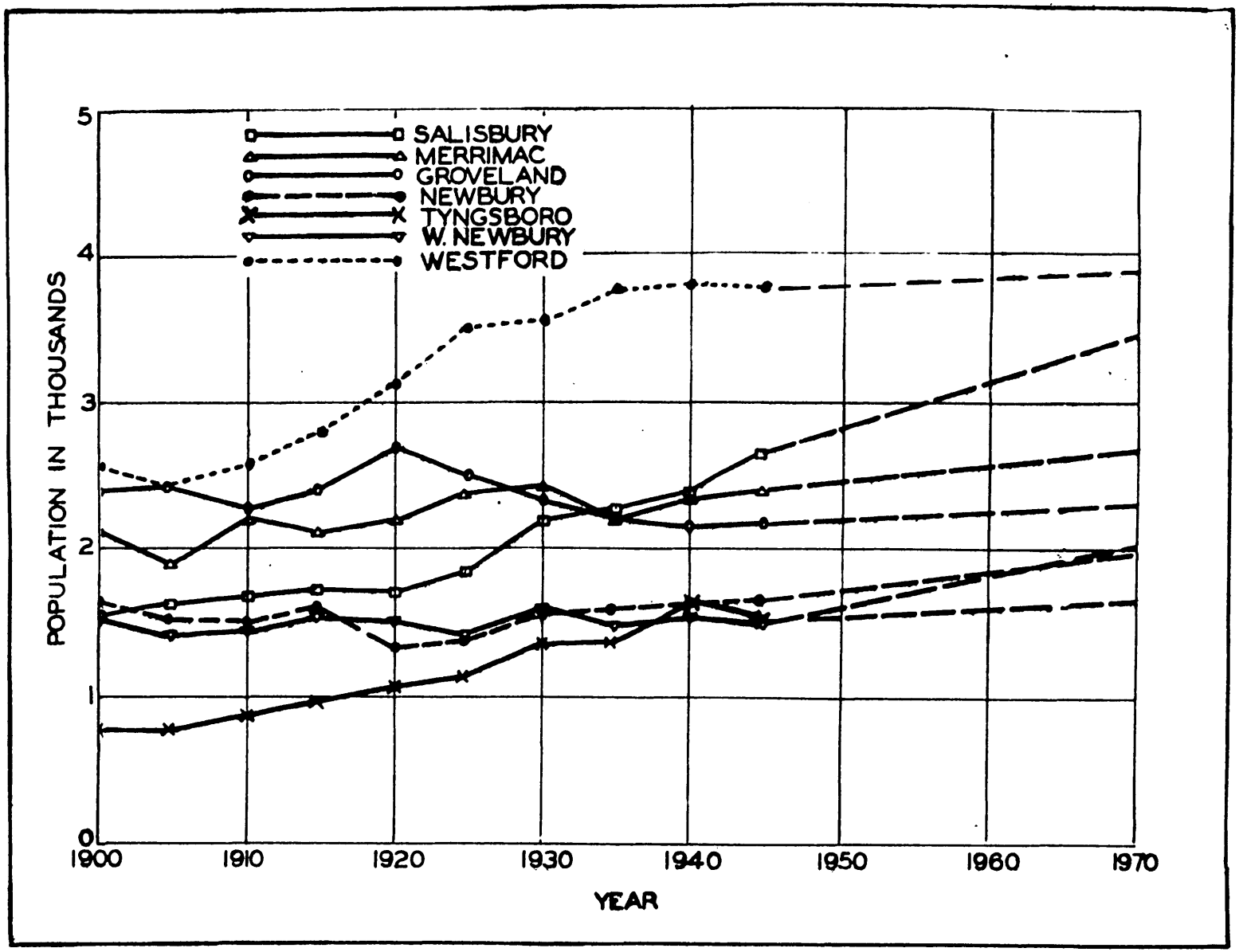

FIG. 4. POPULATION TRENDS

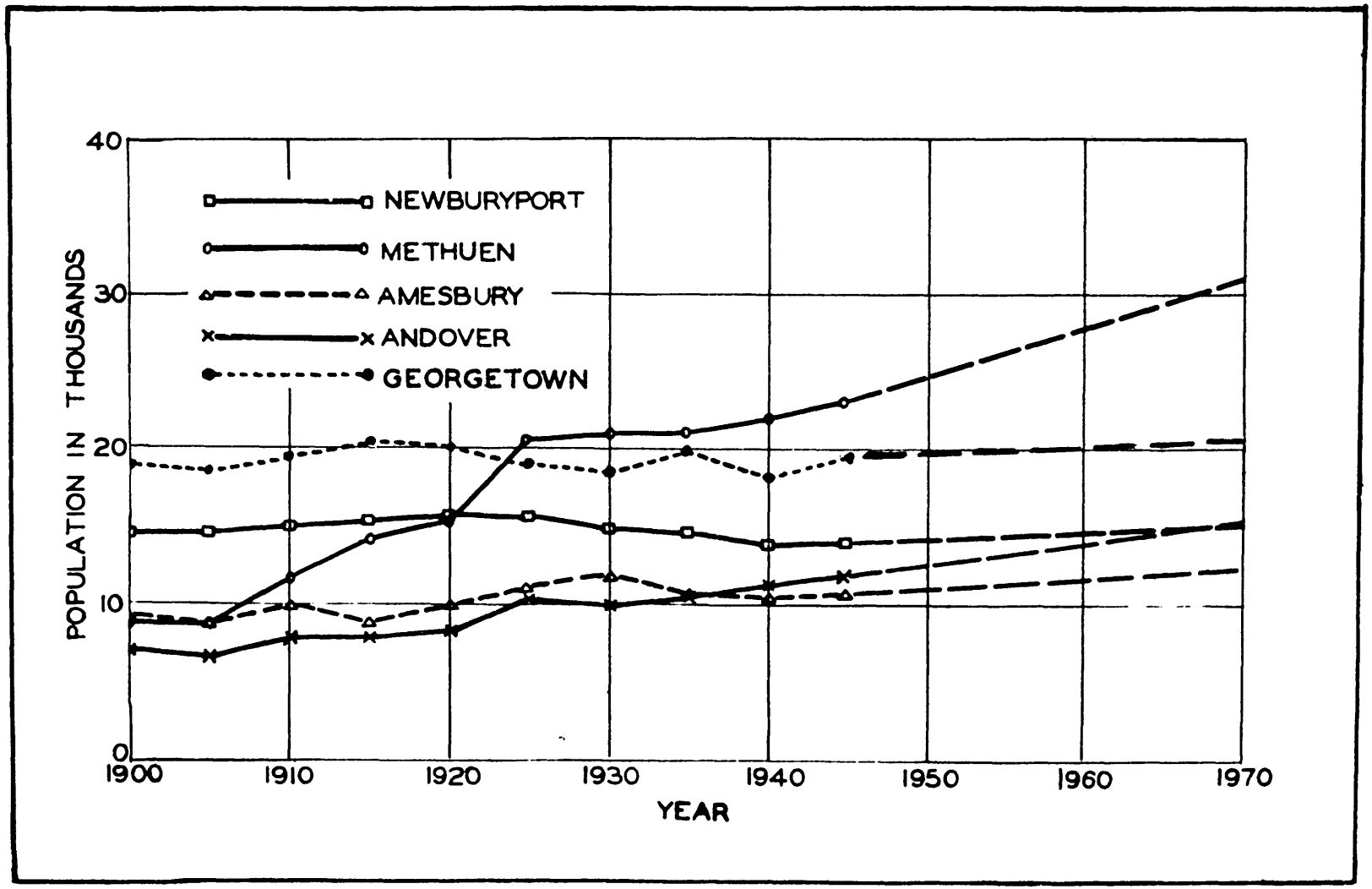

FIG. 5. POPULATION TRENDS

One stricking characteristic of the population in the whole area and in nearby some New Hampshire towns is the predominantly large percentage of Canadians (both French and others) in the foreign born population.

C. INDUSTRIES:

The three principal industrial centres in this area are Lawrence-Lowell-Haverhill, other less important ones being Amesbury, Andover, Methuen, Newburyport and Andover. The following table shows the value of products, wages and the number of wage earners in these industrial centres:

Industrial Centre	Value of Products	Wages	No. of Wages Earners
Amesbury	$ 12,371,834	$ 3,013,245	1,768
Andover	21,046,815	5,319,319	2,806
Haverhill	97,318,709	17,085,840	9,472
Lawrence	190,178,258	43,260,114	23,336
Lowell	144,357,873	28,426,818	16,200
Methuen	15,611,459	3,007,780	1,828
Newburyport	17,932,502	4,788,842	2,751
North Andover	11,306,914	3,624,711	1,684
All other	50,417,020	10,148,119	4,960

Although there are general signs of gradual industrial decline in the area, for years Lawrence has been maintaining rather constantly 150 industrial plants, the chief types of manufacturing being beverages, bobbins and shuttles, factory equipment, paper mill machinery, paper products, textile machinery, textile printing and finishing, cotton cloth, woolens and worsteds, silk and rayon, knit goods, man's clothing, shoes, rubber products, molded plastics, and rugs and yarns.

For the past twenty years the number of industrial

plants in Lowell has been about 200. The types of manufacturing are very familiar to those at Lawrence with a larger number of plants devoted to light industries. The industries in Haverhill has been declining more rapidly than those in Lawrence and Lowell. There are about 200 industrial plants in Haverhill, resulting from a loss of about 200 plants in thirty years. The principal types of manufacturing are boots, shoes, counters, cut stock, findings, lasts patterns, wooden heels, boxes, cement, dies, electirc, refrigerators, foundry and machine shop products, hats, leather, leather products, paper, and shoe machinery. Each of the other industrial centres has about 20 to 30 industrial plants, the chief types of manufacturing including stamped metal products, rooled metals, boats, electirc applicances and automobile accessories.

D. FINANCE:

The following table contained general financial data:

Financial Data for the Cities and Towns in the Area as of 1940:

City or Town	Gross Valuation	Valuation Per Cap.	Tax Rate	Tax Levy	Tax Levy Per Cap.
Amesbury	$ 9,041,000	$ 693	$36.80	$ 276,942	$25.50
Andover	20,952,000	1,246	30.00	415,838	37.39
Billerica	9,684,000	947	36.40	273,478	34.47
Chelmsford	7,581,000	788	32.20	204,916	25.37
Dracut	4,659,000	520	50.00	190,887	26.01
Georgetown	1,890,000	871	38.80	60,909	33.78
Groveland	1,716,000	653	39.20	54,348	25.61
Haverhill	53,530,000	968	40.40	1,828,921	39.12
Lawrence	92,707,000	927	40.80	3,188,848	37.82
Lowell	108,180,000	853	48.60	4,202,497	41.45
Merrimac	1,992,000	692	50.00	80,271	34.60
Methuen	19,538,000	756	41.80	691,679	31.61
Newbury	2,262,000	1,164	36.80	68,517	42.85
Newburyport	13,732,000	783	43.80	477,423	34.31
No. Andover	7,773,000	900	40.20	272,238	36.18
Salisbuey	2,920,000	1,069	49.00	124,464	52.38
Tewksbury	7,438,000	461	29.60	85,484	13.65
Tyngsborough	1,723,000	634	46.00	47,644	29.16
W. Newbury	1,534,000	737	42.00	46,890	30.95
Westford	3,692,000	846	36.00	116,618	30.45

CHAPTER 3

TYPES OF AIRCRAFT AND AIRPORT CAPACITY

Rapid technological improvements in the fields of aeronautics has made it impossible to predict the kinds of aircraft to be used in the future. However, with the standardization regulations enforced by the Civil Aeronautics Administration it is hoped that at least the present airports and their facilities will not soon become obsolete, and that airport planners can still use the present airport standards for planning future airports.

Small Craft:

Small aircraft may consist of the following types:

Two-passenger plane of about 1.000 lbs. gross weight.
Three- and four-passenger plane of about 2,000 lbs. gross weight.
Five- and six-passenger plane of about 3,000 lbs. gross weight.

These planes will be used for flying and training, chartered service, and business executives and for personal use.

There will improvemnets in speed and size of this type of aircraft, but no change in the character of the landing areas will be required. Most of the personal planes can operate safely from a Class 1 or a Class 2 airports which can be developed on tracts of about 160 acres or one-half square mile for all-way operation*.

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* Civil Aeronautics Administration, Airport Planning for Urban Areas. p. 5.

Experience has showm that approximately 100 planes of this category, in the air and on the ground, can be accommodated on a 160 acre field. The ratio therefore is 1½ acres for each plane*. In other words, if there are 150 planes to be accommodated, both in the air and on the ground, the size of the airport should be 240 acres.

Commerical Aircraft:

Commerical aircraft can be grouped under four catergories:

Feeder Plane - for 100 mile range operation sparcely travelled routes.
Small Trunk Transport - for short-haul trunk-line operation.

Intermediate Trunk Transport - for both long- and short-haul trunk-line operation.

Large Transport - for very long-haul trunk-line operation.

Peak hour plane movements determine the capacity of an airport. One-mimute headway between flights or 60 plane movements per hour is considered the best runway capacity in the very large airports. For the Lowell-Lawrence-Haverhill area 30 or at most 40 plane movements per runway hour should be considered a generous basis for planning airport capacity under good weather conditions.

Already a few operators have sprung up after the war, using converted army bombers for all cargo carriers, but for most airlines, the combination passenger-cargo planes are still in use.

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* Idem.

PROJECTED TRANSPORT AIRCRAFT TYPES*

Size	Class	Type of Route For Which Suited	Gross Weight Range (lbs.)	Capacity No. of Seats
1	Small	feeder	10-15,000	10-15
2	Small	trunk	20-30,000	20-25
3	Intermediate	trunk	40-75,000	40-60
3b	Intermediate	trunk	75-100,000	50-60
4	Large	trunk	100-150,000	80-125

However, since small planes and feeders will be the major aircraft in the area within the next decade the change in weight and size of the types of aircraft will not materially affect the class of airports proposed (see Chapter 9).

* Philadelphia-City Planning Commission. Airport Program for the Philadelphia-Camden Metropolitan Area. Oct. 1946. p.8

HELICOPERS:

The helicopter having passed its initial tests with flying colors made tremendous forward strides in 1944. Already it is recognized asa reliable, efficient aircraft for many flying jobs, and even its critics no longer deny that the helicopter's manueverability and verability should earn for it an important place in various fields of aeronautics.

During the war helicopters were delivered in quantities to the military and naval services for use in rescue work, in evacuation of the wounded and as observation craft. Much information as to their uses was restricted in the war years. After the war many aircraft manufactures went in production again for civilian use, and the public began to realize the importance of this type of plane. Chicago is already using helicopters for mail pick-ups in conjested areas, and similar used will be found in many communities.

However, two technological handicaps, namely the low carrying capacity and low speed, must be overcome before the aircraft can be widely used as an established medium of transportation with time-distance being the prime factor, and not just for some special uses.

One siginificant sign in the progress of helicopter development aside from the technological impetus arising out of war conditions has been the general public's enthusiasm in looking forward for use of

helicopters as a necessary means of transportation in conjested areas and also in areas where airports can not be provided for because of insufficient land or funds.

If indeed one day when helicopters can take the place of busses and trains for short distance travel, planners should have new standards for estimating aviation needs.

CHAPTER 4

AIRPORT PLANNING STANDARDS

The following are recommended by the Civil Aeronautics Administration, U.S. Department of Commerce in Airport Planning for Urban Areas, 1945:

CLASS 1 AIRPORTS

Purpose:	To accommodate small private owner types. Includes planes with gross weights up to 4,000 pounds, and index numbers not exceeding 190.
Landing strips:	1,800 to 2,700 feet in length (sea level conditions); 300 feet usable width.
Paved runways:	Not required.
Number and alignment of landing strips:	Sufficient in number to permit take-offs and landings within two points ($22\frac{1}{2}^{o}$) of the true wind direction for 70 percent of winds 4 miles per hour and over. Estimates should be based on a 10-year Weather Bureau wind record.
Facilities:	Drainage, fencing, marking. Wind direction indicator. Basic lighting.
Landing strip grades:	2 percent maximum transverse; 2 percent maximum uniform longitudinal. Grade breaks longitudinal. Maximum algebraic difference 3 percent. (Longitudinal intersecting grades on a runway or landing strips should be joined by a vertical curve at least 500 feet in length.

It is also recommended that tangent intervals between the PT of one curve and the PC of the succeeding curve by not less than 1,000 feet. In general, there should be change in landing area grades of more than ½ percent in any 100-foot intervals.)

CLASS 2 AIRPORTS

Purpose:	To accommodate larger size private owner types and some small size transports. Roughly gross weights from 4,000 to 15,000 pounds, and index number from 190 to 230.
Landing strips:	2,700 to 3,700 feet in length (sea level conditions); 500 feet usable width.
Paved runways:	One surfaced runway for the effective length of each landing strip and having a paved width of 100 feet for day operations only, or 150 feet for night operations.
Number and alignment of landing strips:	Sufficient in number to permit take-offs and landings within two points ($22\frac{1}{2}^{\circ}$) of the true wind direction for 75 percent of winds 4 miles per hour and over. Estimates should be based on a 10-year Weather Bureau wind record.
Facilities:	Drainage, fencing, marking. Wind direction indicator. Lighting. Hangar and shop. Fueling. Weather information. Office space.
Landing strips:	2 percent maximum transverse; 1½ percent maximum uniform longitudinal. Grade breaks

longitudinal. Maximum algebraic difference 2½ percent. (Longitudinal intersecting grades on a runway or landing strip should be joined by a vertical curve at least 500 feet in length. It is also recommended that tangent intervals between the PT of one curve and the PC of the succeeding curve by not less than 1,000 feet. In general, there should be no change in landing area grades of more than ½ percent in any 100-foot interval.)

Distance between centre line of runway and airport buildings: 750-foot minimum for instrument runway; 350-foot minimum for other runways.

CLASS 3 AIRPORTS

Purpose: To accommodate present-day transports. Represents, approximately, gross weights 10,000 to 15,000 pounds, and index numbers of 230 and over.

Landing strips: 3,700 to 4,700 feet in length (sea level conditions); 500 feet usable width. For parallel runways, allow 700 feet minimum between centre lines.

Paved runways: At least one surfaced runway for the effective length of each landing strip and having a paved width of 100 feet for day operating only, 150 feet for night operations, and 200 feet for instrument operations. Parallel runways to be at least 700 feet apart, centre line to centre line.

Number and alignment of landing strips:	Sufficient in number to permit take-offs and and landings within two points ($22\frac{1}{2}^{o}$) of the wind direction for 80 percent of winds 4 miles per hour and over. Estimates should be based on a 10-year Weather Bureau record. The number of parallel landing strips should be determined by the ultimate capacity of the airport.
Facilities:	Drainage, fencing, marking. Wind direction indicator. Lighting. Hangar and shop. Fueling. Weather Bureau. Two-way radio. Visual traffic control. Instrument approach system (when required.)
Landing strips grades:	$1\frac{1}{2}$ percent maximum transverse; $1\frac{1}{2}$ percent maximum uniform longitudinal. Grade breaks longitudinal. Maximum algebraic difference 2 percent. (Longitudinal intersecting grades on a runway or landing strip should be joined by a vertical curve at least 500 feet in length. It is also recommended that tangent intervals between the PT of one curve and the PC of the succeeding curve be not less than 1,000 feet. In general, there should be no change in landing area grades of more than $\frac{1}{2}$ percent in any 100-foot intervals.)

Distance between centre line of runway and airport building:	750 feet minimum for instrument runway; 350 feet minimum for other runways.

CLASS 4 AIRPORTS

Purpose:	To accommodate the largest planes in use and those planned for the immediate future. Represents, approximately, gross weights in excess of 50,000 pounds, and index numbers of 230 and over.
Landing strips:	4,700 to 5,700 feet in length (sea level conditions); 500 feet usable width. For parallel runways, allow 700 feet minimum between centre lines.
Paved runways:	At least one surfaced runway for the effective length of each landing strip and having a paved width of 100 feet for day operations only, 150 feet for night operations, and 200 feet for instrument operations. Parallel runways to be at least 700 feet apart, centre line to centre line.
Number and alignment of landing strips:	Sufficient in number to permit take-offs and landings within two points ($22\frac{1}{2}^{\circ}$) of the true wind direction for 90 percent of winds 4 miles per hour and over. Estimates should be based on a 10-year Weather Bureau record. The number of parallel landing strips should be determined by the ultimate capacity of the airport.

Facilities:	Drainage, fencing, marking. Wind direction indicator. Lighting. Hangar and shop. Fueling. Weather Bureau. Two-way radio. Visual traffic control. Instrument approach system. Administration building.
Landing strip grades:	1½ percent maximum transverse; 1 percent maximum uniform longitudinal. Grade breaks longitudinal. Maximum algebraic difference 2 percent. (Longitudinal intersecting grades on a runway or landing strip should be joined by a vertical curve at least 500 feet in length. It is also recommended that tangent intervals between the PT of one curve and the PC of the succeeding curve be not less than 1,000 feet. In general, there should be no change in any 100-foot intervals.)
Distance between line of runway and airport buildings:	750 feet minimum for instrument runway; 530 feet minimum for other runways.

CHAPTER 5

PRESENT STATUS OF AVIATION

A. SCHEDULED AIR SERVICE

At the present time the Northeast Airlines, Inc, is the only agency providing air transportation to Lawrence in the area. It operates over the route designated as Air Mail Route No. 27-A (see Map 2) by the U. S. Post Office, although it only gives one service each way a day. On this route Lawrence is one of the intermediate stops between the two co-terminals of New York, N. Y., and Newark, N. J., to the south, and Presque Isle, Maine, to the north. The number of passengers and the volume of freight in and out of Lawrence are very limited. Two factors are responsible for preventing the Lowell-Lawrence-Haverhill area from having more scheduled air services. One is the inadequacy in landing facilities. There are five public airports in the area. Lawrence Municipal Airport is the only Class 3 airport capable of accommodating large transports. Others are either Class S-1 or Class 1 airports. Another factor is the proximity of the area to Boston, which is within an hour's ride by train, thus destroying any one's efforts to come to the area by air transportation. Passengers bound for points in Lowell-Lawrence-Haverhill from Boston or points further south, may find it more convienent to use the ground transportation of the Boston and Maine Railway or the

Eastern Massachusetts Street Railway, both of which give hourly services.

B. Feeder Lines:

Two Massachusetts operators, the Northeast Airlines, Inc., and W. E. Wiggins Airways, Inc., have been authorized by the Civil Aeronautics Board to engage in air transportation with respect to passengers, property and mail in New England with routes directly serving the Lowell-Lawrence-Haverhill area. Route 27-A has been designated for operation by the Northeast Airlines and services are now being rendered as mentioned above, although not performing feeder functions alone. Route No. 79, has been designated for operation by the Wiggins Airway. However, no service has yet been rendered because of lack of an airport in Lowell, and inadequate ground facilities in other places and also because of economic reasons*. In addition to Route 79 Wiggins Airways has also applied for certificate, by exemption or otherwise, to render non-stop service between cities and towns, including Lawrence and Lowell, and others. The feeder pattern for Massachusetts as indicated by the feeder line applications as of 1947 with the Civil Aeronautics Board is shown in Map 4. It is expected that new applications have been added since then. Routes No. 27-A and 79 are shown in Map 2.

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* Wiggins Airways claimsthat the present milage for Route No. 79 is too short to warrant economical operations. Negotiations have been in progress with the Civil Aeronautics Board.

C. PERSONAL FLYING

Personal flying includes non-scheduled flying by small aircraft either for commerical or personal use. Despite the present inactivity of scheduled air services, personal flying is rapidly developing.

Record at the Inspector's Office, Massachusetts Aeronautics Commission shows that there are 260 registered pilots and 104 registered aircraft in the Lowell-Lawrence-Haverhill area as of August 1, 1948

Table 2. Distribution of Registered Aircraft and Their Uses, and Registered Pilots as of August 1, 1948.

City or Town	Registered Aircraft	Uses			Registered Pilots
		Operator	Private	Business	
Amesbury	-	-	-	-	13
Andover	-	-	-	-	12
Billerica	29	28	1	-	9
Chelmsford	9	9	-	-	4
Dracut	-	-	-	-	9
Georgetown	-	-	-	-	-
Groveland	-	-	-	-	5
Haverhill	19	9	9	1	40
Lawrence	6	-	5	1	59
Lowell	5	-	4	1	46
Merrimac	-	-	-	-	5
Methuen	13	8	2	3	30
Newbury	-	-	-	-	-
Newburyport	14	14	-	-	11
North Andover	9	7	-	2	9
Salisbury	-	-	-	-	-
Tewksbury	-	-	-	-	5
Tyngsborough	-	-	-	-	3
Westford	-	-	-	-	-
West Newbury	-	-	-	-	-
TOTAL	104	75	21	8	260

Practically all figures for registered aircraft are for small planes.

The term "operator" used in the above table means any individual or organization engaged in air transportation with respects to passengers, cargo or mail, excluding such uses as crop, dusting and training, which are grouped under the term "business". There are no flying clubs in the area.

The above table also shows that the ratio between the number of registered aircraft and the number of registered pilots is exactly 1 to 2.5 as against the ratio of 1 to 3 for the state of Massachusetts (see table 1). These personal planes will be of major importance in this area.

The following are names of some important agencies giving air services in the area:

Billerica-Wilmington Airways, Inc.
Barry Aero Service, Inc.
Dutton Air Transport and Sales
Merrimac Valley Air Service, Inc.
Plum Island Flying Service, Inc.
Reebal Air Service, Inc.

There is no military or naval flying in the area. There are no large educational institutions, and student flying is limited to that of the training schools, since there are no flying clubs.

CHAPTER 6

INVENTORY OF EXISTING PUBLIC AIRPORTS AND SEAPLANE BASES

There are in the Lowell-Lawrence-Haverhill area five existing airports ranging from Class S-1 in Haverhill to Class 3 in Lawrence, and three seaplane bases. The information in this chapter covers the facilities available at the present time at the following airports and seaplane bases:

Airports:

Lawrence Municipal Airport at No. Andover (Class 3)
Plum Island Airport at Newburyport (Class 1)
Shawsheen Pines Airport at Billerica (Class 1)
Richardson Airport at Dracut (Class 1)
Walker-Dutton Airport at Haverhill (Class S-1)

Seaplane Bases:

Lowell Seaplane Anchorage, Lowell
Merrimac Valley Skyport, Lawrence
Plum Island Seaplane Anchorage, Newburyport

Although the Municipal Airports of Ayer and Beverly, State-owned Hanscom Airport at Bedford (all Class 4), and the privately owned Groton Airport (Class 1) are within ten miles outside the area, their influence on the aviation activities in this area is very insignificant. Their activities are therefore eliminated from this chapter.

AIRPORTS

LAWRENCE

Lawrence Airport: (Class 3)

Owned by City. Operated by Lawrence Airport Commission. Location: Lat. 42-43-00; long. 71-07-00. Elevation 155'.

2.5 miles ENE of Lawrence.

Landing Facilities: 3 paved runways: NNW/SSE 3190' x 150; WNW/ESE 3500' x 150'; NE/SW 4000' x 150'. Usable acres, 362. Irreg. Partly fenced. Navigation facilities: Rotating beacon; range, contact, runway, and obstruction lights; lighted wind cone. Obstructions: Trees - SSE, NNW, NE, ESE; building and pole lines - SSE; stack SW.

Services: 3 hangars: 1 - 60' x 70'; 1 - 30' x 42'; 1 - 28' x 120. Office. Telephone.

Fixed Base Operators:

Zinney Flying School: Gas: 80 Octane. Major repairs. Hangar storage. Charter. Training. Aerial photography. Sales and rentals.

Barry Aero Service: Gas: 80 and 91 Octane. Major repairs. Hangar storage. Charter.

Northeast Airlines, Inc: Scheduled air services.

Accommodation: Taxi:

Airport Manager: Joseph Mahoney

Possibility for Expansion: Some.

NEWBURYPORT

Plum Island Airport (Class I)

Owned by Eliza and Agnes Little. Operated by Plum Island Flying Service.

Location: Lat. 42-47-30; long.-70-50-45. Elevation, 15'. 2.3 miles SE of City.

Landing Facilities: 2 sod strips: NW/SE 2450' x 300';

E/W 2050' x 300'. 1 bituminous strips: E/W 1560' x 60. Usable acres, 160. Irreg. Partly fenced. Navigation facilities: Rotating beacon; course lights; wind cone. Obstructions: Trees and building - NW, W, E; water tower - NW.

Services: 3 hangars: 1 - 50' x 49', door 48' x 12'; 1 - 30' x 48', door 48' x 11'; 1 - 40' x 48', door 40' x 10'. Office. Telephone. Major reapirs. Gas: 80 and 91 Octane. Storage. Charter. Training. Aerial photography. Sales and rentals. Day service.

Accommodations: Taxi

Airport Manager: Warren S. Frothingham.

Possibility for Expansion: good; drainage will be required if swamps land is used for expansion.

BILLERICA

Shawsheen Pines Airport: (Class 1)

Owned and operated by Billerica-Wilmington Airways, Inc.

Location: Lat. 42-33-15; long. 71-12-45. Elevation 110'. 2.7 miles E of Town

Landing Facilities: Bituminous strips: E/W 2160' x 150'. Usable area, 240. Irreg. Lighting: Boundary and range. Wind cone. Obstructions: Trees - NE, SE, W; building - WSW. WSW.

Services: Two hangars: 1 - 60' x 81'; 1 - 80' x 80'; and 14 T-hangars, 39' x 25' x 12'. Office. Telephone. Major repairs. Gas: 80 and 91 Octane. Training. Charter. Aerial photography. Sales and rentals.

Accommodations: Taxi

Airport Manager: Russel B. Totman.

Possibility for Expansion: Nil

DRACUT

Richardson Airport: (Class 1)

Owned by J. C. Richardson. Operated by Reebal Flying Service, Inc.

Location: Lat. 42-40-25; long. 71-19-25. Elevation 280'. About 1 mile from Dracut, and 2 miles from Lowell,

Landing Facilities: 2 sod strips: NE/EW 1980' x 100'; NNW/SSE 1240' x 100'.

Services: 1 hangar: 58' x 30'. 7 T-hangars. Office. Telephone. Gas; 80 and 91 Octane. Major repairs. Charter. Training. Aerial photography.

Accommodations: Taxi

Airport Manager: Charles B. Reed, Jr.

Possibility for Expansion: Can be expanded to twice the present size.

Haverhill

Walker-Dutton Airport: (Class S-1)

Owned privately. Operated by Dutton Air Transport and Sales.

Location: Lat. 42-48-00; long. 71-03-45. Elevation 125'. 2 miles NNE of City.

Landing Facilities: 3 allway sod runways: NNE/SSS. 1600; NW/SE 1700; E/W 1600. Usable acres, 56. Irreg. Partly fenced. Wind cone. Obstructions: Trees - N, S,

W; ridge - E, SE; pole line - NW; house - N.

Services: 2 hangars; 1 - 50' x 60', door, 50' x 13'; 1 - 50' x 50', door, 50' x 12'. Office. Commerical radio facilities. Telephone. Major repairs. Gas: 80 Octane. Storage. Training. Charter. Aerial phohography. Sales and rentals. Day service.

Accommodations: Shops. Taxi. Private car.

Airport Manager: Howard F. Dutton.

Possibility for Expansion: Nil

SEAPLANE BASES

LOWELL

Lowell Seaplane Anchorage:

Owned by the City Park Commission. Operated by Merrimac Valley Air Service.

Location: Lat. 42-38-30; long. 71-21-00. Elevation 80'. 1.7 miles W of Lowell on N bank of Merrimac River. 0.7 miles above falls, opposite mill building and water tanks.

Landing Facilities: 1 lane. Longest landing area 7400'.

Services: Gas: 80 Octane. Day service. Buoys. Floats. Crash boat. Dock. Minor repairs.

Accommodations: Taxi. Bus.

Base Manager: Charles R. Musgrave.

LAWRENCE

Merrimac Valley Skyport:

Operated by J. Derderian.

Location: Lat. 42-42-00; long. 71-13-00. Elevation 50'

On city waterfront. 0.5 miles N of falls directly opposite waterworks.

Landing Facilities: 3 lanes. Longest landing area 5700'. Protected anchorage. E/W. Float. Obstructions: Electric wires cross river 0.5 miles above waterworks.

Services: Gas: 80 Octane. Buoys. Ramps. Floats. Hauling-out equipment. Crash boat. Minor repairs. Restaurant at base.

Accommodations: Courtesy transportation normally available in-town. Bus every 30 minutes. Taxi.

Base Manager: James Derderian.

NEWBURYPORT

Plum Island Seaplane Anchorage:

Owned by Fred Kezet. Operated by Plum Island Flying Service.

Location: Lat. 42-48-45; long. 70-52-00. Elevation sea level. 0.3 miles E of city. On S bank of Merrimac River.

Landing Facilities: 1 lane. longest landing area 5000'.

Services: Gas: 80 Octane. Flood lights on dock. Floats. Docks. Combined with airport, 2 miles SE of Newbury-port. Minor repairs.

Accommodations: Taxi

Base Manager: Warren S. Frothingham.

CHAPTER 7

ESTIMATING NEEDS

It is apparent that the number of airports of different classification needed in the Lowell-Lawrence-Haverhill area depends on the volume of future air traffic or different types of aircraft and the capacity of each type.

The best estimate for the volume of future air traffic should be in terms of plane movements, or the number of landings and take-offs of each type of aircraft expected to use the airports during the peak hour. With this information the number and sizes of airports can be determined for handling the load for the entire area.

The method recommended by the Civil Aeronautics Administration for determining needs for airports for metropolitan areas includes prorating the national estimates making due allowance for local variations in terrian, climate, industrial and commerical activities, wealth, population, transportation facilities and air-mindedness of the people. This analysis can by often supplemented by other studies, of which one, the formula employed in the Connecticut Airport Plan by the Department of Aeronautics, State of Connecticut, can be mentioned.

This plan lists the following factors believed to be governing the considerations in the establishment of a formula for judging the need for an air port, and the maximum size to satisfy this need for any city or town:

1. Population
2. Grand list
3. Number of manufacturing establishments
4. Number of employees
5. Town location with respect to civil airway
6. Number of miles to nearest class 2 airport
7. National defence site
8. Educational institutions

A rating formula is created for the above factors, and a special table is used for transposing the joint rating of each city or town to airport size.

The results of studies of this kind often provide valuable checks on the results of the method recommended by the Civil Aeronautics Administraion. This study follows closely the latter method.

For the Lowell-Lawrence-Haverhill area airports must be planned for the following three catagories of flying, each using a different type of aircraft:

Personal Flying
Scheduled Commerical Service
Non-Scheduled Commerical Service

A. ESTIMATING PERSONAL PLANE POTENTIALS

In planning airports for personal flying, this is a substantial agreement that the number of people likely in the future to own and operate their own planes, and where these potential owners will be located will determine the number of airports and the general locations to be of most service.

In order to estimate the number of potential plane owners, it is necessary to know the distribution of the population and income. The standards of the Civil Aeronautics Administration require a break-down of income

into three groups based on the house rentals.

The "high income group" includes all owner- and tenant-occupied dwelling units with estimated or contract rentals of $75 per month and over. The "intermediate income group" includes all owner- and tenant-occupied dwelling units having estimated or contract rentals from $50 through $75 per month. The "medium income group" includes all owner- and tenant-dwelling units with estimated or contract rentals of $40 to $49.

Tenant-occupied farm units are not included in the airport study, but owner-occupied units are included, if the number and value of such farm homes approve to be significant, and are a part of the metropolitan area. The values to be included range from $3,000 to $10,000. Only two groups, the "high income group" and the "intermediate group" are considered. All farm homes of $5,000 and over in value are placed in the "high income group", while those of $3,000 to $5,000, in the "intermediate".

All these data can be obtained from the statistics under Housing U.S. Census, 1940.

Dwelling Units in Selected Rental Groups for Some Cities and Towns:

City or Town	Total Dwllg Units	Total Occ. Units	Total Vac. Units	$40-49		$50-74		$75 and Over	
				Occ.	Vac.*	Occ.	Vac*	Occ.	Vac.*
Amesbury	3,291	2,978	201	78	8	52	1	23	2
Andover	3,211	2,981	151	245	24	509	27	342	16
Dracut	1,910	1,743	155	54	2	25	3	3	1
Haverhill	13,887	13,193	638	816	32	556	10	129	2
Lawrence	22,739	21,987	734	964	30	717	12	311	2
Lowell	25,579	24,953	632	1383	18	1042	9	363	-
Newbury-port	4,327	3,843	396	194	8	156	20	68	150

Assuming that in 1948 there is a 10% increase, mainly by houses built after the war, of all occupied dwelling units in these rental groups, and that the number of vacant units has decreased by 90%,** the number of occupied units can now be computed.

City or Town	Total Dwllg Units	$40-49		$50-74		$75 and Over	
		Units	%	Units	%	Units	%
Amesbury	3,357	93	2.78	58	1.73	27	.81
Andover	3,415	292	8.55	584	1.71	390	1.14
Dracut	2,052	61	2.98	31	1.51	4	.20
Haverhill	13,086	921	6.10	621	4.10	144	.95
Lawrence	24,847	1,087	4,37	800	3.32	344	.30
Lowell	28,706	1,537	5.35	150	5.22	399	.38
Newbury-port	4,573	220	4.81	190	4.15	210	4.60

* Vacant units for sale or rent. Vacant units not for rent or sale are not considered herein because they are unlikely to be used ~~nor~~ for occupation, therefore not affecting the figures.

** It is fair to assumed that 90% of the vacant units in 1940 have been renovated for occupation.

From the above data the percentages of the total number of dwelling units for each group can be computed to be roughly 5% for the $40-49 rental group, 3% for the $50-74, and 1.5% for the rental group of $75 and over.

From Census, the following data for the number of urban, rural non-farm and rural farm units are obtained:

City or Town	Total Dwllg Units	Urban & Rural Non-farm Units			Rural Farm Units		
		Total	Occ.	Vac.*	Total	Occ.	Vac.*
Billerica	2,117	2,008	1,889	119	109	101	8
Chelmsford	2,256	2,048	1,937	111	208	204	4
Georgetown	602	556	468	88	46	46	-
Groveland	676	592	557	35	84	82	2
Merrimac	793	689	628	62	104	96	8
Methuen	6,004	6,004	5,797	207	-	-	-
Newbury	521	382	346	36	139	123	16
No. Andover	2,097	2,097	2,076	21	-	-	-
Salisbury	1,224	1,106	556	530	118	116	2
Tewksbury	772	693	643	50	79	79	-
Tyngsboro	733	544	287	257	189	132	57
Westford	1,027	874	818	56	153	147	6
W. Newbury	440	326	248	42	114	110	4
TOTAL	19,262	17,919	16,296	1,614	1,343	1,236	107

* Vacant units for rent and sale only.

To obtain the number of occupied dwelling units in selected rental groups for 1948. The same assumption that there is a 10% increase for all occupied dwelling units, and that 90% of the vacant units for rent and sale are being occupied will be used.

Number of occupied dwelling units in selected rental groups adjusted for 1948 for towns contained in above table:

Town	Total Occ. Dwellg Units	$40-49 %	$40-49 Units	$50-74 %	$50-74 Units	$75 and Over %	$75 and Over Units
Billerica	2,303	5	115	3	69	1.5	35
Chelsmford	2,459	5	123	3	74	1.5	37
Georgetown	637	5	32	3	19	1.5	10
Groveland	736	5	37	3	22	1.5	11
Merrimac	860	5	43	3	26	1.5	13
Methuen	6,563	5	328	3	197	1.5	98
Newbury	562	5	280	3	168	1.5	134
No. Andover	2,303	5	115	3	69	1.5	35
Salisbury	1,229	5	61	3	37	1.5	18
Tewksbury	831	5	42	3	25	1.5	13
Tyngsborough	743	5	37	3	22	1.5	11
Westford	1,117	5	56	3	33	1.5	17
W. Newbury	485	5	24	3	15	1.5	7
TOTAL (For three groups):			1,293		776		439

Again on the same assumption, the number of farm units can be computed for 1948.

Number of Farm Units for 1948:

Town	No. of Occ. Farm Units (1940 Census)	No. of Occ. Farm Units (1948)
Billerica	86	105
Chelmsford	183	201
Georgetown	42	46
Groveland	69	76
Merrimac	81	89
Newbury	101	111
Salisbury	99	109
Tewksbury	72	79
Tyngsborough	107	118
West Newbury	97	116
Westford	126	139

Assuming that the percentages of farm units for different home value groups for each town is the same as for its county*, the number of farm units for the two selected groups of $3,000 to $4,000 and $5,000 and over can then be computed.

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* Since there are no readily available statistics regarding the selected income groups for these towns, this assumption, though not entirely justifiable is used.

From Housing, General Characteristics, Vol. 1, 3, U.S. Census, 1940, the number of farm units for Essex and Middlesex Counties can be calculated as follows:

Essex County:

Total No. of occupied farm units 1216.

No. of occupied farm units for group $3,000-4,999 - 216.
Thus, 216/1,216 x 100, or 17.7%

No. of occupied farm units for $5,000 and over - 236.

Thus, 236/1,216 x 000 or 19.4%

Middlesex County:

Total No. of farm units - 2682

No. of occupied farm units for group $3,000-4,999 - 636
Thus, 636/2,862 x 100 or 23.7%

No. of farm units for $5,000 and over - 653.

Thus, 653/282 x 100 or 24.2%

Applying these percentages to the following towns, the number of the occupied farm units according to the above value groups can be calculated:

Towns		No. of Occupied Farm Units	
		$3,000-4,999	$5,000 and over
Essex County:	Georgetown	8	9
	Groveland	13	15
	Merrimac	16	18
	Newbury	20	20
	Salisbury	19	21
	West Newbury	17	19
Middlesex Co:	Billerica	25	25
	Chelmsford	48	49
	Tewksbury	19	19
	Tyngsborough	28	29
	Westford	33	34

Having known the population of potential owners and the general distribution in the area, other factors such as the total population, area, density and surface transportation will be considered. Maps 6 to 12 respectively show population, density, transportation and wealth distribution and areas of industrial and commerical activities, and recreational areas.

From an analysis of these factors it becomes apparent that the different cities and towns in this area can be grouped under four zones, each having different characteristics which will be affect the number of potential plane owners.

Zoning Characteristics Affecting Number of Potential Plane Owners:

Zone	Population	Density	Surface Transportation	Wealth Distribution
Zone 1: Amesbury Haverhill, Lawrence, and Lowell	High	High	Excellent	Generally low, but high in Spots
Zone 2: Andover, Billerica, Chelmsford, Dracut, Methuen, Newbury, Newburyport, North Andover, Tewksbury, and Tyngsborough	Fairly High	Fairly High	Good	High
Zone 3: Merrimac, Salisbury, West Newbury	Low	Low	Fairly good	Fairly High
Zone 4: Georgetown Groveland and Westford	Very Low	Very Low	Fair	Sparce but high in Spots

For computing the number of potential plane owners in an average metropolitan area the standards recommended in "Airport Planning for Urban Areas", a publication of the Civil Aeronautics Administration, are applied to the number of units in each rental group and owner farm group. These standards are in terms of percentages of planes per household or per 100 households.

Zone	Income Group	Percent.	Planes / 100 Households
Zone 1	High Income	0.025	2½ Planes
	Intermediate Income	0.005	½ Plane
	Medium Income	0.001	1/10 Plane
2	High Income	.05	3 Planes
	Intermediate Income	.05	5 Planes
	Medium Income	.001	1/10 Plane
3	High Income	.10	10 Planes
	Intermediate Income	.05	5 Planes
	Medium Income	.005	½ Plane
4	High Income	.15	15 Planes
	Intermediate Income	.05	5 Planes
	Medium Income	.005	½ Plane

The table on the following page shows application of these percentages to the cities and towns in the Lowell-Lawrence-Haverhill area.

City or Town	Medium Rental	Intermediate Tental	High Rental	Farm Group		Total
				Intermediate Value	High Value	
Zone 1:						
Amesbury	93	58	27			
Haverhill	921	621	144			
Lawrence	1087	800	344			
Lowell	1537	150	399			
Total Units	3638	1629	914			
Percentages	x.001	x.005	x.025			
Total Potential Planes	3.638	8.145	22.71			34
Zone 2:						
Andover	292	584	390			
Billerica	115	69	35	25	25	
Chelmsford	123	74	37	48	49	
Dracut	61	31	4			
Methuen	328	197	98			
Newbury	280	168	134	20	22	
Newburyport	220	190	210			
No. Andover	115	69	35			
Tewksbury	42	25	13	19	19	
Tyngsborough	37	22	11	28	29	
Total Units	1613	1429	967	140	144	
Percentages	x.001	x.05	x.05	x.05	x.15	
Total Potential Planes	1.613	71.45	48.25	6.00	21.60	149
Zone 3:						
Merrimac	43	26	13	16	17	
Salisbury	61	37	18	19	21	
W. Newbury	24	15	7	17	19	
Westford	56	33	17	33	34	
Total Units	184	111	55	85	91	
Percentages	x.005	x.05	x.10	x.05	x.15	
Total Potential Planes	.920	5.55	5.50	4.25	13.75	30
Zone 4:						
Georgetown	32	19	10	8	9	
Groveland	37	22	11	13	15	
Total	69	41	21	21	24	
Percentages	x.005	x.05	x.15	x.05	x.15	
	.345	2.05	3.15	1.05	3.60	10
GRAND TOTAL						223

Therefore the number of potential planes in the area is estimated to be 223. On the basis of 100 planes per airport, the number of airports needed will be three. However, because of the presence of scheduled commerical and non-scheduled services (to be considered later) in this area, and other local factors, it is necessary for some airports to be used for mixed operations.

Some criticism has arisen in connection with the use of house rentals as indications for wealth. With the high cost of living to-day, it appears to be hardly possible for the medium and intermediate income groups to even consider owing personal planes, and this being the case, another basis must be formulated for a truer estimate. It must be understood, however, that the house rentals are the least variable items compared with other commodities, and if one principal factor is to be used for weighing it must just well be the rentals. Furthermore, those who in 1940 were paying $40 to $49 and $50 to $75 are probably paying higher rents now. Other factors such as the higher production in personal planes than the pre-war years, the airmindedness of the people as a result of war experience, and the growing needs of aviation all indicates that post-war inflation does not necessarily affect the number of future potential plane owners. In the absence of a more satisfactory basis worked out through years of experience, the standards recommended by the Civil Aeronautics Administration is considered justifiable.

B. ESTIMATING FUTURE SCHEDULED AND NON-SCHEDULED COMMERCIAL AIR TRAFFIC POTENTIALS

The volume of scheduled and non-scheduled air traffic potentials for the Lowell-Lawrence-Haverhill area can be estimated by prorating the share of the area in the national estimate of air traffic potentials. The problems becomes one of determining the generating areas called "marketing areas" in the Lowell-Lawrence-Haverhill area and the amount of the total air traffic which each area will generate. Marketing areas are the keys for determining the economic indices, or indices of buying power, to be applied to the national estimate to obtain air traffic potentials.

The economic indices for the principal and secondary trading cities are obtained by studying the various economic factors, which make up each area. The following are some important ones:

1. People in Homes: Total number population; total number of family dwellings; and the number of native white families.
2. Buying Powers: Personal income returns; pay rolls; savings and deposits.
3. Standard of living: Home owning families; passenger car registration, life insurance; wired homes; radio sales; home telephones; and domestic gas consumption.

4. Volume of Business: Whole sale and retail outlets; whole sale and retail sales; amusements; service sales; terminating railroad freights.

Before applying the economic indices, it is necessary to know the national estimates of air traffic potentials. A number of estimates of the future air traffic have been made up by various Federal agencies and aviation industry.especially on the passenger air traffic, air mail traffic, and commodity air traffic.

1. Passenger Air Traffic:

The results of two studies are used as basis for estimating future passenger potentials.

The National Resources Planning Board in its report, the "National Policy and Transportation", May 1942, makes the forecast that 20,000,000 passengers or 600,000,000 ton-miles will be transported annually some time between 1950 and 1960.*

The report of the Curtiss-Wright Corporation, "Air Transportation in the Immediate Post-war Period" forecasts that there will be 6.1 billion passenger-miles in 1948, 6.6 billion in 1949, and 7.0 billion in 1950, comparing with the 1940 figure of 1.04 billions**.

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* Transportation and National Policy, National Resources Planning Board, Washington, May, 1942, p. 354.

** Air Transportation in the Immediate post-war Period, Curtiss-Wright Corporation, Buffulo, New York, March 1944, p. 80.

The Air Traffic Control Division, Civil Aeronautics Administration reported that it would be unsafe to plan facilities for less than 20 billion passenger-miles per annum by 1950*.

It seems reasonable from the these estimates to arrive at a figure of 600 million ton-miles annually for 1950, and 1,000 million ton-miles for 1955, and 1,250 million ton-miles for 1958. Figuring that the average length of trip expected will be 300 miles in 1958, and that 10 passengers with baggage will weigh 1 ton, the tonnage to be handled in 1958 will be 4.1 million tons. Since this figure represents tonnage in transit, and it must be handled at both the origin and destination, it is apparent that the amount to be handled at the airports for the country as a whole will be doubled, i. e., 8.2 million tons.

2. Air Mail:

Both the Curtiss- Wright Corporation report and the National Resources Planning studies were made on the basis of a 400-mile haul and no surcharge. The former estimates the volume of air mail for 1950 to be 86.8 million ton-miles**. The latter's estimated figure 65 million ton-miles for 1950, compared with 58.7 million ton-miles of first class mail actually moved in 1940, the last normal pre-war year.

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* An Airport Program for the Philadephia-Camden Metropolitan Area, Philadephia, October, 1946, p. 46

** Air Transportation in the Immediate Post-war Period, op. cit., p. 103.

For the purpose of this study, a compromised figure of 76 million ton-miles, or 190,000 tons is used for 1950. The projected estimated for 1958 will be 106 million ton-miles or 265,000 tons. Since this amount will be handled twice, the total tonnage will be 530,000.

3. Commodity Traffic:

Commodity traffic includes air express, air freight and parcel post shipment. It is impractical to forecast the future of commodity traffic on the past trends because on the small quantity of shipment. The lag of record prior to 1940 in comparison with other types of air service has been due to the high rates which attracted only a small part of the commodity traffic. Nevertheless, the study of the National Resources Planning Board advances an estimate of 550 million ton-miles for 1950 commodity air traffic potential with the rate reduced to 18 cents. The report of the Curtiss-Wright Corporation gives the most detalied estimates varying with the air cargo rates. The most applicable ones* under the present situation are listed as follows:

Air Cargo Rates per ton-miles Cents	Million of Ton-miles		
	1946	1948	1950
30	63.3	85.1	110.1
25	90.6	121.9	157.6
20	145.5	195.8	253.1
18	180.2	242.4	313.5
16	222.7	299.8	387.6
14	297.8	400.7	518.2

* Ibid, p. 96.

Post-war period has been very favorable for this type of service. Commodity rates have come down to the vicinity of the rates mentioned above. Most hopeful is the air freight industry. Some organizations provide rates only 15 to 25%* percent higher that those of rail express. These reduced rates have been made possible only by reducing operating costs.

The Civil Aeronautics Administration has been using the Curtiss-Wright 30 cents ton-miles estimate for 1950, increased to 130 million to cover feeder lines not recognized in the same report** a figure of 800 ton-miles is arrived for 1950, and 126 million ton-miles for 1958. Using this estimate, and using a 500 mile average haul, the tonnage to be carried will be 2.5 million tons, or 5 million tons for being handled twice.

Recapitulation (1958)

National Estimates Per Annum

Passengers	8,200,000 tons
Mail	530,000 tons
Commodities	5,000,000 tons
	13,730,000 tons***

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* "Information on Slick Airway, Inc"., Slick Airways Inc., San Antonio, Texas, undated.

** An Airport Program for the Philadephia-Camden Area, op. cit., p. 47.

*** See traffic estimates for 1957, from Thomas H. Kuhn, Chief of Airport Engineering Division, Region I, Civil Aeronautics Administration, New York, N.Y., in files of Otis D. Fellows, Chief Planning Engineer, State Planning Board, Boston, Mass.

The economic index for the state has been estimated to be 4.347% of the national buying power, and for the Lowell-Lawrence-Haverhill area .2483%, being made up of 0.0929% for Lowell, 0.1053% for Lawrence, and 0.0679% for Haverhill. The economic index of the area represents 5.7% of that of the state.

The number of tons to be handled at Lowell in 1958 will be 0.000929 x 13,730,000 or 12755 tons per year, or 35 tons per day. Similarly, the tonnage to be handled at Lawrence will be 14458 per year, or 40 per day and 9323 at Haverhill per year, or 26 per day. Thus the total tonnage for the entire area will be 36535 per year or 101 per day.

In order to get a fairly accurate estimate of plane movements, a study of all the marketing areas in the state should be made. However, a reasonable estimate can be determined by using the types of planes, and percentages of total traffic each type will carry for other urban areas having more or less the same characteristics. Based on the assumption made by the Civil Aeronautics Administration*, the dairly tonnage for Lowell, Lawrence and Haverhill can be computed.

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* Data from Thomas H. Kuhn, op. cit.

Marketing Area	Type of Transport	% of Total Load Carried	Dairly Tonnage
Lowell	Feeder	30	35 x .3 - 10.5
	Small Trunk	50	35 x .5 - 17.5
	Intermediate Trunk	20	35 x .2 - 7.0
Lawrence	Feeder	30	40 x .3 - 12.0
	Small Trunk	50	40 x .5 - 20.0
	Intermediate	20	40 x .2 - 8.0
Haverhill	Feeder	30	26 x .3 - 7.8
	Small Trunk	50	26 x .5 - 13.0
	Intermediate Trunk	20	26 x .2 - 5.2

The daily plane movements required to carry the tonnage at Lowell, Lawrence and Haverhill will be as follows:

Type of Transport	Cap. of Plane (Pass.)	(Tons)	% Capacity Available	Ave. Ton. Capacity / Plane	Number of Daily Movements
Lowell:					
Feeder	10-14	1.5	100	1.5	10.5x1.5 - 16
Small Trunk	20-25	2.5	75	1.8	17.5x1.8 - 32
Intermediate Trunk	30-45	5.0	25	1.2	7.0x1.2 - 9
Lawrence:					
Feeder	10-14	1.5	100	1.5	12.0x1.5 - 18
Small Trunk	20-25	2.5	75	1.8	20.0x1.8 - 36
Intermediate Trunk	30-45	5.0	25	1.2	8.0x1.2 - 10
Haverhill:					
Feeder	10-14	1.5	100	1.5	7.8x1.5 - 12
Small Trunk	20-25	2.5	75	1.8	13.0x1.8 - 24
Intermediate Trunk	30-25	5.0	25	1.2	5.2x1.2 - 7

Thus the number of total plane movements per peak day will be 57, or per peak hour, 10 at Lowell; 64 per peak day, or or 11 per peak hour at Lawrence; and 43 per peak day, or 7 per peak hour at Haverhill.

By the above method the estimates of air traffic potentials can be computed at any interval within the 10 year's period ahead.

CHAPTER 8

LOCAL FACTORS DETERMINING NUMBER, LOCATION AND SIZE OF AIRPORTS.

Having estimated the air traffic potentials, local factors mentioned above in section A, Chapter 7 should be considered. These factors, may have been be physical or otherwise, will determine to some extent the number, the location and size of airports. This chapter discusses those factors.

Difficult Topographical Conditions:

The topography of this part of the country results in a scarcity of natural landing areas. The rolling terrian and the New England type of farming make it practical to construct landing fields whenever finanically feasible. The largest level places are usually low intervale land, and are either swampy or under cultivation. Other flat area which are high and dry are either wooded or subdivided into small farm units separated by stone walls or fences. Usually their value as farm land prevents them from being used as landing fields or airports. The difficult topographical conditions makes the construction of landing fields and airports imperative to the proper development of aviation.

Types of Manufacturing:

The types of manufacturing have been mentioned in

Section C, Chapter 2. Shipments of some manufactured products can be best handled by air transportation. The following types of merchandise are carried by air transports and the percentages reported by one of the largest freight carrier operator*:

	Percentage
Apparel, textiles and dry goods	38
Machinery, and parts	19
Perishables, including flowers, fruits, vegetables and seafood	14
Finished merchandise of all types	17
Unclassified	17
	100

With the development of the feeder operation in the future, large shipments of small machinery, parts and especially other manufactured products with demands will be expected.

Transportation:

The area is well supplied with roads, highways, and railroads. Service connecting suburbs and urban centres are rendered every fifteen minutes, and busses and trains Between Boston and Lowell, Lawrence and Haverhill are on hourly schedule. Because of its proximity to Boston where the Logan International Airport is located, there is little likelihood that any of the three urban centres in this area will ever become an important centre of air passenger traffic.

At present Boston and Maine Railroads render only scheduled passenger services, and combined passenger-and

* Letter dated Aug. 16, 1948 from Slick Airways, Inc., San Antonio, Texas.

-freight services. Freight trains are non-scheduled. This condition of freight transportation has not been satisfactory for industries with seasonal manufactured products such as apparel, textile, silk, rayon and shoes.

Feeder Operations:

As indicated by the feeder pattern and industrial needs, there is a definite future in the feeder business.

Population:

There are large concentrations of Canadians (French and others) in the cities and towns in the area. Passenger traffic between Canada and this area is increasing yearly. Although there will not be any heavy traffic between this area and points to the south, there will be considerable passenger traffic between this area and points to the north including Montreal, Quebec and Ottawa in Canada.

Existing Airports:

The existing airports at Beverly, Ayer, Groton, in Massachusetts and Nashua, Manchester and Portsmouth in New Hampshire have little influence on this area.

A survey of the airports in the area shows that ~~the~~ users from outside of the area. The following table shows the number of planes based and whether they are from within the area.

Table 3. Number of Planes Based in the Area:

Location	Airport	Number of Planes	
		From inside the Area	From outside the Area
Billerica	Shawsheen Pines Airport	29	5
Dracut	Richardson Airport	15	
Haverhill	Haverhill Airport	20	
Lawrence	Lawrence Airport	13	1
Lowell	Lowell Seaplane Base	2	
Methuen	Merrimac Valley Skyport	5	
Newbury	Plum Island Airport and Seaplane Base	14	5
TOTAL		98	11*

The number of planes stationed at the airports in this area will be more if the area is provided with sufficient airports with adequate ground facilities. Therefore, a 15% allowance over and above the estimated requirements for the area should be provided for users from the neighboring cities and towns in Massachusetts.

Expansion of the existing airports of Nashua, Manchester and Portsmouth and construction for two landing auxiliary fields at Raymond and Rye Beach and construction of the Hampton-Seabrook Municipal Airport have been proposed in a Plan for the Development of Airports and Airways in New Hampshire in 1940 (see Map 17). However, before such airports can be expanded and constructed to serve also neighboring towns in New Hampshire, as mentioned in Section B. Chapter 1, certain allowance must be provided

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* Representing 11 percent.

~~for~~ in this proposed airport development plan for Lowell-Lawrence-Haverhill area for users from New Hamphsire, Cities and towns such as Hudson, Derry and Exter, which can be served by airports of Manchester and Portsmouth in thier own vicinities, are therefore not considered in this study. It is reasonable that 5 percent allowance over and above the estimated needs will be provided for users from New Hamphsire.

This 20 percent allowance should not be considered generous if all proposed airports will be constructed within the next decade, and all ~~existing now~~ airports under proper management.

Airmindedness:

Residents in this area are quite airminded. Although there are no flying clubs or similar organizations fostering aviation, there are quite a number of privately owned small airports, schools and agencies giving air services. The only large public agency having to do with aviation is the Lawrence Airport, which has control of the Lawrence Municipal Airport. The Lowell seaplane anchorage is under the Lowell Park Commission. The Lowell Airport Commission was at one time very active in promoting a plan for the Lowell airport. A master plan hasnbeen made by a Connecticut engineering office on the site selected in Dracut. Because it is impossible to acquire the land under consideration, the plan is now inactive. Regardless little progress has been made, this,

nevertheless, is an encouraging sign of public airmindedness.

CHAPTER 9

RECOMMENDATIONS AND PROPOSALS

1. It has been estimated that there will be 223 personal planes in this area by 1958, but airports and facilities must be provided for 20 percent or more, or roughly 270 planes for reasons already mentioned in the last chapter.

2. Since the number of potentials plane owners will be highest in Andover, and since there is available land, a Class 1 airport is proposed. There are two promising sites with little or no obstructions and with ample area for expansion. The site about 2.5 miles west of South Lawrence is a highland bounded by Brundrett Avenue on the North, and Chandler Road on the South. Although the Merrimac Valley Skyport is located a short distance away, it is not likely that there will be traffic interference. Another site is located about a mile SSE of Hoggetts Pond, and about 3 miles from Andover. Bellevue Road runs along the west boundary of the site. It is a flat low land, and no elaborate grading is necessary. If recreational facilities can be developed in the vicinity of the pond, more flying activities may be anticipated, and it will be profitable for the airport.

3. A maximum Class 2 or minimum Class 3 airport is proposed for Lowell for feeder line operations. Since there is no available land within the corporated limits of the

city, the airport will have to be located outside of Lowell. Areas in Dracut, Chelmsford and Tewksbury all have possibilities. Although the Marsh Hill site in Dracut is the most promising, the land is now not available because of opposition, and eminent domain can not be exercised by Lowell in a neighboring town. The Pine Hill a Chelmsford site offers the next best solution. This site is chosen for master plan study in Part II.

4. Richardson Airport in Dracut can be expanded to twice its present size, but since the Lowell Airport will be for combined operation of personal planes and feeders this expansion may not be needed.

5. The present mixed operation at Lawrence Municipal Airport makes personal flying hazardous and unpleasant. It is recommended that in the future the airport will be used solely for scheduled and feeder services. The proposed Class 1 airport to be located at Andover will also take over the share of personal flying from the Lawrence Municipal Airport.

6. In view of the high number of plane owners at present, Haverhill should have a larger airport than the present Class S-1 airport. However, since there is no room for expansion at the Dutton-Walker site, the only alternative will be a site about a mile south-east of Lake Kezola, and yet, the development at best will be a maximum Class 1 airport.

7. The need of air transportation has been indicated

from the estimates, but to provide a Class 2 airport for feeder line operations at Haverhill is not only impossible because of the lack of airport sites, but also uneconomical because of its proximity to Lawrence Airport, which can serve Haverhill as well. Therefore it is recommended that the Lawrence Municipal Airport be expanded to maximum Class 3 or minumum Class 4 airport to accommodate the Haverhill traffic load.

8. Although small planes and feeders will be the principal types of aircraft in the area, Intermediate trunk-line transports with increased gross weight (see Chapter 3) may be expected to use the Lawrence Municipal Airport. The recommended maximum Class 3 expansion for this airport will be capable to accommodate these planes.

9. There is ample room for expansion for the Plum Island Airport, but it is believed that the present airport with improved ground facilities will be able to accommodate the personal flying activities expected in the next decade, including the summer activities due to visitors to Salisbury.

10. It is is deemed advisable by both the city of Lowell and the town of Chelmsford, the establishment of a Joint Airport Commission, charged with the custody, care and management of the airport, mentioned above in paragraph 3 is recommended. The share of interest

of each municipality will be determined by its taxable valuation.

CHAPTER 10

EFFECTUATING THE PLAN

Effectuating the plan means to construct and maintain an airport on a sound, planning, engineering, financial and legal basis. By proper planning the aviation needs and airport requirements can be estimated. Accurate development plans and statements of cost and estimate for construction of an airport can be made by competent engineers. On this, methods of financing can be devised. Legislation will make possible protection for the airport by approach zoning, which should be properly incorporated as an integral part of the comprehensive zoning. Finally the development of the airport should be included in the comprehensive master plan.

The following are agencies which will assist in the formulation of airport development plans:

Civil Aeronautics Administration:

The Civil Aeronautics Administration is the federal agency charged with the development and operation of air navigation aids, administering safety regulation, and supervising technical development work in the field of aeronautics, and above all expending funds for construction, improvement and repairs of airports necessary for the national defence. The Administration maintains an engineering section to exercise control over the airport work for which it contributes funds. This section does

not carry out engineering design (except in certain emergencies), but passes on plans and specifications prepared by the sponsors of the project. The Administration engineers are usually available to consult with communities on new projects and advice on such matters as site selection and class of airport to be constructed.

The Administration maintains a District Office in Boston.

Civil Aeronautics Board:

The Civil Aeronautics Board is the federal agency charged with the encouragement and development of an air transportation system properly adapted to the present and future needs of the foreign and domestic commerce of the United States, of the postal service and of the national defence. This is the agency which prescribes safety rules, regulates traffic for carrying persons, property and mail, and generally controls the economic side of the air transportation business. One of the most impobant functions, is the issurance of certificates of public convenience and necessity to agencies operating air routes. From these applications, the future air transportation pattern can be obtained.

Massachusetts Aeronautics Commission:

The Massachusetts Aeronautics Commission was set up in 1939, with the purpose of fostering local avaition. Its regulatory functions are limited since the federal regulations reach into most all phrase of aeronautical

activity. Like the Civil Aeronautics Administration, the Commission also extends engineering supervision to municipalities, and if the projects are approved, the state's share of funds for the construction of the airports. This state agency also acts as natural link between the federal aeronautics agencies and the municipalities.

The State Planning Board:

This state agency has recently completed three airport planning studies for Massachusetts, the Massachusetts Bay Region, Connecticut Region and the Worcester Region. Studies for other regions will soon be published. These studies will serve as guides for airport development.

Municipal Bodies:

Municipal bodies (such as Airport Commission, Park Commission, or Public Works Department as the case may be) usually have direct control over the construction, and maintenance and sometimes operation of their own airports. They are responsible also for the zoning protection for the airports and other matters having to do with public safety and welfare.

Engineering Consulting Offices:

Engineering plans and statements of cost and estimate should be made by engineers with thorough knowledge of the local physical conditions. The following engineering

officers are among those that should be consulted with:

Fay, Spofford and Thorndike, Engineers, Boston.
Thompson and Lichtner, Co., Inc., Boston.
General Airports, Inc., Stampford, Connecticut.
Charles A. Rheinstrom, Inc., New York.

All these officers have ample experience in airport construction in New England are ~~are~~ most familiar with the local conditions in the Lowell-Lawrence-Haverhill area.

Local Airlines:

Large local airline officers generally have departments of research and planning. For the Lowell-Lawrence-Haverhill area Wiggins Airways, Inc. and the Northeast Airlines, Inc. are well informed.

FEDERAL AND STATE REGULATIONS RELATIVE TO FINANCING AIRPORT PROJECTS, APPROACH ZONE REGULATIONS AND OTHERS

For the purpose of providing Federal aid for the development of public airports the Federal regulations specify that the eligible sponsor (or sponsors of a joint project) must be a "public agency", and that the proposed airport project must be within the scope of the latest revision of the National Airport Plan of the Civil Aeronautics Administration, and must be in accordance with the standards established or approved by the Administration for the type of development involved. When the project is approved, the Federal

Government will thereby share part of the project costs. For the development of a Class 3 or smaller airport, the United States' share in the project costs (other than costs of land acquisition) of an approved project shall be 50 percent of the allowable project costs. The United States' share for land acquisition can only be granted under special circumstances such as to prevent or limit the establishment of an airport hazard, or to permit proper use, operation, and management, and maintenance of the airport as a public facility. In this case, the United States' share of the project costs of an approved project which represent costs of land acquisition shall be 25 percent of the allowable costs of such acquisition. Section 39F of the Massachusetts Aeronautics Law states in substance that whenever any city or town undertakes, in conformity with the state airport plan, the acquisition, construction, establishment, enlargement, improvement or protection of an airport and has appropriated sufficient funds, which together with funds available under this section, shall equal at last 50 percent of the cost thereof, the state's share of the costs will be not more than 25 percent.

Other sections of the laws provide for:

(1) the establishment of reasonable airport approach regulations by cities and towns (except Boston), and for this purpose the city or town may take, by eminent domain, or acquire, by purchase or otherwise, such air rights, easements, or other estate or interest in such

real estate as will provide adequate protection (Section 40A-I, and Section 45);

(2) the establishment of an airport commission in the city or town, where a public airport is established, having custody, care and management the airport (Section 51D), and having the right to exercise eminent domain to take property for the purpose of the airport (Section 51G);

(3) for the establishment of a joint enterprise by two or more municipalities agreeing to establish, maintain and operate an airport (Section 51N).

SHADED AREA *
The LOWELL-AWRENCE-HAVERHILL AREA used in this study.

AREA WITH RED BORDER *
Defined as the LOWELL-LAWRENCE-HAVERHILL METROPOLITAN DISTRICT by the U.S. Census, 1940

THE COMMONWEALTH OF MASSACHUSETTS
STATE PLANNING BOARD

PLANNING REGIONS IN MASSACHUSETTS

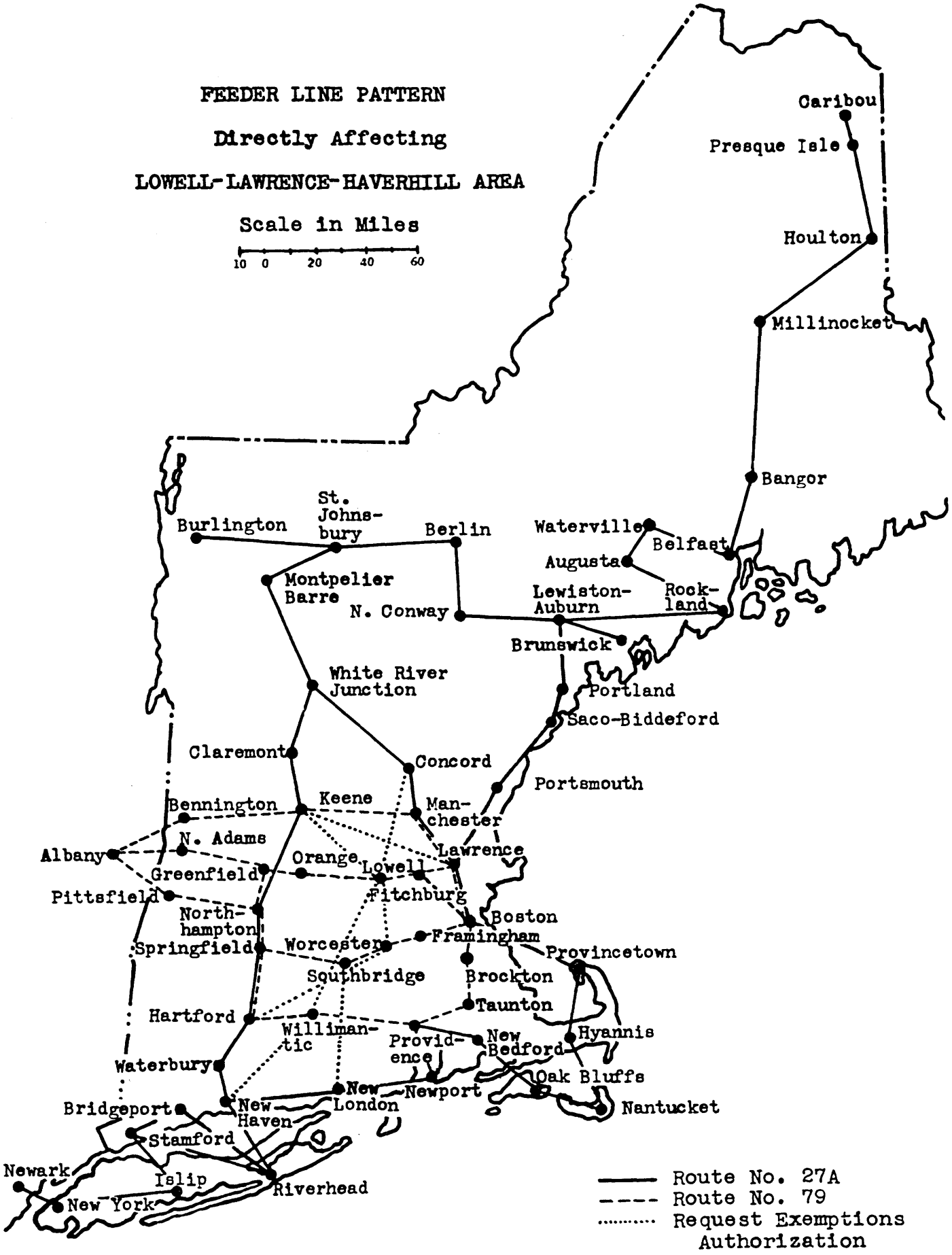
ELISABETH M. HERLIHY, CHAIRMAN — HENRY I. HARRIMAN
JAMES A. BRITTON — FRANK W. HOWARD
FRANK ROSS — JOHN L. ROBBINS
COMMISSIONER OF CONSERVATION
COMMISSIONER-METROPOLITAN DISTRICT COMMISSION
COMMISSIONER OF PUBLIC HEALTH
COMMISSIONER OF PUBLIC WORKS

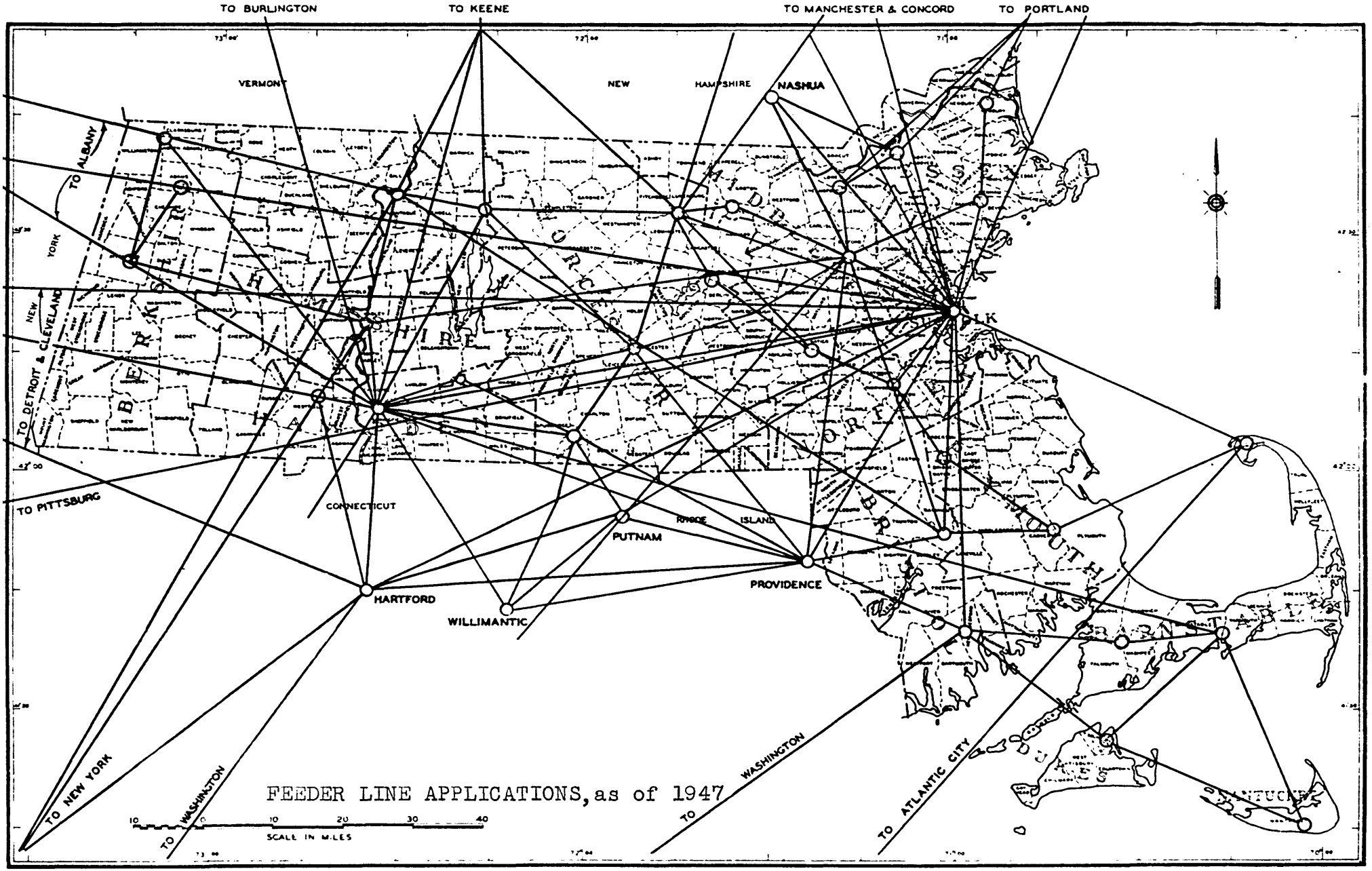
OTIS D. FELLOWS, CHIEF ENGINEER

10 0 10 20 30 40
SCALE IN MILES

NOTE: NORFOLK COUNTY INCLUDES BROOKLINE AND COHASSET.

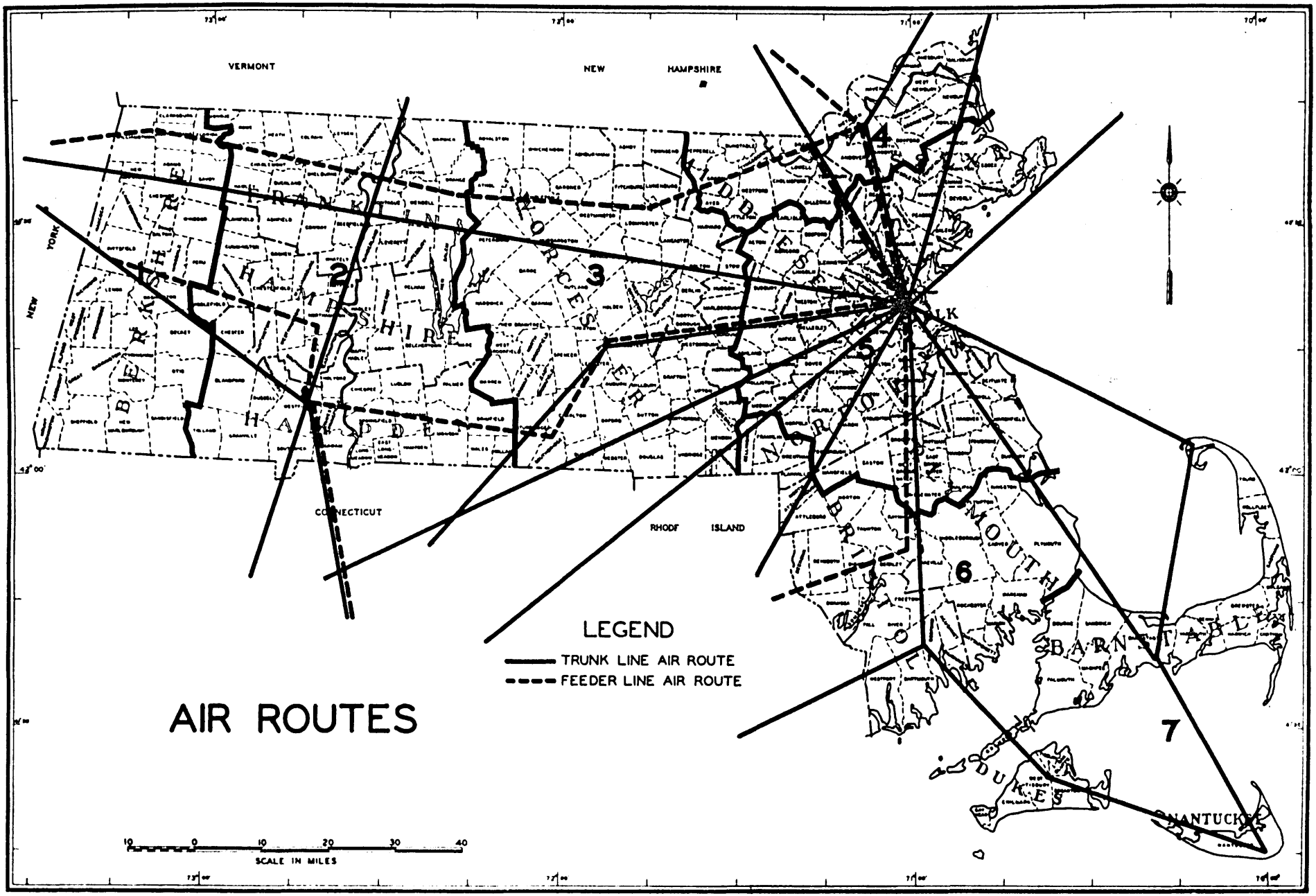
Map 2


FEEDER LINE PATTERN
Directly Affecting
LOWELL-LAWRENCE-HAVERHILL AREA
Scale in Miles
10 0 20 40 60
Caribou
Presque Isle
Houlton
Millinocket
Bangor
Waterville
Belfast
Augusta
Rock-land
Lewiston-Auburn
Brunswick
Portland
Saco-Biddeford
Portsmouth
Burlington
St. Johns-bury
Berlin
Montpelier Barre
N. Conway
White River Junction
Claremont
Concord
Bennington
Keene
Man-chester
Lawrence
N. Adams
Albany
Orange
Lowell
Greenfield
Fitchburg
Pittsfield
North-hampton
Springfield
Worcester
Framingham
Boston
Provincetown
Southbridge
Brockton
Taunton
Hartford
Williman-tic
Provid-ence
New Bedford
Hyannis
Waterbury
New London
Newport
Oak Bluffs
Bridgeport
New Haven
Nantucket
Stamford
Newark
Islip
New York
Riverhead
Route No. 27A
Route No. 79
Request Exemptions Authorization

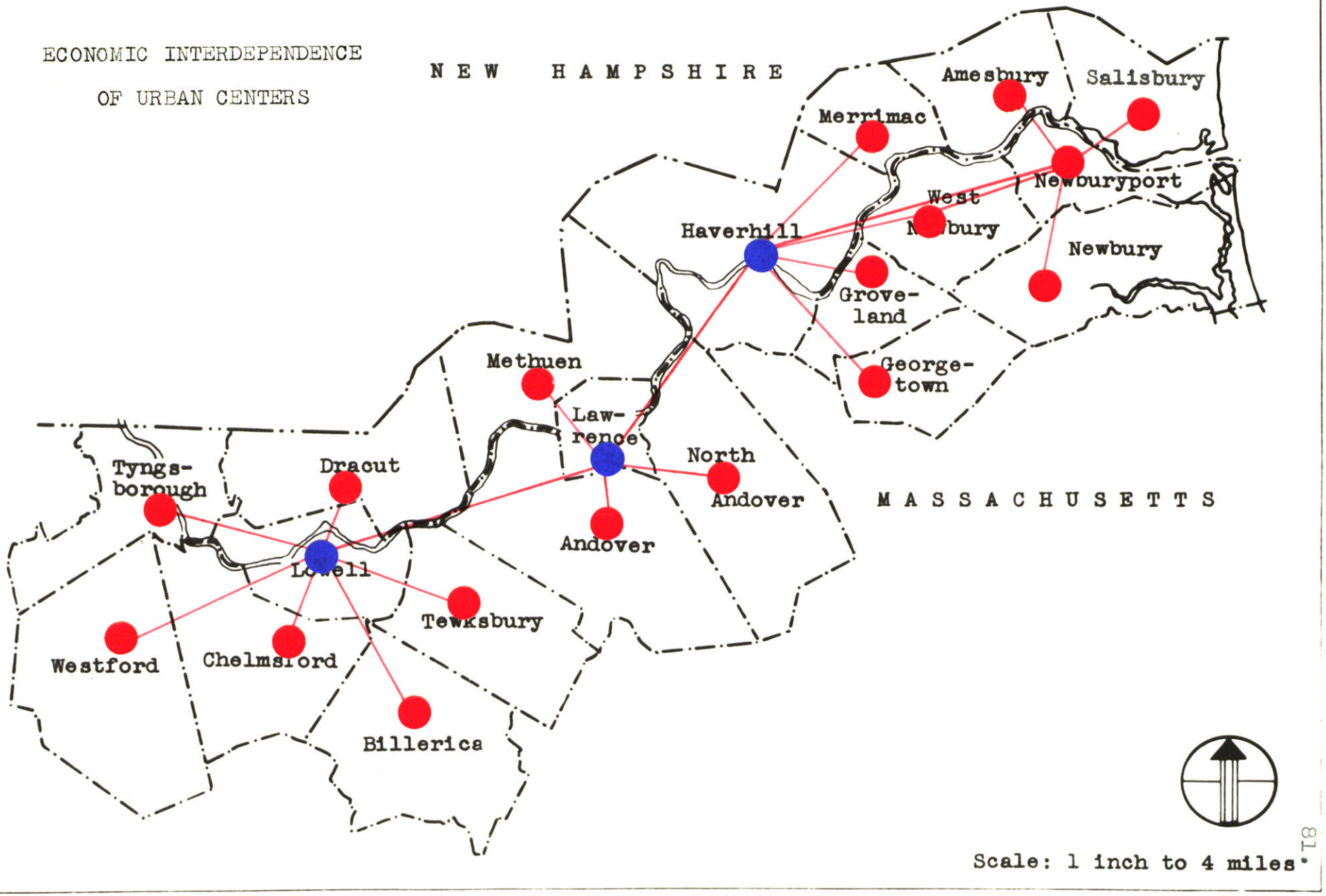


FEEDER LINE APPLICATIONS, as of 1947

Map 3


VERMONT
NEW HAMPSHIRE
NEW YORK
CONNECTICUT
RHODE ISLAND
BERKSHIRE
FRANKLIN
HAMPSHIRE
HAMPDEN
WORCESTER
MIDDLESEX
NORFOLK
SUFFOLK
BRISTOL
PLYMOUTH
BARNSTABLE
DUKES
NANTUCKET
1
2
3
4
5
6
7
LEGEND
TRUNK LINE AIR ROUTE
FEEDER LINE AIR ROUTE
AIR ROUTES
10 0 10 20 30 40
SCALE IN MILES

Map 4


ECONOMIC INTERDEPENDENCE
OF URBAN CENTERS
N E W H A M P S H I R E
M A S S A C H U S E T T S
Amesbury
Salisbury
Merrimac
Newburyport
West
Haverhill
Newbury
Grove-
land
George-
town
Methuen
Law-
rence
North
Andover
Tyngs-
borough
Dracut
Andover
Lowell
Tewksbury
Westford
Chelmsford
Billerica
Scale: 1 inch to 4 miles.


POPULATION
UNDER 2,500
2,500 - 5,000
5,000 - 10,000
10,000 - 25,000
25,000 - 50,000
50,000 and Over
NEW HAMPSHIRE
MASSACHUSETTS
Amesbury
Salisbury
Merrimac
Newburyport
West Newbury
Newbury
Haverhill
Grove-land
George-town
Methuen
Law-rence
North Andover
Andover
Tyngs-borough
Dracut
Lowell
Tewksbury
Westford
Chelmsford
Billerica
Scale: 1 inch to 4 miles

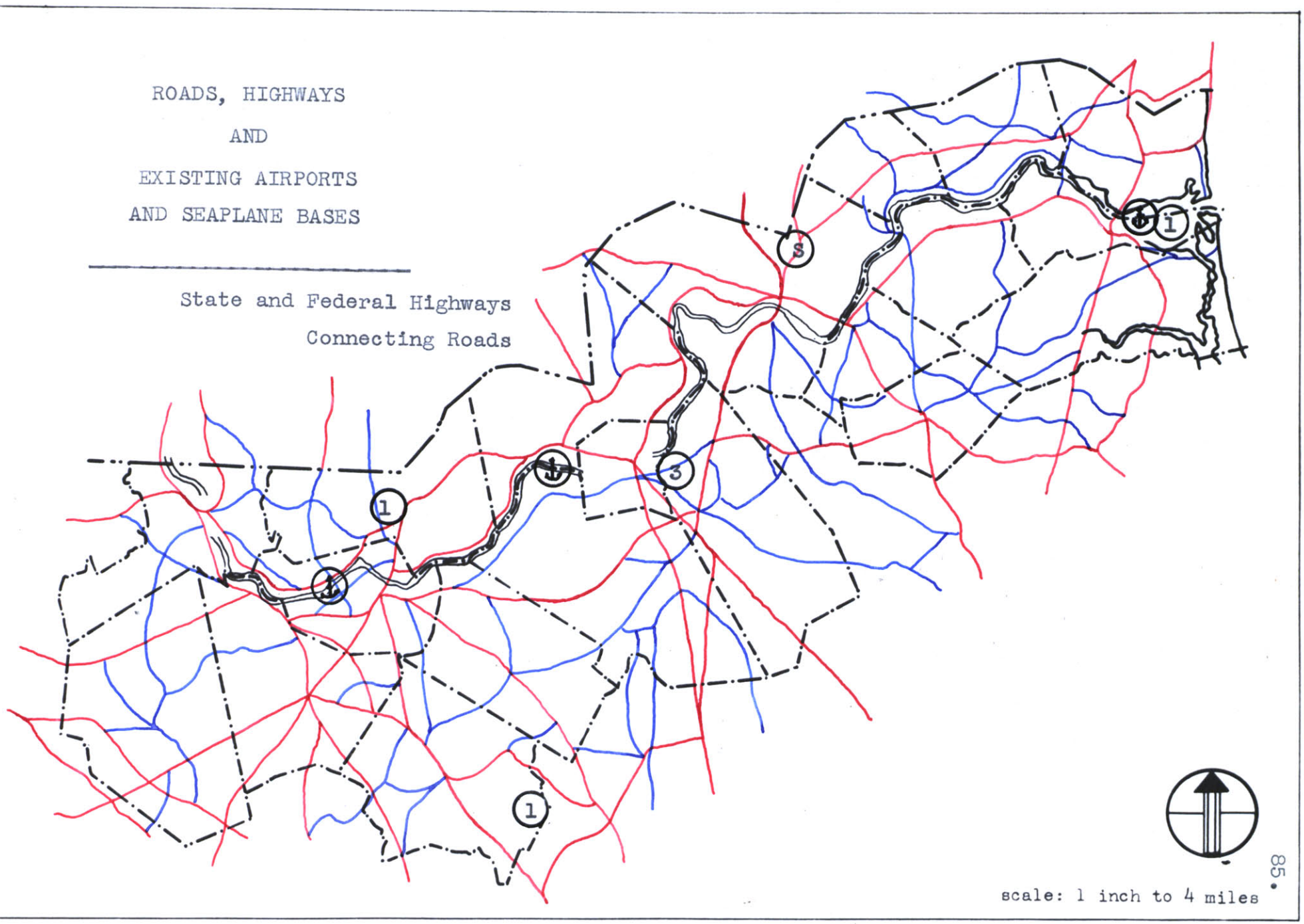
MAP 6


DENSITY
(POPULATION / AREA)
HIGH
FAIRLY HIGH
LOW
VERY LOW
NEW HAMPSHIRE
MASSACHUSETTS
Amesbury
Salisbury
Merrimac
Newburyport
West Newbury
Haverhill
Newbury
Groveland
Georgetown
Methuen
Lawrence
North Andover
Andover
Dracut
Tyngsborough
Lowell
Tewksbury
Westford
Chelmsford
Billerica
Scale: 1 inch to 4 miles.

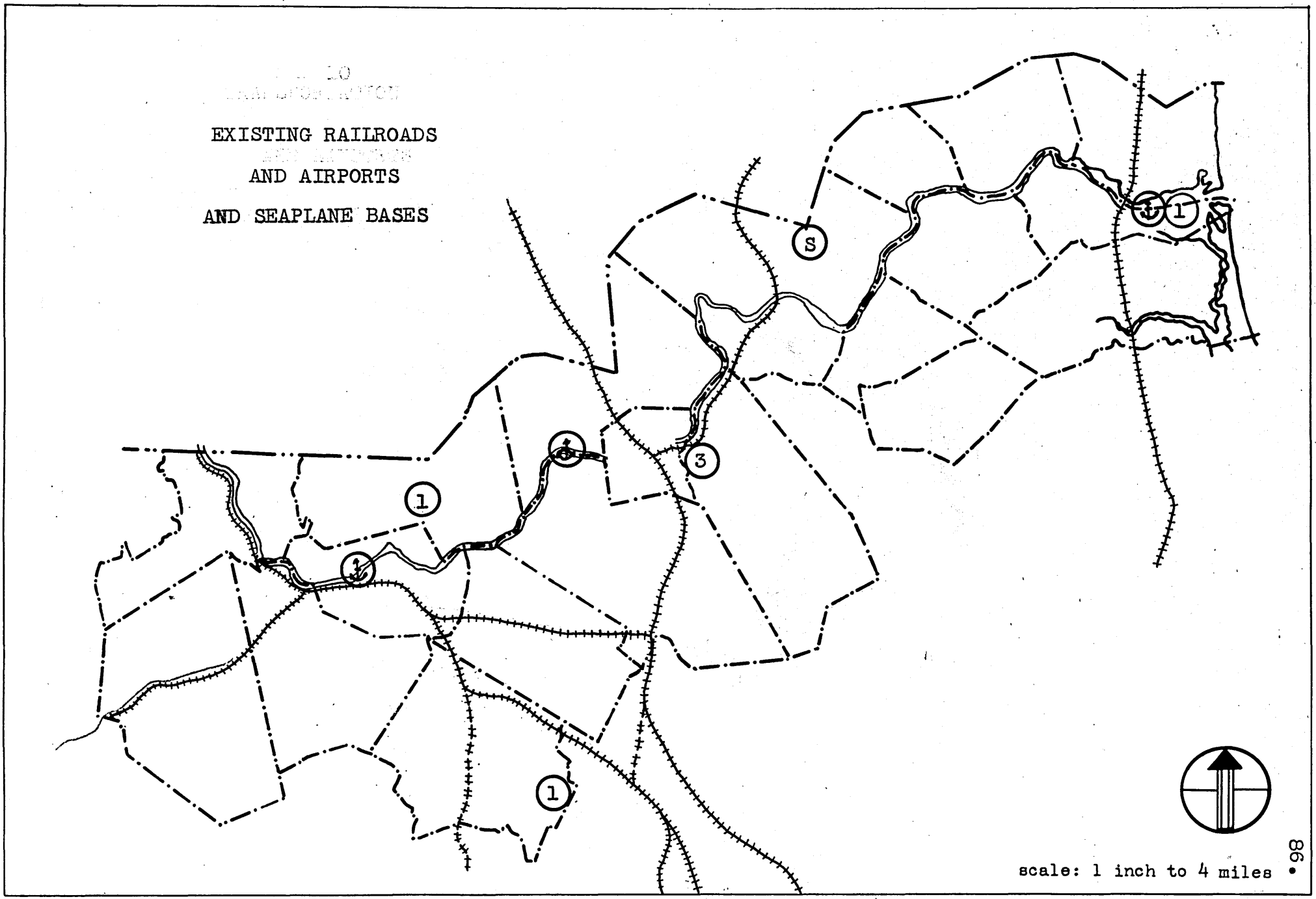
MAP 7


WEALTH DISTRIBUTION
Wealth Low but High in Spots
Very High Distribution
High Distribution
Wealth Sparce but High in Spots
NEW HAMPSHIRE
MASSACHUSETTS
Amesbury
Salisbury
Merrimac
Newburyport
West Newbury
Newbury
Groveland
Georgetown
Haverhill
Methuen
Law-rence
North Andover
Andover
Tyngsborough
Dracut
Lowell
Tewksbury
Westford
Chelmsford
Billerica
Scale: 1 inch to 4 miles.

MAP 8


ROADS, HIGHWAYS
AND
EXISTING AIRPORTS
AND SEAPLANE BASES
State and Federal Highways
Connecting Roads
1
1
3
1
3
1
scale: 1 inch to 4 miles

MAP 9


EXISTING RAILROADS
AND AIRPORTS
AND SEAPLANE BASES
S
1
3
1
1
scale: 1 inch to 4 miles

MAP 10

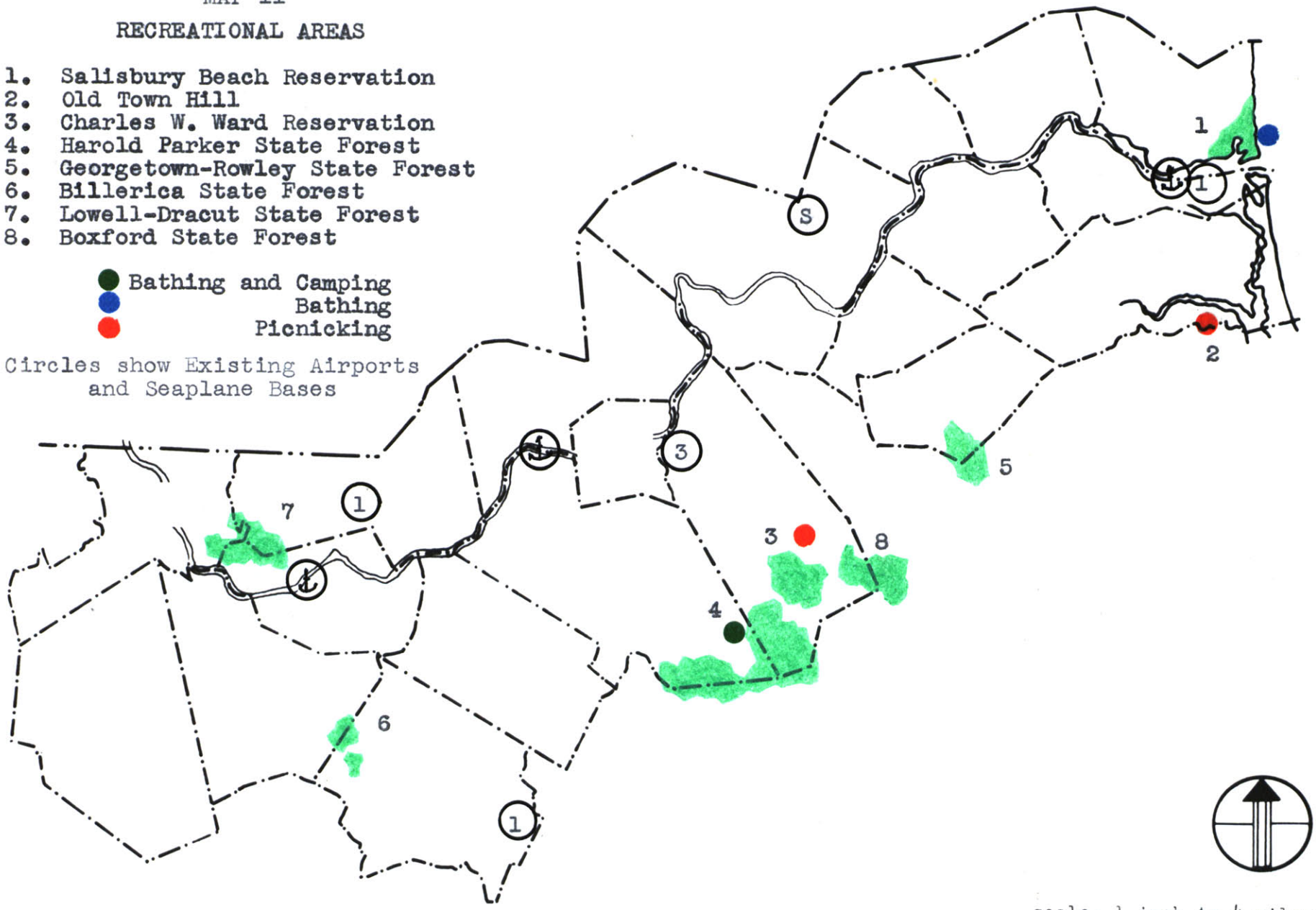
MAP 11

RECREATIONAL AREAS

1. Salisbury Beach Reservation
2. Old Town Hill
3. Charles W. Ward Reservation
4. Harold Parker State Forest
5. Georgetown-Rowley State Forest
6. Billerica State Forest
7. Lowell-Dracut State Forest
8. Boxford State Forest

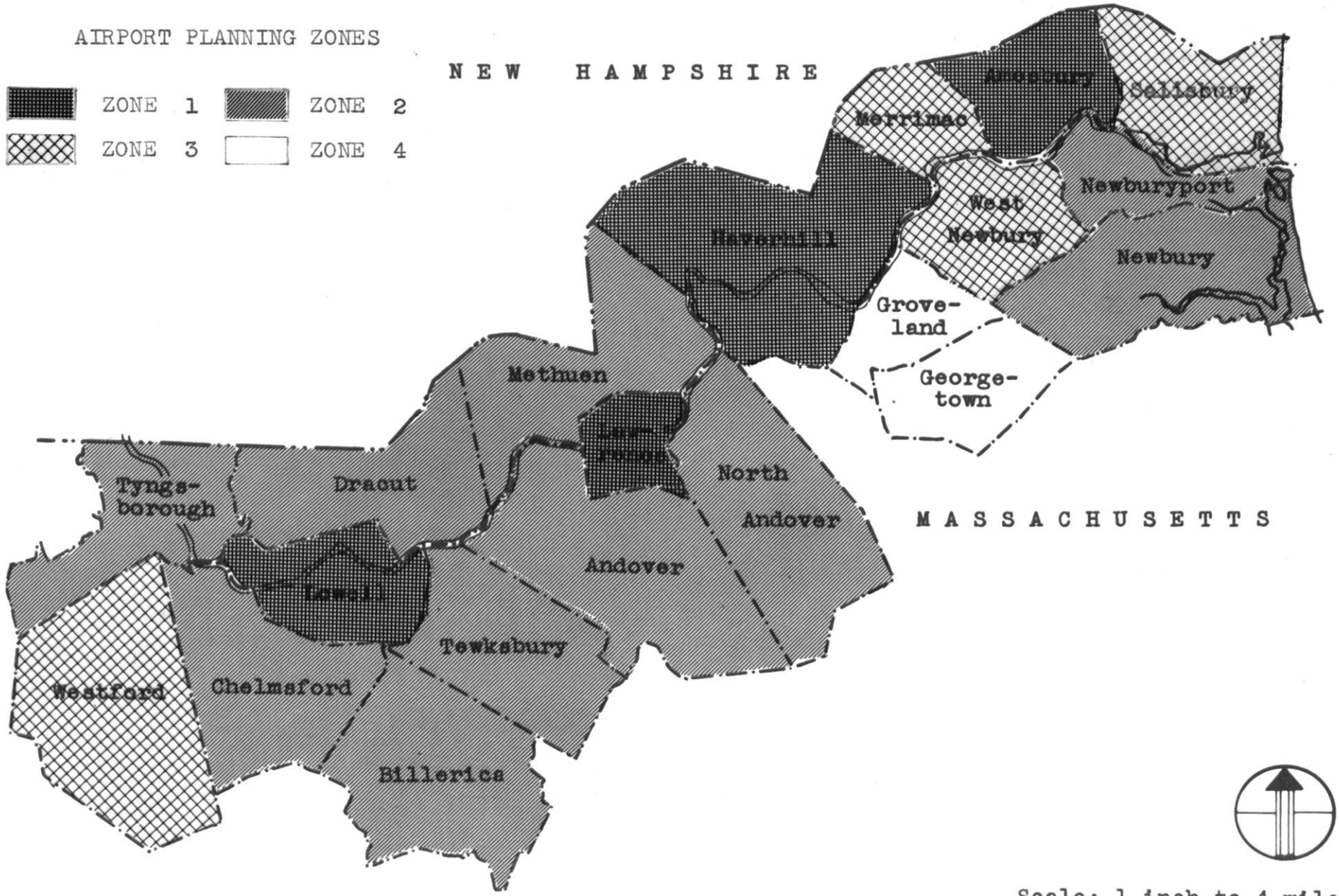
Bathing and Camping
Bathing
Picnicking

Circles show Existing Airports and Seaplane Bases



scale: 1 inch to 4 miles

MAP 11


AIRPORT PLANNING ZONES
ZONE 1
ZONE 2
ZONE 3
ZONE 4
NEW HAMPSHIRE
MASSACHUSETTS
Amesbury
Salisbury
Merrimac
Newburyport
West Newbury
Newbury
Haverhill
Groveland
Georgetown
Methuen
Tyngsborough
Dracut
North Andover
Andover
Lowell
Tewksbury
Westford
Chelmsford
Billerica
Scale: 1 inch to 4 miles

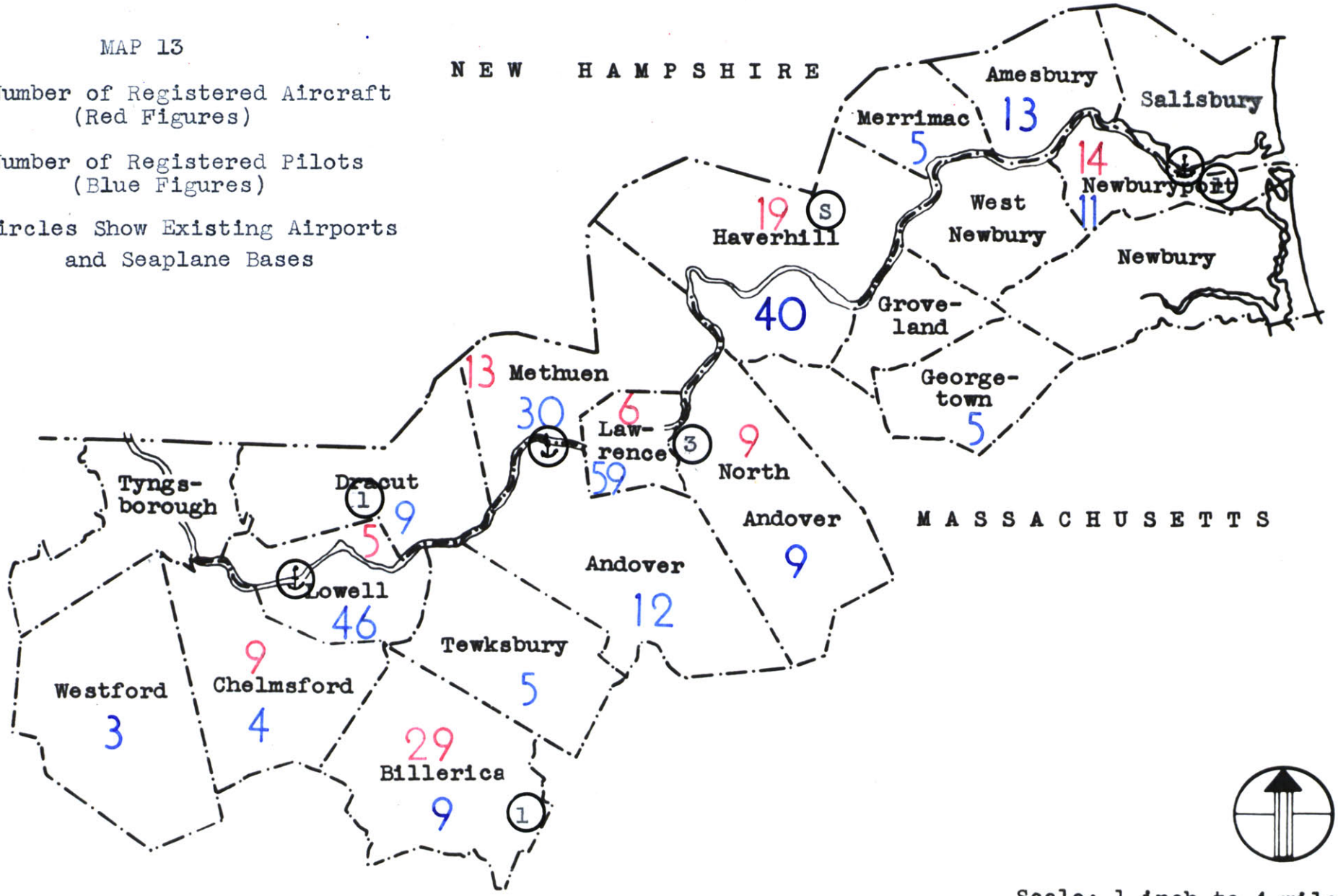
MAP 12

MAP 13

Number of Registered Aircraft
(Red Figures)

Number of Registered Pilots
(Blue Figures)

Circles Show Existing Airports
and Seaplane Bases



Scale: 1 inch to 4 miles

68

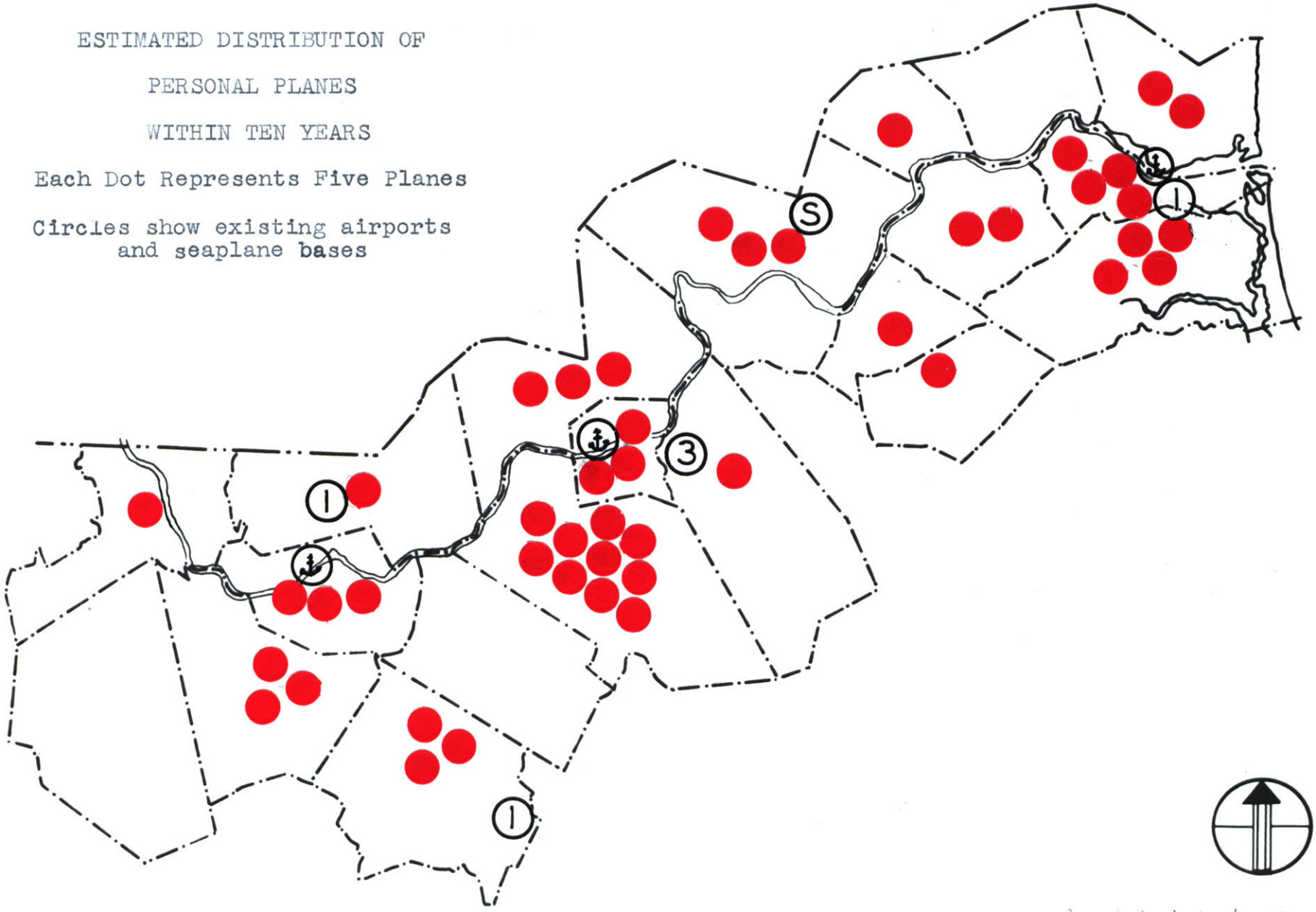
ESTIMATED DISTRIBUTION OF

PERSONAL PLANES

WITHIN TEN YEARS

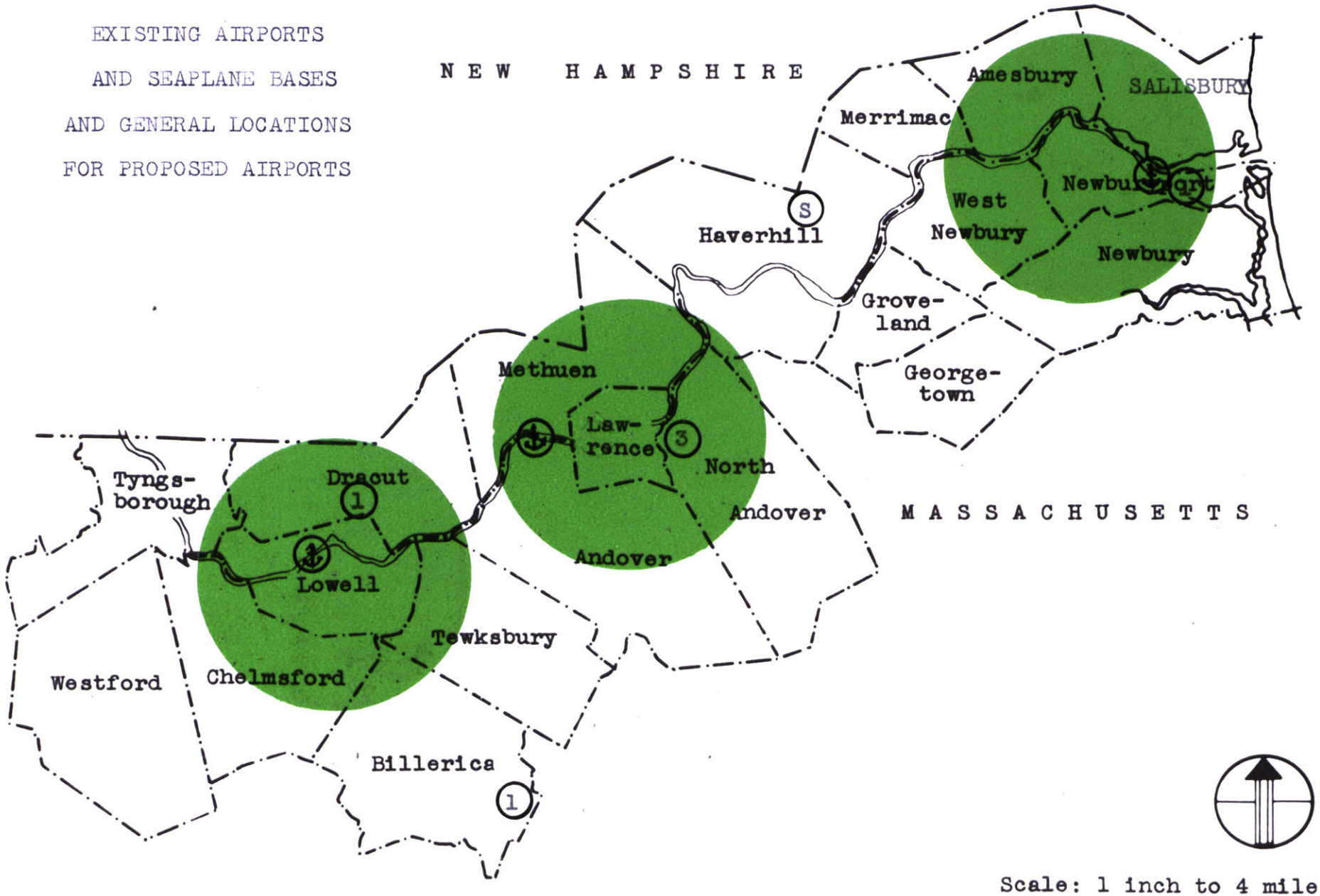
Each Dot Represents Five Planes

Circles show existing airports and seaplane bases



scale: 1 inch to 4 miles

MAP 14


EXISTING AIRPORTS
AND SEAPLANE BASES
AND GENERAL LOCATIONS
FOR PROPOSED AIRPORTS
NEW HAMPSHIRE
MASSACHUSETTS
Amesbury
SALISBURY
Merrimac
Newburyport
West Newbury
Newbury
Haverhill
S
Groveland
Georgetown
Methuen
Lawrence
3
North Andover
Andover
Dracut
1
Tyngsborough
Lowell
Tewksbury
Chelmsford
Westford
Billerica
1
Scale: 1 inch to 4 miles

MAP 15

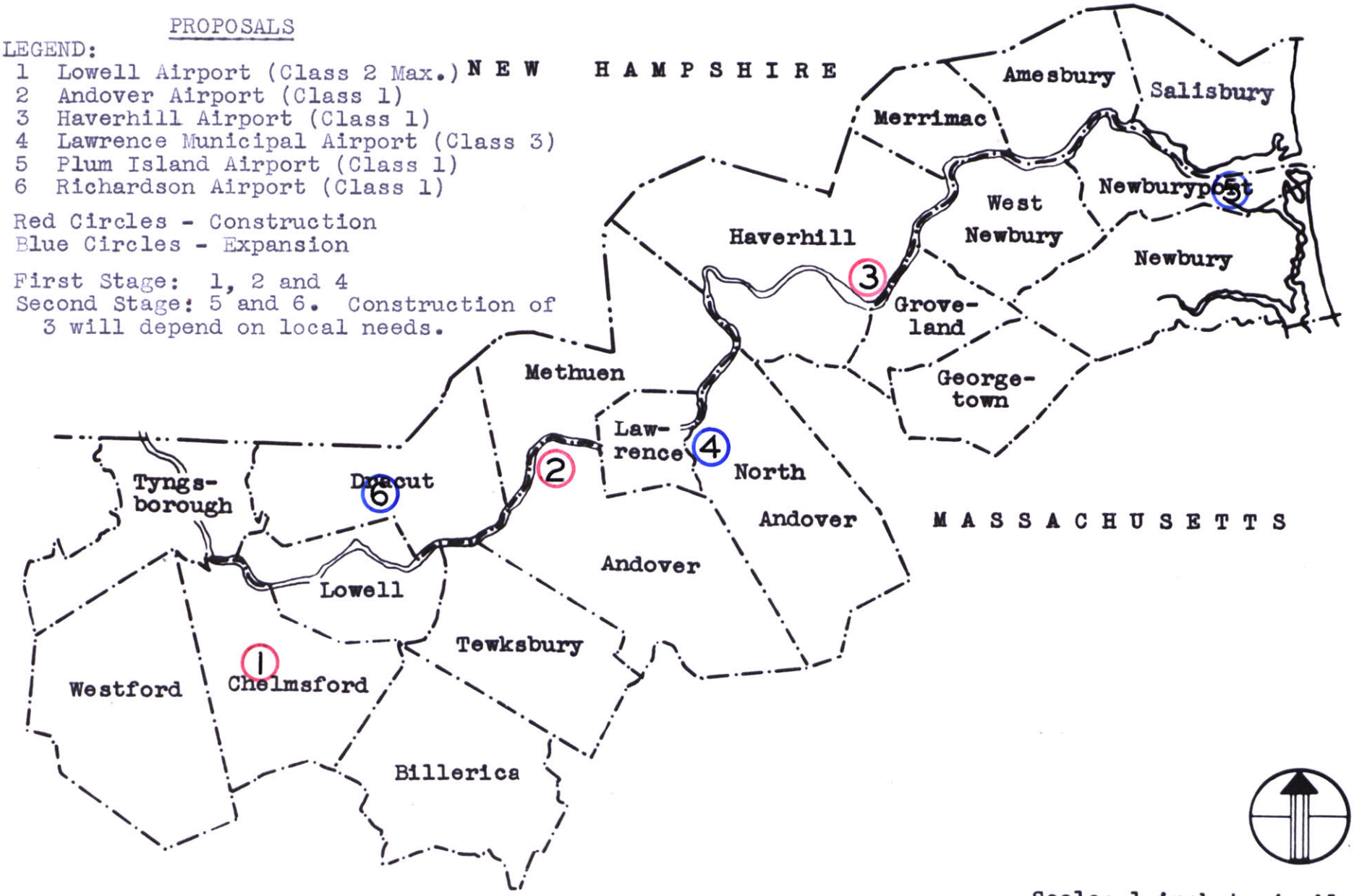
PROPOSALS

LEGEND:

1 Lowell Airport (Class 2 Max.)
2 Andover Airport (Class 1)
3 Haverhill Airport (Class 1)
4 Lawrence Municipal Airport (Class 3)
5 Plum Island Airport (Class 1)
6 Richardson Airport (Class 1)

Red Circles - Construction
Blue Circles - Expansion

First Stage: 1, 2 and 4
Second Stage: 5 and 6. Construction of 3 will depend on local needs.



Scale: 1 inch to 4 miles

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MAP 16

MAP 17

A PLAN FOR THE DEVELOPMENT OF AIRPORTS AND AIRWAYS in NEW HAMPSHIRE 1940

Prepared by the
Advisory Committee on Air Transportation
of the
State Planning and Development Commission
in cooperation with the
State Department of Aeronautics

4 0 4 8 12
SCALE OF MILES

Legend

EXISTING LANDING FACILITIES

Airport

Landing Field

Auxiliary Field

Inland Water Landing Area (limited facilities)

Inland Water Landing Area (no facilities)

Ice Landing Area

FURTHER DEVELOPMENT OF EXISTING LANDING FACILITIES

Airport

Landing Field

Auxiliary Field

PROPOSED LANDING FACILITIES

Airport

Landing Field

Auxiliary Field

AIR NAVIGATION FACILITIES

Existing Federal Airway

Proposed State Airway

Airway Light Beacon, rotating (arrows indicate course lights) shaded area indicates average effective radius of beam

Airport Light Beacon, rotating

Auxiliary Light Beacon, flashing

Radio Range Beam

CANADA

MAINE

VERMONT

MASSACHUSETTS

ATLANTIC OCEAN

PITTSBURG

BEECHER FALLS

W. STEWARTSTOWN

COLEBROOK

DIXVILLE NOTCH

ERROL

N. STRATFORD

GROVETON

MILAN

LANCASTER

BERLIN

JEFFERSON

WHITEFIELD

GORHAM

LITTLE-TON

TWIN MTN

FRAN-CONIA

PINKHAM NOTCH

LISBON

WOODS-VILLE

WELLS RIVER

CRAWFORD NOTCH

JACKSON

BARTLETT

N. CONWAY

CONWAY

LINCOLN
N. WOODSTOCK

WHITE MOUNTAIN NATIONAL FOREST

HAVERHILL

GLENCLIFF

WARREN

CENTER SANDWICH

W. OSSIPEE

FREEDOM

OSSIPEE

PLYMOUTH

ASHLAND

MEREDITH

HANOVER

LEBANON

CANAAN

BRISTOL

THE WEIRS

WOLFEBORO

SANBORN-VILLE

LACONIA

GRANTHAM

ANDOVER

TILTON

FRANKLIN

BELMONT

ALTON BAY

NEW DURHAM

CLARE-MONT

NEWPORT

NEW LONDON

FARMING-TON

CENTER BARNSTEAD

ROCHESTER

NEW-BURY

BRADFORD

CHARLESTOWN

CONCORD

HENNIKER

NORTH-WOOD

SOMERS-WORTH

DOVER

HILLS-BOROUGH

SUNCOOK

DURHAM

NEW-MARKET

PORTS-MOUTH

BELLOWS FALLS

WEARE

HOOKSETT

GILSUM

GOFFS-TOWN

RAYMOND

BENNINGTON

EXETER

RYE BEACH

ISLES OF SHOALS

CHESTER

HAMPTON

HAMPTON BEACH

SEABROOK

KEENE

MARLBORO

PETER-BOROUGH

WILTON

MILFORD

BRATTLE-BORO

TROY

E. JAFFREY

HINSDALE

WINCHESTER

GREENVILLE

NASHUA

HUDSON

SALEM DEPOT

LAWRENCE

TO MONTPELIER, BURLINGTON AND MONTREAL

TO PORTLAND

TO BOSTON

TO NEW YORK

LANDING FIELDS SHOWN OUTSIDE OF NEW HAMPSHIRE BASED UPON DATA FROM NEW ENGLAND REGIONAL PLANNING COMMISSION. SEPT. 10, 1940.

NOTE: THIS MAP IS NOT TO BE USED AS A FLIGHT MAP. REFER TO SECTIONAL AERONAUTICAL CHARTS OF THE U.S. COAST AND GEODETIC SURVEY.

PART II

A MASTER PLAN FOR THE DEVELOPMENT OF AN AIRPORT FOR LOWELL

The Lowell Airport Commission has proposed a plan for the development of an airport for Lowell at the Marsh Hill site in Dracut, but because of the oppositions involved in the land acquisition, the plan has been dropped. Recently there have been little activities reported of the Commission towards promoting an airport for Lowell. However, there are other sites which have not been studied. It is hoped that this study containing enough information as to the desirability and feasibility of another site, the Pine Hill, for use as an airport, may rekindle the interest of the people in airport development.

It is with regret that the subject material can only be treated very briefly because of limited time, and although enough consideration has been given to the existing local factors, it can be only considered as an example of study.

Site Selection:

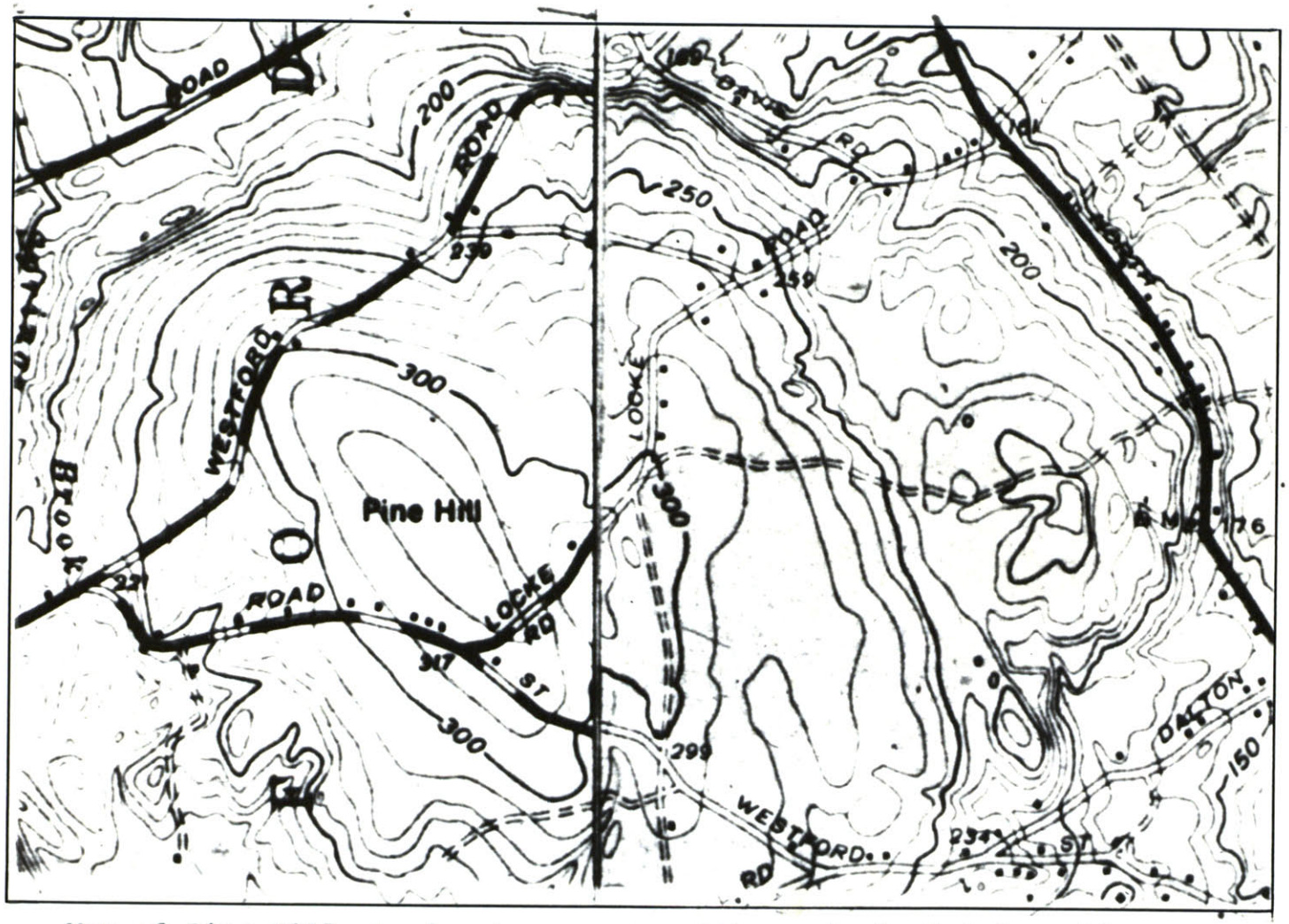
Five sites within the perimeter of five miles from Lowell have been studied: the Marsh Hill site, Tewksbury site, Spruce Swamp site, the St. Joseph Cemetery site and the Pine Hill site. Although not available, Marsh Hill is still the best site. It is free from obstructions, needs little grading, and has good drainage. Furthermore, there is ample area for expansion. Tewksbury site is nearer to Lowell than any other sites. It is sufficient for an average Class 2 airport. Drainage is perhaps necessary if the airport is to be a maximum Class 2, but it will not be an elaborate job since the area is partially drained.

Map of Pine Hill showing topography with geological information shown on overlay

Legend: Water; Swamp; mixed sand and gravel with a small amount of flood plain silt; Sand and gravel terraces; Sand and gravel ridges; Exposed bed rocks; till, or unstratified glacial drift consisting of sand, gravel and boulders intermingled.

MAP 19

MAP 18



Map of Pine Hill showing topography with geological information shown on overlay

Legend: Water; Swamp; mixed sand and gravel with a small amount of flood plain silt; Sand and gravel terraces; Sand and gravel ridges; Exposed bed rocks; till, or unstratified glacial drift consisting of sand, gravel and boulders intermingled.

MAP 19

Its proximity to the center of Tewksbury is the chief objection. The high tension lines to the east within the turning radius of the airport is also hazardous to flying. Spruce Swamp site is under-strewn with bed rocks and is quite rolling, making construction work very costly. It has practically no possibility for expansion. The advantages of the St. Joseph Cemetery site are that the area is relatively flat, and the soil material is chiefly sand and clay. Construction costs may be relatively lower than those for other sites, but again there is no possibility for expansion. The Pine Hill site is a highland, free from obstructions, and with sufficient area for expansion to a maximum Class 2 (or minimum Class 3) airport even with one or two paralell runways. By these factors alone Pine Hill is by far the better site than the others except the Marsh Hill site.

All the sites are easily accessible from Lowell.

Recent geological data from the Department of Public Works working in conjunction with the U.S. Department of Geological Survey show that there may be underlying bed-rocks on the site. The following map drawn from these data shows that the exposed boulders are along elevation 250' and below. It may probably be assumed that if construction is done above elevation 250', there may be little danger of coming into contact with the bed-rocks, thus avoiding elaborate excavation.

The Pine Hill site is therefore recommended for use as an airport site.

Design and Construction:

A maximum Class 2 airport has been recommended for Lowell in Part I of this study. Before an airport can be designed, boring test shoudl be made to determine the exact characteristics of the soil. In the absence of these data, and for the purpose of this thesis, it is assumed that the soil (till) is type E4, has good drainage, and in an area where the annual frost penetration is 34 inches. To prevent the subgrade from freezing and to account for the reduction of the subgrade due to the 15,000 lbs gross weight of planes specified for Class 3 airports*, a 24" pavement consisting of a 2" surfacing, 7" prime coat, and 15" subbase will be used.

The project when completed will have the elements shown on Map 24, a separate map not bound with text.

Costs and Estimates:

The following are costs and estimates for the complete project:

---

* Airport Planning for Urban Areas, op. cit., p. 35.

Estimate of Construction Cost

Item	Unit Price	Am't	Total
Landing Strips:			
Site Preparation:			
Clearing 100 acres	$125.00	12,500	
Removing Topsoil- 65,000 c.y.	.60	39,000	
Earth Excavation - 45,000 c.y.	.60	270,000	
Fine Grading - 80 acres	150.00	12,000	
Surface Drainage - 15,000 l.f.	3.00	45,000	
Surface Drainage (Open Ditches)	Lump Sum	5,000	
Surfacing:			
Runways			
Gravel Base - 20,000 c.y.	2.00		
Bituminous Surfacing - 13,000 s. y.	1.10		
Shoulders			
Gravel Base - 225,000 c.y.	2.00		
Topsoil - 220,000 c.y.	.50		
Fertilizing and Seeding - 60 acres	200.00		
Lighting:	Lump Sum	20,000	654,500
			654,500
Buidling Area and Taxiways:			
Site Preparation:			
Clearing - 16 acres	125.00	2,000	
Removing Topsoil - 27,000 c.y.	.60	16,000	
Earth Excavation - 80,000 c.y.	.60	48,000	
Fine Grading - 20 acres	1.50	3,000	
Surface Drainage	Lump Sum	5,000	
Surfacing:			
Taxiway Graval Base - 3,300 c.y.	2.00	6,600	
Taxiway Bituminous Surfacing - 20,000 s.y.	1.10	24,200	
Concrete Apron and Gravel Base - 8,300 c.y.	2.00	16,600	
Gravel Base for Turf Aprons - 1,150 c.y.	2.00	3,000	
Surface Treated Gravel-72,000 s.y.	.50	36,000	
Topsoil - 32,000 c.y.	.50	16,000	
Fertilizing and Seeding - 12 acres	200.00	2,400	
Removing Road	Lump Sum	5,000	
			188,490
Building:			
Administration Building		40,000	
Services to Building (water: domestic and fire; electric Power; sewer system)		26,000	66,000
			908,990
Engineering and Contingencies (15%)			28,635
	TOTAL		937,625

This is a very loose estimate, and should not be used in actual calculation, but it gives a figure in the vicinity of which the construction cost of a maximum Class 3 airport may well be.

This estimate neither includes the land acquisition, nor construction of private buildings such as hangars, for which public funds should not be used, and which the city must amortized.

Stages of Development:

There may be three stages of development. The first stage covers the construction of two landing strips of 2700' by 300' as indicated in the stage development plan. Construction of these two strips chould be completed by the first year for personal flying.

Enlargement of the airport to accommodate feeder airlines should commenced in the third year with the landing strips lengthened to 3,000', and widened to 500'.

The project should be completed by the end of the fifth year, at which time full use of the airport by the feeder lines and small trunk-line transports may be expected.

Financing and Management:

As recommended in Chapter 9, Part I, a Joint Airport Commission should be established by Lowell and Chelmsford. It shall be charged with the responsibility of appropriating sufficient funds, at least 25 percent of the total construc-

tion, and of acquiring land for the development. With Chelmsford on the Commission, the Commission may exercise the power of eminent domain in connection with land acquisition if it is necessary to do so. The partnership of Lowell and Chelmsford may be based on tax valuation or other basis mutually agreed on by both municipalities, and approved by the state.

After completion of the project the airport may be managed by the Commission or may be leased to an experienced operator. It is expected that beginning the sixth year the airport will bring in sufficient revenues to take care of the maintenance and operation expenses through concessions, instructions, landing charges, charter services, etc.

There are generally two types of user charges, namely hangar and ground space charges; and landing area charges. The hangar and ground space charges should take into consideration the basic ground rent (including the so-called scarcity value if any), the depreciation charge (on the assumption that the economic life of a hangar being 25 years), the costs of maintenance and other special services, and finally a fair return on the capital investment covering only the interest costs. The landing area charges include the interest costs (usually 2 percent) of the investment, depreciation charge (on the assunption that the economic life of a landing strip being 20 years), and maintenance expenses. Consideration must be given to the area to be used for personal flying or commercial flying by feeder or transports, and charges must be made accordingly. Taking all factors into account the

following charges* appear to be generally reasonably:

Three percent on revenues from flight activity (including student and aircraft rentals).

Three percent on line service (including aircraft fuelling) and storage revenues.

One and one-half percent on shop repairs, aircraft parts, and accessory sales.

Three-fourths of one percent on aircraft (new and used) sold retail at that field.

Another schedule of charges which is administratively simpler is to cha rge 3½ percent or 4 percent on the first two items, and then exempt the others, since the first two items normally account for 55 to 60 percent of an operator's entire gross income.

Another guidance without going elaborately into detailed methods of calculating these charges is to go by the customary rates for these items by the nearby airports, but let common sense be the last judgement in airport management. For the first year or two of operation when there are relatively few activities, this method of charging following the customary rates seem more desirable.

Finally, it has to be again emphasized that if an airport is to be successfully managed, let common sense be the final judgement!

---

* Bollinger, Lynn L. How to Determine Landing Area Charges. (Public Management). New York, Esso Aviation Products, Jan. 1948.

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