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URBAN ENVIRONMENTAL HEALTH AND REMOTE SENSING

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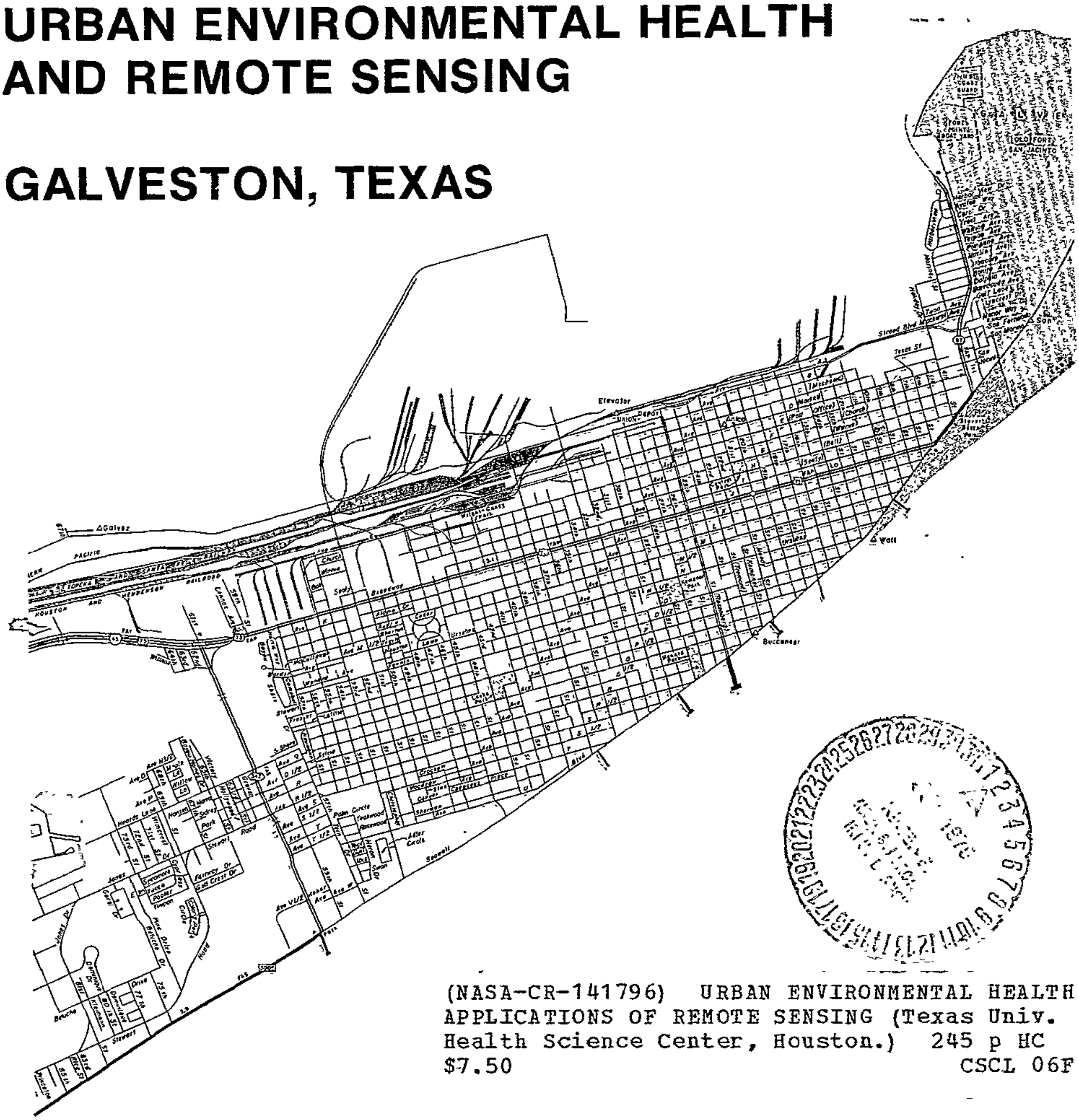

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URBAN ENVIRONMENTAL HEALTH APPLICATIONS OF REMOTE SENSING

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CHAPTER I

LITERATURE REVIEW

A. Prior Uses of Remote Sensing in Urban and Public Health Research

While there exists a growing literature on the uses of remote sensing as a dàta source in areas of urban research such as transportation and planning, there is a paucity of information on its application to the field of urban public health.

Data from aerial photography may be either direct or indirect. The former method provides data about phenomena which can be seen directly on photographs while the latter method contributes information about phenomena which cannot be seen directly but whose existence can be inferred from the presence or absence of other features which can be seen on the photographs and which are known to be associated with the phenomena being investigated (Manji, 1968). Examples of inventory by direct observation include land-use studies and transportation studies. (See Manji, 1968 for a list of references on these kinds of studies.) These studies are concerned primarily with information about the physical city and not with information about urban social phenomena.

Inventory by indirect observation, also referred to as "inventory-by-surrogate" (Manji, 1968), is the method most applicable to our research. While this method has not been as widely used as direct observation, it has at least been used to study problems marginally related to those of urban public health.

Mullens (1969) has observed that "analysis of the urban environment is possibly the most difficult and challenging task in the entire field of remote sensing." He further points out that examining the urban environment by remote sensing calls for a much smaller unit of analysis than in such fields as agriculture, forestry, geology and meterology. In these fields patterns rather than individual objects are examined (Mullens). Because in urban areas it is usually not the physical environment per se in which one is interested but the complex interrelationships between people, activities, and social structure, inventory-by-surrogate must replace direct interpretation of the imagery. A few of the remote sensing studies of urban environments which have application to our project will be briefly reviewed.

Green (1955, 1956, and 1967) used black and white aerial photographs to provide data on the social structure of a city by relating it to the physical spatial structure. He found a statistical association between a number of physical and sociological variables in Birmingham, Alabama. His four physical data categories included: (1) location of the area with respect to three concentric circular zones centered around the central business district; (2) residential desirability as determined by land use characteristics, both internal and adjacent land use; (3) prevalence of single family homes; and (4) density of housing as measured by average number of dwelling units per block.

While high statistical association did exist between each of the four data categories and several sociological variables, any one photo-data category alone had only a limited predictive value and so an attempt was made to combine various categories of social and physical data.

All four photo categories of physical structural attributes were combined using the Guttman Scalogram method (Stouffer, 1950) to construct a "residential desirability scale." A "socio-economic status scale" based on five social data items was also constructed: (1) median annual income, (2) prevalence of within-dwelling crowding, (3) prevalence of home ownership, (4) prevalence of social disorganization, and (5) educational achievement. A correlation of the 2 scales in the case of Birmingham showed that the "residential desirability scale" accounted for 78% of the variation in the "socio-economic status scale."

Wellar (1968a) has criticized Green's four photo-data categories as being too broad and his failure to note the many exceptions to each category, e.g., desirable high-rise and multi-unit dwellings being built in the central city.

Dwelling Unit and Population Estimates Using Remote Sensing: Three studies which dealth with dwelling unit and population estimation are those by Lindgren (1971), Anderson and Anderson (1973) and Eyre, Adolphus and Amiel (1970). While the latter essentially focused on an underdeveloped area, the island of Jamaica, there was an attempt at population estimation in some of the larger cities on the island. In order to predict population intercensually, the study recommends that "if considerable extrapolation is being made beyond tabulated data by the use of air photos, it is very necessary to establish by sampling techniques the basic types of household organization in a region...because each has a characteristic population size and composition as well as a recognizable signature on the photographic image." This study also found it difficult to distinguish commercial uses which were carried on at the ground level of otherwise multi-family structures.

Anderson and Anderson tested the use of the IDECS Scanner. The IDECS "is an analog-digital image processing system designed to perform a wide variety of enhancements, measurements and category discriminations on single and multiple images." Five image analysts were employed to evaluate the same areas and the results of their analyses were compared first against each other for accurracy and then against the IDECS Scanner. The study found that "the range in magnitude of error among human interpreters is from 1.6 percent to 44 percent, whereas the average for the five interpretations errors by about 7 percent. With the IDECS the error was 10.8 percent." This study points out that while there was considerable variation among the human photo interpreters, it "may be possible to direct human interpretations such that consistent results can be acquired." In addition, the use of the IDECS Scanner did not necessarily improve accurracy over human interpretations, but rather was a time saver, and in addition, could minimize perception variation and error which did occur among the five human interpreters.

Lindgren (1971) attempted to estimate the number of dwelling units in a high density area, using a scale of 1:20,000, on a 15 block sample of housing in the Boston area. He developed a set of variables of "keys" for determining number of dwelling units per structure which are as follows:

1. Type of roof
2. Relative size of structure
3. Number of stories
4. Division of buildings
5. Availability of parking
6. Amount and quality of vegetation

Previous remote sensing studies had been far more successful in counting the number of residential units but had found the margin of error much higher in determining the number of actual dwelling units within these residential structures. Lindgren in his small sample was able to reduce his underestimation error to 3.1 percent, as compared to 7 percent in the Green study, 10 percent in the Hadfield study, and 15.7 percent in the Binsell study. Lindgren emphasized that "a familiarity with the area under investigation, no matter how slight (a single visit even) will greatly improve the accurracy of dwelling unit estimates.... If it can be assumed that in most applications an interpreter will have some knowledge of the area in which he is working, then accuracy will remain relatively high."

<u>Use of Remote Sensing in Regional and City Planning</u>: Mallon (1972), in reviewing the Metropolitan Washington COG use of remote sensing for their data base, notes the results of several pilot studies. The highlights of these pilot studies were that considerable amounts of incomplete, out of date information on land use was revealed when comparing the tax rolls against the remote sensing imagery. "The additive values of the measured land use categories from the remote sensing analysis and from the tax roll source were at variance; with remote sensing generally in excess of the corresponding values of the latter." In addition, Mallon notes some of the problems involved in identifying and enumerating housing types and areas. In suburban areas of the region the identification of housing types was relatively successful at a scale of 1:100,000. However, detecting neighborhoods in the process of change or conversion was not reportable at that scale. Variables such as street widths, building density, presence of vegetation, curbing, vacant lots, off-street parking, etc. are observable

at scales of 1:15,000 or 1:20,000 and Mallon feels that for this level of detail, color infra-red is also mandatory.

There were serious problems in the ability of the image analyst to distinguish between multi-family units and single family row houses or twon houses, and for this kind of identification it is necessary to verify with ground survey. Most of this housing occurs within the city center. COG found that in this case the census data was adequate for housing counts.

Howard and Driscoll (1973) noted the assets of remote sensing to urban planners, in that remote sensing provides an opportunity for a monitoring process rather than a statis compilation in time of a land use inventory. They suggested over flights about every two years. In their call for needed research, they focused on environmental quality assessment at the fine screen level of the urban settlement. "Most human social behavior normally occurs within physical structure such as dwellings, manufacturing establishments, schools, etc. The attitudes and values of the persons who occupy the physical structures may be reflected in the overall physical surrounds. These conditions become subtle in their manifestation and are best studies from an overall perspective...(where) the subleties of the environmental conditions are enhanced. One such approach to revealing these subtleties is through remote sensing."

Wellar (1971) summarized the uses of remote sensing for urban housing and land use studies and the need for a data source which is timely. In discussing shortcomings of present data he notes the "coarseness" of the time frame, of most data sets, making reference to the decennial census. Even if a mid-decade census is introduced at the national level there are those who claim that "five years is too long a time period for data used in evaluating progress toward achieving national goals" Wellar states. The advantages of remote sensing are not only for monitoring on an annual basis but also "for cities having a population greater than say 50,000, a remote censor operation could complete a 100 percent survey in the same amount of time that a 10 percent survey was completed by a similar sized staff for those data elements which are common to both sets of agents." In addition, "the recording of phenomena on images makes it possible to derive observations that become of interest at a later date" avoiding the problems of re-surveying an area and in effect creating a visual data bank.

<u>Remote Sensing Usage in Determining Poverty Areas and Housing Quality</u>:

Mumbower and Donoghue (1967) used aerial photography to elicit data on urban poverty areas. They performed detailed photo interpretation of residential areas in order to delimit poverty areas and validated their results by comparing them with census data (Manji, 1968). They utilized color and panchromatic photographs with scales ranging from 1:9,000 to 1:30,000 to examine eight U.S. cities and San Juan, Puerto Rico.

With small scale photography (about 1:30,000) it was possible to identify transportation features and to pinpoint areas as residential, industrial, commercial, recreational, and institutional, but it was difficult to obtain data on structural and environmental characteristics associated with poverty.

With large scale photography (about 1:10,000) poverty areas could be identified by certain indicators such as debris, clutter, vegetation, structural deterioration, sidewalks and streets, junkyards, warehouses and small businesses. It was also possible at this scale to evaluate the quality of individual housing units in each block.

The ability to delineate urban poverty areas using remote sensing data has important implications for our research since many studies, which will be discussed in the following section, have demonstrated an association between poverty and disease or poor health status.

Moore (1968 and 1970), Wellar (1968 a & b) and Bowden (1968) have written on the potential use of remote sensors in evaluating housing quality. Wellar (1968a) was interested in identifying areas of low housing quality on aerial photos, and he used low altitude multiband aerial photography to do so. Because census housing data ignores neighborhood environmental conditions, and provides for the most part subjective evaluation of structures, Wellar adopted the approach introduced by the American Public Health Association (1945). He evaluated each factor in the APHA survey appraisal method regarding its potential for measurement on aerial photographs. He also identified additional factors considered to be indicators of poor housing quality. (See Appendix A.)

Wellar assumes that the internal conditions of dwelling structures are consistently associated with the external conditions found in the immediate environment of the structure. He made inferences about housing quality on the basis of photo interpretation in fifteen subareas in and around Chicago. The results were checked by visual inspection in the field. The photo surrogates on which his inferences were based include: land crowding, non-residential land uses, private open space, hazards and nuisances associated with the transportation system, public utilities, and the presence of basic community facilities. The features which Wellar found to be associated with low housing quality include:

1. the presence of litter, garbage, wrecked or derelict cars, and piles

of lumber and rubbish in the neighborhood on both occupied and vacant lots. In the study areas, this proved to be the best single indicator of low quality housing.

2. a lack of landscaping in yards and parkways together with the presence of weeds on vacant lots.

3. the number of vacant lots.

4. the existence of nonresidential hazards and nuisances, primarily industrial plants and warehouses.

These criteria have not yet been established statistically, but the frequency of appearance and level of association for each criterion has made possible the selection and qualitative evaluation of low housing quality indicators (Wellar, 1968 a & b).

Moore, et. al. (1968) point out that this study merely identifies general relationships between features identifiable on the imagery and an evaluation of housing quality derived from visual inspection in the field. They suggest using statistical methods to establish the necessary and sufficient set of criteria for identifying specific categories of housing quality and for developing reproducible measures of housing quality (Moore, et. al., 1968).

Bowden (1968) used color Ektachrome infrared imagery at a scale of 1:60,000 to differentiate the quality of residential neighborhoods in an area centered over downtown Los Angeles. The study area represented the entire spectrum of income levels and housing types. The primary purpose of the study was to compare a classification of residential areas based on the 1960 census data with a classification of residential areas based on interpretation of imagery taken in 1967 (Moore, et. al., 1968). Mean income and mean home value per census tract were used to differentiate residential areas on the imagery included shape and size of house, condition of yard, swimming pools, roof color, number of cars, parking, street pattern and utility services. When census tract data on income and home value were correlated with residential classifications based on aerial photographs, it was found that four broad categories of "housing quality" could be identified.

Moore, et. al. (1968) point out that while Bowden's study demonstrated the possibility of differentiating the quality of residential neighborhoods into broad categories, it is difficult to compare two widely separated areas using a system of classification devised for the whole area. The reason for this is spatial variation in racial or ethnic values. Within census tracts, differences are presumably diminished and it may be possible to note variation in housing quality within a socially homogeneous environment. Moore, et. al. (1968) believe that from city to city no one-to-one correspondence between housing quality and the socio-economic variables exists. So, while the correlation is interesting in itself, it does not greatly aid in identifying housing quality.

Horton and Marble (1970) and Moore (1970) used data gathered from a survey conducted in Los Angeles by the L.A. County Health Department in the spring of 1968. The area contained some of the worst housing in the country. From this data set, the authors drew a 1% sample of parcels and a 20% sample of blocks. They used 37 structural and environmental variables which they divided into 2 groups -- those potentially measurable by remote sensing and those not measurable by this method. (See Table 1.) Analysis showed that "for each basic housing element, the variables acting as indicators of

TABLE 1

STRUCTURAL AND ENVIRONMENTAL VARIABLES

UTILIZED IN THE LOS ANGELES STUDY*

1.	Land Use - suitability for residential devt.	
2.	Condition of Street Lighting	
3.	Presence of On-Street Parking	
4.	Street Width	
5.	Street Maintenance	
6.	Street Grade	
7.	Condition of Parkways	
8.	Hazards From Traffic	
9.	Adequacy of Public Transportation	Variables Potentially Measurable Using Remote Sensors
10.	Number of Buildings/Lot	
11.	Number of Units/Lot	
12.	Condition of Fences	
13.	Adequacy of Lot Size	
14.	Access to Buildings	
15.	Condition of Sidewalks	
16.	Condition of Landscaping	
17.	Refuse	
18.	Parcel Use	
19.	Adverse Effects of Residences	
20.	Nuisances from Loading/Parking	
21.	Unclassified Nuisances from Industry etc.	
22.	Overall Block Rating	
23.	Noise/Glare (block)	
24.	Smoke	
25.	Condition of Accessory Buildings	
26.	Premise Rating	
27.	Noise, Fumes and Odors (Parcel)	Variables Not Observable Using Remote Sensors
28.	Construction Type	
29.	Age of Dwelling	
30.	Condition of Structure	
31.	Condition of Walls	
32.	Condition of Roofs	
33.	Condition of Foundation	
34.	Condition of Electrical Installations	
35.	Condition of Paint	
36.	Other Exterior Factors	
37.	Overall Parcel Rating	

*Source: Frank E. Horton and Duane F. Marble. "Housing quality in urban areas: Data acquisition and classification through the analysis of remote sensor imagery," in Second Annual Earth Resources Aircraft Program Status Review. Vol. I, Part 15, Manned Spacecraft Center, Houston, Texas, 1970, p. 7.

that element tend to be highly correlated with other variables within the element" (Horton and Marble, 1970).

At the parcel level it was found that the structural dimensions emerged as a single cluster of variables and as a group were not correlated with the environmental variables. This result (which the authors indicate may be unique to Los Angeles and perhaps to cities of the Southwest due to preponderance of single-family residences in this area) led them to reject the idea of estimating overall housing quality at the parcel level based only upon remote sensor observation of environmental variables.

A similar analysis was performed on a 20% sample of blocks. At the block level, they found that the structural variables were associated with a number of environmental variables, primarily those which identify the level of upkeep of lots and the existence of land uses incompatible with residential development. Overall housing quality, then, may be estimated at the block level by using the environmental subset.

Both investigations found that it was possible to reduce the original 37 structural and environmental variables first to a set of 21 and later to a set of 7 environmental variables and still correctly assign 82.8% of the sample blocks to 5 quality classes. The 5 quality classes were based on similar profiles of factor scores derived from an analysis of observations on all 37 variables (Horton and Marble, 1970). The seven environmental variables were: (1) on-street parking; (2) loading and parking hazards; (3) street width; (4) hazards from traffic; (5) refuse; (6) street grade; and (7) access to buildings.

Evaluation of black and white, color, and color infrared photography from NASA Aircraft Mission 73 indicated that color infrared imagery was the most useful in defining the seven variables important in housing quality identification. Using remote sensor imagery to estimate the values of the seven variables made it possible to correctly classify 69% of the blocks when compared to a classification into 5 quality classes based on similar profiles of factor scores derived from an analysis of ground survey data using all 37 variables. Reducing the set to four -- (1) street width; (2) on street parking; (3) street grade; and (4) hazards from traffic -- by eliminating those associated with interpretation difficulties made it possible to correctly assign 78% of the blocks when compared to a classification using all 37. The authors feel that the use of more highly trained interpreters would increase the percentage of successful classifications.

The major problem that faces investigators in their attempts to study housing quality and evaluate its effects -- health and other -- on individuals is the lack of knowledge of the interrelationships between household, dwelling and environment. Arbitrary 'a priori' statements on minimum standards for individual dwelling attributes contributes little to measurement procedures if the needs and values of individuals and the role of the environment are not understood. Moore, et. al. (1968) further emphasize the need to specify in a more meaningful way the relative weights assigned to various dwelling and environmental attributes. The effective use of remote sensing as a tool in delimiting housing quality hinges on the resolution of these problems.

The importance of housing quality studies to our research will be seen in the next section when the relationship of housing quality to health is discussed. Wellar (1968b) and Moore (1970) have noted the value to urban planning and public health agencies of outlining the spatial distribution of different grades or levels of housing quality. Wellar has also commented on the time-consuming and expensive nature of current methods of assessing housing quality and the considerable error involved when these methods are used. If remote sensing techniques can be used to gather this same data and do so with a reduction in time and cost, an important contribution will have been made. Moore cites the objectives of the American Public Health Association and the Public Health Service, two agencies concerned with the measurement of housing quality:

(1) To delineate geographic areas needing more detailed study based on identified significant environmental health problems.

(2) To identify incipient blight so that community decision makers will be able to program coordinated corrective action based on comprehensive up-to-date information.

(3) To quantify environmental health problems uniformly so that they can serve as an indicator of national needs.

Remote sensors may have the potential to accomplish these objectives.

Mullens (1969) used low altitude, large scale, color infrared photos to differentiate and classify types of residential areas in Los Angeles on the basis of characteristics of the physical environment. The author wished to investigate the hypothesis that since socio-economic characteristics of large urban populations are associated with specific types of residential environments, it would be possible to associate characteristics of the physical environment with socio-economic variables within residential environments. The residential areas in this investigation are not diverse -- they include mostly low and middle income housing -- and this is a limiting condition of the study.

Photographic surrogates were correlated with census information on income, home value, occupation, education, and with local public agency statistics on mental health, public health, crime, and delinquency. These variables are believed to be related to the quality of residential areas.

Mullens identified 18 features on the photographs which might be related to quality of residential areas. These were condensed into 9 categories to simplify data collection and analysis for a large number of areas. They are: (1) dwelling type (single family, multi-family), (2) vegetation, (3) litter, (4) vacant land, (5) land use (residential and industrial), (6) location, (7) pools and patios, (8) lot and home size, (9) streets (width, pattern, lighting, traffic, sidewalks and curbs).

A numerical scale was developed for each of the nine surrogate categories. Each study area was assigned a number from this scale ranging from 1 to 5 for each variable after areas were examined in relation to all of these variables. Lower numbers represented desirable conditions which previous research had indicated would be associated with better quality residential areas. Assignment of numerical values for each variable for each study area was the basic interpretive task which was performed from the photography. The most difficult interpretation and least reliable information applied to the dwelling types category.

Census tract and public agency information was collected within study areas on income, home value, occupation, education, public health, mental health, adult probation, juvenile probation and crime rate. Study areas were then ranked with regard to each category and the scale values for each of the nine photographic surrogates derived for each area were used to rank the study areas for each surrogate. Correlations between income rank and the rankings obtained for the nine photographic surrogates were then determined using the Kendall Rank Correlation technique.

Dwelling type surrogate (single family or non-single family), was not closely correlated with income ranking but influenced correlations of all surrogates with the income variable. Mullens found that single family dwelling areas were not necessarily of high quality in Los Angeles, at least in the areas examined. Los Angeles has a large area of single family unit slums rather than vertical slums. It should be noted that this is characteristic of Houston also.

Information on dwelling types became more meaningful by dividing all census tracts into single family census tracts (90% + single family units by area), mixed tracts (less than 90%, more than 50% single family units), and multi-unit tracts (more than 50% multi-unit dwellings by area). Five tracts fell into this last category and were eliminated from correlations -- for these areas, photographic surrogates were not good indices of the socio-economic levels present. Thus it was necessary to divide the study areas into categories based upon dwelling types in order to accurately reflect relationships between photographic surrogates and socio-economic variables.

In general Mullens found that surrogates which were good indicators for one socio-economic variable were also good indices for most of the other socio-economic variables he examined.

Mullens also obtained statistics from local public agencies in the Los Angeles area on public health, mental health, crime, and delinquency. His findings here are of special interest to our research and will be discussed in some detail.

<u>Public Health Correlations</u>: Mullens measure of public health consists

of the total morbidity counts compiled by the Los Angeles County Health Department for a number of reportable diseases during a two year period. Public health rankings and photographic surrogate rankings did not have very strong correlations. Vegetation, litter, vacant land, streets, location, and pools and patios combined, produced correlations between .55 and .60 with public health rankings. He cites two factors which reduced the expected close association between high quality areas and public health rankings: (1) multi-unit family dwelling areas when examined by themselves showed little correlation between health ranking and ranking of residential quality using photograph surrogates. But, single family areas had health rates which followed very closely the ranking of residential areas using these surrogates. In most cases the increase in multi-unit dwellings in an area were related to higher disease rates; (2) location also influenced the correlations. One section of Los Angeles containing five study areas seemed to have higher disease rates than the quality of the residential areas indicated. Other scattered areas had much lower disease rates than expected.

The correlations between health rankings and social rank indicators were also lower than expected (less than .35 with education, about .44 with occupation and about .71 with income). Mullens feels that either public health conditions did not relate to social rank as closely as they should according to the concepts of urban ecology or the information of the public health department did not accurately reflect the health conditions of the area.* If the public health statistics reflected the health

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*The latter explanation may indeed be the case. In the Houston study the investigators found a strong underreporting bias for most communicable diseases. For this reason, many communicable diseases were eliminated from the data analysis and mortality data was collected. See Chapter III, Section D1.

status of the study areas then census information and CIR aerial photographs would both seem somewhat useful, but generally poor, indicators of health conditions in these areas. If public health statistics were not accurate, it may be that CIR located areas of poor public health conditions better than statistical surveys (Mullens, 1969).

Mental Health Correlations: Mental health statistics refer to inpatient and outpatient admissions to all county mental health facilities for a number of six-month periods from 1964 to 1966. Before 1964, statistics were not collected on a census tract basis. Public health statistics on morbidity were available for only 20 to 24 study areas. (1) Statistics on mental health followed similar patterns to those on public health. (2) Correlation between mental health ranking and the social rank variables were similar to the correlations between the public health ranking and these social rank variables. (3) But the correlation between the mental health ranking and the photographic surrogates increased in general between .10 and .20 above public health correlations. This might mean that the location factor which influenced statistics on public health conditions had less influence on mental health conditions. It is not possible to say, however, if this difference is due (a) to a spatial variation in the services provided, (b) to different methods of collectiong statistics, or (c) to true differences in environmental influences on public and mental health conditions.

Crime Correlations: Differences in reporting procedures due to existence of five separate police and sheriff's departments made collection and comparison of statistics difficult. (1) Statistically significant but low correlations indicate that the relationship between quality of residential area and degree of criminal activity can be observed using this photography, but photographic surrogates can only broadly separate areas of high crime from areas with lower crime rates. (2) Although CIR aerial photography permits more accuracy of analysis of socio-economic factors like criminal activity (in terms of locating spatial variation of these features) than any other remote sensor, the level of accuracy which is possible with respect to each individual socio-economic variable is still somewhat limited. The real value of CIR is its ability to identify different levels of residential quality, each of which has associated with it a different range of socio-economic characteristics.

The author grouped the study areas into 4 categories on the basis of rankings of the areas by socio-economic variables and ranking of the areas by values of photographic surrogates. A correlation of .83 existed between the ranking produced by the total of all socio-economic ranks and the ranking produced by the total of all surrogate ranks. This indicated a close association between residential area quality as identified by CIR aerial photographs and the socio-economic characteristics identified in this study.

Senger (1969) sought to test the validity of the relationships established by Mullens between socio-economic characteristics of the urban population and photographic surrogates from color infrared imagery in the Ontario-Upland area. He selected this rural-urban area to contrast with Los Angeles which is highly urbanized. This contrast was expected either to increase the significance of the Los Angeles study or to point out its limitations. Unlike Mullens' study area, imagery for Ontario-Upland covered the entire range of socio-economic groups and so provided a good test as to the applicability of the methodology employed in the Los Angeles study. The results of Senger's investigation confirm the validity of the methodology developed by Mullens for areas in Southern California, but further research is necessary to test the criteria at different scales and in different areas.

Davies, et. al. (1972) used conventional suborbital black and white photography at a scale of about 1:23,000 and suborbital color infrared photography at a scale of about 1:190,000 to examine a middle and low income residential area in Austin, Texas. The investigators found that poverty areas can be delimited from the imagery and that suitable, environmental indicators of urban blight form useful parameters in determining housing quality. Davies, et. al. classify the difference in the signatures which serves to exemplify substandard housing under three headings: (1) Physical structures which include signatures produced by the appearance of homes and other buildings. These indicators are size of house, diversity of building material, density, geographic pattern and uniformity, lot size and shape of lot; (2) Site which includes indicators for the property on which the house is located such as the quantity and quality of the vegetation surrounding the house, the number of cars, garages and driveways, and the degree of debris and litter. The upkeep of the immediate environment surrounding the house offers signatures of the environmental quality of the immediate neighborhood; (3) Situation indicators are those associated with neighborhood characteristics and include maintenance of streets, configuration of street networks, relative location to older areas in the city, the relative absence of consumer retail outlets, and the presence of air and water pollution (as denoted by its closeness to manufacturing plants and the CBD? Davies does not say precisely) and noise and traffic congestion.

Davies notes, as did Mullens (1969) and Senger (1969) that some of these surrogates may not be appropriate in other areas of the country, for example quality of vegetation could not be discerned during winter in the

North and so they should be tested elsewhere.

Davies further notes that aerial photography combined with ground truth data can be used to extract socio-economic, health and demographic data on individuals living in poverty areas. He has proposed using this technique in rural areas in an attempt to identify environmental health problems by helping health workers to trace and detect communicable diseases.

B. Environmental Features Associated with Health

Initially, a substantial amount of time was spent reviewing the social science and health literature in an effort to determine the relationships between environmental features and health variables. No studies were found in the remote sensing literature which used aerial photography to examine this relationship for urban areas, although Fuller and Jones (1971) have noted its potential application to the field of urban public health. Mullens (1969) as discussed earlier, established low correlations between his photographic surrogates and rates for public health, mental health, crime and delinquency, but the correlations are not striking and no attempt was made to specify the relationship between environmental and health variables. Davies, et. al. (1972) as noted above are currently engaged in an effort to detect and trace communicable diseases in rural areas but so far no published information on their research results is yet available.

Unfortunately, the results of the literature review in this area were not as definitive as we might have hoped. However, despite the equivocal nature of many of the findings, some relationships are suggested and their possible validity should not be dismissed due to lack of "hard" data. It should also be noted that the data required to test all of these relationships was not available for the Houston study.

It became apparent as the literature review of this area progressed the health was generally viewed in a negative sense as meaning the absence of or lesser magnitude of disease in various populations. The World Health Organization has rejected this narrow definition of health in favor of one that includes positive as well as negative aspects of health. For this reason we decided to speculate on environmental features that might be associated with some positive aspects of health. Although there was not a great deal of literature relating environmental features to positive health, some articles suggested positive concepts of health and their measures (Heideman, 1968 and unpublished manuscript).

Leonard Duhl (1966) has remarked that health is a "total community phenomenon," that it is "related to everything, that affects the human being." He also emphasizes that societal problems are interwoven and so health cannot be regarded separately but must be viewed in relation to other social ills. Our concern for mental and physical health cannot be considered apart from the problems of crime and delinquency, of unemployment and poverty, of inadequate housing and education.

A brief summary sheet of the environmental factors and health outcomes serves as an introduction to our discussion. (See Table 2.) Studies on the effects of housing on health will be discussed first. The relevance of remote sensing studies which identified and classified various levels of housing quality will be apparent here. The first housing variable to be discussed is crowding.

1. Crowding. Poor housing correlates to a high degree with rates of illness and death, with the rate of mental illness, with juvenile and adult delinquency and with other social problems (Schorr, 1966 and Rosow, 1961). Of course, a correlation is not necessarily a causal relationship. Yet all housing legislation and codes in the U.S. are based on the assumption that safe and sanitary housing is essential to public health (Pond, 1957).

a. Biological effects of crowding on health. While very few controlled research studies have been done on isolating specific housing conditions which influence health, it is generally agreed that crowding is

TABLE 2

SUMMARY OF ENVIRONMENTAL FACTORS ASSOCIATED WITH HEALTH OUTCOMES

Environmental Factors	Health Outcomes					
	Biological				Behavioral	
	Respiratory	Childhood Communicable	Chronic Disorders	Other	Social	Other
Crowding	Pneumonia Tuberculosis Influenza	Diphtheria Mumps Scarlet Fever German Measles Chicken Pox Measles Whooping Cough	Arthritis Rheumatism Circulatory Disorders	Mortality Fertility general Rheumatic Fever	Divorce Ineffectual Parental Care Juvenile Delinquency	
Dilapidated housing, vacant lots, junk piles, vacant and vandalized structure, discarded autos						Accidents Rat Bites
Poverty	Tuberculosis		Heart Disease Cardiovascular Disorders Diabetes	Mortality Morbidity general Rheumatic Fever Infant Mortality		Schizophrenia Mental Retardation
Urban air pollution	Emphysema Lung Cancer Bronchitis					

a significant variable. Pond (1957) has stated that "overcrowding is the present greatest single characteristic of poor housing conditions." Rates of communicable and respiratory diseases (such as pneumonia, tuberculosis, and influenza) have been found to be higher under crowded living conditions, at least for certain age groups (Britten, 1942; Pond, 1957; and Wilner, 1962). Cassel, (1972) on the other hand, argues that few investigators have specified the processes through which increased social interaction, a presumed result of crowding, leads to disease other than to say that increased interaction facilitates the interpersonal spread of disease agents, and he points to weaknesses in this model.

Wilner, et. al. (1960b) in a study done in Baltimore attempted to evaluate the effects of housing quality on health. The investigators had the opportunity to study a group of families who moved from slum housing to public housing and to compare their health states with a group of families remaining in the slums. Numerous criticisms can be leveled at this attempt to do a controlled, experimental study, the most significant of which is that the control families, those presumably staying in the slum, did not all remain there. Many moved -- most to better housing - and although interviews with these families were still done, the attempt at experimental design was somewhat undermined. Nevertheless, this research is perhaps the earliest attempt to hold constant housing quality in order to determine its effect on health.

Wilner, et. al. found that a test group - who moved to better housing - of children under 20 years of age had lower rates of illness than a control group in three of five categories examined. The five categories comprised 90% of the episodes of illness occurring among children. The three categories in which the test group had lower rates included:

(1) infective and parasitic conditions, mainly the communicable diseases of childhood; (2) digestive conditions, and (3) accidents (Wilner, et. al., 1960b. See also R.H. Britten, 1940, 1941 and 1942.) The other two categories were respiratory diseases and allergic, endocrine, etc. Accidents were one-third lower in rehoused families possibly due to reduction of crowding and dilapidation. The lower rates of communicable disease Wilner partly attributes to the reduction in crowding and the elimination of doubled up families -- both of these factors supposedly reduce the chances that infecting material will be introduced and transmitted into the dwelling unit.

In an earlier study, Britten (1942) used data collected in the National Health Survey made by the Public Health Service in 1935-36, and found that rates of communicable diseases, especially diphtheria and mumps, were much higher in crowded households. More striking perhaps with respect to these diseases was the tendency for all of them to occur at an earlier age than in uncrowded households. Included in the childhood diseases were diphtheria, mumps, scarlet fever, german measles, chicken pox, measles, and whooping cough. The tendency for these diseases to occur earlier is significant because of the high rate of fatality at early ages. Brownlee (de Groot et. al., 1970) noted that while there is a relationship between density and mortality, the strength of this relationship has been declining over the years.

For adults, morbidity data shows somewhat less consistent results than those for children, and the effects observed are less related to communicable diseases (Wilner, 1960b). For young adults, ages 20-34, test rates were lower than control rates in more than half of the disease categories when both sexes were combined. This was especially true in the "late after" period of the investigation (Wilner, 1962). The disease categories included: (1) infective and parasitic; (2) allergic, endocrine, etc.; (3) mental, psychoneurotic, etc.; (4) circulatory; (5) respiratory; (6) digestive; (7) genito-urinary; (8) arthritis-rheumatism, etc.; (9) accidents, poisoning, etc.; (10) other symptoms. It was observed that for women in the 20-34 age group of child-bearing age there were lower test than control episode and disability rates. A tendency to lower birth weights among infants born alive to control mothers and an attendant higher rate of prematurity was noted. No particular facets of housing quality were isolated to account for this.

For adults between the ages of 35-59, respiratory conditions constituted the only category of illness in which uniformly lower test than control rates occurred for the whole "after" period for both sexes combined. Counter to the hypothesis, there were higher test than control rates, both in episodes of illness and in home days of disability. These rates were the most marked and consistent for 3 types of chronic illness: "allergic and related conditions, circulatory diseases, and diseases of the bones and organs of movement," e.g., arthritis, rheumatism, etc. (See Wilner 1956, pp. 738-739; and 1962, pp. 26-27 for his original hypotheses relating morbid condition to housing components.)

In seeking to account for these unexpected findings, the authors discovered that despite attempts to match on demographic and health characteristics, there were a number of persons in the test sample who had an unusually high incidence of chronic conditions in the "before" period. When the "after" rates were adjusted to account for this, disability rates were lower for males in "late after" period in the test group and for episode and disability rates in the two later periods for females (Wilner, 1962). The author doesn't make clear what aspects of housing are associated with these adjusted lower "after" rates. Is crowding still the significant variable?

Gordis, Lilienfeld and Rodriquez (1969) investigated the incidence of rheumatic fever in Baltimore. The incidence of this disease, which is rarely seen in private practice, is thought to be related to environmental factors, especially socio-economic conditions. In 1930 Glover wrote that "no disease has a clearer cut 'social incidence' than acute rheumatism which falls perhaps thirty times as frequently upon the poorer children of the industrial town as upon the children of the well-to-do... The incidence of acute rheumatism increases directly with poverty, malnutrition, overcrowding and bad housing." The acceptance of the concept of the "social incidence" of this disease has, however, been based on inadequate epidemiological evidence. Data to support this conclusion have come from clinical observations that most children with this disease come from the lower socio-economic classes.

Gordis et. al. found that rates for rheumatic fever were higher among non-whites than among whites. In fact, the rates were lower in the lowest white socio-economic group than in the highest non-white socio-economic group. This finding made questionable the belief that socio-economic status differences adequately account for ethnic differences in incidence. The authors then investigated the characteristics of the housing inhabited by different ethnic and socio-economic groups to see if any housing characteristic was associated with the incidence of rheumatic fever. Census tracts in these two groupings were compared in terms of 3 characteristics of housing - age of housing, condition, and crowding. Degree of crowding was identical for both groups (high non-white and low white) suggesting that it may be the critical socio-economic factor in determining incidence. This was confirmed by comparing white and non-white groups living in the same degree of crowding: incidence rates are no higher among non-whites than among whites when degree of crowding is held constant.

Cassel (1972) takes issue with the orthodox model that crowding increases the risk of disease through an increased opportunity for the spread of infection. This model, he claims, cannot account for the increase in non-infectious diseases which also occurs under conditions of crowding. Mitchell (1969a and 1969b) has noted the tendency for infectious and non-infectious diseases to cluster together. Robert Straus (1965) has also remarked on the tendency for several illnesses to occur simultaneously. Even for infectious diseases, some think that this view is only a partial explanation for effects of crowding. Rene DuBos (1965) believes that micro-organisms may exist in the body without causing disease and that microbial disease is not necessarily acquired through being exposed to a new micro-organism. In many cases, disease occurs through factors which upset the balance between the organisms and the host that is harboring them. Cassel states that "It may well be that under conditions of crowding this balance may be disturbed, but this disturbance is then not a function of the physical crowding but of other processes" (Cassel, 1972). While the factors that produce "physiological stress" are not likely to occur in the absence of crowding "they are not themselves due necessarily to the physical presence of many infected individuals."

Cassel further argues that current views as to the health consequences of crowding have not taken into account "the adaptability of living organisms." Most studies have gathered data on crowding at one point in time rather than examining individuals' reactions to crowded conditions over time. Cassel argues that the few studies which have been done indicate that organisms can adapt to a diverse range of conditions including crowding if the changes are slow. Many of the harmful effects occur chiefly in those individuals who are newly exposed to crowding. This may explain Kessler's findings (19?, cited by Cassel) with regard to mice which contradict other animal studies — studies which have examined the effects of crowding on first generation animals only. Kessler purports to show that once an animal population has reached its maximum density and no further growth is occurring, no increase in pathology occurs. "Under these circumstances asocial behavior was common but physical pathology no more frequent than in the control group living under uncrowded conditions" (Cassel, 1972). Prior to this, that is during the phase of rapid population growth, disease was much more frequent in the experimental group.

Some data show that since 1960 the ratio of rural to urban deaths has been steadily increasing (Cassel, 1972). The explanations for this violation of the "crowding" hypothesis may have to do in part with the improved sanitation and medical facilities in the cities and to the migration of younger people there. But while improved sanitation and immunization programs in cities may account for the lower urban rates of typhoid fever and diphtheria and pertussis, it cannot account for higher rural incidence rates of scarlet fever since we do not yet have the means to prevent streptococcal infections (Cassel, 1972).

The lower incidence of certain other diseases such as tuberculosis also may have little to do with improved sanitary conditions, lower degrees of crowding and improved medical care (1972). Cassel reports that in all countries for which there is available data, tuberculosis rates rose for 75-100 years following industrialization and consequent urbanization. Then they began to decline and continued to do so despite increasing population density. As evidence for this statement he points to the fact that the decline in England and the U.S. began 60 to 100 years before any effective anti-tuberculosis programs were inaugurated. Lieberman and Duhl (1964) state that tuberculosis rates are again beginning to increase.

In addition, Cassel cites a British study and an American study both of which showed tuberculosis to occur most frequently in people who were socially isolated. (See Brett and Benjamin, 1957 and Holmes, 1956.) Higher rates of tuberculosis prevailed in "ethnic groups who were distinct minorities in the neighborhoods in which they lived, in people living alone in one room, in those who had had multiple occupational and residential moves, and who were more often single or divorced than was true of the general population" (Cassel, 1972).

Some studies on schizophrenia, accidents, suicide, and some respiratory diseases have produced similar findings. One explanation of this phenomenon is that urbanization tends to be associated with the atomization of groups -- groups which in a more rural society provided emotional support and protection for the individual.

On the other hand, a recent study by Galle, et. al. (1972) in Chicago suggests that overcrowding may indeed have an impact on human behavior and that it should be considered an important variable in attempting to explain a wide range of pathologies from mortality and fertility to ineffectual parental care (measured by percent receiving public assistance), juvenile delinquency and psychiatric disorder.

Their measure of density consists of four components: (1) number of persons per room; (2) number of rooms per housing unit; (3) number of housing units per structure; (4) number of residential structures per acre. The first two elements refer to "interpersonal press" -- a type of overcrowding at the personal or individual level. Number of persons per acre, the authors' original measure of density, was not significantly related to any of the five pathologies. This contradicts Schmitt's (1966) study in Honolulu which found number of persons per acre correlated with his pathologies.

The authors' statistical analysis suggests that one component of density, persons per room, accounts for most of the explained variance for four pathologies: mortality, fertility, juvenile delinquency, and public assistance. Second, but less important, is the number of housing units per structure. For admissions to mental hospitals, the pattern is quite different. The most important component of density as a predictor of admissions to mental hospitals is rooms per housing unit. In fact it accounts for virtually all of the variance in hospital admissions associated with density. Two pathologies are of a biological nature -- mortality and fertility and will be discussed here. The other two will be treated in the following section.

According to the authors, density may be related to <u>mortality</u> in four ways: (1) increased interaction heightens one's chances of contracting various infectious diseases; (2) if it is the case that persons do become tired and run down because of overcrowding, their susceptibility to disease would be increased; (3) sick persons in an overcrowded situation are unlikely to get the rest and relaxation they need for recovery if they are constantly disturbed by the activities of others; (4) if indeed overcrowding is associated with instability withdrawal and ineffectual behavior, the sick person may not receive as effective treatment in an overcrowded setting.

Increased fertility was also associated with overcrowding. This finding is in contradiction to the animal studies which found that density led to a drop in natality. The authors feel that it is not difficult to reconcile this contradiction, however, and they put forth the following explanations: (1) while density does have an impact on animals, both its effects and the mechanisms involved differ from species to species; (2) one effect of overcrowding among animals is hypersexuality which, if true for humans, would be likely to lead to increased natality since women, in contrast to most female animals, are able to conceive 12 months a year; (3) factors which appear to limit natality in animals, like lack of territory or intense social competition do not seem to be important factors in human populations; (4) if, as has been suggested by Plant (1930), overcrowding makes it difficult to step back, examine one's situation and plan ahead, persons in overcrowded situations may not be as likely to perceive the long-range consequences of having more children and thus less likely to use birth control techniques; (5) overcrowding makes it difficult to follow through on plans so birth control may be ineffectually practiced.

b. Behavioral effects of crowding on health. Many deprivations and stresses have been found to be associated with high density and housing quality. Loring (1956, 1964, 1967) found that "over density" is the only housing characteristic associated with his measures of social disorganization. Gruenberg (1954) found that inner city high density areas account for a disproportionate number of first admissions for psychoses. Schorr (1966) has noted that housing quality may contribute to stress. Crowding, arrangement of space, dilapidation, and the presence of cockroaches and rats may all be interpreted as stressful. The amount of space per person and the way space is arranged to promote or interrupt privacy have been related to stress (Plant, 1930 and 1960.) Schmid (1937, 1960) found high population densities and high crime rates in the ghettos and central city of Minneapolis and Seattle and a decrease in both as one moved toward the suburbs. This relationship has been confirmed by studies in other major cities (Bordua, 1958;

Lander, 1954; Lottier, 1935-39; Shaw and McKay, 1942; Sorokin and Zimmerman, 1929; Watts, 1931). In an ecological analysis of census tracts in Honolulu, Schmitt (1966) found that even when education and income were statistically controlled, the correlations between ground density or population per acre and various measures of morbidity and illness held up.

Ido de Groot has pointed out that studies on both animals and humans "suggest that interaction under overcrowded conditions is a source of stress which can lead to systematic malfunctionings, especially those mediated by higher brain functioning, i.e., those expressing themselves as mental disorder, heart disease and endocrine deficiencies" (Loring, 1967).

In his psychiatric work with delinquent children, Plant (1960) found that crowding may affect the personality structure of the child in a number of ways: (1) it may destroy the sense of individuality and affect the self-sufficiency of the child; (2) it may destroy the illusions which children build up about others; (3) it may prevent the building of illusions about sex necessary for heterosexual adjustment; (4) it may cause "mental strain" -- feelings of irritability and negativity resulting from fatigue which develops when one constantly has to get along with others; and (5) it may inhibit the development of a sense of objectivity -- "the phenomenon of being so much in the world that there is no chance to look at it." Downs and Simon (1954) found that various diseases and maladies, including psychoneurosis, were clustered together in Baltimore. Buell (1952) and Lemkau (1970) came up with similar findings for St. Paul. Faris and Dunham (1967) found that in a number of cities the incidence of mental illness decreased as one moved outward from city centers to suburbs.

Not all studies support the crowding hypothesis. Guerrin and Borgatta (1965) showed illiteracy to be the best predictor of morbidity. Zlutnick and Al man (1972) also emphasize the need for caution in interpreting the findings of correlational studies which link indicators of social disorganization and population density. Other explanations might account for the density-related data since the central city is distinguished from the suburbs by other variables besides density such as economic status, health facilities, physical well-being and education.

In a position paper for the American Public Health Association, Lemkau (1970) stated that his review of the existing research indicates that "estimates of the power of emotional factors in influencing the healthfulness of housing are so rarely based on sound data, or any data at all, that the relationship of them to health is possible only in the most extreme conditions." Wilner and Baer (1970) state: "There is no body of convincing evidence that crowding in a dwelling unit contributes materially to mental disorder or to emotional instability. Nor is there evidence as yet that crowding (or other housing deficits) interferes with a promotive style of life; that because of crowding, family roles and rituals cannot satisfactorily be carried out; or that the development of infants and children is severely impaired."

Mitchell (1971b) in a comparison of rat and human responses to density distinguishes density from congestion or intensity: "Congestion refers to the simultaneous demands for the use of very limited resources." Similarly, Loring (1967) suggests "that a lot of health problems stem not from mere physical crowding, but from activity overcrowding, role overdensity, and possible subsequent withdrawal into psychological isolation."

Mitchell (1971a) in an attempt to overcome some of the limitations of previous studies, considered the effects that various housing characteristics in Hong Kong "had for attitudes toward one's housing, for levels of emotional strain felt by residents, and for effects upon several kinds of family and non-family relationships."

He found the major effects of high density to be:

1. Attitudes toward housing, especially toward the amount of space that one has and toward a lack of privacy, respond clearly to densities within dwelling units.

2. High densities also affect two somewhat superficial manifestations of emotional strain: worry and unhappiness. It is necessary, however, to control statistically for other stresses producing these strains. When only one of these controls -- the stress of poverty -- is applied, these two superficial strains still respond to high densities, but they do so only for the poorest members of the community.

3. Densities do not affect deeper and more basic levels of emotional strain and hostility.

4. Although high densities and other physical features of housing do not affect deeper levels of strain, the social features of housing have an important impact on these strains. Most importantly, the doubling-up of non-related households tends to create stressful situations, especially if it is difficult for the household members to easily escape each other by retreating outdoors. It is more difficult to retreat in this way when the dwelling unit is on an upper floor of a multistory building. Therefore, multistory buildings when combined with sharing arrangements, can have negative effects on the emotional health of individuals. These effects, it is conjectured, probably arise from forced interaction among non-relatives, not from high densities or large number of fellow kinsmen. Large numbers of people in high density housing can be tolerated more easily if these people are one's kinsmen.

5. Although the various housing conditions have no apparent effect on patterns of husband-wife interactions, densities have a clear impact on parent-child relationships. Parents in high-density housing evidently do not discourage their children from leaving the house, thereby temporarily relieving the high densities. But this solution to high densities tends to reduce the parents' knowledge of and control over their children (Mitchell, 1971a). And this autonomy may lead to their participation in juvenile delinquent gangs (Galle, et. al. 1972).

6. High density housing also discourages interaction and friendship practices among neighbors and friends.

While these findings are of interest, cultural differences must be kept in mind when attempting to generalize these results.

Galle, et. al. (1972) as has been mentioned earlier found density, as measured by number of persons per room, to account for a large share of the variance for four of their pathologies. Two of these -- mortality and fertility -- have already been discussed. The two social pathologies -- ineffectual parental care and juvenile delinquency -- also show an association with this component of density while admissions to mental hospitals show an opposite trend. They suggest the following explanations for these relationships.

Overcrowding may lead to tensions and irritations in the home which could cause the breakup of the family and might mean the loss of financial support. If overcrowding leads to ineffectual performance and withdrawal by parents, children may receive less effective care.

If in overcrowded conditions parents are irritable, weary, harrassed and inefficient, children are likely to find the home an unpleasant environment from which they seek relief by leaving. This provides relief for both parents and children. But a major factor in the development of delinquent gangs seem to be a high degree of autonomy.

Admissions to mental hospitals has a high correlation with percentage of persons living alone. Isolation, then, may be a contributing factor in the development of mental illness. However, the authors suggest that the correlation between rooms per housing unit and admissions may involve a self-selection factor: people who have difficulty getting along with others are likely to live by themselves and these are the persons most likely to be admitted to mental hospitals.

Density then is a complex phenomenon with several aspects as Galle et. al. (1972) have acknowledged in delimiting four components of this variable. Schmitt (1957, 1966) and Hutt and McGrew (1967) also make a distinction between "inside" density or social density (the number of people per unit of living space) and "outside" density (the number of people in a larger community, e.g., a census tract). Zlulnick and Altman (1972) also view crowding as a "multi-dimensional set of inter-locked properties" which include (a) situational/environmental characteristics of high density of people per unit of space for long periods of time, in environments where resources are limited; (b) certain interpersonal events where persons are unable to adequately control their interactions with others, and/or where the psychological and physiological costs controlling interactions are high; and (c) personal/subjective events where there is a network of personal and subjective feelings reflecting an inability to control interpersonal exchange, discrepancies in expectations, and incongruities with past experience.

Estimates about internal densities such as the number of persons per room obviously cannot be made from aerial photographs. External densities however can be estimated by remote sensing. Some examples of this might be number of residential structures per acre, amount of lot coverage, amount of foot frontage, and number of housing units per structure. The last measure pertains only to duplexes and multi-unit structures.

2. Dilapidation. Another housing component which the literature revealed to be associated with a health problem -- home accidents -- is dilapidation. While dilapidation in these studies refers to the internal condition of the dwelling, there is a precedent in the remote sensing literature for considering external conditions as surrogate measures for internal conditions (Wellar, 1968b and Davies, 1972). Externally dilapidated housing then is assumed to have more environmental defects which might facilitate accidents.

Britten (1942) examined the frequency of home accidents in relation to monthly rental value or in the case of owner-occupied dwellings to estimated value. For rental dwellings, the author distinguished between multiple and single-family dwellings. As the rental or value of the house decreases the accident rate increases (Britten, 1942). Britten emphasizes that "the lower the rental or value, the more dilapidated the dwelling is likely to be, the darker the rooms, the greater the accident and fire hazard."

Pond (1957) points out that there are few clear-cut data on the relationship between housing quality and the occurrence of either fatal or seriously disabling accidents. It seems fairly certain however. that broken stair treads, lack of handrails in stairwells or poorly lighted staircases produce falls. Other environmental features in the home which are likely to be associated with accidents include: (1) flaking lead-based paint as a cause of lead poisoning; (2) use of kerosene heaters predisposes to home fire; and (3) improperly adjusted and vented heating equipment produces deaths from gas poisoning.

Another health problem associated with substandard or dilapidated housing is rat bite. Scott (1965) in an article discussing factors of epidemiological significance in rat bite states that it occurs chiefly in lower socio-economic areas exhibiting substandard housing, crowding and poor sanitation. Other factors of importance in the epidemiology of this health outcome include: (1) Rat bite cases have a tendency to grouping, e.g., people bitten once are more likely to be bitten again. Certain blocks of a city and certain buildings show higher incidence than comparable blocks or buildings; (2) Rat bite incidence increases when the ecology of an infested area is disrupted by expressway construction, building destruction, land clearance or similar activities; (3) Rat bite is endemic, that is, it shows little seasonal or annual variation; and (4) Disaster situations produce greater incidence of rat bite.

3. Poverty. Poverty is known to be associated with many diseases (Sexton, 1961; James, 1965; Yerby, 1966a & b; Hurley, 1969) and with the absence of health care and health care facilities (Koos, 1954 and Robinson, 1965). Thompson (1971) has suggested that spatial clusters of poverty in the United States may be associated with distinct concentrations of other variables, some environmental, some demographic. From the convergence of these poverty-related variables, "poverty landscapes" can be identified. Thompson points out that the exact causal linkages of these variables have not yet been specified so it is not possible to spell out the exact nature of the association between, for example, poor housing and crime. However, he also emphasizes that this inability to trace causal linkages does not negate the possibility that a relationship exists. In public health many have rejected

the "doctrine of specific etiology of disease" in favor of the proposition that most diseases are the "indirect outcome of a constellation of circumstances" (Walker, 1970).

Thompson lists the following environmental variables as being associated with poverty landscapes. Some of these are measurable by remote sensing. They include:

(1) Social geographic isolation. (This applies primarily to rural areas.)

(2) A depleted or technologically defunct resource base.

(3) Institutional discrimination.

(4) Poorly developed or stagnant circulation networks. E.g., inadequate transportation networks.

(5) Sanitary and other conditions detrimental to physical health.

(6) Stress conditions detrimental to educational development and mental health. These stress conditions may result in social disorganization, indices of which include population crowding, high crime rates, divorce rates, large number of illegitimate births, and drug addictions.

(7) Esthetic deterioration of the physical environment.

(8) Dysfunctional housing.

It is our expectation that these poverty landscapes, which are potentially identifiable on remote sensor imagery, will experience a preponderance of health problems. The basis for this expectation is documented in the following discussion.

We want to stress at the outset of this discussion that the health problems of the urban poor are, to a degree, problems of urban populations in general. The urban dweller whether he is rich or poor breathes air polluted with auto exhaust and industrial wastes and drinks water tainted with pesticides and other pollutants. Cities, Alonzo Yerby (1965) has noted, show a "unique and enduring propensity to create health problems and then to treat the symptoms rather than deal with the casues." Statistical information on respiratory disorders, cancer, heart disease, and mental illness convincingly demonstrates that we may have approached a crisis in the field of urban public health (Heber, 1965). Still, evidence points to the fact that the urban poor are disproportionately affected by the health problems that beset urban populations. Leonard Duhl (1964) has characterized the relationship between urban poverty and health as "pathological urbanization" the marks of which include complexity, loss of identity and poverty. Hurley (1969) has noted that the poor suffer more from cardiovascular disorders, rheumatic fever, heart disease, diabetes, cancer, prematurity, infant mortality, schizophrenia (Irelan, 1966), dental disorders, arthritis (Yerby, 1966b), rheumatism, visual impairments, and general mental disorders (James, 1965).

James (1965) in a study conducted in New York City found higher death rates for five of ten leading causes of death in a Black and impoverished area as compared to rates in a middle-class area. In the Black area, death rates from these five causes were higher than for the city as a whole and lower in the middle-class area than for the city as a whole. Included in the causes were the cardiovascual-renal group, cancer, diabetes, the pneumonia-influenza group and accidents.

Other statistics reveal that a preponderance of health problems exists among the poor. In Flushing, a middle-class suburb of New York City, in 1963 the rate of newly reported tuberculosis cases was 20 per 100,000; on the Lower East Side it was 183 per 100,000 and in Central Harlem it was 226 per 100,000 (Hurley, 1969). In 1964 East and Central Harlem, which contained 24%of Manhattan's population, accounted for 40% of its tuberculosis deaths and Bedford-Stuyvesant with 9% of Brooklyn's population accounted for 24% of its tuberculosis deaths (Hurley, 1969). Another indicator of the extent of health problems among the poor is that the largest number of those rejected from the Armed Forced for physical reasons come from a poverty environment (Hurley, 1969).

In Watts the same situation prevails. Health data from 1960 show that in this area which contained only 17% of the city's population, in most health categories it was stricken with about 50% of the city's ills as the following table illustrates.

TABLE 3

PERCENTAGE OF REPORTED CASES OF SELECTED DISEASES OCCURRING IN WATTS

48.5%	of the amoebic infections
42%	" " food poisoning
44.8%	" " whooping cough
39%	" " epilepsy
42.8%	" " rheumatic fever
44.6%	" " dysentery
46%	" " venereal disease
36%	" " meningitis
65%	" " tuberculin reactors

The death rate unsurprisingly was 22.3% higher than for the remainder of the city.

Other statistics which throw light on the health condition of the poor include:

(1) 20.9% of children from families with incomes of $3,000 and under have not received small pox vaccinations compared to 3.9% for children from families with incomes of $9,000+. For diphtheria-tetanus vaccination the figures are 18.9% and 1.7%.

(2) Health exams: In the low-income group 49.3% did not receive routine health exams compared to 7.0% for the highest group.

TABLE 4

RATES PER 10,000 CHILDREN FOR 3 DISEASES

	Lowest Income Group ($3,000 or Less)	Highest Income Group ($9,000+)
Rheumatic fever	7.9	2.6
Tuberculosis	6.8	0
Diphtheria	15.1	0

(Data from Patricia Sexton, Education and Income, New York 1961, pp. 99-104).

Mental retardation is considered by many to be a poverty-induced condition. Brain damage is a result of poor prenatal care; poor prenatal care is more likely to occur among the poor. A study done in Boston (Donabedian and Rosenfeld, 1958) found that the "percentage of women receiving satisfactory prenatal care was directly related to income and to the educational level of the women" (cited by Hurley, 1969). Infant mortality rates have also been found to increase as family income decreases (Yerby, 1966b).

Koos (1954) showed that the poor are given fewer health exams, fewer immunizations, hold fewer health insurance policies and participate in fewer public health activities than the middle and upper classes. Low income has been shown to be a barrier to the use of preventive medical techniques and services. Health, Education and Welfare statistics also reveal drastic differences in health care for children between the lowest and the highest socio-economic groups. A child from a three-person family with an income of $7,000 or more has five times more spent on his health care than a child in a seven-person family with an income of $2,000 or less (cited in Hurley, 1969. Taken from "Medical Care, Health Status and Family Income:, U.S. Government Printing Office, 1964.) The number of phsycian visits per person per year also differs between these two groups: 4.6 for persons from the lowest compared with 5.7 for persons from the highest (Bergsten, 1960). This difference is significant in light of the fact that the poor have higher illness and disability rates. The number of visits for the poor child 15 years and under is 1.6 compared to 5.7 for the rich child. When poor children do come for care, they are likely to present a long backlog of untreated illnesses (Robinson, 1965).

Chronic disease is a cause of and a result of poverty. Yerby (1966a) reports that in 1957 in New York City 43.8% of all adult recipients of public assistance were reported to have some kind of chronic illness or disability. A study done by Bigelow and Lombard (1933) showed a strong correlation between chronic illness and economic status. The National Health Survey showed that the rate of chronic illness for persons on relief was about two and one-half times greater than the rate for persons with incomes of $1,000 to $1,500. By extrapolation, one might expect the difference between this low income group and a high income group, say $9,000+, to be tremendous. The Department of Health, Education and Welfare found that the percent of the population with one or more chronic conditions was 57.6% for the group with a family income of $2,000 or less and only 42.9% for the

$7,000+ group. Even though higher income groups also suffer from chronic illness, their activity is not generally limited by their diseases. For the poor, chronic illness limits activity more than three times as much as for the highest group (Gleeson, 1959). For the most serious chronic conditions, the gap is even greater.

TABLE 5

CHRONIC CONDITIONS LIMIT ACTIVITY FOR THE POOR

Heart conditions	4 1/2	times greater for the poor as compared to highest group	
High blood pressure	6	"	"
Mental & nervous conditions	6+	"	"
Arthritis & rheumatism	7	"	"
Visual impairments	8	"	"
Confined to homes	5	"	"

The result is that persons from the lowest income group have more than two times as many disability days per year (Bergsten, 1959). Yerby (1965) has remarked that for poor people, the complex of degenerative diseases start to take their toll after the age of 45.

While it is not yet possible to specify a precise and direct relationship between poverty and disease, it is generally agreed that poverty is a major factor in malnutrition and in the presence of unsanitary living conditions. These conditions in turn may be responsible for reduced resistance to disease organisms and for the spread of infectious diseases, especially those of the intestinal tract (Pond, 1961). Although poverty alone causes neither tuberculosis nor shigellosis, it may provide an environment in which disease can flourish. Rene DuBos has written that health is a "never-ending...

adaptation to the total environment" (Quoted by Hurley, 1969). If this is so, then the health problems of the poor may be related more closely to their deteriorated environment than to their health practices as some have suggested. Yerby (1965) questions whether the best medical care if delivered to the slum dwelling indigent would have any meaning in the face of substandard living conditions. Substandard housing is a significant aspect of the environment to which the poor are exposed, and as we have seen many health problems seem to be associated with this part of their environment. Lieberman and Duhl (1964) feel that the attainment of urban health depends on the development of a comprehensive ecological model which relates health to almost all the other problems faced by metropolitan areas. They posit a model which relates health to poverty, to education, to planning and architecture, to transportation, to population and to many other factors. A knowledge of the interrelationships of problems (such as of ulcer, hypertension, accidents, suicide, crime rates, and poverty) is a prerequisite to effective planning for health.

4. Urban air pollution. The concentration of population and industry in large cities has created "air pollution districts". Epidemiological studies suggest that urban air pollution may be a causative factor in chronic bronchitis and other respiratory diseases. Martin (1967) believes that air pollution has been shown to have both immediate and chronic effects on health. A report by the World Health Organization Committee on Environmental Health Aspects of Metropolitan Planning and Development (1964) declares that there is "ample circumstantial evidence of a general deterioration in health in large urban centres where air pollution is increasing."

Cassel (197) argues that the distribution of various diseases may change as more groups are exposed to them. A study by Haenszel et. al. on death rates from lung cancer in the United States showed that when controlled for degree of smoking, death rates were higher for farm-born who had migrated to the cities than they were in lifetime urban dwellers. Urban dwellers apparently had "adapted" better than migrants to the effects of atmospheric pollution. Death rates for hypertensive heart disease have been declining in the U.S. since about 1940-50, before the introduction of hypertensive drugs (Paffenberger, et. al., 1966).

The automobile is the single most important source of air pollution in the United States today. In areas of heavy continuous traffic, little dilution of exhaust gases from all the cars is likely to take place. Each tailpipe is a source of pollution so, aside from areas of concentrated traffic, pollutants are emitted over a vast area rather than being limited to a particular industrial district of the city. Middleton & Ott (1968) discuss vehicular pollution in terms of two separate environments: "The small environment of the individual street and the large geographical environment of the entire urban area." Pedestrians, drivers and traffic policemen are exposed to very high levels of pollution. The urban area levels include not only vehicular pollutants but also pollutants from non-vehicular sources like industry and power plants. These two environments have different implications for health: the street environment consists of short-term, peak exposures, while exposures in the urban area are longer-term and of lower magnitude. As urban centers continue to expand, the duration of exposure to these levels will increase especially for urban residents, as it takes longer and longer to leave an urban area.

It seems reasonable to assume that people living near busy freeways and major thoroughfares and/or industrial sites will be exposed to higher levels of concentrated pollutants than those not living near freeways or industrial areas. Our expectation is that these people (or areas) would have higher rates of respiratory diseases.

5. Street condition. Accidents differ in their geographic location, occurring more frequently at certain sites which may be considered "block spots" and differing in incidence between urban and rural areas (World Health Organization, 1962). Incidence of road traffic accidents also varies with such environmental factors as time of day, day of the week, weather conditions, type of road design and surface, lighting and visibility.

There is a strong association between road traffic accident rates and the design, construction and surfacing of roads. Improved lighting of roads, especially in urban areas, may have a good effect on accident rates.

6. Green belts, green streets, open green space and good residential environment. Britten (1942) has suggested that people living in the slums have diminished opportunities for positive health. As has been mentioned, the socio-economic structure of a community indicates accessibility to various types and levels of health care, especially preventive health care. Slums probably also have a depressive influence on aspirations for self and family, upon morale and upon general outlook on life.

It may be possible to assess the residential environment of different areas in terms of opportunities for positive health. The residential environment is defined by the World Health Organization's Expert Committee on the Public Health Aspects of Housing as "the physical structure that man uses for shelter and the environs of that structure including all necessary services, facilities, equipment and devices needed or desired for the physical and mental health and the social well-being of the family and individual" (World Health Organization, 1961). These community services and facilities include: public and administrative services; schools; social, medical, recreational and cultural centers; business premises; open space; transport systems; water supply, sewerage, waste disposal and drainage systems; gas, electricity, telephones, etc. (World Health Organization, 1964). Residential areas should be protected against all sources of pollution -- air, water, soil and noise.

Green belts (open green space) serve as living buffers between residential areas and industry. They protect residents from the noise and fumes of motor traffic, from wind and excessive heat or cold; they divide urban areas from one another. In short, "They are a micro-climate regulator against the dangers of pollution" (World Health Organization, 1964). To what extent are residential areas in Houston differentiated by the presence of green belts? Assuming areas to be so differentiated, are there differences in health outcomes that might be accounted for by the presence of green belts? For instance, lower rates of chronic respiratory ills like emphysema and bronchitis might characterize areas where there are green belts.

Open space is also necessary to accomodate active recreational needs for groups of all ages. Open space also needs to be available for more passive activities: calm and tranquility. In urban areas access to open space is becoming a necessity at the same time that it is decreasing and deteriorating. The Department of the Interior reports that over 75% of all recreational activity occurs close to home after work and school and on short outings. In urban areas only 25% of the recreation facilities and only 3% of public recreation lands are reasonably accessible. Does the presence or absence of opportunities for recreation or sulitude (golf courses, parks, lakes, camps, etc.) seem to affect the physical and mental health of an area? Green areas also give aesthetic pleasure, though the importance of this may not be measurable. Remote sensing is an effective tool for taking inventory of recreation resources both indoor and outdoor (Dunn, 1972). Dunn also notes that remote sensing can be used to monitor changes in the use or function of open space and recreational facilities "due to development, demographic change, accessibility improvement, weather or seasonal variation, difference in time of day or day of week, holiday occurrence, modification of school or work patterns, or other social, cultural, or technical evolution." Sources of pollution around urban recreation resources can be identified and corrected and use patterns can be detected on a periodic basis.

Another way of assessing opportunities for positive health might be to develop an index of environmental quality. Aschmann (1971) has listed several aspects of environmental quality that can be remotely sensed. Remote sensors can be used to identify "patterns and associations of variable and disparate environmental features, both natural and cultural, that society can associate with desirable or undesirable environments" (Aschmann, 1971). Some of Aschmann's indices are as follows:

(1) Pollution Levels. Quantity of pollution correlates positively with the level of economic activity, technological advance and population density.

(2) Diversity. A diverse environment is considered to be a positive qualitative value. This applies more to the cultural landscape since it is difficult to increase the diversity of the natural physical environment. Diversity means different things in urban and rural environments. Surrogates would have to be developed. Some examples might be extensive public housing projects or large areas of uniform suburban tract housing in urban areas. How different sub-groups of the population react to varying degrees of diversity in their work, residential and recreational environments would have to be investigated.

(3) Privacy vs. accessibility; Security vs. interest or opportunity. The author postulates that individuals need both privacy and social contact although the amount of each that is needed will differ for individuals and for cultural groups. While it is uncertain that the physical concomitants of these variables can be identified in the cultural landscape and so be subject to remote sensing, the author cites two situations which indicate that there is the possibility. "The contrast between the fenced yards of suburban southern California and the unfenced ones of small and middle-sized midwestern towns is readily perceptible. It is conceivable that each system provides the desired environment for its respective residents. It is likely, however, that one system is extending itself and superseding the other, a fact subject to monitoring by fairly remote sensors, and the associated reactions of residents where changes are occurring can be investigated."

(4) Relations between Energy Consumption and the Amenities of Living. The author suggests that the question might be asked "To what degree is increasing energy consumption making for better living?" You might get an answer to this question by sensing the energy flux in a wide variety of urban areas within and outside of the United States. This might make it possible to assess how much more unpleasant the outdoor summer climate of Manhattan is made by air conditioners.

(5) Single-Purpose Preemptive Land Use. Space is the least elastic of society's resources and its value is highest in urban areas where population is most concentrated. The author suggests that it might be "worthwhile to inventory the spaces in and around urban population concentrations to see what fractions of them are being preempted for a single 'use' and what fractions remain for carrying on the variety of activities that constitute human life." Changes in the proportions in the direction of exclusiveness

may signal the need for modifying land use policies.

(6) Concomitants of Blight. The census, welfare and policy records provide indices of social malaise but at a time almost too late for corrective action. Are there signatures of blight which can be early identified? What are the combinations of features in the physical and cultural landscape that are associated with, precede, or produce blighted neighborhoods? Many, like location in relation to traffic arteries that form barriers to local communication, may be sensed remotely. Expressions like "back of the yards" and "wrong side of the tracts" indicate the existence of such barriers.

It seems reasonable to expect that an attempt to delineate health level areas would include aspects of positive health as well as more traditional measures of health, for environmental features can be expected to assist or hinder an individual's chances for both.

Review of Selected Studies of Heart Disease and Environment.

Myocardial infarction, or what the lay public knows as "heart attack" simply means inadequate blood supply to the heart organ resulting in death of the heart muscle tissue, or death or cardiac muscle secondary to interruption of necessary blood supply. About 25-30% of those who suffer myocardial infarction or heart attacks will not survive. Because of the severity of this heart disease, hospitalization is almost always required. Also to be included in the heart disease data gathered for Galveston is cardiac arrest which is another diagnostic category similar to myocardial infarction, falling under the term "heart attack".

Hypertension, an underlying cause of "heart attack" and "heart failure" is the third major heart disease for which data will be gathered.

Studies of Heart Disease and Socioeconomic Status

Heart disease in general, including myocardial infarction, cardiac arrest and arteriosclerotic diseases has been exhaustively studied, vis-a-vis the social environment, with as yet no conclusive results. One of the most well known and widely cited studies is the Framingham Study (1959) which found an inverse relationship initially between heart disease and socioeconomic status. However, after a follow-up study was completed which corrected for age, these findings were not found to be statistically significant. Yet the basic association remained.

Stockwell (1963) working with mortality data in Hartford and Providence, found an inverse relationship between heart disease and socioeconomic status with standardized rates per 100,000 varying from 350.7 per 100,000 for the group with the highest socioeconomic status, to 418.3 per 100,000 for the group with the lowest socioeconomic status. This rate difference of 67.6 felt to be significant enough to draw the conclusion that the inverse relationship existed.

In one of the few studies to relate heart disease to geographic distribution, a group of researchers in New York City (Kent, et al, 1958) found a tendency toward an inverse relationship between median income and death rates from coronary heart disease. The rates differential in this study was far greater than in the Stockwell study, with the span ranging from a low of 249 per 100,000 to a high of 689. This study could find no correlation between heart disease and sex, race or age. The income correlation could also be explained by occupation, education, marital status and ethnic background perhaps, but these would all be only possibilities. This study found, in addition, real geographic differences in death rates. The same inverse relationship between socioeconomic status and death from heart disease was observed in this New York study, with areas such as East Harlen and the lower West Side displaying greater rates than other areas of middle income residents.

Socioeconomic differentials were looked at in mortality rates for the nine leading causes of death. Nagi et al (1973) examined variations among small geographical units within a city (census tracts and census tract groups) that have been differentiated according to some index of socio-economic status. The socioeconomic differential was most pronounced for infectious and parasitic diseases. The differential for heart disease was smaller but still pointed to an inverse association with socioeconomic status even for those with chronic disease. Heart disease accounted for more than 60% of excess deaths in all three areas of socioeconomic measurement: income, education and occupation.

Theorell (1973) found that again there was an inverse relationship between lower socioeconomic groups and myocardial infarction rates. He found that those patients who had higher rates of heart disease were more likely to have had a lower education, lacked satisfaction with their work situation and were less likely to live in a house of their own.

We can see then, that a great many of the studies associating heart disease with socioeconomic status confirm an inverse relationship between the two. On the other hand, this relationship has failed to materialize in a few other studies (Cassel, et al, 1971) and the issue is still somewhat ambiguous. If the physical environment is indeed a surrogate for the socioeconomic and sociocultural environment, we should see something of an inverse relationship in our Galveston Study, between higher disease rates and neighborhood physical environment of lower quality.

Summary

This literature review has given an overview of the uses of remote sensing in land use, housing and population studies. There has also been a review of the literature concerned with various aspects of health and disease as they relate to the man-made environment.

From this literature review certain variables have been selected for further investigation. These variables will be further elaborated upon in the forthcoming chapters. The thrust of this investigation will be to carry one step further the results derived from this review. It will attempt to establish whether or not there exists a relationship between the man-made urban environment as delineated through remote sensing, and lev els of morbidity and mortality in the population living in this environment.

CHAPTER II

TAXONOMY OF LAND USE AND QUALITY VARIABLES

INTRODUCTION AND METHODOLOGY OF COLLECTION

The City of Galveston constitutes fourteen (14) square miles with a population of about 60,000 people. There are 25 census tracts in the city, with seventy five (75) block groups and roughly 1300 blocks to be analyzed. This is almost twice as much area as that covered by the Houston Remote Sensing Project. It is, in fact, the first time that an entire city in the Southwest area of the country has, to our knowledge, been analyzed by remote sensing in order to assess health outcomes.

The Galveston Remote Sensing Project is a follow-on study from the Houston Pilot study. While there is some replication between the two, there have been some significant changes. These changes have been made both in the methodology and in the data to be gathered. The changes result from the Houston Pilot study and are an attempt to both refine and enlarge upon that study.

Photo Interpretation

Photographs for the Galveston Project were taken in August, 1973, when a special flight was undertaken for this purpose. Color infra-red was used rather than the regular color photographs which the Houston project utilized. Photographs were taken from 12,000 feet. The scale of analysis for the Galveston project is 1:24,000 with enlargements to 1:6000 for purposes of photo interpretation, while the scale of analysis for the Houston project was 1:6000 initially. The size of the developed photographs for the Galveston project are much larger, at 24" x 24" as contrasted to the Houston project which used 9" x 9" photographs.

GENERAL HIGHWAY MAP

SUPPLEMENTARY SHEET

SHOWING

DETAIL OF CITIES AND TOWNS

IN

GALVESTON COUNTY TEXAS

PREPARED BY THE

TEXAS STATE HIGHWAY DEPARTMENT

PLANNING AND RESEARCH DIVISION

IN COOPERATION WITH THE

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

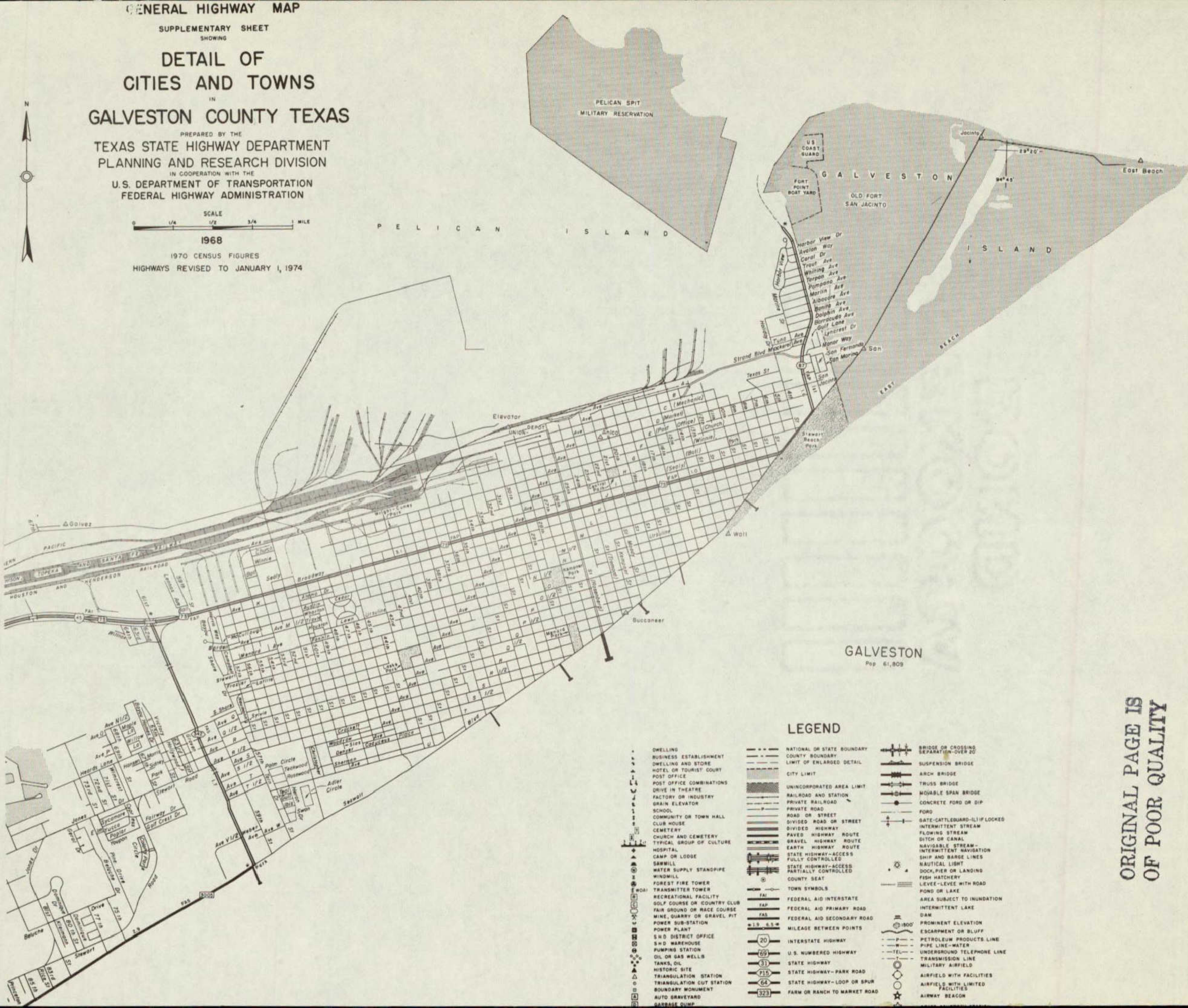
SCALE

0 1/4 1/2 3/4 1 MILE

1968

1970 CENSUS FIGURES

HIGHWAYS REVISED TO JANUARY 1, 1974



These changes in methodology are not expected to influence the actual photo interpretation. Rather, it was felt that the color infra-red would yield a better texture and image of greenery and foliage while preserving the clarity of other urban signatures. The larger photographs enable the viewer to associate contiguous land uses and to better judge the inter-relationships among these land uses.

Another major change in methodology is the measurement of all of the square footage of each major land use by grid overlay and slide rule conversion, rather than using the dot pattern employed on the Houston project. The photo interpreter felt that this method would be just as feasible and perhaps more efficient than the previous method used on the Houston project. See Chapter V for further discussion.

Changes in Classification Scheme and Quality Factors

In developing a methodology for assessment of urban residential quality through the use of remote sensing, one of the problems continually being faced is the selection of photo factors which will prove to be the best surrogates for determining this quality. These factors must serve two purposes: they must be readable to the photo interpreter and they must be objective enough to permit both manipulation mathematically and to allow replication by other researchers.

Several of the major remote sensing studies of the last five years have developed sets of these factors. These studies have been carefully reviewed to determine applicability to the Galveston area. Out of this review, 10 factors were derived which, when taken as a composite measure, should yield a measurement of residential quality which will be pertinent to the test area. Table I gives a listing of these factors as well as the authors of previous studies which have also utilized the same factors. A brief explanation as to the choice of each factor is given here.

The amount of foliage (trees and shrubs) and green lawn has been found to be a useful measure of urban quality in virtually every one of the remote sensing studies just reviewed. Greenery and foliage is directly correlated to better housing quality while its absence is a correlate of poor environmental quality. Utilizing this factor for Galveston should yield some interesting results, inasmuch as there are some areas of the city with little open green lawn, and very dense housing which are nevertheless considered to be middle income areas, socioeconomically. They are atypical of the middle class housing of the southwest which is generally single family surrounded by green open space. There are areas of the city which are typical and the comparison of the two areas should be statistically useful.

Sidewalks have only been used in one study as an indicator of quality, and that was as a unit in a composite measure of general street quality. However, most urban poverty areas in the Houston-Galveston county area are characterized by lack of sidewalks and this factor was felt to be potentially useful for this purpose.

The lack of garages and driveways in many urban poverty areas had been noted by Holz, Tumayov and Davies in their study of Austin (1973) as well as by Bowden (1968) and Moore (1970). This factor is interchangeable with the title "on street parking". This characteristic is especially prevalent in poverty areas in the Southwest United States.

TABLE 1

QUALITY INDICANTS USED IN GALVESTON STUDY

Quality Indicant	Previous Appearance in Literature
Foliage	Used by Davies, Holz (Austin, 1973), Wellar (Chicago, 1968), Bowden (Los Angeles, 1968), and Mullens (Los Angeles, 1969)
Sidewalks	Used by Mullens (Los Angeles, 1969) under overall category "Streets"
Curbs and Gutters	Used by Davies, Holz (Austin) and Mullens (Los Angeles)
Paved Streets	Used by Davies, Holz (Austin) and Mullens (Los Angeles)
Garage and Driveway	Used by Bowden (Los Angeles) under "parking and number of cars", Moore (Los Angeles, 1970) under "on street parking" and by Davies, Holz (Austin)
Street Width	Used by Davies, Holz (Austin), Mullens (Los Angeles) and Moore (Los Angeles)
Litter	Used by Davies, Holz (Austin) Mullens (Los Angeles) and Moore (Los Angeles)
Lot Frontage	Used by Davies, Holz (Austin)
Size of House	Used by Bowden (Los Angeles, 1968), Wellar (Chicago), Mullens (Los Angeles) and Davies, Holz (Austin)

The presence of curbs and gutters in middle class developments is usually in sharp contrast to their absence in urban poverty neighborhoods especially in the Houston-Galveston area. Holz et al in Austin note this especially, as did Mullens (1969). Paved streets usually accompany curbs and gutters in middle and upper income areas but often do not in lower income residential neighborhoods where the street has been hastily installed and drainage ditches remain. Therefore it was felt that these two items should be separated for more careful analysis.

Litter is as widely used a factor as foliage and green open space and appears in the Austin study, and in the work of Mullens and Moore especially. The presence or absence of litter is not a localized geographic occurrence but rather one which manifests itself in any urban area in the U.S.

Lot frontage has not been widely used as a quality/density factor, with the exception of the Austin study. It is generally assumed that smaller lots appear in low income housing areas due to the higher cost of larger residential parcels. In addition, as stated in the Austin study, shorter frontage reflects the trend for poverty areas to be subdivided into smaller tracts with less frontage to avoid larger property taxes. Again, there are some areas in Galveston which may prove the exception to this general observation. These are the areas of high density, short frontage and older two story residences referred to earlier which could be described as middle income areas in some blocks, and as lower income areas in others.

This measurement of frontage to indicate both density and quality should yield an interesting association between these two groups of socioeconomic classes.

Size of house as a quality factor has been used in four previous studies: Bowden, Wellar, Mullens and Holz. Size will be given in three sub-categories: small (1200 or less square feet); medium (1200-2000 sq. ft.); and, large (2000 plus). It should be noted here that the Austin study grouped housing in roughly equivalent categories; low income areas revealed average sizes of from 380 to 1220 square feet, middle income areas from 1110 to 1560.

All of the above factors of housing quality have been delineated in a fashion so as to be measured objectively. Each is quantifiable in terms of <u>amount</u> so that there is less opportunity for subjective judgment to intervene. Thus, presence or absence of driveway, sidewalks, curbs and gutters, paved street, litter and foliage are recorded by percentages which can yield an ordinal scale. The scale quantities can either be aggregated into a composite measurement, or can be isolated and compared as separate quality factors for each health outcome.

The one exception to this system of classification is the factor "residential quality". This has been included for purposes of comparison, in order to determine the comparability of a subjective judgment and an objective measurement. The juxtaposition and correlation of the subjective and objective quality factors should reveal an interesting comparison, of value to future photo interpretation methodology.

Changes In Land Use Categories

There have been some changes made in the land use categories for the Galveston research project. These changes will more closely reflect the categories developed by the Conference on Land Use Information and Classification under the sponsorship of the Department of the Interior and the National Aeronautics and Space Administration of July, 1971.

This conference, and the work of the Steering Committee which met subsequently, attempted to "standardize a national framework for land use in response to the recurring problem of the lack of a compatible land use classification scheme based primarily upon remote sensing techniques." Two levels of classification schemes resulted from this effort, and it is Level II, developed for more urban detail, which has been employed here.

Table II shows the Level II classification scheme, along with the classification scheme for both the Houston study and the Galveston study. Some divergences from Level II have been made in order to employ a better "fit" to the city of Galveston. For instance, it will be noted that the categories "extractive" and "strip and clustered settlement" have not been employed. Also, the categories "vacant" and "water" which do not appear as Level II categories have been included for Galveston. However with the exception of these items the "fit" is rather close.

An advantage of the broad classification of Level II categories is to enable a more specific classification of sub-categories for each urban area. This has been done for Galveston. It should be noted that all of the previous land use categories for the Houston project have been subsumed within the Galveston classification, either as sub-categories, or, in the case of commercial and industrial, as major groupings. Table II displays these trade-offs in categories between Houston and Galveston. For purposes of analysis, each sub-category can be compared to health outcomes if a finer discrimination of the data is required. However, it is felt that the major categories of the classification scheme should be suitable for statistical analysis either through techniques of correlation or regression.

TABLE 2

COMPARABLE LAND-USE CATEGORIES

Houston: Land-Use Categories	Galveston: Land-Use Categories	U.S. Geological Survey: Land Use Categories Level II Classification
RE RG all RF residential RF including RH quality RM and RL quantity Apts.	Residential R - Single family unit RA - 1-3 story building RH - Over 3 story building Trailer Parks no comparable category	Residential Mixed* Strip & Clustered Settlement
Schools Hospitals Churches	Community Facilities	Institutional
Cemetaries Parks Green open space	Recreation & Open Space	Open and Other
	Water	No comparable category
Streets Railroads	Streets, Highways, Parking Lots	Major transportation routes
Commercial	Commercial	Commercial & Services
Industrial	Industrial	Industrial
	No comparable category	Extractive
Unimproved	Vacant & unimproved	

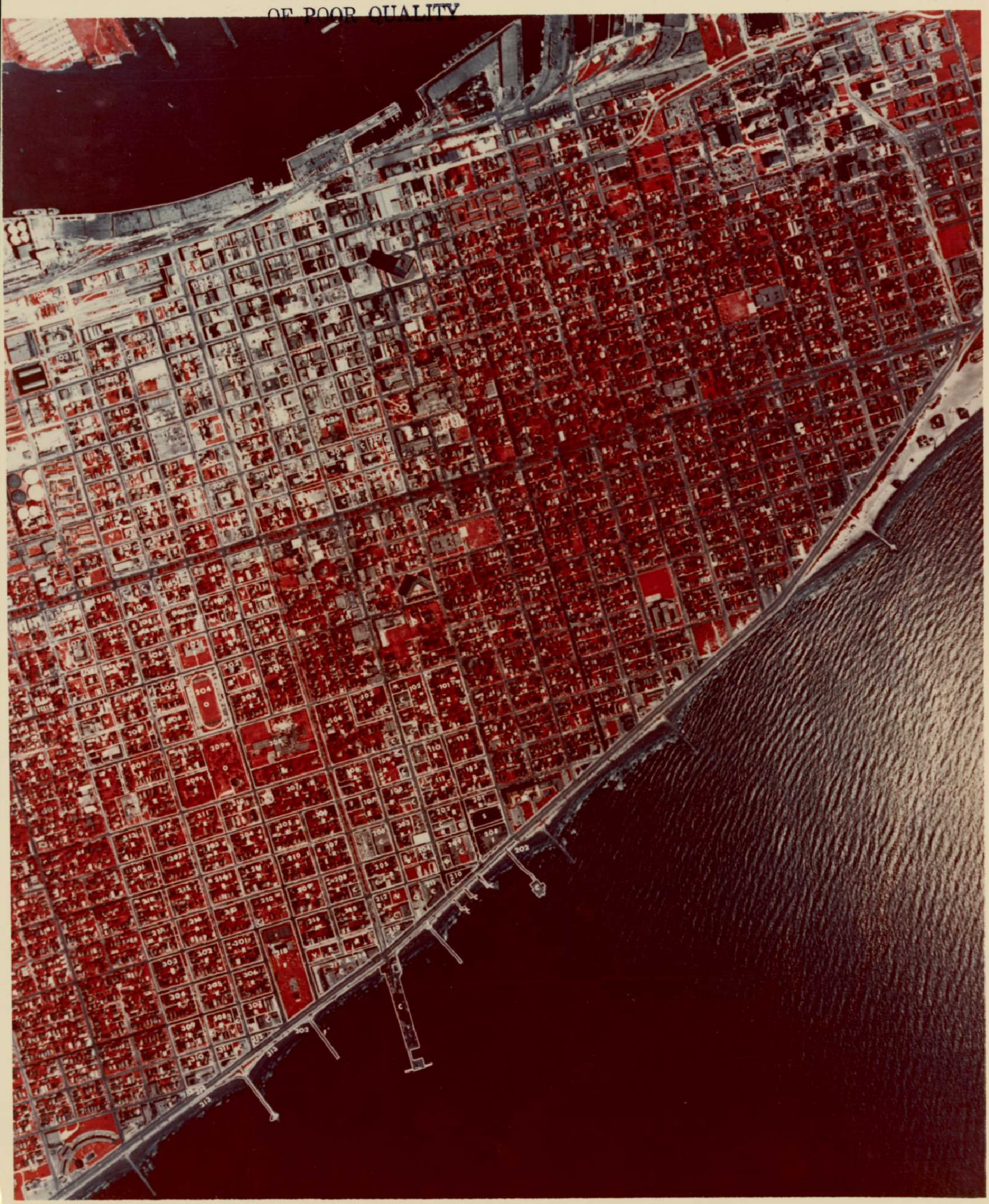
*This category has not been included as such in the initial classification scheme but will appear later when blocks with 50% or less residential use are isolated and aggregated as a new category.

INFRA-RED PHOTOGRAPH CAPTION

On the following page is a reproduction of an infra-red photograph typical of that used in this study, showing a section of the City of Galveston. A partial overlay used in analysis is super-imposed on the photograph. The scale is 1:24,000.

The reader will note unique Galveston landmarks such as the wharves at the top of the photograph, the downtown area in the upper left, and hospitals and medical school in the upper right section.

ORIGINAL PAGE IS
OF POOR QUALITY



Scaling and Calculations of Land Use Quantity and Quality

The photo interpreter completed the analysis of 750 blocks in about a 4 month period so that scaling and calculations of the data began 5 months after the project commenced. While there are two groups of census blocks, those drawn from the sample and those which cover an entire census tract which were completed before the sample was drawn, the initial procedure for scaling and calculations was the same. The process of aggregating the data for each block into census tracts differred between the approach used for the sample blocks (see explanation of Dr. Hsi, Chapter IV, page 85) and the approach used for all the blocks in an entire census tract.

Quality Measurements

To repeat, then, the quality variables used in the analysis are as follows:

A. Amount of Foliage and Green Lawn

B. Presence of Sidewalks

C. Presence of Driveway and Garage

D. Street Width Over 30 Feet

E. Presence of Paved Streets

F. Presence of Curbs and Gutters

G. Presence of Litter

H. Frontage of Houses

    a. Over 90 Feet

    b. 50-90 Feet

    c. Less than 50 Feet

I. Size of Houses

a. Large (over 2000 square feet)

b. Medium (1200-2000 square feet)

c. Small (1200 or less square feet)

The final quality variable is a subjective one, entitled

J. Quality

a. Excellent

b. Good

c. Poor

This final variable will act as a subjective comparison to the objective quality points obtained for each census block and in this way test the reliability of the subjective evaluation vis-a-vis the objective procedure.

Each quality category was evaluated quantitatively, with three basic categories of quantity given in the check sheets. These were Low (less than 25%), Medium (25-75%) and High (over 75%).

The only quality variable which proved troublesome to the photo interpreter was that of "litter". His initial interpretation was that a block had to be over 25% or one fourth covered with litter in order to fall into the Medium category, and over 75% or three-fourths covered with litter in order to fall into the High category. When this was discussed, it was found that there was a difference of interpretation for this particular variable and that the relationship of litter to the number of residences was the basic intent of the evaluation. Therefore, the amount of litter (Low, Medium, or High) would have been directly related to the approximate number of residences in the block, i.e., if about half of the residences had litter scattered in a contiguous pattern, then the category Medium would have been checked.

In order to adjust for this problem it was decided that the photo interpreter would go back through all of the sheets and mark the variable "litter" as either Yes or No, meaning either it exists or it does not exist in each block. This kind of measurement will not yield the more finite breakdown which was originally intended, but will indicate at least the presence or absence of litter and it was felt that this would suffice.

<u>Methodology for Scaling</u>

A three point scale value system was chosen as the simplest method for totaling scale points. This means that each quality category can earn up to 3 points; with Low counting as 1 point, Medium as 2 points, and High as 3. Therefore, quality categories A through F can receive a 1, 2 or 3 depending upon where the photo-interpreter has put a check mark.

In categories H and I, the basic 3 point system operates in the same manner but in duplicate fashion. That is, a check can appear in the category Low in a sub-category of "House Frontage." These sub-categories are in turn numbered 1, (less than 50 feet), 2 (50-90 feet) and 3 (over 90 feet).

In categories H and I, the basic three points system operates as a multiplier of the percentage category. That is, the three numbers appear opposite the sub-categories of house frontage: 1 is less than 50 feet, 2 is 50-90 feet, and 3 is over 90 feet. This scale number is then used as a multiplier of the percentage category which has been checked by the photo interpreter. The percentages are either a midpoint of a percentage category, or the endpoints of a percentage category. Two examples of the procedure followed are given below:

Example 1:

		0-25% Low	25-75% Med	Over 75% High	
3	Over 90 Ft.	25%			.25 x 3 = .75
2	50-90 Ft.		75%		.75 x 2 = 1.50
1	Under 50 Ft.				Scale Value Total: 2.25

Example 2:

		0-25% Low	25-75% Med	Over 75% High	
3	Over 90 Ft.				
2	50-90 Ft.		25%		.25 x 2 = .50
1	Under 50 Ft.			75%	.75 x 1 = .75
					Scale Value Total: 1.25

In cases where a check appears in the column marked Medium, a midpoint calculation is required. That is, the midpoint of 25-75% is 50%. There will also be a check in either the Low or High column as well. In either case, the midpoint of that column is also recorded. For 0-25% the midpoint is .125 and for 75% and over the midpoint is .875%. These midpoints are in turn multiplied by either 1, 2 or 3 scale values to give a total scale value. For example:

Example 3:

		0-25% Low	25-75% Med	Over 75% High	
3	Over 90 Ft.		.50		3 x .50 = 1.50
2	50-90 Ft.	.125			2 x .125 = .25
					Scale Value Total: 1.75

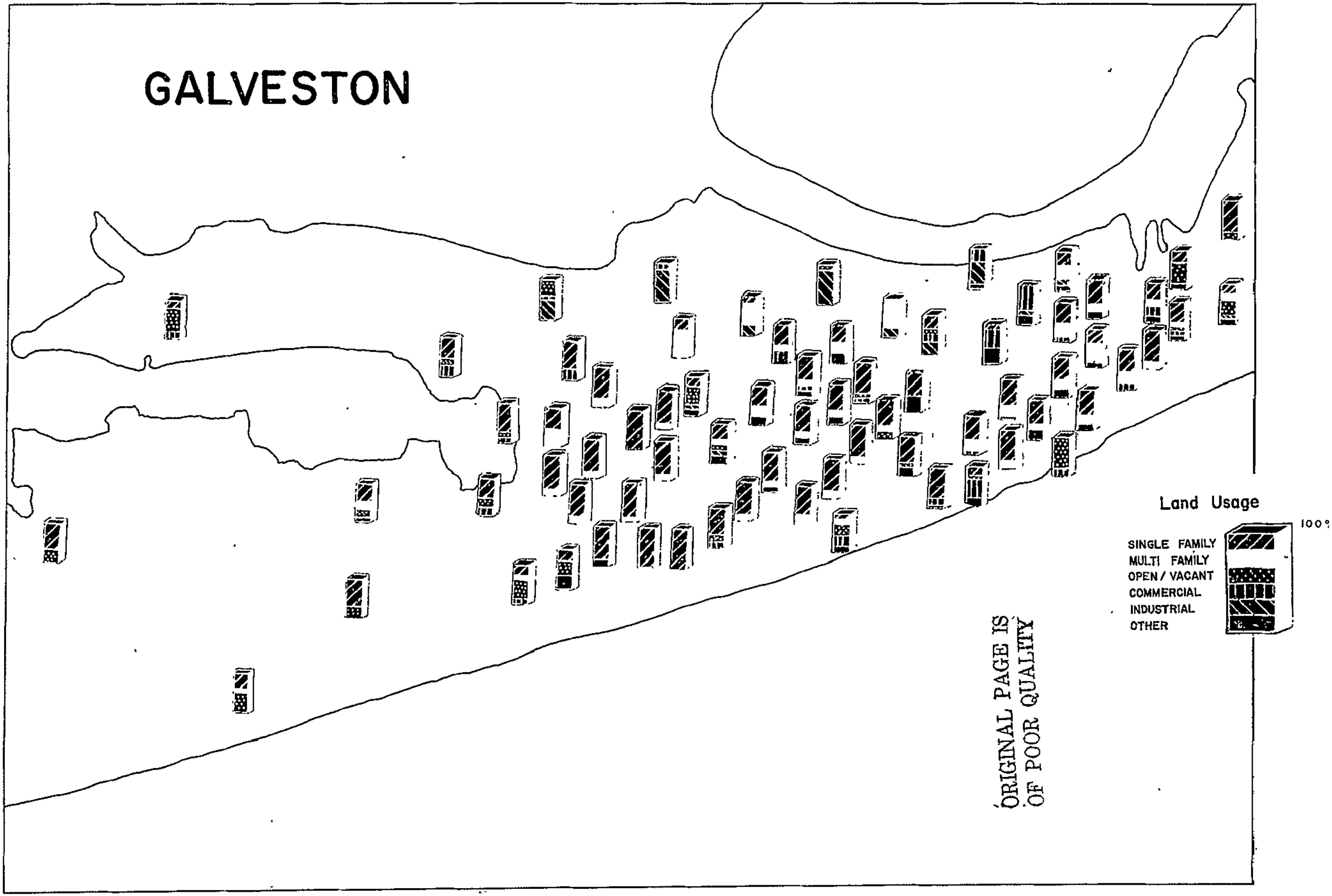
The maximum number of quality points to be obtained are twenty-four (24). Any block with 24 such points could be unequivocably termed "Excellent". The range of points for excellent will fall between 18-24, the range of points for good between 9-17 and the range for poor between 0-8. These ranges will be re-adjusted when all totals are completed.

The land use categories and their codes are given as follows:

Code	Land Use Category
F	Community Facilities
O	Open Space and Recreation
W	Water
S	Streets and Parking Lots
C	Commercial
I	Industrial
V	Vacant and Unimproved
R	Residential
R	Single Family
H	Multi-Family 1-3 Story
A	Multi-Family Over 3 Story

In the land use category "residential" the photo interpreter gave a single figure as the total square footage for residential land use. The sub-categories were indicated by a percentage calculation. These percentages were transferred back into square footage calculations so that the residential land use category may be analyzed both in toto and by sub-categories. The finer screen analysis is intended to determine if any differences do exist between types of residential land use when correlated with disease rates by sub-categories of single family and multi-family uses.

Appendix I gives an example of the analysis form or block scoring sheet used for every block in the image analysis process.


GALVESTON
Land Usage
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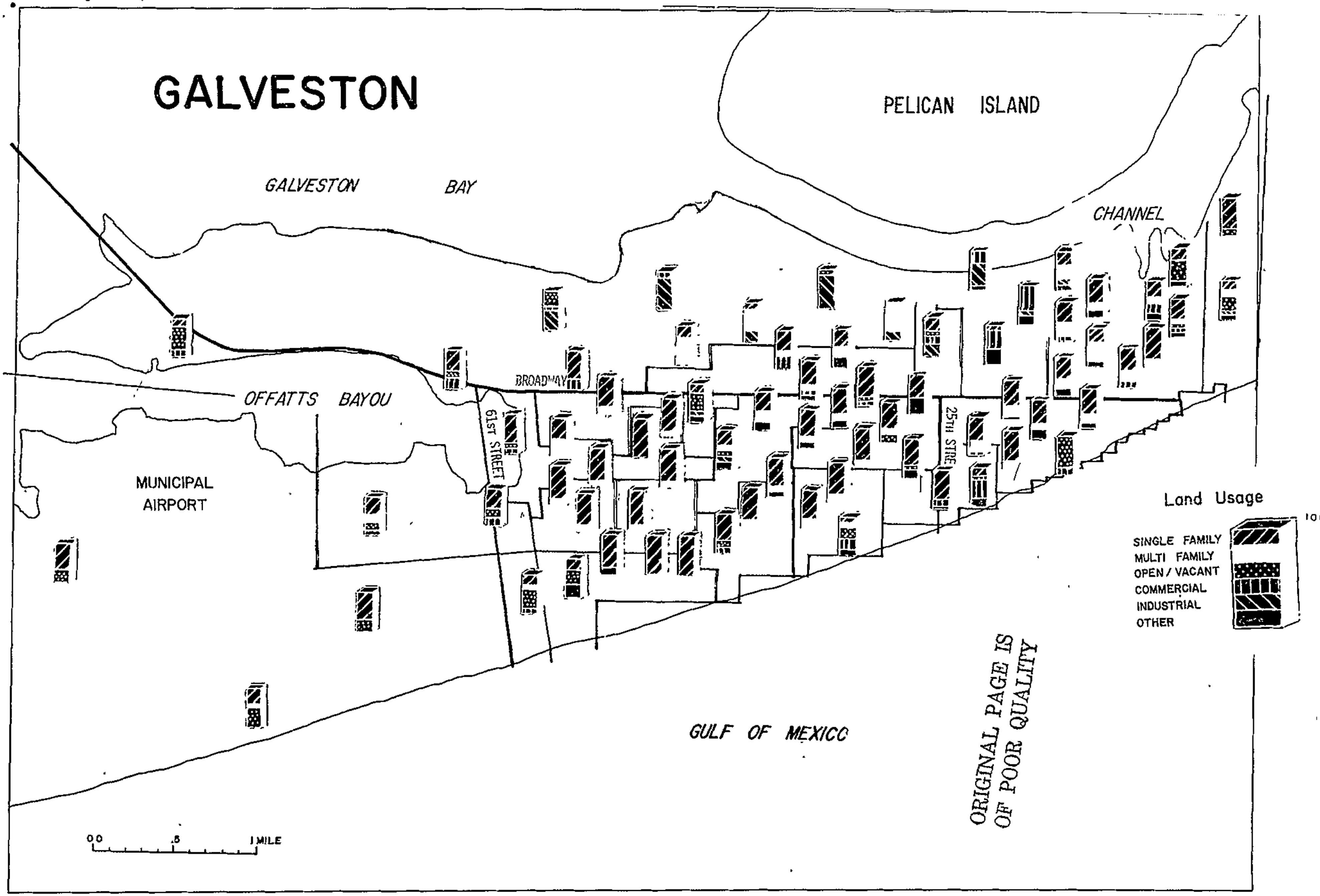
SINGLE FAMILY
MULTI FAMILY
OPEN / VACANT
COMMERCIAL
INDUSTRIAL
OTHER



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CHAPTER III

HEALTH DATA: COLLECTION AND PROCESSING

Changes were made between the Houston Pilot Study and the Galveston Study not only in the categories of land use and residential quality, but also in the health data which was collected. The diseases which have been added to this study are discussed in more detail in the following section. Briefly, those which have been retained from the Houston study are shigella and salmonella, hepatitis and meningitis and tuberculosis. Those which have been added to the Galveston study are venereal disease, and three chronic heart diseases; hypertension, myocardial infarction and cardiac arrest.

Heart Disease Data

Heart disease is the No. 1 cause of death in the United States. Several influences have been isolated in the studies of the etiology of this disease, including heredity, diet, exercise and physical activity, the hardness of water, and stress. Studies which analyze heart disease geographically, or which compare heart disease data for socioeconomic groups, are fewer in number, but in general have reached the tentative conclusion that heart disease is inversely correlated with higher socioeconomic levels in the population. Hypertension, a cause of heart disease, is also thought to be inversely related to socioeconomic status. (See Chapter I for Literature Review.)

In making the decision to gather heart disease data for the Galveston study, two main considerations were decisive. The first is that this kind of study is rarely undertaken because as yet there is no evidence of any environmental associations (other than hard water) with heart disease. Therefore this would be somewhat of an unusual study epidemiologically. The other reason is that heart disease has never been investigated utilizing remote sensing as the methodology for environmental analysis. For both these reasons it was felt that a unique opportunity presented itself to study heart disease and its geographic distribution, especially since this study had the full cooperation of the major hospitals in Galveston and therefore we could be relatively certain that we would obtain the majority of the heart disease cases which occurred in the city in the years 1971-1972.

Sources of Data

The city of Galveston is small enough to enable the researcher to utilize additional sources of data which was not feasible for the Houston project. Specifically, the use of hospital data for some health indices rather than data from the Health Department was judged to be feasible for Galveston, since there are only two major hospitals which serve virtually the entire community. (The third hospital, the Public Health hospital serves mainly transients and military personnel). Access to the records of these hospitals was obtained after several visits by the Research Associate to both John Sealy Hospital and St. Mary's Hospital.

The advantage of using hospital data for some communicable diseases is that sometimes the reporting system between hospital and health department does not operate to insure full reporting of all communicable diseases. In addition, there are some communicable diseases, such as streptococcal infection, which are not reportable and therefore never reach the Health Department. By going to the source, and obtaining discharge records for patients with communicable diseases, it is felt that a much more accurate accounting of disease incidence can be obtained.

Mortality data has been collected for the Galveston study just as for the Houston study and the methodology for both collection and processing will remain substantially the same. All mortality data was collected from the records of the Vital Statistics division of the Galveston City Health Department.

Data on both venereal disease and tuberculosis was also gathered from the Galveston Health Department. Because of the addition of new personnel from the Communicable Disease Center in Atlanta, the reporting and recording of venereal diseases has been greatly improved. This is one of the main factors in the decision to use data on venereal disease as a health outcome.

Recording of tuberculosis has also improved in Galveston in past years. The most complete data was to be found in the City of Galveston Health Department records and these were therefore used as the data source.

All other data on both communicable and chronic disease were gathered from the two hospitals previously mentioned.

It should be noted that inasmuch as these two hospitals serve two basically diverse groups of clientele it was absolutely necessary to utilize both so as to minimize the socioeconomic bias inherent in these two utilization patterns.

Summary of Health Data Collected

In summary then, the following data regarding health indices, were collected for this project.

A. Mortality - all causes - 1971-72

B. Morbidity

1. Tuberculosis 1973
2. Venereal Disease 1971-72
3. Myocardial Infarction 1971-72
4. Cardiac Arrest 1971-72
5. Hypertension 1971-72
6. Meningitis 1968-72
7. Hepatitis 1968-72
8. Salmonella & Shigella 1968-72

Data Gathering

Since the data gathering phase of the Galveston Remote Sensing project has been of a different nature than that of the Houston pilot project, in that most of the disease data was collected directly from the hospitals rather than the City Health Department, it was decided to attempt to calculate the man hours involved in this data gathering phase to be used as a guide to future projects which might be faced with the same data gathering needs and constraints.

As previously stated, the major difficulty with the data gathering for the Galveston project revolved around securing the addresses for each person on the hospital print out records. In addition, because John Sealy Hospital services so many out of town patients, it was necessary to first determine how many names on the print out sheets were Galveston residents. This two fold process of first sorting for Galveston residents and then sorting for addresses, probably account for at least a doubling of the time involved in the data gathering processes.

An approximate tabulation of the total number of visits made to the Health Department, John Sealy Hospital and St. Mary's Hospital in Galveston is given in Table 1. The total man hours accounted for in these visits was 185 man hours or about 23 days. The number of people utilized on these trips varied from six to two, depending upon the assigned location for each trip and the amount of data to be recorded. In other words, there were some trips when all of the six people involved in data gathering went to one place and other trips when the group divided up between the two hospitals.

Preparation for these data gathering trips necessitated several hours of transferring information from the hospital print out sheets to small 3 x 5 cards which could then be easily handled in the address recording process. The 3 x 5 cards were used after it was discovered that the computer sheets upon which we had originally transferred the data were not easily usable in the address sorting procedure. This turned out to be the case because of the variability of location of addresses of each patient, which in some cases had to be looked up in three different locations. The change to the 3 x 5 cards necessitated an additional two weeks of recording the data. An estimate of time spent to transfer this information averaged out to be about 175 cards processed per hour. Since there were about 1500 cases from John Sealy and about 1000 from St. Mary's, this meant that about fifteen hours were spent on this data transferral process. (It should be remembered

TABLE 1

TIME SPENT IN ON-SITE RECORDING OF

MORBIDITY AND MORTALITY DATA

Place	Month	No. of People	Hours Spent	Total Man Hours
Health Dept.	Oct.	5	3	15
Health Dept.	Oct.	3	4	12
Health Dept.	Nov.	2	4	8
John Sealy	Oct.	2	3	6
John Sealy	Nov.	6	4	24
John Sealy	Nov.	4	4	16
John Sealy	Dec.	6	8	48
John Sealy	Dec.	3	8	24
John Sealy	Jan.	3	4	12
St. Mary's	Dec.	3	4	12
St. Mary's	Jan.	2	4	8
				185

Approximate Total Man Hours: 185

Approximate Total Days: 23

that only about half of the John Sealy cards resulted in Galveston residents. The rest were from out-of-city and had to be discarded.) Once all the data was transcribed onto 3 x 5 cards (including name, address, Patient History number, age, sex, and race) this information, excluding name, was then transferred a final time to coding sheets which were then used for keypunching the information. This operation took about the same amount of time as the original transferral from print out sheets to the cards.

Once the basic information was put on the coding sheets, each address had to be put into a census tract block group and block location. Finally, each entry had to be numbered. This process took much longer than had been expected, since the census tract map was consulted for each address and often it took as long as five minutes to locate an address. A street coding guide had been prepared in advance in order to facilitate this particular operation, but there were many addresses which had not been previously located in the guide. Often these addresses had to be verified by calling four sources in Galveston: the Galveston Chamber of Commerce; the United States Post Office Department; the County Surveyor; and, the City of Galveston Engineer.

The time period involved in recording all of these census tracts and block group locations was approximately eight weeks. Four people worked on this part of the project at various times during those eight weeks. Estimated man hours required for the approximately 3500 address identification units were 35 hours, since it took about one hour to locate about 100 addresses. (These 3500 addresses included cases recorded at City of Galveston Health Department as well as the two hospitals.) Table 2 summarizes total man hours spent on gathering and processing disease data.

Finally, all of the data had to be keypunched on IBM cards. This process also occupied the better part of the eight week period. As soon as one disease group was fully completed with census tract and block group recorded, the information was given to the keypunch operator. Since the operator had other projects to work on besides this one, a week's lead time was necessary for each group of disease data. By the 10th week, all the data except hepatitis and meningitis, shigella/salmonella had been keypunched. Duplicate decks were made for each set of disease, dated and stored. At this point, the data was ready to be transferred into incidence and prevalence rates. Table 3 gives total number of mortality and morbidity cases collected for Galveston.

Calculation of Rates: Mortality and Morbidity

The calculation of a mortality or morbidity rate involves two principal components; a numerator and a denominator. The numerator is always the total number of cases of the disease being investigated, or the total number of deaths, or the total number of a particular cause of death, and so forth.

The denominator of a rate is always a population at risk (PAR) within a particular geographic area. When two cities or SMSA's are being compared the denominator is often an adjusted population known as the "standard million", based on a standardized United States population (as of the last census) which is adjusted for age and sex. When a smaller geographic area is being investigated, such as areas

TABLE 2

SUMMARY OF TOTAL HOURS SPENT IN RECORDING

AND IDENTIFYING DISEASE DATA

Month	Total Hours for Basic Data Gathering in Galveston	Total Hours Converting Data to 3 x 5 Cards	Total Hours Transferring Data to Coding Sheets	Total Hours Locating Census Tracts and Block Groups	Total Hours Allowed for Key Punching
October	23	0	0	0	0
November	48	15	5	0	0
December	84	0	10	20	0
January	20	0	5	10	24
February	0	0	0	5	24
March	0	0	0	0	8
TOTAL	175	15	20	35	56

TABLE 3

TOTAL NUMBER GALVESTON CITY ADDRESSES RECORDED FOR MORTALITY AND MORBIDITY*

Mortality 1971-1972	1200
Tuberculosis 1973	300
Venereal Disease 1972	830
Myocardial Infarction 1971-1972	360
Cardiac Arrest 1971-1972	200
Hypertension 1971-1972	540
Meningitis 1968-1972	85
Hepatitis 1968-1972	110
Shigella and Salmonella 1968-1972	90
TOTAL	3715

*Venereal Disease includes both syphilis and gonorrhea. Tuberculosis includes active and arrested cases. Hypertension includes primary hypertension only. Meningitis includes meningococcal and asceptic strains. Hepatitis includes all strains except serum hepatitis.

of a city or SMSA, the denominator is usually a standardized population for that particular city.

Mortality Rates

A crude death rate for a given community is usually computed on a residence basis and is quoted as deaths per 1000 population per year. It is important to differentiate between deaths by place of occurrence and deaths by residence, especially for a city like Galveston where the number of deaths by place of occurrence was almost double those by residence for the years 1971 and 1972. This happened because the John Sealy Hospital in Galveston serves a very large out-of-city population.

There are two major disadvantages of a crude death rate. The first is that it oversummarizes the complex patterns of rates which therefore results in loss of information. In other words, by using a gross figure, population differences such as age or sex are screened out. The second disadvantage is the lack of comparability for any two communities (or even two census tracts within a community) inasmuch as we know that no two cities are alike in population composition. The crude rate masks these dissimilarities, so that two cities with two different populations do not then lend themselves to comparison.

A crude death rate is composed of a numerator which is the total number of deaths for a particular area for a specific year and a denominator which is the total population of that area, for that same year, without adjustment for age and sex. In the case of Galveston, the crude rate would be

$$\frac{\text{total deaths in 1972}}{\text{total population in 1972}} \text{ or } \frac{580}{63{,}528} \times 1000 = 9.12 \text{ per thousand.}$$

A crude death rate is useful however only for comparison purposes with a standardized rate or an expected rate. Standardized and age-specific rates are calculated to adjust for age and sex. The age specific rate is calculated by taking all deaths for a specific age group for one year as the numerator, with the denominator as the total number of persons in that age group in the general population for the same year.

An age-specific rate is usually calculated at the city or SMSA level. However, in the case of Galveston, it has been calculated by census tract and block group. Appendix II gives the age specific death rates by these geographic units. They are not adjusted for sex differences at the block group level since the numbers in the numerator become too small to yield a meaningful rate when observed at this scale. It is to be remembered that the population of a block group averages only about 700 or 800 people.

A cause specific death rate uses as the numerator the number of cases of a specific disease in a given year, and as the denominator the total population in that same given year. A proportional mortality rate (PMR) is a simple statement of the proportion of all deaths which were assigned to one specific cause. In this case, the numerator does not change, but the denominator becomes the total number of deaths in a given year, rather than the total population.

An expected rate is calculated using as a numerator the total number of deaths by age and sex for a particular year at the national, state or local level, depending upon the level of comparison which is needed. The denominator is the population by age and sex for the same calendar year for the same geographic area. In the case of Galveston, an expected rate for each block group was calculated using as numerator the total deaths by age group of the Galveston SMSA in 1970.

When measured against the observed rate, a standardized mortality ratio (SMR) results. The differences between the actual death rate for each block group, and the expected death rate for each block group, are instructive in that they provide an indication that intervening variables other than age and sex may account for whatever differences are revealed. In the case of the Galveston study, (as in the case of the Houston study) these intervening variables may be environmental, or they may emanate from differences in socio-economic status. The computer analysis of the data in the final stage of the project will provide the researcher with the opportunity to perhaps explain some of the possible reasons which could account for these differences.

Morbidity Rates

The same principles involved in calculating mortality rates are operative in the calculation of morbidity rates. However, whereas a mortality rate is almost always an incidence rate, morbidity rates can be either incidence or prevalence rates. The difference between these two rates is one of time period. A prevalence rate is composed of all cases of a disease occurring at a specific point in time. The denominator is the population at risk for that same point in time. A prevalence rate reveals the extent of a disease at a cross section of time. It does not indicate when each disease began or ended, but only how many cases of that disease existed at that specific point in time.

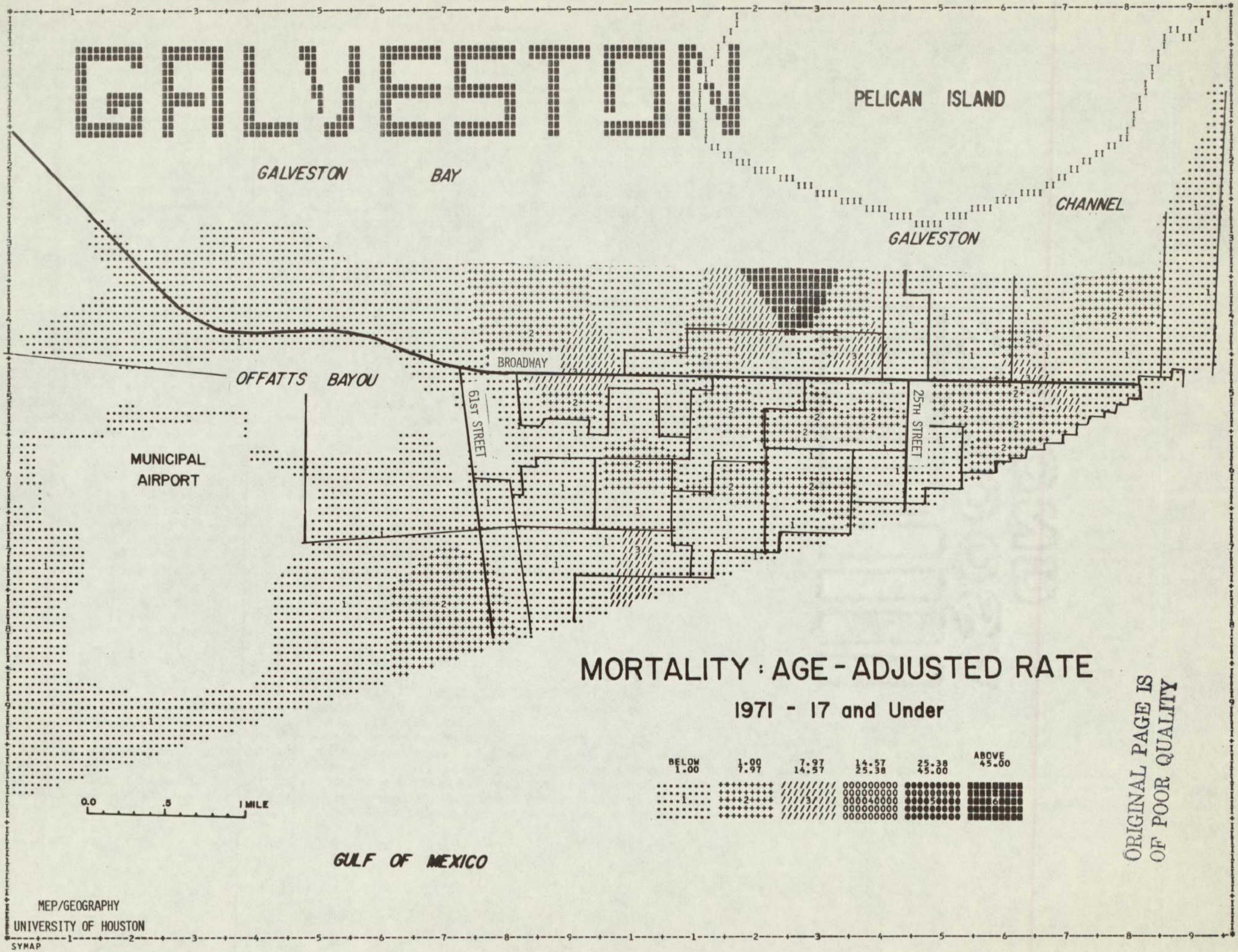
An incidence rate measures the extent of new cases of a disease over a specified time span, generally that of a 12 month period but sometimes for a two, three or six year period. It measures all cases of a disease which began in that time period; in other words, all new cases of a disease for that period. The denominator usually is given as the midyear population.

Prevalence rates are generally used for chronic diseases, since chronic diseases are of a lingering nature. Prevalence rates are well suited in revealing the existence of tuberculosis since this is a com-comunicable disease which is of a long term nature. Incidence rates are more ideally suited to diseases which are more short-lived. However, both incidence and prevalence rates can be calculated for both chronic and short-lived communicable diseases, depending upon the nature of the data, the manner in which it was collected, and the intent of the investigator.

Appendix III and IV give both incidence and prevalence of venereal disease and tuberculosis respectively. It should be noted that these rates are not adjusted for age and sex, again because of the limited amount of data available at the block group level. In other words the number of cases occurring at the block group level do not allow for a finer break-down in either numerator or denominator. Too many blanks or gaps in the data would result. The rates as given will be those used in the future computer analysis.

There are some extreme rates in both sets of data. For instance TB prevalence rate for census tract 1237, block group 1, and for census tract 1249, block group 2, are both over 40 per 1000, contrasted to a range of from 1 to 10 for most of the other block groups. The PAR or population at risk, in both of these block groups, which is the denominator, is very small. Therefore, while the number of actual cases of tuberculosis may be only a little larger than the other block groups, the small size of the denominator produces a much higher rate. This is shown by contrasting block groups 2 and 3 in census tract 1249. Block group 2 has a population of 1,176. The number of cases in these two block groups differs by only one case (12 cases in block group 2 and 13 cases in block group 3). However, the extreme differences in population produces a prevalence rate four times higher in one block group than the other.

If one looks at the actual geographic placement of disease prevalence in these two block groups, by block, it will be noted that 11 of the 13 cases in Block Group 3 existed in one particular public housing project, so that perhaps an even finer breakdown by census block should be undertaken in cases such as this. In Block Group 2 however, the cases of tuberculosis were rather evenly distributed over four blocks in the block group so that a different picture emerges. It would be ideal to go into a finer grain analysis such as this, but a decision has to be made as to which geographic entity is the most suitable at the city scale and if the block level were used citywide there would again be gaps in the data for all of the city blocks where no disease of any kind occurred. In the final analysis of the data, idiosyncrasies of this sort will be taken into account, with attempts at explanation which hopefully will allow for concentrated distributions such as that in block 302 of census tract 1249.



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GALVESTON
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OFFATTS BAYOU
61ST STREET
25TH STREET
MUNICIPAL AIRPORT
MORTALITY : AGE-ADJUSTED RATE
1971 - 17 and Under
BELOW 1.00
1.00 7.97
7.97 14.57
14.57 25.38
25.38 45.00
ABOVE 45.00
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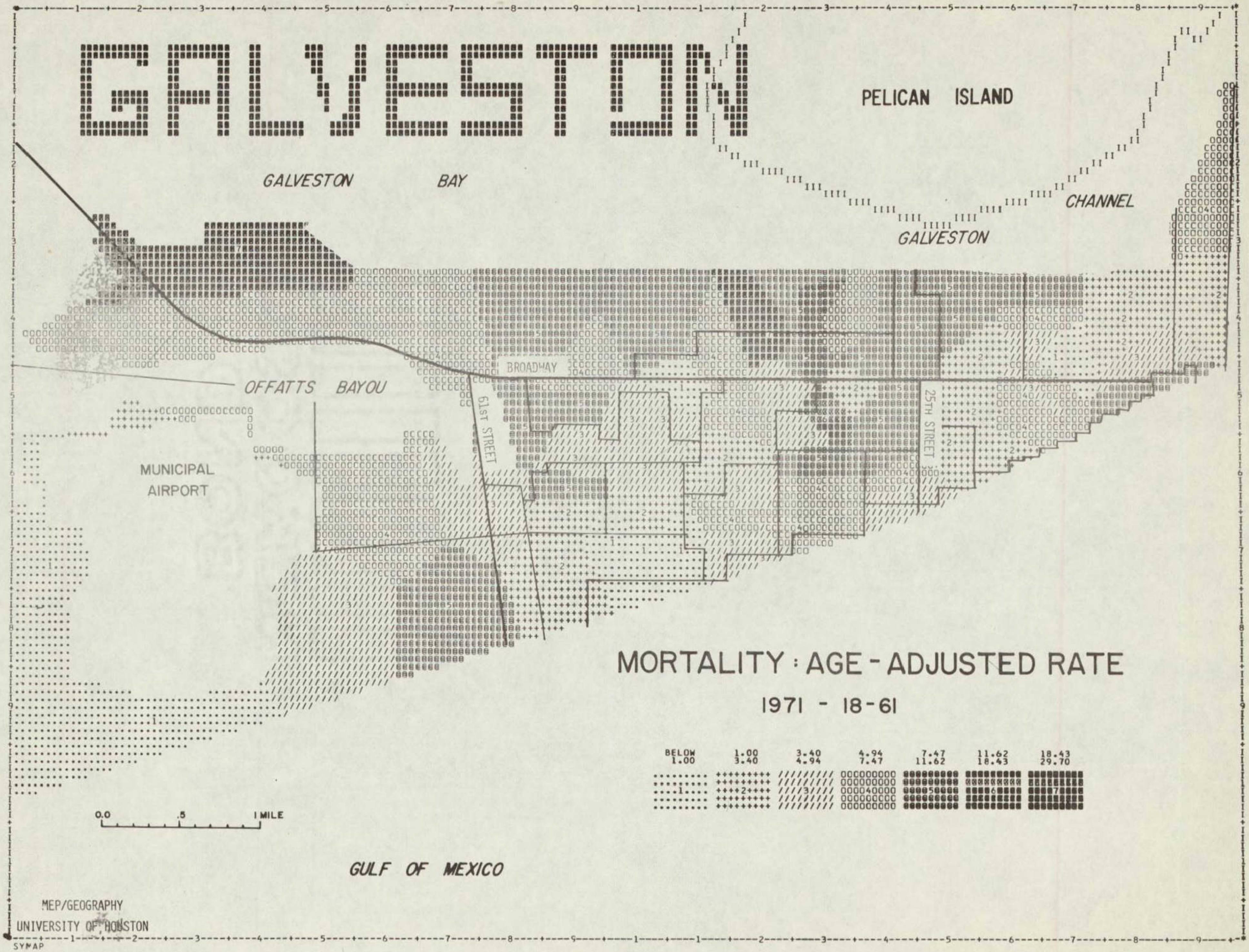
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MORTALITY : AGE - ADJUSTED RATE
1971 - 18-61
BELOW 1.00
1.00 3.40
3.40 4.94
4.94 7.47
7.47 11.62
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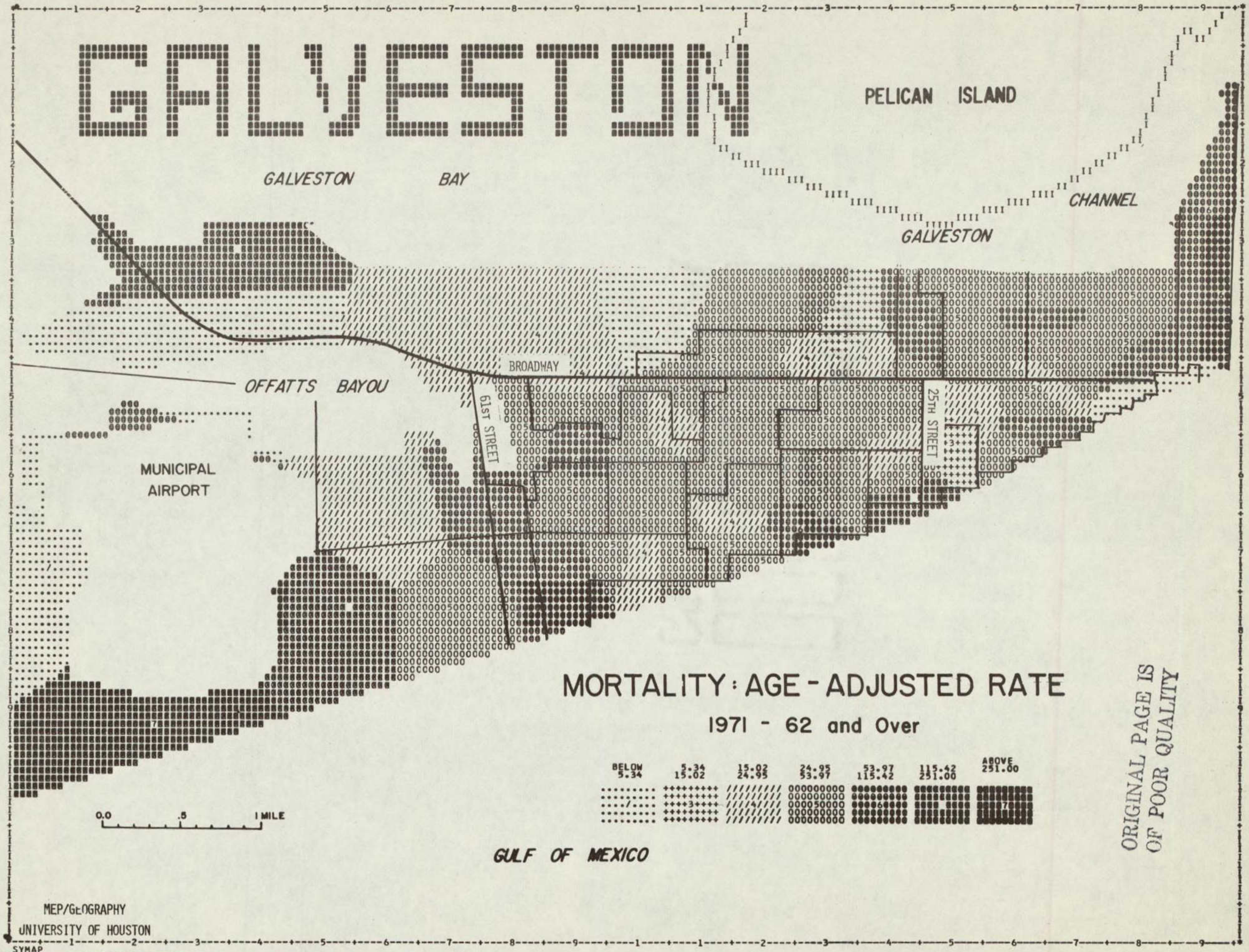

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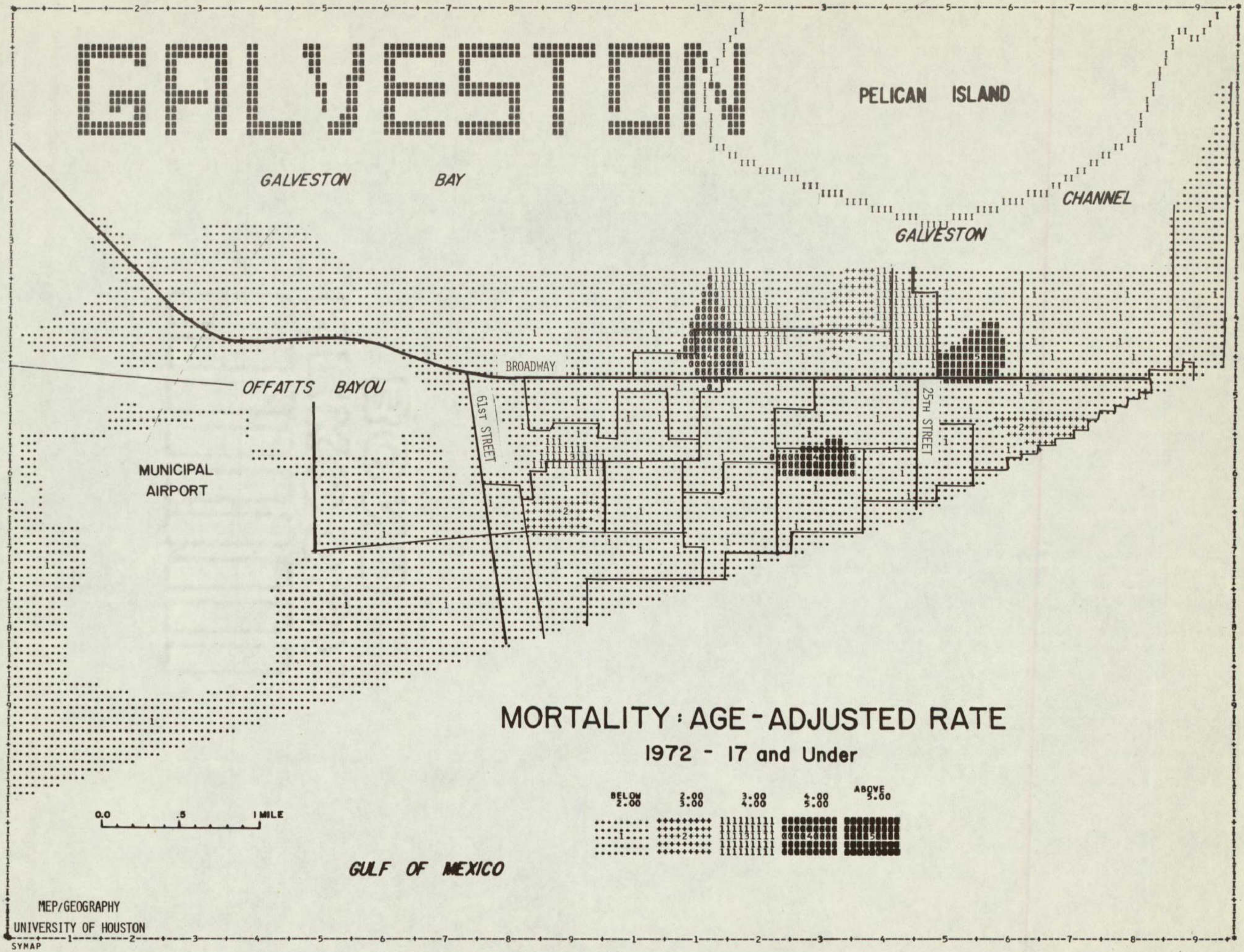
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25TH STREET
MUNICIPAL AIRPORT
MORTALITY : AGE - ADJUSTED RATE
1972 - 17 and Under
BELOW 2.00
2.00 3.00
3.00 4.00
4.00 5.00
ABOVE 5.00
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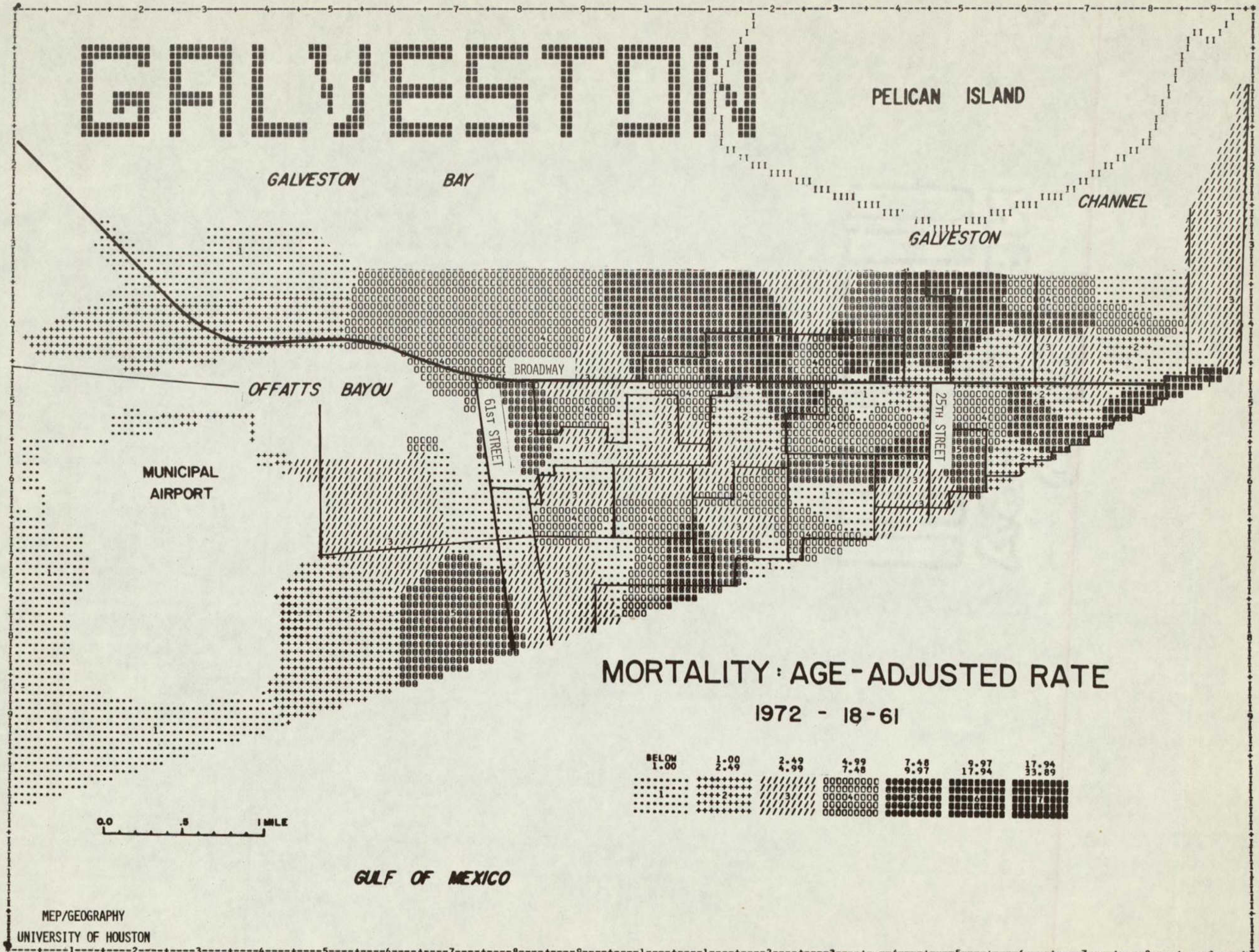
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25TH STREET
MUNICIPAL AIRPORT
MORTALITY: AGE-ADJUSTED RATE
1972 - 18-61
BELOW 1.00
1.00 2.49
2.49 4.99
4.99 7.48
7.48 9.97
9.97 17.94
17.94 33.89
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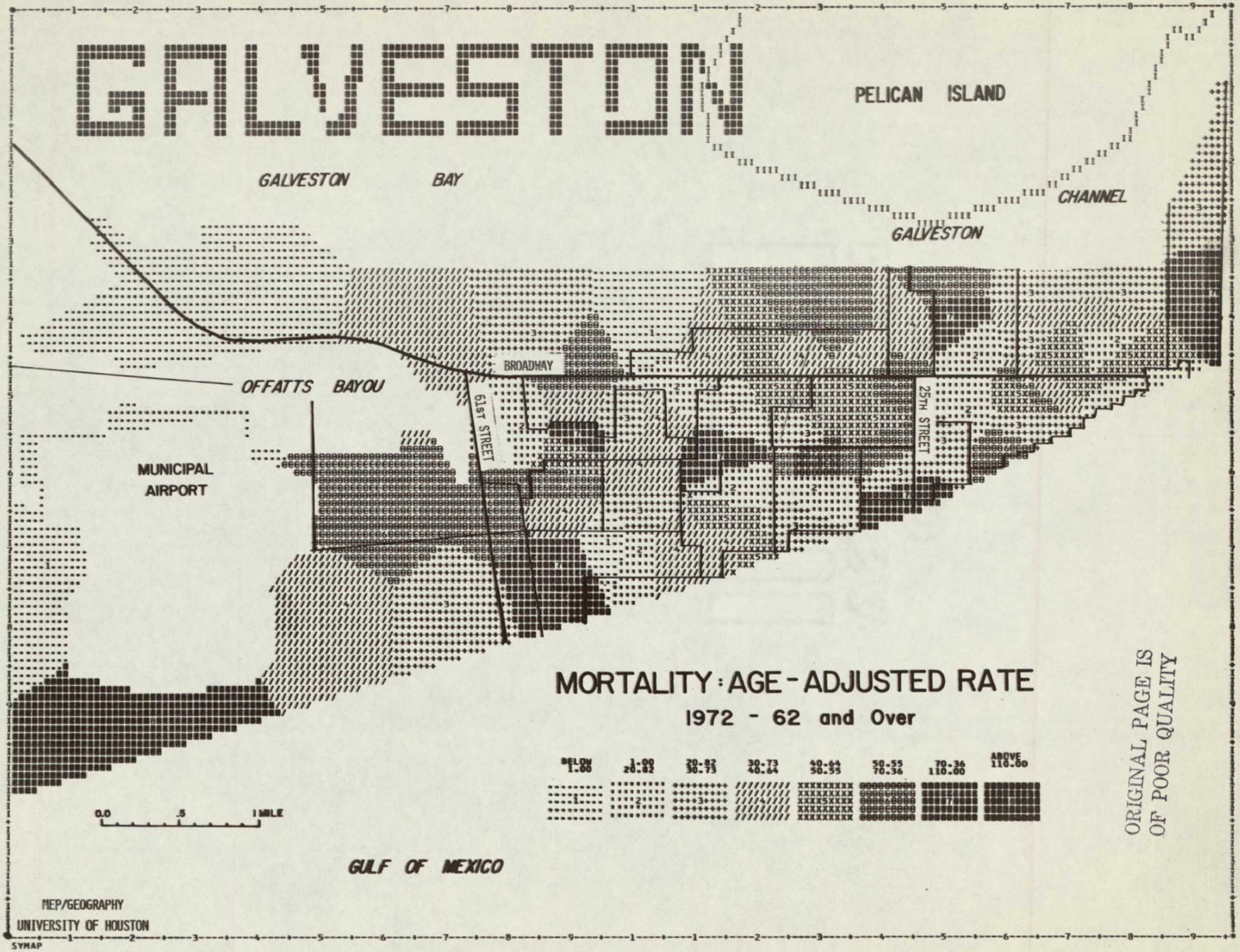

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GALVESTON CHANNEL
BROADWAY
OFFATTS BAYOU
61st STREET
25TH STREET
MUNICIPAL AIRPORT
MORTALITY : AGE - ADJUSTED RATE
1972 - 62 and Over
BELOW 1.00
1.00 20.82
20.82 30.73
30.73 40.64
40.64 50.55
50.55 70.36
70.36 110.00
ABOVE 110.00
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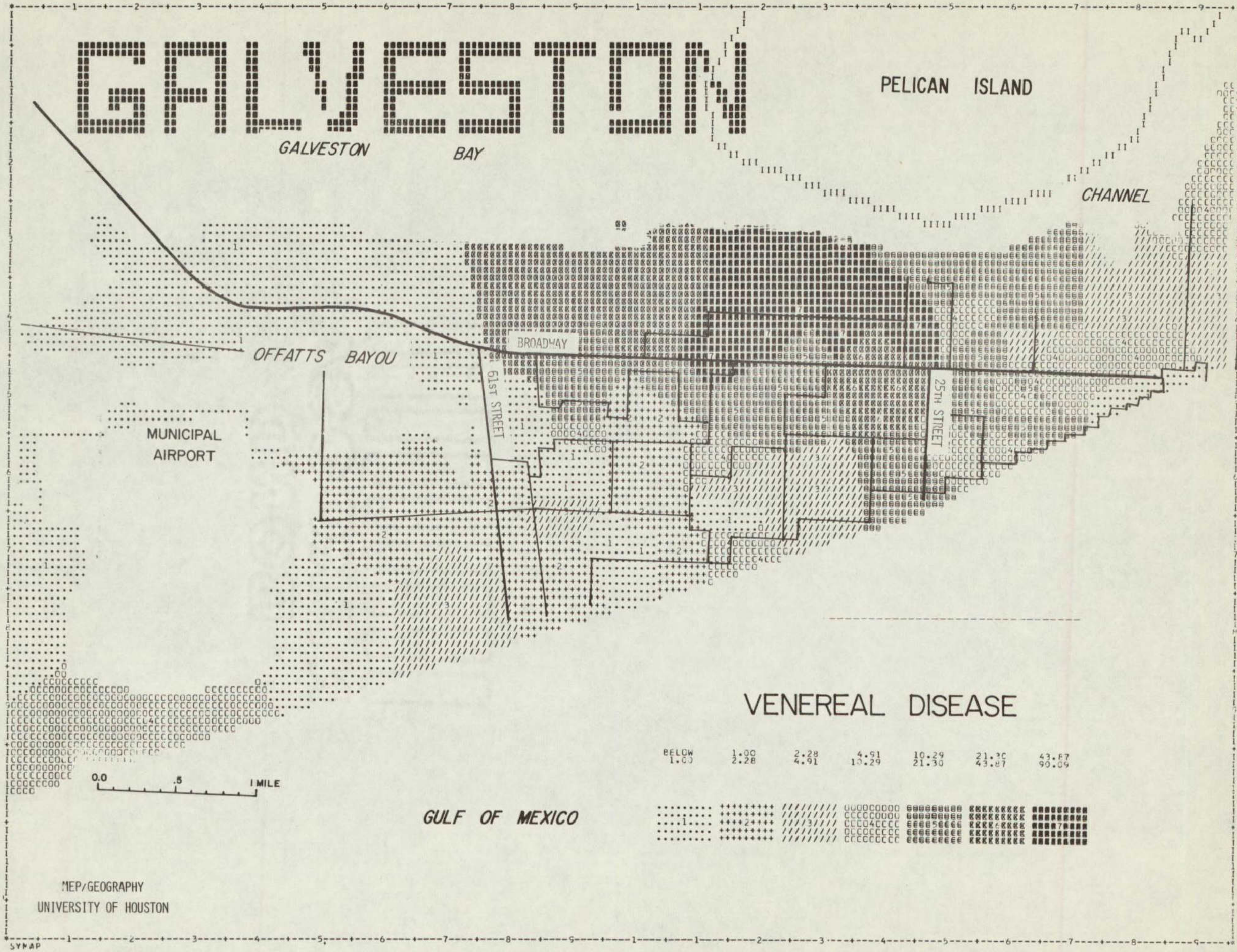

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CHANNEL
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BROADWAY
61ST STREET
25TH STREET
MUNICIPAL AIRPORT
VENEREAL DISEASE
BELOW 1.00
1.00 2.28
2.28 4.91
4.91 10.29
10.29 21.30
21.30 43.87
43.87 90.09
0.0 .5 1 MILE
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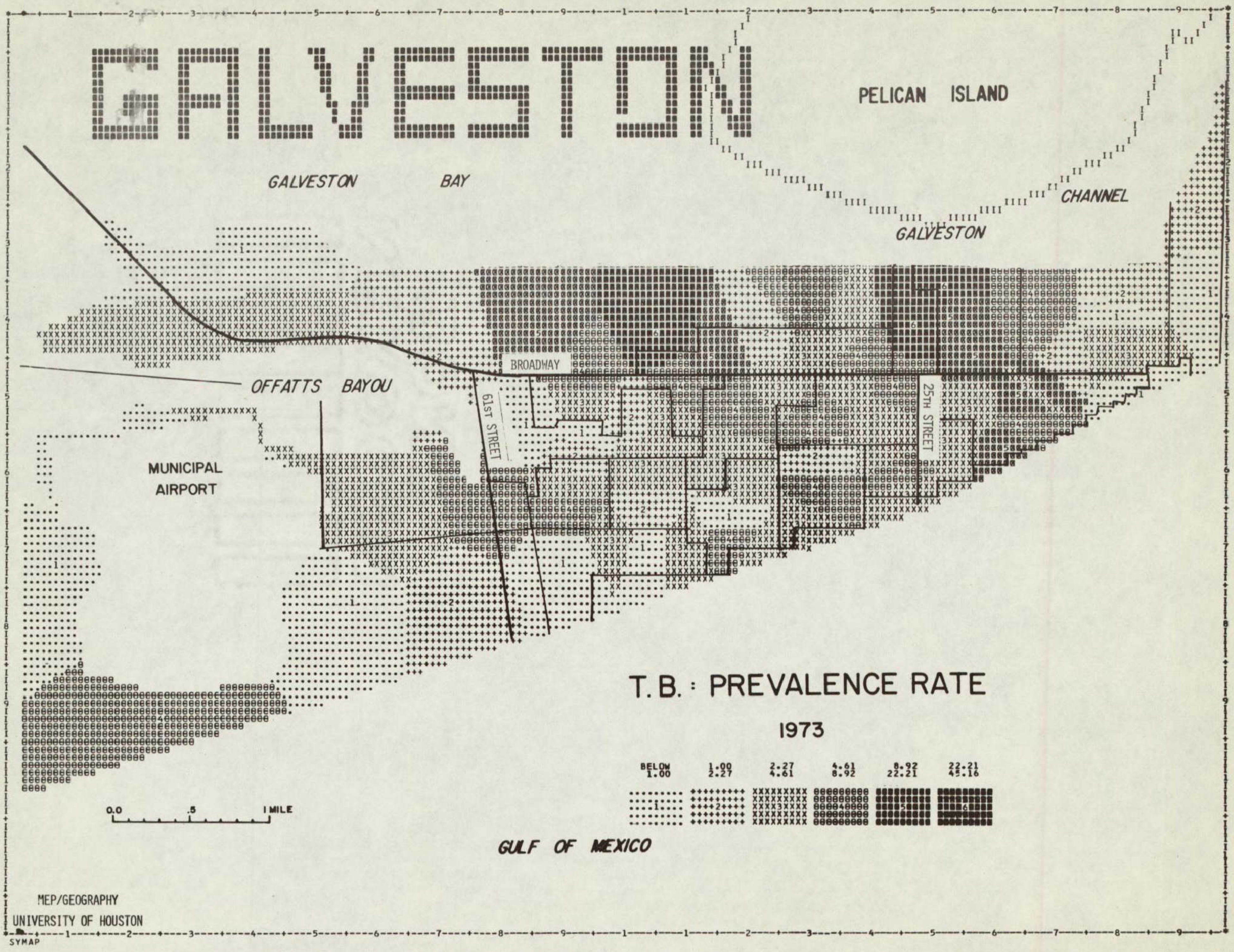
MEP/GEOGRAPHY
UNIVERSITY OF HOUSTON
SYMAP



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CHANNEL
GALVESTON
BROADWAY
OFFATTS BAYOU
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25TH STREET
MUNICIPAL AIRPORT
T.B. : PREVALENCE RATE
1973
BELOW 1.00
1.00 2.27
2.27 4.61
4.61 8.92
8.92 22.21
22.21 45.16
0.0 .5 1 MILE
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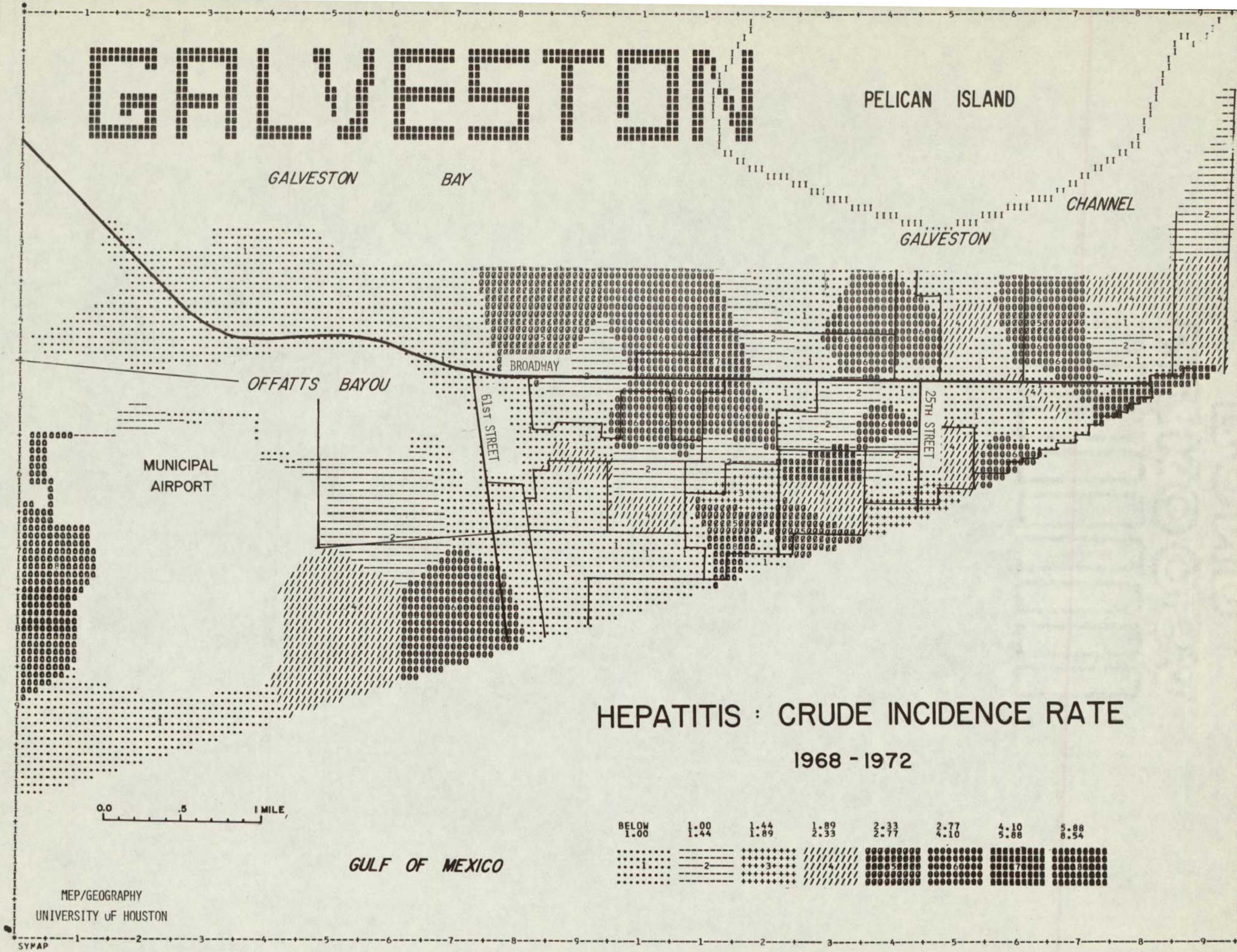
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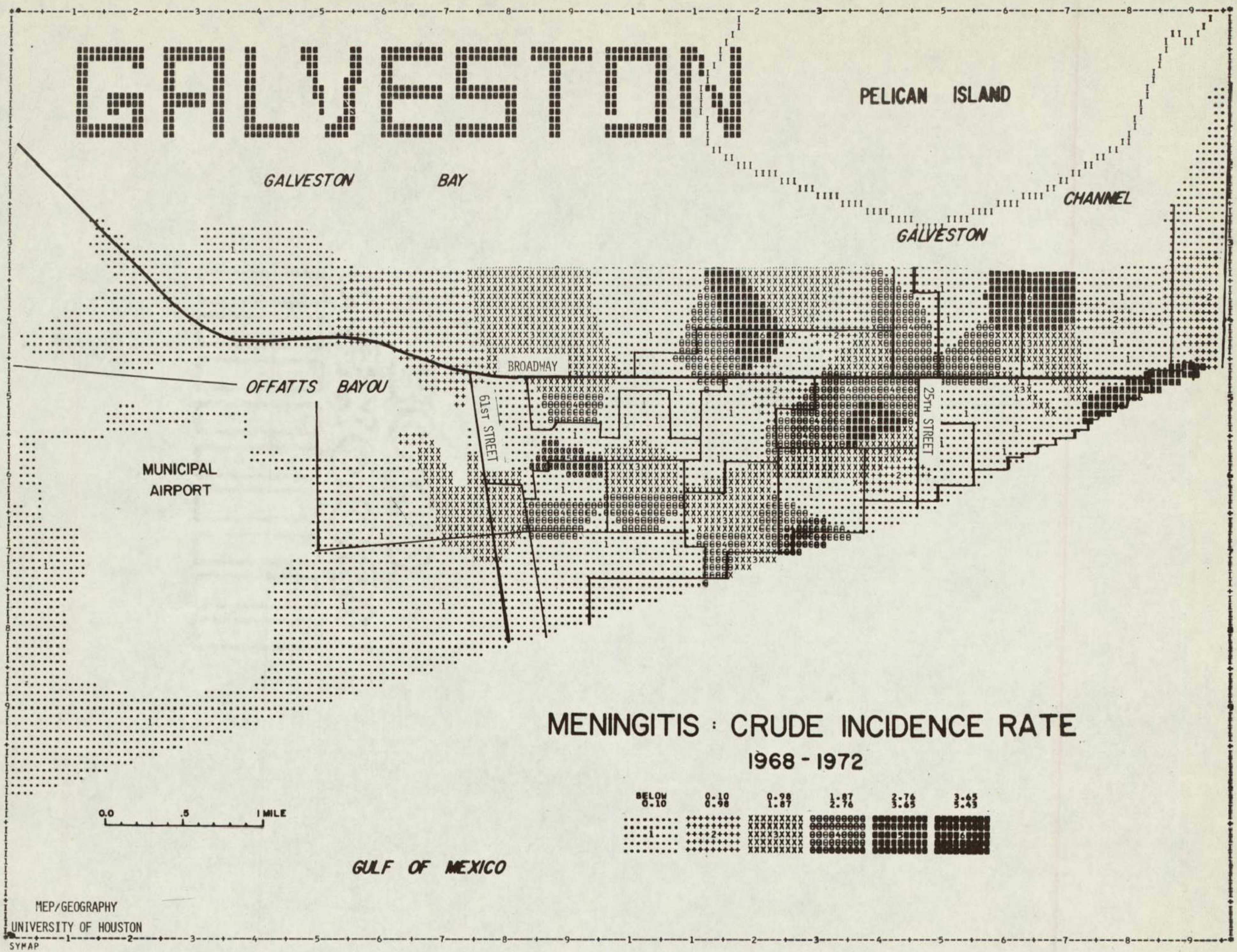
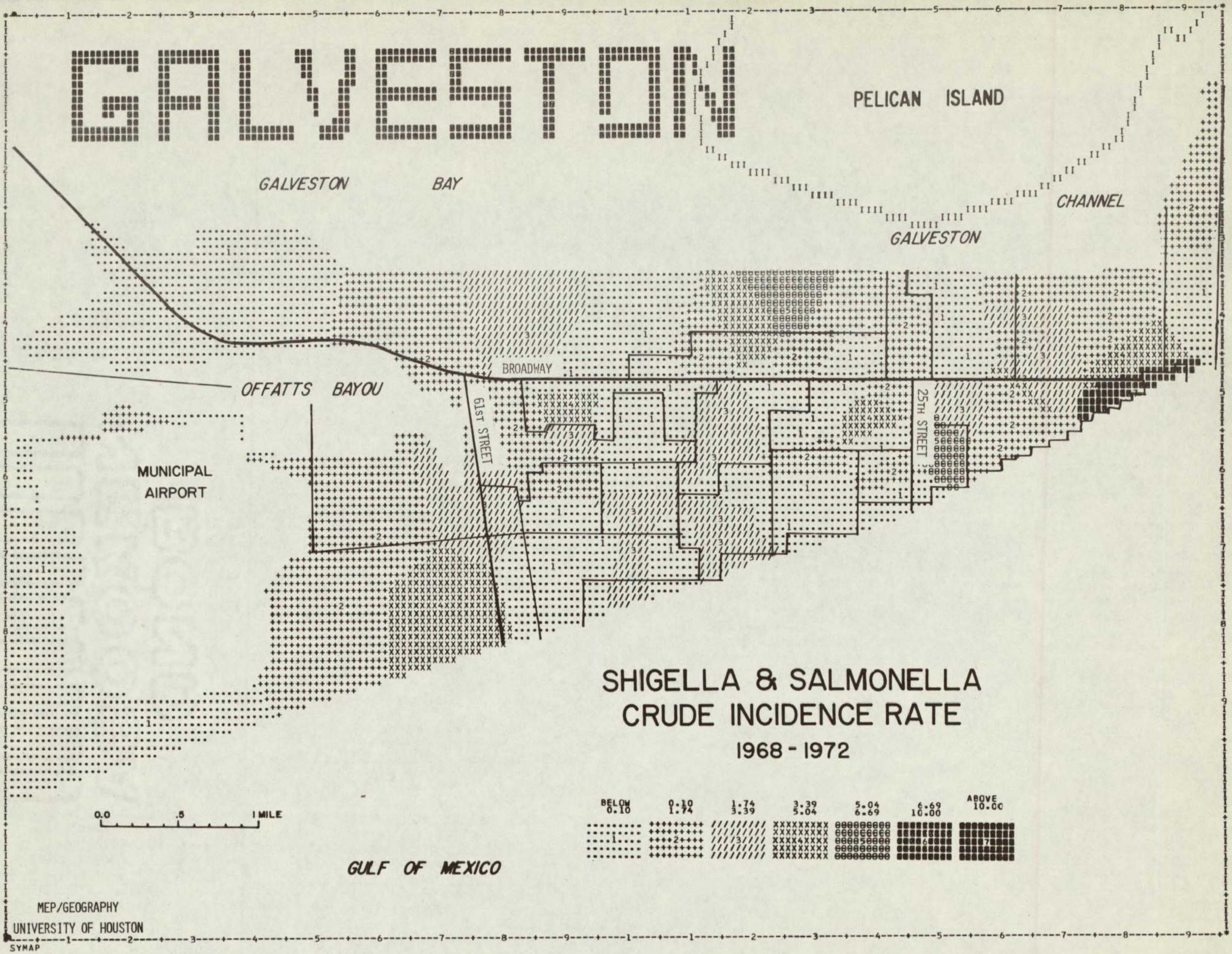
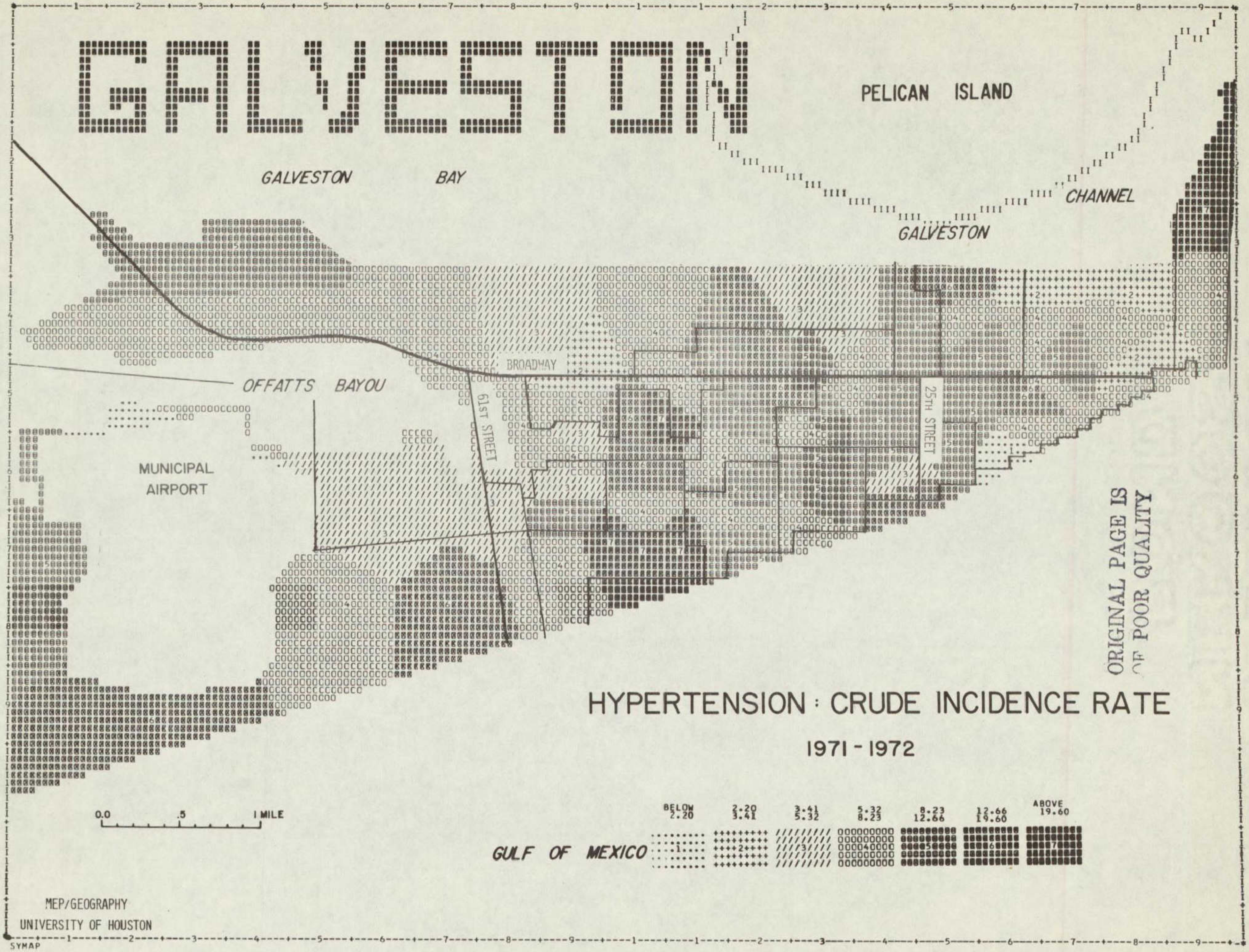
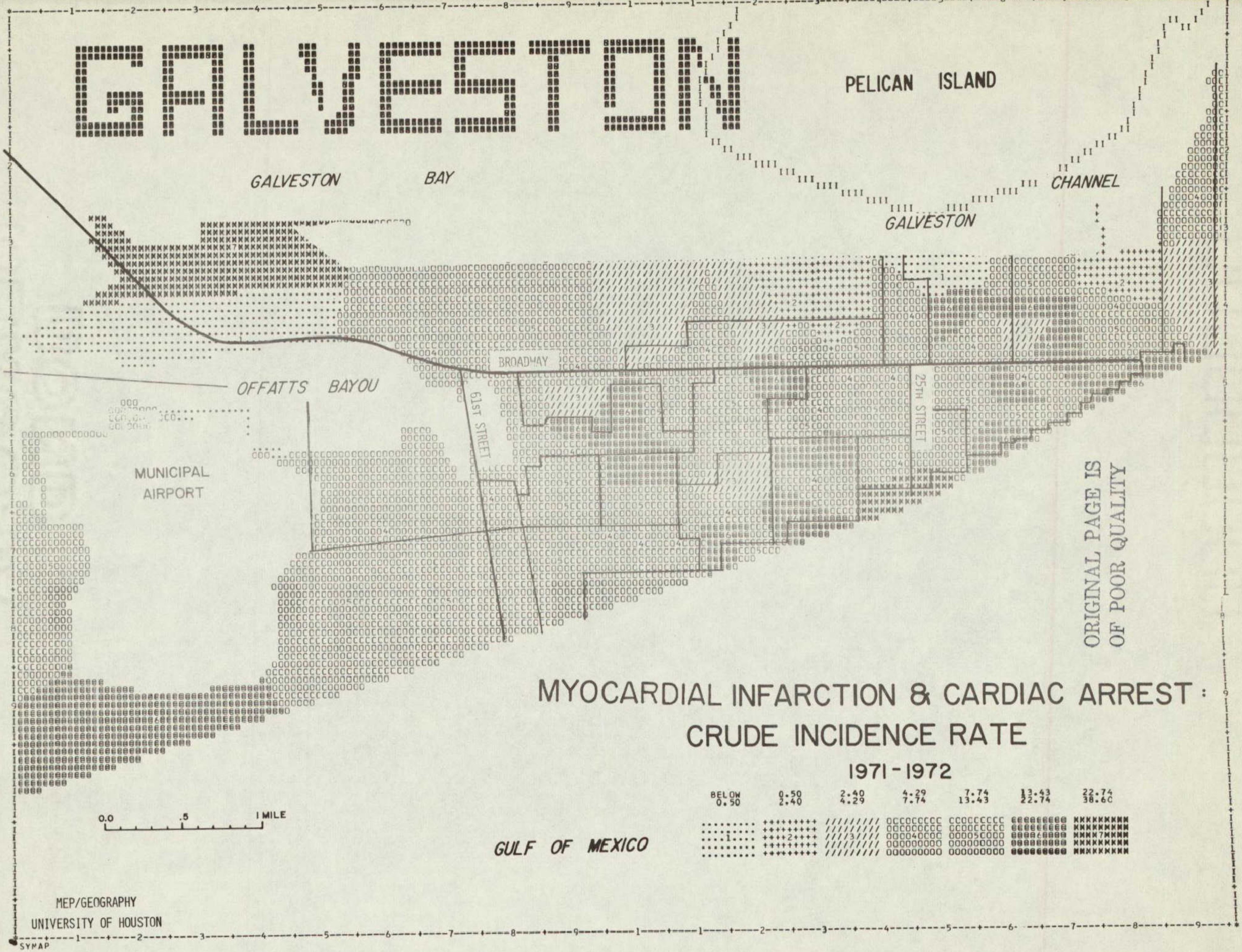
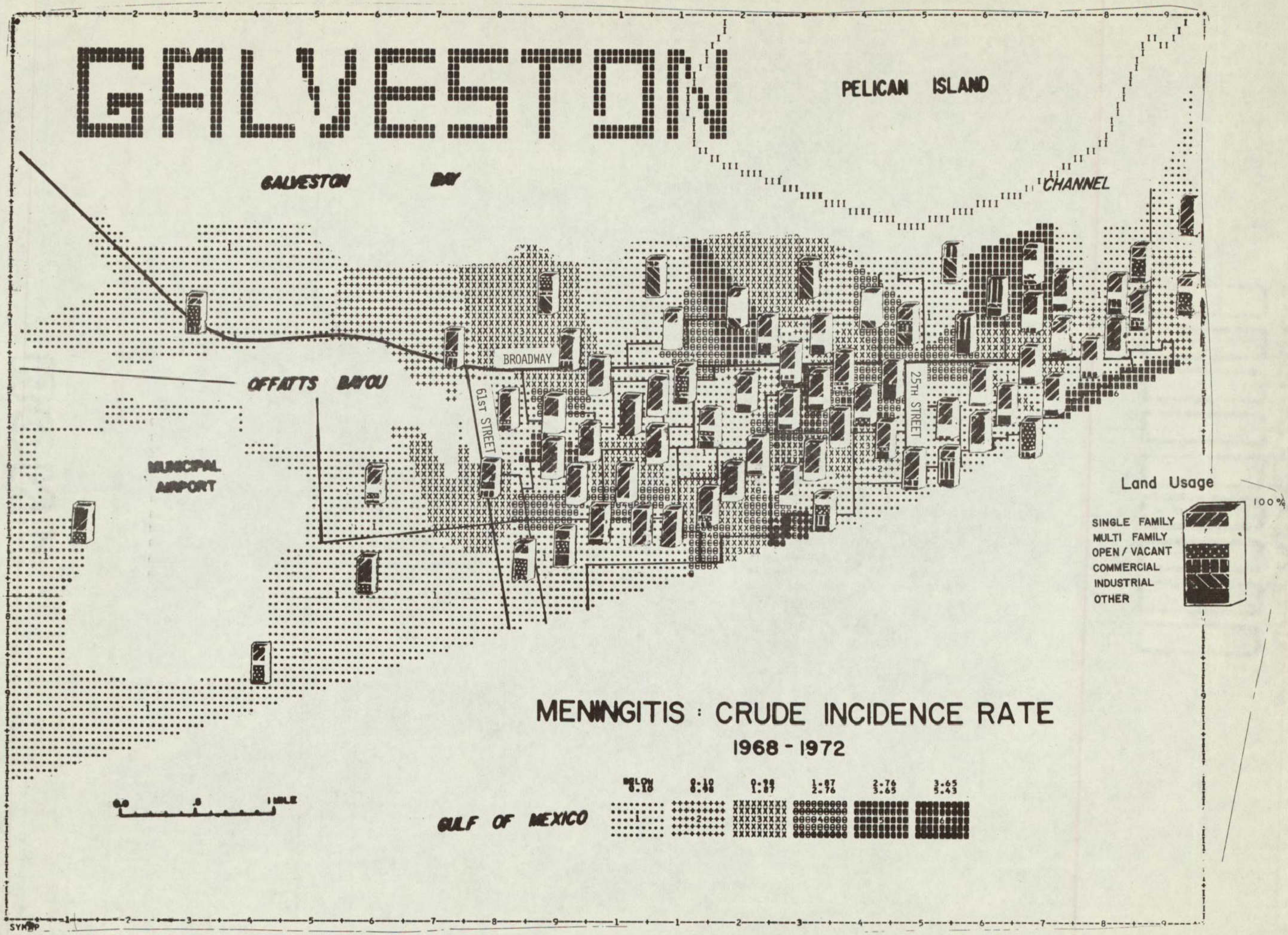
BROADWAY
61ST STREET
25TH STREET
MUNICIPAL AIRPORT
HEPATITIS : CRUDE INCIDENCE RATE
1968 - 1972
0.0 .5 1 MILE
GULF OF MEXICO
BELOW 1.00
1.00 1.44
1.44 1.89
1.89 2.33
2.33 2.77
2.77 4.10
4.10 5.88
5.88 8.54
MEP/GEOGRAPHY
UNIVERSITY OF HOUSTON
SYMAP

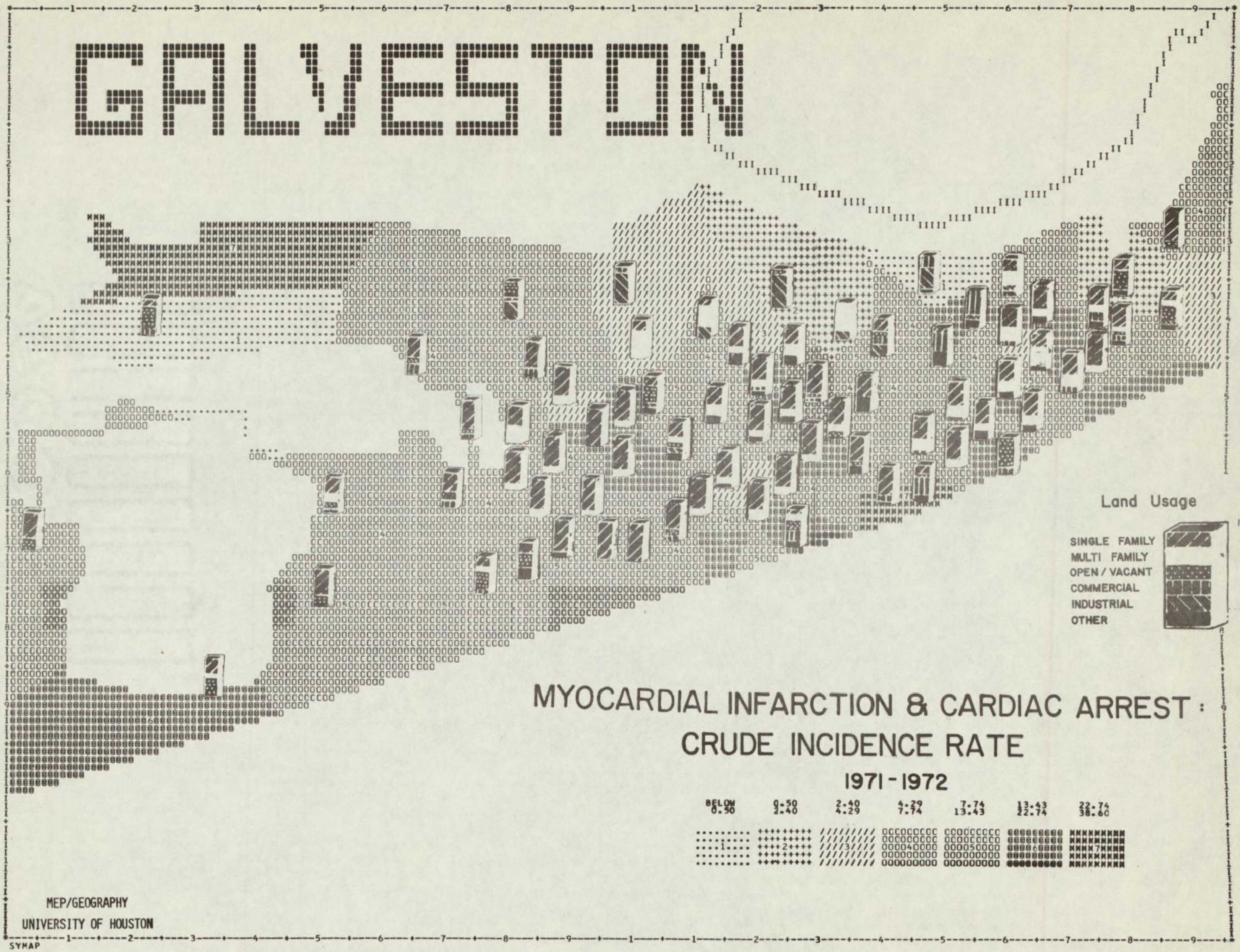

GALVESTON
PELICAN ISLAND
GALVESTON BAY
CHANNEL
GALVESTON
BROADWAY
OFFATTS BAYOU
61st STREET
25TH STREET
MUNICIPAL AIRPORT
MENINGITIS : CRUDE INCIDENCE RATE
1968 - 1972
BELOW 0.10
0.10 0.98
0.98 1.87
1.87 2.76
2.76 3.65
3.65 5.43
0.0 .5 1 MILE
GULF OF MEXICO
MEP/GEOGRAPHY
UNIVERSITY OF HOUSTON
SYMAP


GALVESTON
PELICAN ISLAND
GALVESTON BAY
CHANNEL
GALVESTON
BROADWAY
OFFATTS BAYOU
61ST STREET
25TH STREET
MUNICIPAL AIRPORT
SHIGELLA & SALMONELLA
CRUDE INCIDENCE RATE
1968 - 1972
BELOW 0.10
0.10 1.74
1.74 3.39
3.39 5.04
5.04 6.69
6.69 10.00
ABOVE 10.00
0.0
.5
1 MILE
GULF OF MEXICO
MEP/GEOGRAPHY
UNIVERSITY OF HOUSTON
SYMAP


GALVESTON
PELICAN ISLAND
GALVESTON BAY
GALVESTON CHANNEL
OFFATTS BAYOU
BROADWAY
61st STREET
25TH STREET
MUNICIPAL AIRPORT
HYPERTENSION : CRUDE INCIDENCE RATE
1971 - 1972
0.0 .5 1 MILE
BELOW 2.20
2.20 3.41
3.41 5.32
5.32 8.23
8.23 12.66
12.66 19.60
ABOVE 19.60
GULF OF MEXICO
MEP/GEOGRAPHY
UNIVERSITY OF HOUSTON
SYMAP


GALVESTON
PELICAN ISLAND
GALVESTON BAY
CHANNEL
GALVESTON
BROADWAY
OFFATTS BAYOU
61ST STREET
25TH STREET
MUNICIPAL AIRPORT
MYOCARDIAL INFARCTION & CARDIAC ARREST:
CRUDE INCIDENCE RATE
1971-1972
BELOW 0.50
0.50 2.40
2.40 4.29
4.29 7.74
7.74 13.43
13.43 22.74
22.74 38.6C
0.0 .5 1 MILE
GULF OF MEXICO
MEP/GEOGRAPHY
UNIVERSITY OF HOUSTON
SYMAP


GALVESTON
PELICAN ISLAND
GALVESTON BAY
CHANNEL
BROADWAY
OFFATTS BAYOU
61st STREET
25TH STREET
MUNICIPAL AIRPORT
Land Usage
100%
SINGLE FAMILY
MULTI FAMILY
OPEN / VACANT
COMMERCIAL
INDUSTRIAL
OTHER
MENINGITIS : CRUDE INCIDENCE RATE
1968 - 1972
BELOW 0.10
0.10 0.98
0.98 1.87
1.87 2.76
2.76 3.65
3.65 5.43
0.0 .5 1 MILE
GULF OF MEXICO
SYMAP


GALVESTON
Land Usage
100%
SINGLE FAMILY
MULTI FAMILY
OPEN / VACANT
COMMERCIAL
INDUSTRIAL
OTHER
MYOCARDIAL INFARCTION & CARDIAC ARREST :
CRUDE INCIDENCE RATE
1971 - 1972
BELOW 0.50
0.50 2.40
2.40 4.29
4.29 7.74
7.74 13.43
13.43 22.74
22.74 38.60
MEP/GEOGRAPHY
UNIVERSITY OF HOUSTON
SYMAP

CHAPTER IV

THE SAMPLING PROCESS

A time projection early in the project revealed that an analysis of the whole city could not be performed in the time allotted. Therefore it was decided to take a sample of the city, in order that land use and residential quality data be available for the computer analysis within the time schedule of the project. The sample data would be used for the computer analysis and later on the city could be "filled in" by the photo-interpreter so that the sample could be compared to the total city to ascertain its accuracy.

This sample included fourteen (14) census tracts of the twenty (20) major census tracts in the city. The remaining six had been completed by the photo-interpreter. The sample was a 50% stratified random sample. Appendix X gives the sample blocks and their location. The procedure followed is given below, as described by Dr. Bart Hsi, the project's faculty consultant in Biometry.

<u>Steps in Taking a Stratified Random Sampling of Galveston Census Tracts</u>

1. Stratify on the map, based on ground observations, the city blocks according to the land use and neighborhood quality patterns.

2. Assign consecutive numbers to city blocks in a manner which observes the following principles:

    a. Assignment of one number to each city block among the group of the smallest city blocks.

    b. Assignment of several consecutive numbers to a large city block according to the multiple in size of the large block to the smallest block.*

3. Draw a set of random numbers corresponding to a fixed fraction of the assigned numbers among all the strata.

Procedure of random number selection: The lines of the digit table are numbered from 00000 to 19999. Open the book to an unselected page of the digit table and blindly choose a five digit number. This number with the first digit reduced modulo 2** determines the starting line. The two digits to the right of the initially selected five digit number are reduced modulo 50 to determine the starting column in the starting line.

After determining the beginning line and column the numbers are selected according to increments of two or three digits each. These increments have been determined by analysis of the number of blocks to be included in the sample. The incremental digits are selected by reading from left to right on the initial line and from right to left on the succeeding line. This alternation process is repeated for each successive line until the sample is completed. The increments of two or three digits each depend upon the largest number of the sampling units in census blocks, needed for a solo sample in each sampling area. In other words, if a sampling area required 126 blocks, then a three digit unit would be used. If a sampling area required 80 blocks, a two digit unit would be used.

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*Note: Slight inaccuracy in assigning the random numbers according to relative sizes is unavoidable, but it will be shown later that this will not substantially affect the final estimate of land use proportions.

**Note: Modulo is defined as dividing the highest multiple of two into the first number of the five digit number selected and calculating the remainder. The remainder plus the last four digits of the original number becomes the line on which to begin the selection.

All the blocks in the sampling area were numbered consecutively from left to right, row by row. The blocks to be sampled are then selected by the method described above. Whenever a random digit unit is selected which is bigger than the numbered blocks, a reducing process must be employed. This reducing process consits of subtracting a multiple of 2 from the random digit unit. For instance suppose the number of blocks needed for a 50% sample is 200. Then three-digit numbers from 001 to 200 will be selected. If a number larger than 200 is encountered then the largest multiple of 200, less than the encountered number, is subtracted from the number (i.e. if the number is 599 then it is reduced by subtracting 400 from it which gives 199--a usable number between 001 and 200).

4. Record the blocks on which the corresponding numbers are selected. Where a city block has been assigned more than one number, record the number of the assigned numbers, as well as the number of random numbers, corresponding to this large block. For example, a large city block has been assigned nine consecutive numbers; 17, 18, 19, 20, 21, 22, 23, 24, 25. In the random sampling process, random numbers 18 and 21 are selected. The "sample fraction" for this particular block is two out of nine numbers.

It was projected by the photo-interpreter and the project staff that the sample of 500 blocks could be completed within five months. Working on this time schedule, the photo-interpreter estimated that he was able to complete one census block in approximately 20 minutes. This time frame included four basic steps in the photo interpretation process:

a. Outline the overlay

b. Analysis and measurement

c. Completion of data sheet

d. Annotation (inking on overlay)

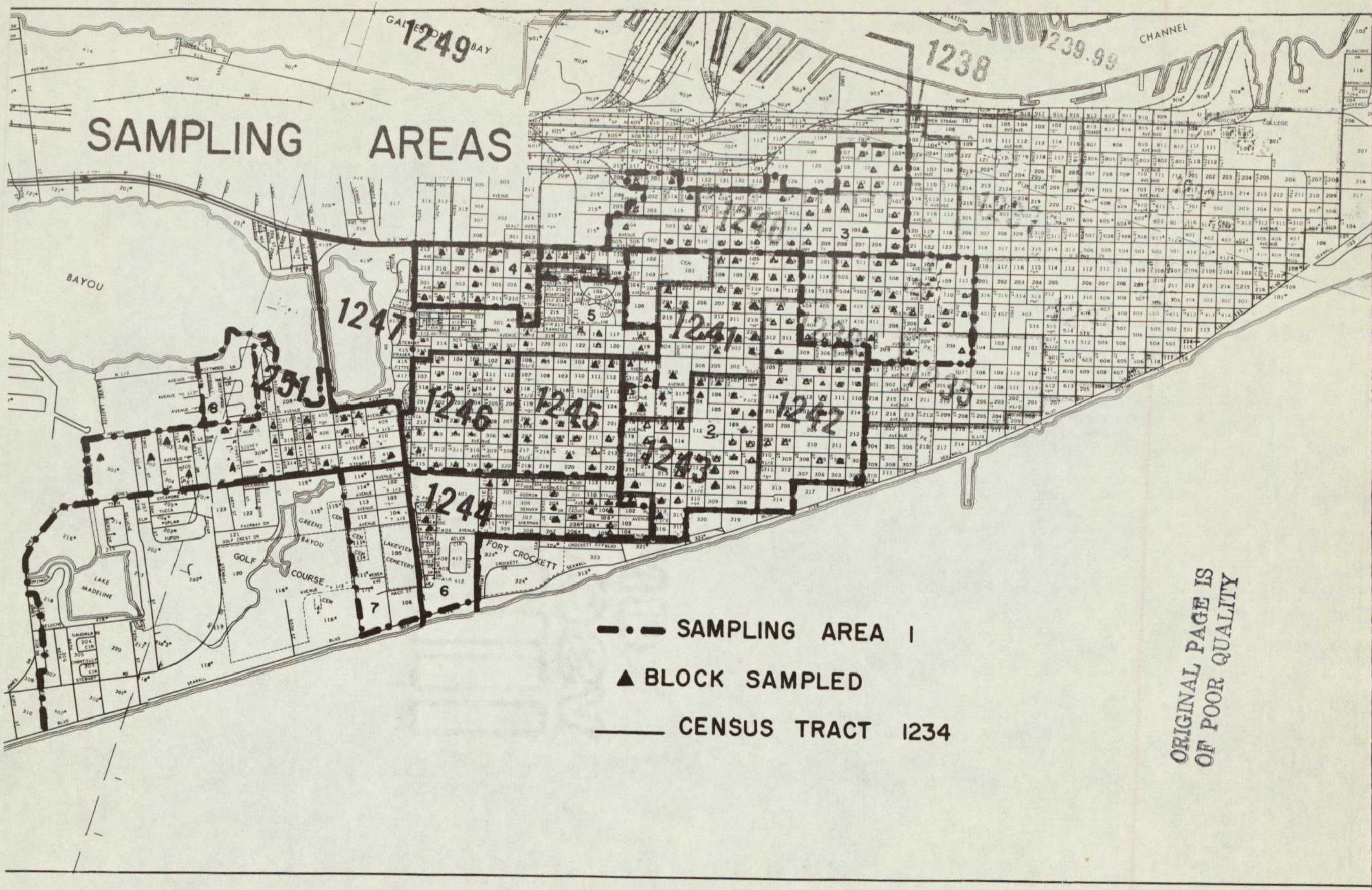
e. Four-way cross check (on overlay, on light table, on census tract map and on city engineers map).

Validation of the Sample

The sample was completely analyzed by the photo interpreter in the time span allotted. Once this was completed, the rest of the city which had not been sampled was "filled in", with the photo interpreter completing the remaining 50% of the census tracts sampled. It remained for the sample to be compared to the total city as a validity test.

This comparison of the validity of the sample was carried out in two ways. One comparison was made by census tract boundaries with block groups included within the census tracts. The second comparison was made for the sampling areas which had been originally drawn. These sampling areas, it will be remembered, at times crossed over census tract boundaries, because "natural areas" rather than artificial boundaries were delineated. Therefore, each block group, as well as sections of block groups, had to be aggregated in a different fashion to test validity of the sample for the large sampling areas.

The results of both comparisons are shown in Appendix XI. The sample in both cases was shown to have closely approximated the total city in both type and amount of land use. On the basis of the results, it is felt that this procedure could be recommended in the future, provided that areas of like characteristics, whether they be "natural areas" or agglomerates of census tracts which are as homogeneous as possible, are used as the sampling frame.


SAMPLING AREAS
SAMPLING AREA 1
▲ BLOCK SAMPLED
CENSUS TRACT 1234
1249
1238
1239.99
1247
1251
1246
1245
1241
1242
1243
1244
GALVESTON BAY
CHANNEL
BAYOU
FORT CROCKETT
LAKEVIEW CEMETERY
GOLF COURSE
LAKE MADELINE

CHAPTER V

RELIABILITY AND VALIDITY TESTING OF MEASUREMENT METHODS AND IMAGE ANALYSIS

The Houston Project established the reliability of the use of several measurement devices in photo interpretation analysis. Tests performed to compare four methods of measurement; the slide rule, the dot pattern (after Dr. Bart Hsi), the grid method and the planimeter showed that the difference in reliability was not statistically significant (when using a nonparametric method of testing). On the basis of this analysis, the use of the dot pattern was verified for the Houston study.

In addition, the demonstration that the grid method was comparable in accuracy to the dot pattern, left a choice open as to which method to use for the Galveston Study.*

During the initial conferences at the outset of the Galveston Study, the image analyst decided to use the grid method to give the square footage of each type of land use. He felt that this would be faster and just as efficient as the use of the dot pattern, which yielded percents changeable into square footage. While there was some discussion as to the feasibility of the use of the grid method in terms of the extra time it required for the image analyst to record and interpret each city block, the final decision was to use the grid method instead of the dot pattern for the Galveston Study.

Since the reliability of the grid method vis-a-vis the three other methods of measurement, had already been established, it was not necessary to repeat reliability studies of this method. However, it was felt that a further

*The grid scale used is 100 x 100 square feet.

reliability study had to be performed in order to ascertain the amount of error occurring in the image analysis process en toto. Since reliability tests are designed to test the measuring device itself, and to calibrate that instrument, whether the instrument be a man-made device or man himself, it was necessary to test the image analyst against himself to determine the amount of error occurring.

Accordingly, a sample of some 28 blocks was taken from the original 50 percent sample of city blocks utilized for the first computer analysis of the data. These 28 blocks had already been analyzed by the photo interpreter with a sufficient time lapse so that memory would not have influenced the second analysis. The first step in the reliability test was to compare the results of the two photo interpretations. A percentage discrepancy was calculated for each block. The use of non-parametric statistical analysis was ruled out in this instance inasmuch as even non-parametric measures will not operate correctly when there is no absolute from which to measure. In other words, since we know that there is error in every image analysis that is undertaken due to the vagaries of human nature, there is no absolute base of correct date from which to measure the deviations in each subsequent analysis.

What can be measured, however, is the reliability of two separate human analyses, one from the air and one from the ground. This is not a validity test, where a ground analysis is measured against a photo analysis. This is rather a measure of two types of analysis, with the discrepancies within each method to be matched between methods. Thus, discrepancies were calculated between the two photo interpretations and likewise, discrepancies were calculated between two ground truthing forays. Then the discrepancies for each were compared.

Not all of the variables on the land use and residential quality analysis sheet were compared for the reliability test. Those variables selected for comparison were the following:

1. Sidewalks
2. Curbs & Gutters
3. Lot Frontage
4. Litter
5. Foliage
6. Land Uses (Only categories, not square footage) in each block
7. Number of houses in each block

A form of Chi square test* for the data was used to ascertain whether there was a significant difference between the human measurement methods, photo interpretation and ground truthing. The results showed that only for one variable, sidewalks, was there a significant difference, (using .05 level of significance). Nevertheless, this variable was used in the computer analysis. In the other six variables, there was no significant difference, meaning that the reliability of the aerial photography method was comparable to that of the ground survey method.

An example of the methodology used is given below. The variable, curbs and gutters, has been chosen as an illustration. It should be noted that each of the 28 blocks** was evaluated twice by each measurement method; thus the

	Photo-Interpreter		
	Same	Different	Total
Ground Survey Same	15	2	f 17
Ground Survey Different	3	1	4
Total	f18	3	21F

Y^2 Formula:

$$\Sigma\frac{(f-F)^2}{F}$$

$X^2=1.75$

Not sig. at. α =.05

D.F.=1

*The formula utilizes the margins of the Chi square matrix, rather than the cells and can be found in Snedecor & Cochran, Statistical Methods, 6th Ed., p. 215. The .05 significance was used.

**Seven of the twenty-eight blocks did not contain residential uses. This leaves twenty-one blocks for comparison.

photo interpreter analyzed each block twice, and the same blocks were ground surveyed twice. This yields the four-fold contingency table given on the preceding page.

Having established the basic reliability of the photo interpretation method when compared to the comparable reliability of the ground truthing method, it was necessary to look at validity of the method; in other words, can photo interpretation reveal what actually exists, in contrast to other methods of measurement and recording of land use and housing characteristics.

The literature is replete with comparisons between remote sensing results and census data and APHA survey data which satisfy the validity of remote sensing in the analysis of urban areas but the questions remain to be posed for this study.

The reliability test partially answered this question. It acted to determine the congruence of evaluation of each block, at the same time that it established the reliability of the methodology. In other words, not only were the two methods not significantly different in their results, but in fact the ground survey method did authenticate the photo interpretation as to the validity of the type and amount of each of the variables measured.

The second method of validation was to compare the image analysis to an independent land use survey carried out by the City of Galveston Planning Dept. in the summer of 1973, the same time period as that of the overflight for the Galveston project. This assured that no land use changes have taken place which would account for error between the photographs and the land use survey; therefore, all error would be due to difference in interpretation between ground observation and image analysis. This time, a different group of blocks was selected than that used for ground-surveying.

These blocks contain much older housing, most of it two-story, with many garage apartments and mixed land uses on a micro basis, which are difficult to see from a photograph. Some of the housing is single-family, much of it is duplex or multi-family. It was felt that if a certain level of congruence between image analysis and ground, foot and windshield survey could be achieved for these areas which were perhaps the most difficult in the city vis-a-vis photo interpretation, the validity test would be all the more significant.

The comparison with the Planning Dept. block survey was carried out for census tract 1232. Two variables were used for comparison; the number of housing units and the general condition of these units. A 25% sample was taken of the census trancts, giving a total of 45 city blocks (omitting a large hospital, university complex) and these blocks were then compared against the photo interpreter's analysis.

In this case, the methodology employed was a paired T-Test for two sample groups of data. In both cases, that of the number of housing units and the general condition of the units, there was a significant difference (at the .05 level) between the results of the two methods. In the case of the general condition of housing, the difference was much greater than for the comparison of the number of housing units.

It is felt that in large part, this difference in validity can be attributed to the difference in both methodology and interpretation, between the City Planning Dept. block survey and the remote sensing survey.

In the first place, the kind of housing units chosen for this comparison are the most difficult to evaluate by remote sensing, as the literature has frequently pointed out. (See Lindgren, 1971).

In the second place, the evaluation of the general condition of the housing was done from a different perspective by both methods; the City's block survey used the standard census classifications of sound, deteriorating and dilapidated, while the photo interpreter used a broader frame of reference to establish general condition (taking into account lot size, house size, roofing, sideyard, etc.) Obviously, the two types of classification were not comparable as judged by the comparison. This points up the fact that assessment of housing quality is two-dimensional; the structure itself, and the structure as a part of its immediate surroundings (i.e. the lot and the block.) Remote sensing appears to be more suited to evaluation of the structure as part of its surroundings.

The direction of the differences in evaluation of general housing condition was generally higher for the ground survey than for the photo interpretation. This could be explained by the fact that the three basic categories used for classification by both methods were not only different in terms of the number and type of characteristics observed, but also in the degree to which these characteristics were separated into categories. That is, the housing quality category "deteriorated" may not be comparable in interpretation to the category "medium quality" used by the remote sensing survey. It could well be that both census categories "deteriorated and dilapidated" would fall into the category "low quality" used in this study. For this reason, it was concluded that the validity study carried out for these two methods did not attain the level needed for a true "criterion" validity comparison, and therefore, should be discounted. Criterion validity must, of necessity, utilize a criterion which can be held comparable to the method being tested, and in this case, comparability was not attained.

<u>Validity Test Using Census Data Count of Dwelling Units</u>

The literature on remote sensing points up the difficulties in comparing multi-family dwelling unit counts, in that many kinds of multi-family units are difficult to discern from aerial photographs. In view of this difficulty and in view of the lack of time comparability between the census counts (1969) and the overflight (1973), it was felt that validity could only be tested for single family dwelling unit counts.[1]

Six census tracts were selected for comparison with the remote sensing counts. These tracts consisted of predominantly single family dwelling units. One block group in each of these tracts was used, giving an approximate total of 1,452 units in the remote sensing count, and 1,689 units in the census count. This was a difference of 237 or about 14% more units in the census count than in the remote sensing count. This is consistent with reports in the remote sensing literature in terms of percentage difference, although in this case it was the remote sensing analysis which under-counted, rather than the census, reversing the trend which has been to over-count single family units in photo interpretation, while undercounting all dwelling unit types.

Using the T-Test for paired comparisons, the analysis revealed that of the six census tracts analyzed, differences in counts in three of them were significant at .05. The differences tended to occur in tracts where the housing is older and more densely situated.

Inasmuch as there is no way to adjust for error in the time frame between the census data collection and the remote sensing data collection, this comparison for validity must be viewed with caution. A reiteration of the above mentioned disclaimer is in order; this type of validity test does not employ true criterion validity, and thus the error that is introduced is much greater.

What these two validity tests point up is the proven efficacy of the ground survey method as the preferred method to use in validity testing, and only then when the same variables are used within the same time frame.

Ground Survey as Validity Test

The traditional ground survey as a validity test was employed for a sample of thirty-six blocks throughout the city. Table 3 gives a listing of these blocks by percentages recorded for each land use category. Table 4 gives the actual square footage for these same blocks and land uses.

A Spearman Rank Correlation test was utilized to determine the correlation between the results of the ground survey compared to the photo interpretation. For single family dwellings the correlation was significant at the .05 level, meaning that there was concurrence between the two methods. The results for commercial and industrial uses were rather poor, showing little correlation between the amount of percentage of land uses determined by both methods. However, when the industrial land uses were added to commercial uses in the blocks where industrial uses occurred, the two methods showed a correlation which was significant between .05 and .10. Likewise, when commercial was combined with community facilities the correlation was much higher (barely reaching .05). This points out the difficulties in separating out some types of commercial uses from industrial uses, as well as the confusion between land uses classified as community facilities and those classified as commercial. The sharpest difference between the two methods of measurement was in multi-family housing where there was little congruence between the two. Much of the time this confusion was caused by ground survey interpretation of multi-family as commercial. The greatest discrepancies in the multi-family category occurred in the older, more densely developed areas of the city where the mix between frame dwelling units and corner grocery stores is quite common and quite easy to be mistakenly identified with photo interpretation.

Measurement of Quality

The reader will recall that there were 10 variables utilized in the study to determine the quality of a residential land use block. None of these variables were specific, measuring such things as amount of sidewalks, paved streets, foliage, size of house, lot frontage, etc. The 10th variable was a subjective one, which was labelled excellent, good and poor, in which the photo interpreter gave an overall rating to the block which fell in one of these three categories.

An attempt was made to determine the correlation between the subjective quality judgement and the score arrived at by combining and averaging the objective quality variables. First, the 8 variables (litter was not included) were averaged, and then four of these eight were singled out and averaged. Both groups, the 8 factor and the 4 factor variables were compared against the single subjective score. Table 4 gives the results of the Four Factor comparison.

The results showed a correlation between the subjective score and the Four Factor score. This four Factor Score was composed of the four variables the interpreter appeared to take into consideration in his subjective rating; foliage, driveway and garage, frontage of houses and size of houses.

The correlation between the subjective measure and the Factor Score was rather high, at .59, which was statistically significant, at the .01 level. This was a most interesting and unexpected result, showing that a subjective rating of quality appears to include all of the eight characteristics singled out as quality indicants, in one subjective judgement of the residential quality of a block. For purposes of research, in order to isolate specific variables for analysis, it is still wise to separate variables into distinct measurable indicants. However, in the interest of time and speed, it appears that a subjective, impressionistic evaluation of block quality sufficies as well as singling out individual indicants.

TABLE 1

T TEST ON DWELLING UNIT COMPARATIVE COUNTS:
CENSUS VS. PHOTO INTERPRETATION
(See Appendix XII for Raw Data)

Tract B.G.	T Table .05	Values .10	Test T Value	Significance and Difference
1234 - 3	2.26	1.83	2.99	Yes
1235 - 2	2.17	1.78	4.42	Yes
1241 - 1	2.26	1.83	5.41	Yes
1242 - 2	2.20	1.79	1.22	No
1245 - 2	2.08	1.72	1.92	No
1246 - 2	2.16	1.77	0.58	No

TABLE 2

CITY OF GALVESTON GROUND SURVEY-

LAND USE COMPARISON: VALIDITY STUDY

CENSUS TRACT 1232

BLOCK NO.		COMMUNITY FACILITIES	VACANT	SINGLE FAMILY	MULTI-FAMILY	COMMERCIAL
108	Air			39,900	2,100	
	Ground		5,160			
113	Air		50,000	50,000		
	Ground	10,320		20,650		
201	Air			85,000		15,000
	Ground			61,900		10,300
208	Air		34,000			65,000
	Ground	20,640		25,800		
209	Air					96,000
	Ground	5,160			56,760	
309	Air					90,000
	Ground				78,000	
311	Air			100,000		
	Ground		5,160	56,760	10,320	
405	Air			90,000	10,000	
	Ground	5,160		67,800		
412	Air			69,375	23,125	7,500
	Ground			69,660		2,580
413	Air			50,000	50,000	
	Ground			72,240	0	
504	Air			67,500	22,500	15,000
	Ground	10,380	10,600	57,280		
606	Air			55,000		50,000
	Ground	10,320	5,160	30,960	10,320	
608	Air			52,500	52,500	
	Ground		5,160	67,000		
609	Air			63,000	42,000	
	Ground			67,000		5,160

TABLE 2 Continued

BLOCK NO.		COMMUNITY FACILITIES	VACANT	SINGLE FAMILY	MULTI-FAMILY	COMMERCIAL
611	Air			94,500	10,500	
	Ground		5,160	67,000		
702	Air			84,000	21,000	
	Ground		10,320	61,900		
703	Air			52,500	52,500	
	Ground		5,160	64,500	2,580	
706	Air			78,250	26,250	
	Ground		20,640	15,480	25,800	
709	Air			90,000	10,000	
	Ground		15,480	51,600	5,160	
804	Air			90,000	10,000	
	Ground			51,600	15,480	5,160
805	Air			94,500	10,500	
	Ground	10,320		25,800	23,220	7,740
806	Air			20,000	5,000	60,000
	Ground		5,160	56,200	5,160	10,320
814	Air			65,700	7,300	27,000
	Ground	10,320	7,740	25,800		28,380
816	Air			59,850	3,150	
	Ground		5,160		1,720	32,680

TABLE 3

IMAGE ANALYSIS AND LAND USE COMPARISON: VALIDITY STUDY BY PERCENTAGE

CT	BN		F	S	V	O	R	H	C	I
1232	503	Air					100%			
		Ground			10%		90%			
	509	Air					90%	10%		
		Ground			10%		90%			
1233	112	Air					80%	10%	10%	
		Ground					100%			
	103	Air					80%	10%	10%	
		Ground			10%		80%		10%	
1234	324	Air	11%	18%	55%		5%		11%	
		Ground	45%		25%	25%	5%			
1235	103	Air					75%	15%	10%	
		Ground			10%		65%		25%	
	110	Air					65%		35%	
		Ground	100% (Moody House)							
1236	512	Air	10%	20%	25%		40%		5%	
		Ground	10%	20%	50%		5%		15%	
	202	Air	30%				50%	20%		
		Ground	25%		50%		25%			
	204	Air	100%							
		Ground	100%							
1237	109	Air			30%				40%	30%
		Ground			40%				60%	
	310	Air	30%		10%		5%	15%	40%	
		Ground	25%		10%		25%		40%	
	305	Air		15%			40%	15%	30%	
		Ground		10%	10%		10%		70%	
	306	Air	60%	40%						
		Ground	100%							
1240	304	Air					30%	10%	30%	30%
		Ground	10%				15%		75%	

TABLE 3 Continuation

CT	BN		F	S	V	O	R	H	C	I
1240	305	Air					50%	20%	30%	
		Ground			20%		20%		60%	
1240	502	Air					100%			
		Ground					100%			
1241	204	Air					100%			
		Ground					100%			
	205	Air					100%			
		Ground					50%		50%	
	314	Air			20%		5%	15%		60%
		Ground			20%		10%		70%	
	316	Air	20%				5%	25%		50%
		Ground			10%		10%	20%	10%	50%
1242	204	Air					90%	10%		
		Ground	10%				90%			
	208	Air					80%	20%		
		Ground					100%			
1238	122	Air	15%				45%		40%	
		Ground	15%		15%		20%		50%	
1244	106	Air					90%	10%		
		Ground					100%			
	110	Air					90%	10%		
		Ground					100%			
1246	301	Air					100%			
		Ground					100%			
	307	Air					90%	10%		
		Ground					100%			
1247	302	Air					90%	10%		
		Ground					100%			
	309	Air					100%			
		Ground					100%			
1248	201	Air					100%			
		Ground					100%			

TABLE 3 Continuation

CT	BN		F	S	V	O	R	H	C	I
1248	202	Air					90%	10%		
		Ground					75%		25%	
1249	211	Air			60%				25%	15%
		Ground								100%
	215	Air							20%	80%
		Ground								100%
1250	115	Air				60%			40%	
		Ground				80%			20%	
	122	Air			30%		50%		15%	5%
		Ground			40%		60%			

KEY:

CT: Census Tract	O:	Open Space
BN: Block Number	R:	Single Family
F: Community Facilities	H:	Multi-Family
S: Parking Lots	C:	Commercial
V: Vacant	I:	Industrial

TABLE 4

IMAGE ANALYSIS AND LAND USE COMPARISON: VALIDITY STUDY BY SQ. FTG.

(Figures shown are number of thousand square feet.)

CT	BN		F	S	V	O	R	H	C	I	T
1232	503	Air					105.0				
		Ground		10.5			94.5				105.0
	509	Air					90.0	10.0			100.0
		Ground			10.0		90.0				
1233	112	Air					70.4	8.8	8.8		88.0
		Ground					88.0				
	103	Air					80.0	10.0	10.0		100.0
		Ground			10.0		80.0		10.0		
1234	324	Air	167.4	273.9	836.9		76.1	167.4			1521.6
		Ground	684.7		380.4	380.4	76.1				
1235	103	Air					75.0	15.0	10.0		100.0
		Ground			10.0		65.0		25.0		
	110	Air					65.0		35.0		100.0
		Ground	100.0								
1236	512	Air									
		Ground	10.0	20.0	50.0		5.0		15.0		100.0
	202	Air	30.0				50.0	20.0			100.0
		Ground	25.0		50.0		25.0				
	204	Air	208.0								
		Ground	208.0								208.0
1237	109	Air			15.0				20.0	15.0	50.0
		Ground			20.0				30.0		
	310	Air	30.0		10.0		5.0	15.0	4.0		100.0
		Ground	25.0		10.0		25.0		40.0		
	305	Air		15.0			40.0	15.0	30.0		100.0
		Ground		10.0	10.0		10.0		70.0		
	306	Air	60.0	40.0							
		Ground	100.0								100.0
1240	304	Air					30.0	10.0	30.0	30.0	100.0
		Ground	10.0				15.0		75.0		

TABLE 4 Continuation

CT	BN		F	S	V	O	R	H	C	I	T
1240	305	Air					50.0	20.0	30.0		100.0
		Ground			20.0		20.0		60.0		
	502	Air					200.0				200.0
		Ground					200.0				
1241	204	Air					100.0				100.0
		Ground					100.0				
	205	Air					100.0				100.0
		Ground					50.0		50.0		
	314	Air			20.0		5.0	15.0		60.0	100.0
		Ground			20.0		10.0		70.0		
	316	Air	64.4				16.1	80.5		161.0	322.0
		Ground			32.2		32.2	64.4	32.2	161.0	
1247	309	Air					20.0				20.0
		Ground					20.0				
1248	201	Air					105.0				105.0
		Ground					105.0				
	202	Air					94.5	10.5			105.0
		Ground					78.8		26.3		
1244	110	Air					90.0	10.0			100.0
		Ground					100.0				
1246	301	Air					40.0				40.0
		Ground					40.0				
1247	302	Air					90.0	10.0			100.0
		Ground					100.0				
1246	307	Air					90.0	10.0			100.0
		Ground					100.0				
1249	211	Air			168.0				70.0	42.0	280.0
		Ground								280.0	
	215	Air							400.0	1600.0	2000.0
		Ground								2000.0	
1250	115	Air				958.2			638.8		1597.0
		Ground				958.2			638.8		

TABLE 4 Continuation

CT	BN		F	S	V	O	R	H	C	I	T
1250	122	Air			238.8		398.0		119.4	39.8	796.0
		Ground			238.8		398.0		119.4	39.8	
1242	204	Air					90.0	10.0			100.0
		Ground	10.0				90.0				
	208	Air					84.0	21.0			105.0
		Ground					105.0				
1238	122	Air	15.0				45.0		40.0		100.0
		Ground	15.0		15.0		20.0		50.0		
1244	106	Air					265.5	29.5			295.0
		Ground					295.0				

KEY:
CT: Census Tract
BN: Block Number
F: Community Facilities
S: Parking Lots
V: Vacant
O: Open Space
R: Single Family
H: Multi-Family
C: Commercial
I: Industrial
T: Total Sq. Ft.

TABLE 5

COMPARISON OF SINGLE FAMILY DWELLING UNITS

COUNTS: 1970 CENSUS AND 1973 IMAGE ANALYSIS

FOR SIX SELECTED BLOCK GROUPS

CT/BG	DWELLING UNITS		DIFFERENCE	PERCENT DIFFERENCE
	I/A	CENSUS		
1234-3	152	191	39	20%
1235-2	226	318	92	28%
1241-1	145	187	42	22%
1242-2	312	332	20	6%
1245-2	393	428	35	8%
1246-2	224	233	9	4%
Total	1,452	1,689	237	14%

TABLE 6

SPEARMAN'S RANK CORRELATION TEST FOR QUALITY MEASUREMENTS

CENSUS	BLOCK GROUP	1 FACTOR SCORE	4 FACTOR SCORE	d	d^2
1232	509	1.75	2.42	16.0	256.0
	503	1.75	2.50	17.0	289.0
1233	112	1.50	1.53	6.0	36.0
	103	1.75	1.75	8.0	64.0
1235	103	2.90	1.59	7.5	56.25
	110	1.50	1.72	9.5	90.25
1236	202	1.22	1.31	2.5	6.25
1237	304	1.22	1.53	10.0	100.0
	307	1.90	1.25	9.0	81.0
1240	305	1.50	1.45	.5	2.5
	103	2.0	1.50	10.0	100.0
	504	2.0	1.75	1.5	2.25
	502	2.0	2.25	5.5	30.25
1241	204	1.50	1.22	4.5	20.25
	205	1.50	1.50	3.0	9.0
1242	105	2.0	1.43	13.5	175.5
	213	2.12	1.53	8.5	72.25
	307	2.0	1.78	2.0	4.0
	308	2.0	1.75	1.5	2.25
1243	204	1.62	1.75	10.0	100.0
	208	1.50	1.50	3.0	9.0
1244	106	3.0	2.65	4.5	20.25
	110	3.0	1.95	.5	2.5
1246	301	2.0	2.21	4.5	20.25
	307	1.50	1.78	15.0	225.0
1247	302	2.0	1.78	2.0	4.0
	309	2.0	1.59	5.0	25.0
1248	201	1.50	1.50	3.0	9.0
	202	1.90	1.75	6.0	36.0
1251	103	1.50	1.28	2.5	6.25
					d^2 = 75293.25

r_s = .59 which is measure of correlation

From Table Values for r_s:------------------- N = 30 at .05 level of significance = .306
N = 30 at .01 level of significance = .432

The r_s value shows the correlation is significant at the .05 level. Therefore, there appears to be a congruence in the methods of subjective and objective evaluation of residential quality.

CHAPTER VI

RESULTS

SECTION A: TESTS OF HYPOTHESES

The review of the literature, with the addition of the Houston Pilot Study, has given this project a focus which may be stated as an empirical generalization. This empirical generalization, which is at the foundation of this research project, may be stated as follows:

LAND USE AND RESIDENTIAL QUALITY ARE ASSOCIATED WITH AND ACT AS AN INFLUENCE UPON HEALTH AND PHYSICAL WELL-BEING.

From the empirical generalization can be derived some general hypotheses which are usable for testing. These hypotheses are six in number and can be stated as follows:

Hypotheses:

1. Variations in health status, as reflected in morbidity and mortality rates, can be explained by land use and residential quality.
2. Variations in health status, as reflected in morbidity and mortality rates, can be explained by socio-economic and housing indices as given in the census.
3. When combining land use, residential quality and census variables, in order to explain variations in mortality and morbidity rates, the land use and residential quality variables will account for a higher level of association than will the census variables.
4. Residential quality alone is associated with and can explain variations in mortality and morbidity rates.
5. Residential density alone, both measured internally and externally, is associated with and can explain variations in mortality and morbidity rates.

6. Neighborhoods of mixed land uses are more strongly associated with poor levels of health than are purely residential neighborhoods.

These six hypotheses were tested by means of several computer models. In an attempt to determine which independent variables would account for the strongest predictability in an association with the dependent variables, a step-wise regression program was utilized. Within this program (BMD02R) there were ten basic models run on the computer. These ten models are given as follows:

.1 - Land use and census variables alone with one total quality index;

.2 - Land use variables with one total quality index;

.3 - Census variables alone;

.4 - Land use variables with 10 individual quality factors;

.5 - The nine quality variables alone;

.6 - A model of mixed land uses in 42 block groups of the city;

.7 - A land use and census model combining the 10 land use categories, the census variables and the 9 individual quality variables;

.8 - Six density variables alone;

.9 - A weighted regression model, adjusting for population differences in the block groups. (This model was run for land use alone, and land use and census variables in combination.) and

.10 - A model combining several block groups with smaller than average population totals into eight "super" block groups.

These models served not only to explore the strength of predictability of the various independent variables, but also to test the efficacy of the hypotheses just mentioned. The ten computer models then, tested the six hypotheses. We will take each hypothesis in turn and discuss the results of these tests.

<u>Hypothesis I - Variations in health status, as reflected in morbidity and mortality rates, can be explained by land use and residential quality.</u>

Models .2 and .4 tested hypothesis 1. Model .2 included all 12 land use variables and the additional variable, total quality points or quality index. This latter variable, the index, is the sum of the 8 individual quality points, omitting the 9th quality point which is a subjective measure of the general condition of a residential block.

Model .4 included all 12 land use variables and the 9 individual quality variables, without a total index of quality. Litter, while acting as a quality variable in the analysis, was not included in the group of 9 individual quality variables as it was not measured in the same manner. Therefore, it technically fell into the land use variable category.

Models .2 and .4 also included a created variable entitled Dwelling Unit/Square Footage, which was a ratio of the square footage of each house and lot to total square footage in a block group.

The land use model alone (Model .2) explained 67% of the variance for the dependent variables TB and VD. However, the predictive value of this model was much lower for the remaining dependent variables, amounting to only 12% for hypertension, 17% for meningitis and 19% for hepatitis. The remaining variables ranged from 26% to 32% prediction. Clearly then, the land use model alone, without individual quality variables, could not be considered to show a strong predictive association with mortality and morbidity indices.

When the individual quality variables were added to the land use model however, (Model .4) the predictive levels changed appreciably.

The dependent variables TB and VD increased to 82% and 74% respectively. Hypertension increased from 12% to 45%, meningitis from 17% to 37% and two mortality variables, under 18 and between 18 and 61 increased from 28% to 42% for the former and 32% to 49% for the latter. All models reached significance levels of .05 and in most cases, .001. This would affirm Hypothesis 1, emphasizing that land use alone without individual quality indicators is not sufficient to account for variation in mortality and morbidity rates.

Hypothesis 2 - Variations in health status, as reflected in morbidity and mortality rates, can be explained by socio-economic and housing indices as given in the census.

Model .3 tested Hypothesis 2. Model .3 included 13 census variables with an additional created variable entitled Pop/DU which was a ratio of population to dwelling units. The two dependent variables which showed the highest levels of prediction were again TB and VD, accounting for 54% and 71% respectively. In addition, the dependent variables cardiac arrest/myocardial infarction, and hypertension, showed predictability levels of 50% and 49%. These four variables showed the strongest association with the census data.

The remaining variables did not show higher than 35% levels of association and the mortality variable "Over 62" did not reach beyond 12%. Three dependent variables did not reach significance levels, and two were significant at .05. The remainder all reached to .001 levels of significance.

Therefore, Hypothesis 2 is verified for all but three of the dependent health variables; Mortality Under 18 and Over 62, and hepatitis.

There remains now a comparison between the predictive strengths of the census model versus the land use and quality models. This takes the form of Hypothesis 3.

Hypothesis 3 - When combining land use, residential quality and census variables, in order to explain variations in mortality and morbidity rates, the land use and residential quality variables will account for a higher level of association than will the census variables.

The census model .3 is herewith compared to the combined land use and quality model .4 to ascertain the relative predictive strength of each of these models vis-a-vis each dependent health variable. This comparison is given in the table on the following page.

It can be seen that for 8 of the 10 dependent variables, the land use and quality model accounted for a greater level of association and therefore a greater predictive strength than the census model. In only two cases, for the dependent variables hypertension and cardiac arrest/ myocardial infarction, did the predictive strength of the census model exceed that of the land use/quality model, and in both of these cases the differences were slight, amounting to 4% more in the former and 5% more in the latter.

This then, confirms Hypothesis 3, verifying that mortality and morbidity levels can be predicted by land use and residential quality as well as by census data, and for 3 of 10 variables at higher levels of statistical significance.

Hypothesis 4 - Residential quality alone is associated with and can explain variations in mortality and morbidity rates.

Can residential quality alone, without accompanying land uses, account for any variability in mortality and morbidity rates? Hypothesis 4

TABLE 1

SUMMARY OF PREDICTIVE STRENGTH OF FIVE MODELS USING FIRST TEN VARIABLES ONLY

	Under 18	18-61	Over 62	TB	HEP	HYPER	CA/MI	VD	Shig/Sal	MEN
.4 LAND USE AND QUALITY MODEL % Variance Explained by 1st 10 Var.	42***	49***	26*	82***	28*	45***	45***	74***	42***	37***
.2 LAND USE MODEL % Variance Explained by 1st 10 Var.	28*	32***	31**	67***	19	12	26*	67***	31*	17
.3 CENSUS MODEL % Variance Explained by 1st 10 Var.	20	35***	12	54***	16	49***	50***	71***	25*	29*
.7 COMBINED MODEL % Variance Explained by 1st 10 Var.	41***	41***	32**	67***	27*	56***	55***	80***	44***	38**
.10 SUPER BLOCK MODEL No. of 1st 5 Variables which were land use Variables	44***	37**	51***	62***	22*	43***	58***	85***	24*	34**

SIGNIFICANCE LEVEL
KEY: *** .001
** .01
* .05

states that it can, and model .5 tested this proposition. The results of the computer calculations are given in the table on the preceding page.

Four dependent variables did not show an association between residential quality alone and health. Two of these variables were mortality variables and two were morbidity (Over 18, Over 62, hepatitis, shigella/salmonella). Two morbidity variables showed a very strong association with residential quality, namely TB and VD and the remaining four variables showed a significant association.

A comment on the dependent variables themselves is in order. It could be surmised that one of the reasons for the continually weak association of hepatitis, shigella/salmonella and meningitis with both land use and quality variables and the census variables, is the spareness of the data. Although a five year rate was obtained for each of these morbidity variables, the number of cases did not reach 100 for any of them. The same is true for the mortality category, deaths under 18 years of age. Therefore, there is not sufficient numbers in the data itself to allow a very meaningful association to any of the independent variables. This problem always arises when studies of this kind are carried out and the reason is twofold: first, reporting of the three communicable diseases is poor, as has already been stated earlier in this report. And second, the areal unit under investigation is also small. By using the block group instead of the census tract, one increases sensitivity but also increases variance or spread of data. In other words, associations will be weaker and precision is lessened but more exact locations and associations are determined.

It has been recognized that the use of the next largest areal unit, whether it be the census tract, or the SMSA, will mask associations which may be revealed in the lower level areal unit, and it was for this reason that block groups were selected for this study rather than census tracts. Therefore, by increasing the opportunity for truer homogeneity (the census tract often is more heterogeneous than block groups) one decreases the possibility of stronger statistical associations, thereby reducing the levels of significance. This is what has resulted in the case of some of the dependent variables used in this study.

Therefore it should be stated that Hypothesis 4 is only partially verified and that the results point out that individual residential quality variables alone, without land use, are not a strong predictor of mortality and morbidity overall.

Hypothesis 5 - Residential density alone, both measured internally and externally, is associated with and can explain variations in mortality and morbidity rates.

A separate model was tested to determine the association between density, both external and internal, and mortality and morbidity as the dependent variables. There were seven independent density variables used in the model and they are as follows:

a. More than 1.01 persons per room (Internal)

b. Average number of rooms, rental dwelling units (Internal)

c. Average number of rooms, owner occupied dwelling units (Internal)

d. Lot frontage (External)

e. House size (External

f. Dwelling units per block group (or dwelling unit per total block group square footage) (External)

g. Persons per dwelling unit (Internal)

Four of these variables were measures of what could be called "internal" density, that is, characteristics of density occurring within a dwelling unit. The other three were "external" density measures or characteristics occurring outside the dwelling unit, within the block. Three of the variables, d, e, and f, were measured through remote sensing. Four were taken directly from the census (a, b, c, and g). Variable "f" used the dwelling unit count from the census divided into the total square footage derived from remote sensing calculations.

It was postulated that variable "a", more than 1.01 persons per room, the traditional measure of over-crowding used in the general literature investigating the effects on health of overcrowding, would emerge as the dominant predictor of mortality and morbidity rates. The results showed that for three of the seven morbidity measures, this variable indeed appeared as the initial variable in the equation associating density and health measures, but in one of the three models it was not a significant association. Thus, for VD and for meningitis, this traditional measure of internal density (i.e. overcrowding) accounted for a significant amount of the variation explained in the equation; for VD it accounted for 40% of the variation and for meningitis, 12%. However, for hepatitis it only reached 3%. As an explanatory variable for mortality, variable "a" accounted for only 4% of the variation in the Under 18 equation and only 1% in the 18-61 model. For the TB model, where it was expected that this variable would be quite significant, it entered the equation as the fifth variable out of the seven, accounting for only

1% of the variation. In all cases, there was a positive association between overcrowding and higher morbidity rates, except for hypertension and cardiac arrest/myocardial infarction where the association was inverse. This was to be expected, based on the neighborhood profiles generated by these latter two variables.

House size emerged as a strong predictor in the models for two morbidity and one mortality measure. Its strongest association was with TB, accounting for 28% of the variance. It accounted for 22% of the variance in the Mortality, 18-61 model. In both cases the association was a negative one; the higher the rate, the smaller the house size. For cardiac arrest and myocardial infarction the association was reversed; there was a positive (9%) association between this variable and house size, again congruent with the neighborhood profile of this dependent variable. (See Appendix XVIII for computer results.)

Finally, the density model reached significance levels for 6 of the 10 dependent variables, with the internal measures generally outweighing the external measures as the strongest entries in the equation. Of the first three variables in each of the ten equations, totalling 30 altogether, 20 were internal density measures and 10 were external density measures. However, it is difficult to say with certainty that in general, internal measures of density are stronger predictors of health status than external measures. One can readily see, by studying each model, that this is entirely dependent upon the health measure itself. In the epidemiological setting of each of the morbidity measures, one notes the diversity of host, agent and vector (see Appendix IX) and therefore, one must conclude that the ecology of each disease involves complex interactions between density and other environmental factors which as yet are undefined. The density model for this study then is inconclusive as a predictor of mortality and morbidity levels in general.

Hypothesis 6 - Neighborhoods of mixed land uses are more strongly associated with poor levels of health than are purely residential neighborhoods.

Public health professionals have long associated poor health with residential areas which are contiguous to and mixed with heavy industrial and commercial land uses, especially those industrial and commercial uses which generate pollution, heavy traffic, litter and generally poor sanitary and environmental conditions. Zoning ordinances traditionally have attempted to separate these land uses whenever and wherever possible.

However, every city has its areas of mixed land uses, some of them of poor quality and some of them occurring in middle income areas. Often residential areas abut strips of commercial development or shopping areas which serve local shopping and employment needs.

Galveston has areas of mixed uses which are of both of the above mentioned types. It also has areas of strictly residential land uses. In an effort to test the efficacy of this hypothesis, 42 block groups containing mixed land uses were selected. The criteria used was 3 or more types of land uses in each block group and of these, each land use must account for at least 20% of the total square footage of the block group. Therefore, if a block group had only two types of land use, residential and vacant, or only residential and open space as two dominant land uses, it was not selected. If it had three types of land use but the third accounted for less than 20% of the total area, it also was not included.

The resulting model, Model .6, showed very interesting results. In almost all cases, when compared to the city-wide model using the same variables (land use and individual quality) the mixed use model showed stronger associations. In only 3 cases did the mixed use model fail to show stronger levels of association; these variables were Mortality 18-61 (with only 3% less explanation) TB (which dropped from 82% to 68%) and hypertension (45% to 36%). For all the other mortality and morbidity variables, the mixed use model performed better and in one case, that of hepatitis, there was a three-fold increase in the level of association, from 28% to 80%. Results of the comparison between the mixed use and all city models are shown in the table on the preceding page. Hypothesis 6 then is partially answered, in that the mixed use model showed generally higher levels of association with mortality and morbidity than did the all city model which included block groups of primarily residential uses. The proposition has not been fully answered, however, inasmuch as there was no direct experimental control group of purely residential block groups. Since there were less than thirty block groups of this latter type, it was felt the number was not sufficient for comparison. What we can say is that land use variables in a mixed land use model seem to be better predictors of poor health than a model which includes a great deal of purely residential uses.

See Appendices XIX through XXIV for additional results of computer models.

SECTION B: NEIGHBORHOOD PROFILES

Introductory Note: This Section B of Chapter VI contains a large number of tables. There are six tables for each dependent variable, accounting for a total of 60 tables. These six tables represent the six computer models given in Section A of this chapter and are numbered accordingly as the first six.

Explanation of Quality Variables

The reader will recall that in the operationalization of "quality" nine specific quality indicants and one general indicant were used. The one general indicant was a purely subjective measure of general condition of a block which contains residential units. This subjective measure was essentially a composite of several variables employed by the photo interpreter in an "impressionistic" rating. The other nine variables or indicants were used in an attempt to delineate specific quality indicants which can be observed and measured with remote sensing. The total score of these nine indicants makes up the Quality Index for a block containing residential land uses.

Meaning of Symbols in Tables

Sign - The positive or negative direction of statistical association is the sign given to the left of each variable. If the sign is positive, one can say "the more of one, the higher the other." If the sign is negative, one can say, "the less of one, the higher the other," or that there is an inverse relationship between the two variables.

F Level - The statistical term given in the results of the step-wise regression program used in this study. The "F Level" varies with the number of variables employed in the equation and with the strength of association of these variables.

The F Level is used to test significance of association, by consulting a special table giving significance levels for various F levels depending upon the number of "degrees of freedom" in the equation.

Significance - Levels of significance are used in hypothesis testing. Generally, one assumes a null hypothesis of no difference, and then proceeds to set an arbitrary significance level for testing whether this null hypothesis will be accepted or rejected. In these particular tables, the significance levels are testing the strength of association of variables in the regression equation. The F value is the key to significance levels, which one obtains by consulting a table of levels of significance. The reader will note that in the following tables, significance levels increase (i.e. from .10 to .001) as F levels increase. The higher the level of significance the stronger the association of the variables. The most commonly used levels of significance are .05 and .01, meaning alternatively, a 95% and 99% level of significance.

R^2 - R^2 is the measure of the amount of association between the independent and dependent variables explained by the regression equation. The higher the R^2 value, the more of the variation is being explained. For example, if an R^2 value reaches .70 or 70% of the variation explained, this means that 30% remains unexplained, either due to random variation or to other independent variables not entered into the regression equation.

Neighborhood Profiles

The Profile is a widely used method of description in the health field. The etiology of a disease can be viewed as that of a profile of its causes. Epidemiologists describe disease occurrences in terms of a profile of the community and the population at risk as well as the ecological setting of the disease. Physicians in medical research often develop a profile of a person who is susceptible to a disease in terms of physiological, heredity and psychological characteristics.

Likewise, those who work with cities and their characteristics have developed profiles in terms of both urban morphology and urban living standards. Even the layman keeps in his mind a profile of different residential settings in terms of desirability when he considers his own location in space.

It was therefore felt appropriate to develop a series of profiles generated by remote sensing and to a lesser extent, by selected census characteristics, in order to describe the ecological setting for the mortality and morbidity indices developed in this study. These profiles may be likened to the "ideal type" used in conceptualization processes in research methodology, except that in many cases they do in fact exist and are not simply a compilation of characteristics to aid in conceptual-ization.

What the following profiles will show is that health and poverty continue to be strongly inter-related, even into the 1970's with the extensive health intervention systems thus far developed. This is certainly not an unusual finding but rather one which confirms previous research over the last two decades which has linked the two in a positive relationship; i.e., the greater the poverty the higher the mortality and morbidity rates.

The poverty neighborhoods revealed by the data in this report are characterized by familiar indices. Primarily mixed land uses of an older vintage (early 20th century industrial establishments for instance rather than newer post-war industrial parks), coupled with poor environmental maintenance are the most familiar characteristics. Lack of greenery and sidewalks, narrow streets, external and internal crowding yielding high densities both of buildings to total square footage and larger numbers of persons living in smaller dwelling units, are additional characteristics. Multi-family housing, rooming houses and single person households generally complete the picture. There is almost always a complete lack of amenity either of nature or man-made.

The implications for health are obvious and have been well documented. Litter and poorly maintained streets, yards and alleyways are a breeding place for flies and insects which are disease carriers as well as a myriad of bacterial and viral hosts. People living crowded in on each other experience both psychological and physical stress, lowering body resistance to disease. Children who play in a poorly maintained environment are much more likely to contact and pass on disease to each other. The fecal and oral transmission of disease bacteria is facilitated in this kind of environment.

While it must be noted again that the reporting of disease as indicated by the rate distribution in this report is acknowledged to be incomplete, [in some cases such as shigella and salmonella it is grossly understated] nevertheless the geographic distribution of the data we do have cannot be denied. Except for hypertension and heart attacks, ill-health predominates in poor neighborhoods. The existence of higher morbidity rates in middle and upper income areas is neither confirmed nor denied by the data gathered here. It is simply a question mark.

What follows then, are profiles of prototypical neighborhoods. They are not to be taken as literal representations nor as mutually exclusive in terms of disease incidence. Rather, these profiles are meant as a rough sketch of areas where each morbidity and mortality measure is likely to occur. The basis for the profiles are the computer generated statistical associations which are significant enough not to be occurring simply by random chance.

The full definitions of the variables are given at the end of this chapter.

Neighborhood Profile: Mortality Under 18

The traditional association between higher death rates for persons under 18 years of age, and poverty areas, is reflected in the neighborhood profile for the "Under 18 Mortality" data in Galveston. The overall death rate, it is to be remembered, is composed of accidents and homicides as well as death from communicable and chronic diseases, and the kinds of neighborhood in which these kinds of deaths occur are pictured here. Primarily industrial land uses, mixed with multi-family housing of very poor quality are indicated. Wide paved streets indicating dense traffic patterns (leading to a larger number of accidents) and larger houses probably of much older housing stock are also shown. No greenery exists, and only in the mixed land use model of selected block groups (see Model 1.6) is there some evidence of an increase in vacant areas. This could mean demolished housing units which have not been replaced. The indication of narrow lots (lot frontage) confirms the high ratio of dwelling units to residential square footage in the total block group. It is to be remembered that in low income neighborhoods, especially in the Southwest area of the country, narrow lot frontages meant lower taxes, inasmuch as property taxes were based on front footage; this gave rise to the crowding of larger houses on small lots resulting in high external densities.

These neighborhoods also contain a large amount of black families whose death rates are still proportionately higher in most American cities than white families. It will be noted further on that the neighborhood profile for VD and TB yields a similar picture to that of death rates for this age group.

TABLE 2

AGE ADJUSTED 1971-72 MORTALITY

DEPENDENT VARIABLE 1; MORTALITY UNDER 18

1.1 UNDER 18 MORTALITY CENSUS AND LAND USE COMBINED

SIGN	VARIABLE	R^2
+	INDUSTRIAL	.20
+	% BLACK	.25
+	LITTER	.27
(∓)	1 PERSON HOUSEHOLDS	.29
-	COMMERCIAL	.31
-	AVG. # ROOMS, RENT. D.U.	.31
+	AVG. # ROOMS, OWN. OCC. D.U.	.35
+	TOTAL # RENT. D.U.	.36
+	MULTI-FAMILY	.39
+	TOTAL POPULATION	.41

F. = 3.74
Sig. at. .001

1.2 UNDER 18 MORTALITY AND LAND USE.

SIGN	VARIABLE	R^2
+	INDUSTRY	.20
+	MULTI-FAMILY	.24
-	VACANT	.25
-	QUALITY INDEX	.26
-	HIGH RISE APT.	.27
+	PARKING LOTS	.27
-	COMMERCIAL	.28

F. = 2.44
Sig. at. .025

1.3 UNDER 18 MORTALITY CENSUS

SIGN	VARIABLE	R^2
+	% BLACK	.12
-	AVG. ROOMS, RENT. D.U.	.16
+	% UNDER 18	.165
(±)	>1.01 PERSONS PER ROOM	.169
-	AVG. VALUE OWN.OCC. D.U.	.17
+	AVG. ROOMS OWN.OCC. D.U.	.18
+	1 PERSON HOUSEHOLDS	.19
(±)	TOTAL POPULATION	.198
+	AVG. RENT	.20
+	POPULATION/D. U.	.207

F. = 1.60
Sig. at. .25

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient). When only one sign is given both coefficients are in agreement.

TABLE 3

AGE ADJUSTED 1971-72 MORTALITY

DEPENDENT VARIABLE 1; MORTALITY UNDER 18

1.4 COMBINED LAND USE & QUALITY FOR TOTAL CITY

SIGN	VARIABLE	R^2
+	INDUSTRIAL	.159
+	PAVED STREET	.337
-	LOT FRONTAGE	.357
+	CURBS & GUTTERS	.37
(∓)	SQ. FT./D.U.	.38
-	GENERAL CONDITION	.39
+	HOUSE SIZE	.397
+	MULTI-FAMILY RES.	.407
-	HIGH RISE APT.	.41
(∓)	VACANT	.42

F. = 4.45
Sig. at. .001

1.5 QUALITY

SIGN	VARIABLE	R^2
+	STREET WIDTH	.03
-	GENERAL CONDITION	.079
+	CURBS & GUTTERS	.08
-	FOLIAGE	.09
(∓)	HOUSE SIZE	.10
-	LOT FRONTAGE	.105
(∓)	STREET WIDTH	.107
-	SIDEWALKS	.107

F. = .95
Not Significant

1.6 SELECTED BLOCKS OF MIXED USES: COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
+	INDUSTRIAL	.31
+	PAVED STREETS	.437
+	MULTI-FAMILY	.448
+	VACANT	.46
+	COMM. FACILITIES	.479
+	SQ. FT./D.U.	.488
+	STREET WIDTH	.527
+	PARKING LOTS	.54
-	HIGH RISE APT.	.55
+	CURBS & GUTTERS	.55

F. = 3.89
Sig. at. .005

Neighborhood Profile: Mortality Between Ages 18-61

The same type of neighborhood profile which exists for "Mortality Under 18" is generated by the regression model for "Mortality Between 18 and 61 Years." Industrial and multi-family land uses are contiguous to each other. In addition litter appears in the equation, indicating poorly maintained residential areas and a low quality physical environment. Overcrowding is present, indicated by a high population per dwelling unit ratio and the standard measure of more than 1.01 persons per room. However, there is also an indication of many one person households. Again, we find the presence of many non-white persons, corroborating the higher death rates in this age group; suffered by blacks in proportion to whites.

The kinds of neighborhoods indicated by the profiles for these two age groups have been variously called Zones of Transition, Blue Collar Neighborhoods or Working Men's Sectors by the various schools of human ecology, and are almost always to be found adjacent to the central business district of a city, acting as buffer area between industrial and commercial uses and multi-family, low and middle income housing of a slightly better quality than that in the zone of transition. Many rooming houses and low quality rental units are generally found in this zone.

The presence of the variable "water" in both Model 2.1 and 2.2 may be spurious. Certainly it does not indicate affluent residential areas which is usually the case where water adjoins residential uses. Inasmuch as the residential areas contiguous to the various bodies of water in Galveston are neither neighborhoods of the above type, nor those showing above average death rates for these age groups, it is felt that the 4 and 5% of variances explained by this land use variable should be discounted.

TABLE 4

AGE ADJUSTED 1971-72 MORTALITY

DEPENDENT VARIABLE 2; MORTALITY AGES 18-61

2.1 CENSUS AND LAND USE COMBINED

SIGN	VARIABLE	R^2
+	% BLACK	.20
+	WATER	.25
+	1 PERSON HOUSEHOLDS	.29
+	>1.01 PERSONS PER ROOM	.31
-	AVG. VALUE-RENT. D.U.	.34
(∓)	SQ. FT./D.U.	.36
-	VACANT	.37
+	INDUSTRIAL	.39
(±)	% UNDER 18	.40
+	TOTAL D. U.	.41

F. = 4.95
Sig. at. .001

2.2 LAND USE

SIGN	VARIABLE	R^2
+	MULTI-FAMILY	.09
+	INDUSTRIAL	.15
+	WATER	.20
+	LITTER	.25
-	VACANT	.28
-	HIGH RISE APT.	.31
+	COMM. FACILITIES	.31
+	SQ. FT./D.U.	.32

F. = 2.97
Sig. at. .001

2.3 CENSUS

SIGN	VARIABLE	R^2
+	1 PERSON HOUSEHOLD	.12
-	AVG. RENT	.20
-	TOTAL D. U.	.23
+	>1.01 PERSONS PER ROOM	.27
(±)	POPULATION/D.U.	.31
-	% OVER 62	.33
-	AVG. VALUE OWN. OCC. D.U.	.338
+	TOTAL POPULATION	.34
-	TOTAL RENTAL D.U.	.346
-	TOTAL OWN. OCC. D.U.	.35

F. = 3.27
Sig. at. .001

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient). When only one sign is given both coefficients are in agreement.

TABLE 5

AGE ADJUSTED 1971-72 MORTALITY

DEPENDENT VARIABLE 2; MORTALITY AGES 18-61

2.4 COMBINED LAND USE & QUALITY FOR TOTAL CITY

SIGN	VARIABLE	R^2
-	HOUSE SIZE	.22
+	INDUSTRIAL	.277
+	WATER	.319
-	VACANT	.35
+	OPEN SPACE	.40
(∓)	LOT FRONTAGE	.44
-	CURBS & GUTTERS	.458
(∓)	LITTER	.47
-	HIGH RISE APT.	.48
(∓)	SIDEWALKS	.49

F. = 5.90
Sig. at. .001

2.5 QUALITY

SIGN	VARIABLE	R^2
-	FOLIAGE	.19
-	PAVED STREETS	.23
-	DRIVEWAY	.25
-	CURBS & GUTTERS	.25
(∓)	FRONTAGE	.27
-	GENERAL CONDITION	.28
-	STREET WIDTH	.29
-	HOUSE SIZE	.30

F. = 3.57
Sig. at..005

2.6 SELECTED BLOCKS OF MIXED USES: COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
-	VACANT	.089
-	HOUSE SIZE	.189
+	LOT FRONTAGE	.289
+	OPEN SPACE	.34
+	WATER	.397
+	INDUSTRIAL	.41
+	DRIVEWAYS	.428
-	HIGH RISE APTS.	.44
+	SIDEWALKS	.456
-	FOLIAGE	.46

F. = 2.68
Sig. at. .01

Neighborhood Profile: Over 62 Mortality

The neighborhood profile for deaths occurring in later years shows a distinct difference from the two previous types of neighborhoods. In the "Mortality Over 62" neighborhood we find owner-occupied dwellings with much shrubbery and green lawns, larger houses, wider lot frontages and a higher overall quality rating. The square footage of dwelling units in these blocks is high; however there is less open space than in the outer suburban areas.

There is a small amount of commercial and light industrial uses contiguous to residential land uses but litter is absent, indicating well maintained mixed land uses. These are generally neighborhoods of older, well-kept homes populated by retired persons. Community facilities such as public buildings, churches and schools are often to be found in these neighborhoods indicating the fact that once younger households with children necessitated these services and facilities, and are still present to some extent.

It can be noted that the predictive power of the combined land use and census regression equation (model 3.1) is much less strong for the age group "over 62" than for the "18-61" age group (32% vs. 48%). No doubt this is due to the simple fact that age-adjusted rates are much higher for this older group due to natural causes of death, thus environmental and socio-economic variables play a very small role in an association with death at this age.

TABLE 6

AGE ADJUSTED 1971-72 MORTALITY

DEPENDENT VARIABLE 3; MORTALITY OVER AGE 62

3.1 CENSUS AND LAND USE COMBINED

SIGN	VARIABLE	R^2
+	QUALITY INDEX	.16
+	COMM. FACILITIES	.21
+	SQ. FT./D.U.	.24
+	COMMERCIAL	.27
−	WATER	.29
+	MULTI-FAMILY	.30
(∓)	INDUSTRIAL	.307
(∓)	1 PERSON HOUSEHOLDS	.31
+	TOTAL/RENT. D.U.	.32

F. = 2.35
Sig. at .025

3.2 LAND USE

SIGN	VARIABLE	R^2
+	QUALITY INDEX	.16
+	COMM.FACILITIES	.21
+	D.U. PER BLOCK GROUP	.24
+	COMMERCIAL	.27
−	WATER	.29
+	MULTI-FAMILY	.30
(∓)	INDUSTRIAL	.307

F. = 2.76
Sig. at. .01

3.3 CENSUS

SIGN	VARIABLE	R^2
+	AVG. VALUE-OWN.OCC D.U.	.03
(±)	AVG. ROOMS-OWN.OCC. D.U.	.04
(±)	1 PERSON HOUSEHOLD	.048
(±)	>1.01 PERSON PER ROOM	.05
−	TOTAL OWN. OCC. D.U.	.07
+	TOTAL RENTAL D.U.	.08
−	AVG. RENT	.09
+	AVG. ROOMS-RENT. D.U.	.10
−	% BLACK	.11
−	POPULATION/D.U.	.12

F. = .80
Not Significant

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient). When only one sign is given both coefficients are in agreement.

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 7

AGE ADJUSTED 1971-72 MORTALITY

DEPENDENT VARIABLE 3; MORTALITY OVER AGE 62

3.4 COMBINED LAND USE & QUALITY FOR TOTAL CITY

SIGN	VARIABLE	R^2
+	SQ. FT./D.U.	.07
+	COMM. FACILITIES	.158
-	OPEN SPACE	.176
+	COMMERCIAL	.189
+	FOLIAGE	.197
+	INDUSTRIAL	.22
(∓)	MULTI-FAMILY RES.	.24
-	WATER	.25
+	PAVED STREETS	.25
-	CURBS & GUTTERS	.26

F. = 2.35
Sig. at. .02<>.05

3.5 QUALITY

SIGN	VARIABLE	R^2
+	SIDEWALKS	.03
-	STREET WIDTH	.05
-	HOUSE SIZE	.06
(±)	DRIVEWAY	.08
-	CURBS & GUTTERS	.09
-	GENERAL CONDITION	.10
+	PAVED STREETS	.10

F. = 1.34
Sig. at. .25

3.6 SELECTED BLOCKS OF MIXED USES: COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
+	FOLIAGE	.17
+	COMM. FACILITIES	.248
+	PAVED STREETS	.285
-	OPEN SPACE	.324
-	CURBS & GUTTERS	.360
+	INDUSTRIAL	.409
+	COMMERCIAL	.459
+	HOUSE SIZE	.49
-	WATER	.51
-	HIGH RISE APT.	.518

F. = 3.39
Sig. at. .005

Neighborhood Profile: TB

Every city has older industrial areas (as opposed to the newer industrial parks) characterized by scattered infusions of contiguous residential areas consisting of rooming houses and frame dwelling units where workers were housed for these nearby plants. Small commercial establishments such as taverns, small grocery stores, auto repair shops, etc. are often found interspersed with these older dwelling units and heavy manufacturing plants. The dwelling units are generally small and in disrepair. There is little vacant land, with each of the three dominant land uses crowding in on each other. Dwelling units which were once single family have been converted to multi-family and multi-person residences with a high degree of overcrowding. Streets are narrow and unpaved, as a result of poor civic maintenance given to the area.

It is this type of neighborhood where TB is predicted by all of the computer models. The combined land use and quality model (Model 4.4) for the entire city showed 82% of the variation in TB rates explained by most of the characteristics listed above (significance at .001).

The one strong census variable to emerge in the full model (4.1) is the variable measuring one person households. This variable accounted for 30% of the variance and could indicate the presence of both elderly persons living alone and single males living in rooming houses; both groups might well be found in the kind of neighborhood drawn by this profile.

The linkages between tuberculosis and poverty as reflected in poor housing and substandard environment has been well established in the literature (Guerrin and Borgatta, 1965). The results of these regression models confirm the persistence of these associations even into the mid 1970's.

In comparing the Houston and Galveston studies we find that the census variable "1 person households" accounts for 8% of the variance (Houston Study p. 122) as compared to 30% in the Galveston study. The position in entering the equation is close in both studies; 3rd in the Houston study and 1st and 2nd (Models 4.3 and 4.1) in the Galveston study. Other similarities are the variable "percent rental units" in the Houston study; (17% of the variance) with the variable "multi-family units" accounting for 6% and 2% (Models 10.6, 10.4) in the Galveston equation.

TABLE 8

DEPENDENT VARIABLE 4; TB

4.1 CENSUS AND LAND USE

SIGN	VARIABLE	R^2
+	INDUSTRIAL	.368
+	1 PERSON HOUSEHOLDS	.639
-	QUALITY INDEX	.579
-	VACANT	.606
-	LITTER	.627
+	>1.01 PERSONS PER ROOM	.55
+	AVG. VALUE-OWN. OCC. D.U.	.657
-	TOTAL POPULATION	.667
-	% OVER 62	.67
-	POPULATION/D.U. RATIO	.678

F. = 12.85
Sig. at..001

4.2 LAND USE UNWEIGHTED

SIGN	VARIABLE	R^2
+	INDUSTRIAL	.43
+	COMMERCIAL	.52
-	VACANT	.58
-	QUALITY INDEX	.63
-	LITTER	.65
(∓)	PAVED AREAS	.65
+	COMM. FACILITIES	.66
(∓)	MULTI-FAMILY	.66
-	SINGLE FAMILY	.67
-	WATER	.67

F. = 12.93
Sig. at. .001

4.3 CENSUS ONLY

SIGN	VARIABLE	R^2
+	1 PERSON HOUSEHOLDS	.31
+	% UNDER 18	.38
+	TOTAL POPULATION	.45
+	>1.01 PERSONS PER ROOM	.47
-	% BLACK	.49
-	POPULATION/D.U. RATIO	.509
+	AVG. RMS./OWN. OCC. D.U.	.52
-	TOTAL D.U.	.53
-	% OVER 62	.54
+	AVG. RMS./RENT. D.U.	.54

F. = 7.22
Sig. at. .001

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient). When only one sign is given both coefficients are in agreement.

TABLE 9

DEPENDENT VARIABLE 4; TB

4.4 UNWEIGHTED REGRESSION LAND USE/INDIVIDUAL QUALITY

SIGN	VARIABLE	R^2
-	PAVED STREETS	.57
-	SQ. FT./DWELL. UNIT	.70
-	VACANT	.73
-	SINGLE-FAMILY RES.	.75
-	STREET WIDTH	.77
(∓)	SIDEWALKS	.77
-	LITTER	.79
-	GENERAL CONDITION	.79
(∓)	HOUSE SIZE	.81
-	HIGH RISE APT.	.82

F. = 28.42
Sig. at. .001

4.5 QUALITY

SIGN	VARIABLE	R^2
-	PAVED STREETS	.57
-	DRIVEWAY	.65
(∓)	SIDEWALKS	.66
-	GENERAL CONDITION	.66
-	STREET WIDTH	.67
-	FOLIAGE	.67

F. = 17.94
Sig. at. .001

4.6. SELECTED BLOCKS OF MIXED USES: COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
+	COMMERCIAL	.209
-	VACANT	.34
-	PAVED STREETS	.51
-	LITTER	.59
-	SQ. FT./D.U.	.61
(±)	PARKING LOTS	.64
+	SIDEWALKS	.65
-	MULTI-FAMILY RES.	.668
-	SINGLE FAMILY RES.	.678
-	DRIVEWAYS	.689

F. = 6.87
Sig. at. .001

Example of commercial and residential mixed land uses.

Example of multi-family and commercial mixed land uses.

Neighborhood Profile: Hepatitis

When viewing the neighborhood profile for the distribution of hepatitis city-wide (Model 5.4), the regression model gives us a picture of a neighborhood of duplex type multi-family housing with developed open space, sidewalks, an absence of litter, wide streets and lot frontages and a lower ratio of dwelling units to total block group square footage, indicating lower external densities. These are predominantly residential areas with little commercial or industrial usage. The predictive value of this model only reaches 28% at best, however, with significance levels between .005 and .01.

The profile changes decidedly when the mixed land use model (Model 5.6) is analyzed. Here we see neighborhoods which are of low quality with multi-family and industrial uses contiguous to each other, with small dwelling units, unpaved streets and a poorly maintained neighborhood appearance. Litter accounts for 20% of the variation in this model. The predictive value of the mixed land use model reaches to 80%, or about three times that of the model for the city as a whole.

The presence of litter in this mixed land use model repeats the outcome of the Houston study, which associated undeveloped land and streets with areas of refuse and trash. The additional connection to the neighborhood profile generated by the meningitis equation should be noted, in that the neighborhoods are not only of similar types, but the presence of litter as a result of alleyways, undeveloped areas and streets is striking in both models for both cities.

Since hepatitis is a disease which is often transmitted through infected shellfish, other food vehicles, and food handlers, the association between poor neighborhoods poorly maintained, is an indirect association between people with a greater likelihood of contracting hepatitis due to poor nutritional habits and higher succeptibility to disease in general rather than an association with land uses which harbor infected foods. It should also be pointed out that hepatitis is transmitted fecally as well as orally and therefore persons in poorly maintained physical environments would be at greater risk than those in well maintained neighborhoods.

TABLE 10

DEPENDENT VARIABLE 5; HEPATITIS

5.1 CENSUS AND LAND USE

SIGN	VARIABLE	R^2
+	MULTI-FAMILY	.05
+	OPEN SPACE	.13
+	% OVER 62	.16
+	AVG. ROOMS-RENT. D. U.	.187
-	COMM. FACILITIES	.208
(∓)	VACANT	.22
-	AVG. VALUE-RENT. D.U.	.24
(±)	SQ. FT./D.U.	.25
+	QUALITY INDEX	.26
(±)	% BLACK	.278

F. = 2.35
Sig. at. .025

5.2 LAND USE UNWEIGHTED

SIGN	VARIABLE	R^2
+	MULTI-FAMILY RES.	.05
+	OPEN SPACE	.13
+	QUALITY INDEX	.15
-	COMM. FACILITIES	.16
-	WATER	.17
(±)	INDUSTRIAL	.17
+	HIGH RISE APT.	.18
	COMMERCIAL	.18
	SINGLE FAMILY RES.	.18
	VACANT	.19

F. = 1.47
Sig. at. .25

5.3 CENSUS ONLY

SIGN	VARIABLE	R^2
-	AVG. VALUE-OWN.OCC. D.U.	.04
+	AVG. ROOMS-RENT D.U.	.06
+	% OVER 62	.09
+	% UNDER 18	.11
-	% BLACK	.12
+	>1.01 PERSONS PER ROOM	.13
-	POPULATION/D. U.	.14
-	TOTAL OWN. OCC. D.U.	.149
-	1 PERSON HOUSEHOLDS	.15
+	TOTAL RENTAL D. U.	.16

F. = 1.17
Sig. at. .25

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient). When only one sign is given both coefficients are in agreement.

TABLE 11

DEPENDENT VARIABLE 5; HEPATITIS

5.4 UNWEIGHTED REGRESSION LAND USE/INDIVIDUAL QUALITY

SIGN	VARIABLE	R^2
+	MULTI-FAMILY	.05
+	OPEN SPACE	.13
+	SIDEWALKS	.16
-	LITTER	.19
-	HOUSE SIZE	.21
-	PARKING LOTS	.23
+	STREET WIDTH	.25
+	LOT FRONTAGE	.26
-	COMM. FACILITIES	.27
-	DWELL. UNIT/SQ. FT.	.28

F. = 2.39
Sig. at. .025<>.01

5.5 QUALITY

SIGN	VARIABLE	R^2
+	SIDEWALKS	.05
+	HOUSE SIZE	.07
+	CURBS & GUTTERS	.09
+	STREET WIDTH	.10
-	FOLIAGE	.11
+	LOT FRONTAGE	.14
+	GENERAL CONDITION	.14
-	DRIVEWAY	.15

F. = 1.00
NOT SIGNIFICANT

5.6 SELECTED BLOCKS OF MIXED USES: COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
+	INDUSTRIAL	.29
+	LITTER	.54
+	MULTI-FAMILY RES.	.71
(∓)	CURBS & GUTTERS	.74
-	HOUSE SIZE	.76
-	APTS.-HIGH RISE	.77
(∓)	COMM. FACILITIES	.78
(∓)	DWELL UNIT/SQ. FT.	.78
(∓)	PARKING LOTS	.79
(∓)	OPEN SPACE	.80

F. = 12.54
Sig. at. .001

Example of vacant land abutting residential land uses.

Example of typical Galveston alley in middle income neighborhood.

Neighborhood Profile: Hypertension

Public health professionals are wont to point out that the diseases of this generation are diseases of affluence. Chronic rather than communicable, often asymptomatic, diseases such as heart disease and hypertension are linked with stress, rich diets, middle age, etc.

The neighborhood profile associated with hypertension is characterized by single family homes with driveways and garages, wide lot frontages, shrubs and trees and a generally well tended, high quality environmental character. This would be a neighborhood where "diseases of affluence" might well be found.

Industrial and commercial land uses are not present in this neighborhood, and vacant land, which often signifies "skipped" development, is also non-existent.

Paved streets with curbs and gutters appear to be sporadically lacking, indicating an association perhaps with outlying suburban areas of a semi-rural character. The association with a high value of owner-occupied housing (explaining 19% of the variance in Models 6.1 and 6.3) confirms the general picture of a typical suburban middle class, single family residential neighborhood.

The profile does not allow for the general observation that hypertension is twice as common among the black population as the white population. This is most likely due to the fact that this study is measuring total cases by place of occurrence rather than by race. Inasmuch as there are still far more cases in absolute numbers of whites suffering from hypertension, the proportion of blacks to whites will not be revealed geographically.

TABLE 12

DEPENDENT VARIABLE 6; HYPERTENSION

6.1 CENSUS AND LAND USE

SIGN	VARIABLE	R^2
+	AVG. VALUE-OWN. OCC. D.U.	.19
+	% OVER 62	.35
-	VACANT	.39
-	TOTAL D.U.	.426
-	COMM. FACILITIES	.47
(∓)	% BLACK	.50
(±)	QUALITY INDEX	.518
-	COMMERCIAL	.54
+	AVG. VALUE-RENT D.U.	.55
(∓)	LITTER	.56

F. = 7.97
Sig. at..001

6.2 LAND USE UNWEIGHTED

SIGN	VARIABLE	R^2
+	SINGLE FAMILY RES.	.07
-	INDUSTRIAL	.09
-	VACANT	.10
+	QUALITY INDEX	.11
-	MULTI-FAMILY RES.	.11
+	HIGH RISE APT.	.12
-	WATER	.12
-	COMM. FACILITIES	.12

F. = 1.19
Not Significant

6.3 CENSUS ONLY

SIGN	VARIABLE	R^2
+	AVG. VALUE-OWN.OCC. D.U.	.19
+	% OVER 62	.35
+	AVG. ROOMS-OWN.OCC. D.U.	.37
-	TOTAL D.U.	.40
+	% BLACK	.416
-	POPULATION/D. U. RATIO	.42
+	TOTAL POPULATION	.47
-	>1.01 PERSONS PER ROOM	.48
-	TOTAL RENTAL UNITS	.48
-	TOTAL OWN. OCC. D.U.	.49

F. = 5.98
Sig. at. .001

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient). When only one sign is given both coefficients are in agreement.

TABLE 13

DEPENDENT VARIABLE 6; HYPERTENSION

6.4 UNWEIGHTED REGRESSION LAND USE/INDIVIDUAL QUALITY

SIGN	VARIABLE	R^2
+	DRIVEWAYS	.12
-	VACANT	.22
-	CURBS & GUTTERS	.31
-	WATER	.37
+	GENERAL CONDITION	.39
$(\mp)$	PARKING LOTS	.41
-	COMM. FACILITIES	.42
+	LOT FRONTAGE	.43
$(\mp)$	LITTER	.44
-	SIDEWALKS	.45

F. = 5.06
Sig. at. .001

6.5 QUALITY

SIGN	VARIABLE	R^2
+	DRIVEWAYS	.12
-	PAVED STREETS	.157
+	GENERAL CONDITION	.187
$(\mp)$	STREET WIDTH	.209
+	FOLIAGE	.22
$(\pm)$	FRONTAGE	.23
-	SIDEWALKS	.24

F. = 2.77
Sig. at. .01

6.6 SELECTED BLOCKS OF MIXED USES: COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
-	VACANT	.06
+	OPEN SPACE	.139
+	MULTI-FAMILY RES.	.19
$(\pm)$	STREET WIDTH	.245
$(\mp)$	LITTER	.267
+	CURBS & GUTTERS	.29
-	WATER	.30
+	DRIVEWAYS	.31
$(\pm)$	HOUSE SIZE	.347
-	SINGLE FAMILY RES.	.357

F. = 1.72
Sig. at. .10

Neighborhood Profile: Cardiac Arrest/Myocardial Infarction

The neighborhood profile associated with cardiac arrest and myocardial infarction seems to be similar to that for hypertension. The appearance of commercial uses with the concomitant absence of parking lots and large paved areas indicates small neighborhood service establishments such as cleaners, corner grocery stores and drugstores, located on major street arteries which abut residential areas.

There is an absence of vacant land and a large square footage of dwelling units and residential lots in each block, indicating somewhat older, built-up neighborhoods. Large, single family houses account for the absence of any indication of internal overcrowding (an inverse relationship explaining 8% of the variation in the census profile). A lack of driveways and garages could also indicate an older neighborhood, prior to World War II, when driveways and garages were not commonplace in otherwise middle income areas. The age of residents of the neighborhood is also revealed in Models 7.1 and 7.3 which indicate 25% of the variance explained by the presence of persons 62 years and older.

It should be observed that the highest rate for cardiac arrest and myocardial infarction in the city appears in a block which contains two homes for the elderly, or nursing homes. These homes are adjacent to the kind of neighborhood described above, and are classed under "hotels as commercial facilities" rather than as community facilities or multi-family dwellings. It is in situations such as these that the difficulties of classification using remote sensing arise in borderline cases. However, the neighborhood in which these nursing and resident homes are located

TABLE 14

DEPENDENT VARIABLE 7;

CARDIAC ARREST/MYOCARDIAL INFARCTION

7.1 CENSUS AND LAND USE

SIGN	VARIABLE	R^2
+	% OVER 62	.26
+	SQ. FT./D.U.	.34
+	AVG. ROOMS-RENT. D.U.	.40
+	COMMERCIAL	.42
−	1 PERSON HOUSEHOLDS	.45
−	AVG. VALUE-OWN. OCC. D.U.	.466
−	>1.01 PERSON HOUSEHOLDS	.50
−	TOTAL OWN. OCC. D.U.	.52
(±)	AVG. VALUE-RENT. D.U.	.537
−	% BLACK	.55

F. = 7.50
Sig. at. .001

7.2 LAND USE UNWEIGHTED

SIGN	VARIABLE	R^2
+	OPEN SPACE	.04
−	VACANT	.09
+	COMMERCIAL	.12
−	PAVED AREAS	.17
+	QUALITY INDEX	.21
−	INDUSTRIAL	.23
−	MULTI-FAMILY RES.	.25
+	HIGH RISE APT.	.26

F. = 2.33
Sig. at. .025

7.3 CENSUS ONLY

SIGN	VARIABLE	R^2
+	% OVER 62	.26
−	1 PERSON HOUSEHOLDS	.34
−	% BLACK	.37
−	AVG. VALUE-OWN. OCC. D.U.	.40
−	>1.01 PERSON PER ROOM	.43
−	TOTAL OWN. OCC. D.U.	.45
+	AVG. ROOMS-RENT. D.U.	.47
+	% UNDER 18	.49
+	POPULATION/D. U. RATIO	.498
−	AVG. ROOMS-OWN. OCC. D.U.	.50

F. = 6.14
Sig. at. .001

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient). When only one sign is given both coefficients are in agreement.

TABLE 15

DEPENDENT VARIABLE 7;

CARDIAC ARREST/MYOCARDIAL INFARCTION

7.4 UNWEIGHTED REGRESSION
LAND USE/INDIVIDUAL QUALITY

SIGN	VARIABLE	R^2
+	HOUSE SIZE	.09
+	COMMERCIAL	.17
−	PARKING LOTS	.24
$(\pm)$	LOT FRONTAGE	.28
+	OPEN SPACE	.30
+	SIDEWALKS	.33
$(\pm)$	CURBS & GUTTERS	.38
+	STREET WIDTH	.42
+	FOLIAGE	.44
+	SQ. FT./D.U.	.45

F. = 4.97
Sig. at. .001

7.5 QUALITY

SIGN	VARIABLE	R^2
+	HOUSE SIZE	.09
−	DRIVEWAYS	.15
−	CURBS & GUTTERS	.19
+	STREET WIDTH	.25
+	PAVED STREETS	.27
+	FOLIAGE	.27
−	GENERAL CONDITION	.28

F. = 2.74
Sig. at. .01

7.6 SELECTED BLOCKS OF MIXED USES:
COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
+	COMMERCIAL	.15
−	PARKING LOTS	.258
+	STREET WIDTH	.46
+	HOUSE SIZE	.55
−	LITTER	.597
−	INDUSTRIAL	.637
$(\mp)$	SQ. FT./D.U.	.649
−	MULTI-FAMILY RES.	.65
+	PAVED STREETS	.659

F. = 7.79
Sig. at. .001

Neighborhood Profile: Venereal Disease

A heavy mix of industrial and residential land uses with poor environmental maintenance appears to describe the neighborhood profile association with V.D. Industrial uses, multi-family and litter account for up to 70% of the variation in Models 8.2, 8.4 and 8.6. When the census variable measuring black population enters the equation, these four independent variables account for 77% of the variation (see Model 8.1).

As is common in so many American cities, this type of neighborhood is to be found where public housing and older industrial establishments exist side by side. Since public housing is generally occupied by black families, this accounts for the association of percentage of blacks with multi-family units. (Simple correlation coefficient of .437, significant at .01 level.) In addition rooming houses converted from former single family dwellings often appear in these kinds of neighborhoods.

In this analysis, VD shows an overwhelming appearance, then, in the poorest neighborhoods of the city, populated predominantly by blacks. Since VD reporting suffers from an acknowledged bias in favor of the poor (upper and middle class whites suppress VD information) this neighborhood profile must be viewed with these facts in mind. While the disease data certainly acknowledges the overwhelming preponderance of cases appearing in this kind of neighborhood, it must be recognized that this does not preclude the existence of other types of neighborhoods where VD exists but is not a matter of public record.

TABLE 16

DEPENDENT VARIABLE 8; VD

8.1 CENSUS AND LAND USE

SIGN	VARIABLE	R^2
+	% BLACK	.62
+	INDUSTRIAL	.707
+	MULTI-FAMILY RES.	.748
+	LITTER	.769
+	PAVED AREAS	.778
(∓)	QUALITY INDEX	.79
+	COMM. FACILITIES	.79
-	HIGH RISE APTS.	.795
(∓)	AVG. VALUE-RENT. D.U.	.797
(∓)	% OVER 62	.80

F. = 24.62
Sig. at. .001

8.2 LAND USE UNWEIGHTED

SIGN	VARIABLE	R^2
+	LITTER	.28
+	INDUSTRIAL	.46
+	MULTI-FAMILY RES.	.61
(±)	COMM. FACILITIES	.63
(∓)	QUALITY INDEX	.64
-	HIGH RISE APT.	.65
+	PARKING LOTS	.66
-	OPEN SPACE	.67
-	VACANT	.67
-	SINGLE-FAMILY RES.	.67

F. = 12.71
Sig. at. .001

8.3 CENSUS ONLY

SIGN	VARIABLE	R^2
+	% BLACK	.62
-	TOTAL OWN. OCC. D.U.	.66
+	<1.01 PERSONS PER ROOM	.67
+	AVG. VAL.-OWN. OCC. D.U.	.69
+	TOTAL D.U.	.70
(±)	TOTAL RENT./D.U.	.71
-	TOTAL POPULATION	.71
-	% UNDER 18	.71
-	1 PERSON HOUSEHOLDS	.71
-	POPULATION/D.U. RATIO	.68
-	%OVER 62	.71

F. = 15.20
Sig. at. .001

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient). When only one sign is given both coefficients are in agreement.

TABLE 17

DEPENDENT VARIABLE 8; VD

8.4 UNWEIGHTED REGRESSION LAND USE/INDIVIDUAL QUALITY

SIGN	VARIABLE	R^2
+	LITTER	.28
+	INDUSTRY	.48
+	MULTI-FAMILY RES.	.63
(∓)	CURBS & GUTTERS	.69
-	HOUSE SIZE	.71
+	COMM. FACILITIES	.73
-	SINGLE-FAMILY RES.	.73
(±)	SIDEWALKS	.73
(∓)	PAVED STREETS	.73
+	PARKING LOTS	.74

F. = 17.58
Sig. at. .001

8.5 QUALITY

SIGN	VARIABLE	R^2
-	DRIVEWAYS	.22
+	SIDEWALKS	.26
-	FOLIAGE	.29
(∓)	GENERAL CONDITION	.33
(∓)	PAVED STREETS	.35
-	HOUSE SIZE	.35
-	LOT FRONTAGE	.36
+	STREET WIDTH	.36

F. = 4.02
Sig. at. .001

8.6 SELECTED BLOCKS OF MIXED USES: COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
+	INDUSTRIAL	.298
+	LITTER	.57
+	MULTI-FAMILY	.72
(∓)	CURBS & GUTTERS	.75
-	HIGH RISE APT.	.77
-	SINGLE-FAMILY RES.	.78
-	HOUSE SIZE	.787
(∓)	COMM. FACILITIES	.79
(∓)	SQ. FT./D.U.	.80
(∓)	PARKING LOTS	.808

F. = 13.12
Sig. at. .001

Example of industrial and residential mixed land uses.

Example of public housing project.

Neighborhood Profile: Shigella/Salmonella

A neighborhood of parks and open space with multi-family duplexes and low rise garden apartments with few single family residences is suggested by analyzing the associations of these characteristics with shigella and salmonella. There may be abutting industrial areas in this profile as well, but in general the neighborhood is predominantly residential, with paved streets and curbs and gutters, and no large parking areas usually associated with large commercial and industrial establishments.

There is an absence of shrubs and greenery around the multi-family units in general. In addition, the models indicate a sparseness of community facilities such as schools, churches, hospitals and public buildings.

The amount of open space associated with shigella and salmonella shows up strongly in all four models which include land use, accounting for 22% of the variance in the total city model (Model 9.4) and a full 30% in the mixed land use model (Model 9.6). Inasmuch as shigella and salmonella are predominantly children's communicable diseases, the association with parks and open space, where children congregate, would appear to have some validity. This is buttressed by the findings in the Houston study where "parks and green space" together accounted for 9% of the variance (see Model 2, p.132). The Houston study also confirms the profile in general, showing similarities in the absence of higher quality residential units, the presence of apartments and industry and the lower value of the housing in general.

TABLE 18

DEPENDENT VARIABLE 9; SHIGELLA SALMONELLA

9.1 CENSUS AND LAND USE

SIGN	VARIABLE	R^2
+	OPEN SPACE	.22
-	AVG. VALUE-OWN. OCC. D.U.	.287
-	COMM. FACILITIES	.32
-	AVG. ROOMS-RENT. D.U.	.349
-	PAVED AREAS	.38
+	QUALITY INDEX	.40
+	MULTI-FAMILY RES.	.415
+	AVG. VALUE-RENT. D.U.	.427
-	COMMERCIAL	.437
+	% BLACK	.44

F. = 4.87
Sig. at. .001

9.2 LAND USE UNWEIGHTED

SIGN	VARIABLE	R^2
+	OPEN SPACE	.22
+	MULTI-FAMILY RES.	.26
-	COMM. FACILITIES	.298
(±)	INDUSTRIAL	.30
-	PAVED AREAS	.308
(∓)	LITTER	.31
+	QUALITY INDEX	.31
-	COMMERCIAL	.31
-	SINGLE-FAMILY RES.	.31
(±)	VACANT	.31

F. = 2.79
Sig. at. .005

9.3 CENSUS ONLY

SIGN	VARIABLE	R^2
-	AVG. VALUE-OWN. OCC. DU	.10
-	AVG. ROOMS-RENT. D.U.	.13
-	1 PERSON HOUSEHOLDS	.20
+	AVG. VALUE-RENT. D.U.	.23
-	TOTAL POPULATION	.24
+	% BLACK	.248
+	% OVER 62	.25
+	% UNDER 18	.25
-	>1.01 PERSONS PER ROOM	.25
-	TOTAL OWN. OCC. D.U.	.25

F. = 2.08
Sig. at. .05<>.025

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient).

TABLE 19

DEPENDENT VARIABLE 9; SHIGELLA SALMONELLA

9.4 UNWEIGHTED REGRESSION LAND USE/INDIVIDUAL QUALITY

SIGN	VARIABLE	R^2
+	OPEN SPACE	.22
+	MULTI-FAMILY RES.	.26
-	COMM. FACILITIES	.29
-	FOLIAGE	.33
$(\mp)$	PAVED STREETS	.37
+	STREET WIDTH	.38
$(\mp)$	HOUSE SIZE	.39
+	INDUSTRIAL	.40
-	PARKING LOTS	.41
+	CURBS & GUTTERS	.41
$(\mp)$	SQ. FT./D.U.	.42

F. = 5.51
Sig. at. .001

9.5 QUALITY

SIGN	VARIABLE	R^2
-	FOLIAGE	.02
+	PAVED STREETS	.12
+	HOUSE SIZE	.16
+	LOT FRONTAGE	.17
-	SIDEWALKS	.18
+	CURBS & GUTTERS	.18
-	GENERAL CONDITION	.18
+	DRIVEWAY	.18
-	STREET WIDTH	.19

F. = 1.60
Sig. At. .25

9.6 SELECTED BLOCKS OF MIXED USES: COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
+	OPEN SPACE	.30
-	COMM. FACILITIES	.36
$(\pm)$	STREET WIDTH	.40
-	FOLIAGE	.425
+	CURBS & GUTTERS	.49
-	PARKING LOTS	.54
-	SINGLE FAMILY RES.	.579
$(\mp)$	HOUSE SIZE	.59
$(\mp)$	SIDEWALKS	.61
+	PAVED STREETS	.637

F. = 5.45
Sig. at. .001

Neighborhood Profile: Meningitis

A characteristic which stands out in the neighborhood profile for the distribution of meningitis is the seemingly pronounced areas of vacant open space which could be receptacles for litter. This includes playgrounds and grassy play areas. While the quality of the environment is not poor, in that the streets are wide and paved, with curbs and gutters and wide lot frontages, the values of the owner-occupied housing units are not high, indicating a middle to low income neighborhood with small houses, probably located close in to the central business district.

No commercial or industrial land uses appear in this profile, which could mean that litter does not arise from poorly maintained nonresidential land uses but is related to household trash. Since litter accounts for 3%, 4% and 5% of the variation respectively in three different models (Models 10.4, 10.6 and 10.2) it must be assumed that these are poorly maintained residential neighborhoods.

In general, while the neighborhood profile generated from all of the models is not a clear one, it appears that the distribution of meningitis occurs in the inner city areas, especially in those neighborhoods where the housing is older and borderline conditions of deterioration exist. The profile especially suggests the older areas of the city which still retain a system of alleyways running through the center of the residential block, behind the housing on each side where residential litter tends to accumulate. This system of alleyways is characteristic of the "old" Galveston and is not typical of most Southwestern American cities. These areas are transitional, both upward and downward in terms of social mobility patterns; some are being purchased and rehabilitated by upper income families and some are run-down rooming houses and duplex apartments occupied by students, transients and low income families.

The neighborhood profile for meningitis is again similar to that developed by the Houston study (p. 124) where unimproved land accounted for 16% of the variance in both the mixed model and the land use model. The similarity between unimproved or vacant land, and the kinds of open spaces which appear in inner city neighborhoods is close, in that much open space in these areas are intended for recreational purposes but are not well-maintained.

TABLE 20

DEPENDENT VARIABLE 10; MENINGITIS

10.1 CENSUS AND LAND USE

SIGN	VARIABLE	R^2
-	AVG. VALUE-OWN. OCC. D.U.	.16
+	QUALITY INDEX	.21
+	>1.01 PERSONS PER ROOM	.24
$(\mp)$	AVG. ROOMS/OWN. OCC.	.26
-	SQ. FT./D.U.	.277
$(\mp)$	VACANT	.299
$(\pm)$	POPULATION/D. U.	.318
-	1 PERSON HOUSEHOLDS	.359
+	OPEN SPACE	.378
+	COMM. FACILITIES	.385

F. = 3.83
Sig. at. .005<>.001

10.2 LAND USE UNWEIGHTED

SIGN	VARIABLE	R^2
+	LITTER	.05
+	OPEN SPACE	.10
+	MULTI-FAMILY	.14
+	VACANT	.15
-	WATER	.158
+	QUALITY INDEX	.16
-	INDUSTRIAL	.17
+	HIGH RISE APTS.	.17
$(\mp)$	PAVED AREAS	.17
-	COMMERCIAL	.175

F. = 2.79
Sig. at. .025<>.01

10.3 CENSUS ONLY

SIGN	VARIABLE	R^2
-	AVG. VAL.-OWN. OCC. D.U.	.16
+	% BLACK	.19
-	1 PERSON HOUSEHOLDS	.216
-	% UNDER 18	.23
+	>1.01 PERSONS PER ROOM	.246
-	POPULATION/D.U. RATIO	.27
-	TOTAL OWN. OCC./D.U.	.28
+	TOTAL POPULATION	.29
+	AVG. ROOMS-OWN.OCC D.U.	.29
-	AVG. ROOMS-RENT. D.U.	.29

F. = 2.5
Sig. at. .025

NOTE: Where two signs are given, (the top sign is the simple correlation coefficient and the lower sign is the regression correlation coefficient). When only one sign is given both coefficients are in agreement.

TABLE 21

DEPENDENT VARIABLE 10; MENINGITIS

10.4 UNWEIGHTED REGRESSION LAND USE/INDIVIDUAL QUALITY

SIGN	VARIABLE	R^2
-	SQ. FT./D.U.	.11
+	OPEN SPACE	.15
+	LITTER	.18
(±)	MULTI-FAMILY RES.	.20
+	CURBS & GUTTERS	.22
-	HOUSE SIZE	.30
+	HIGH RISE APT.	.32
-	PARKING LOTS	.34
(∓)	LOT FRONTAGE	.36
-	COMMERCIAL	.37

F. = 3.59
Sig. at. .001

10.5 QUALITY

SIGN	VARIABLE	R^2
+	STREET WIDTH	.09
-	DRIVEWAYS	.15
(∓)	LOT FRONTAGE	.189
+	PAVED STREET	.21
-	FOLIAGE	.22
(±)	CURBS & GUTTERS	.23
+	GENERAL CONDITION	.23

F. = 3.25
Sig. at. .005

10.6 SELECTED BLOCKS OF MIXED USES: COMBINED LAND USE AND QUALITY

SIGN	VARIABLE	R^2
+	STREET WIDTH	.16
+	OPEN SPACE	.207
+	MULTI-FAMILY	.266
+	LITTER	.30
-	HOUSE SIZE	.319
+	CURBS & GUTTERS	.398
	STREET WIDTH REMOVED BY COMPUTER	
(±)	PAVED STREETS	.428
-	FOLIAGE	.44
(∓)	DRIVEWAYS	.46
-	VACANT	.496

F. = 3.56
Sig. at. 005

Example of duplex housing which appears as single family dwelling.

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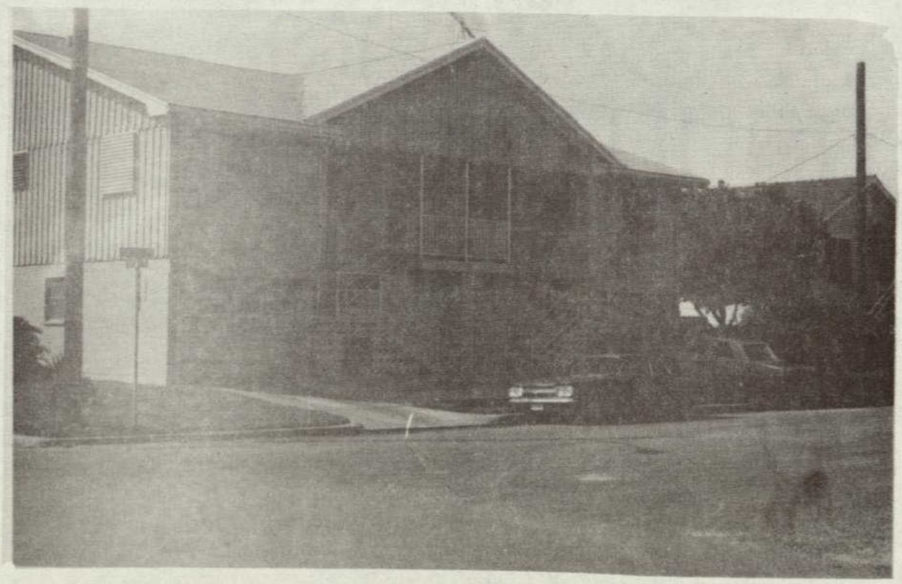

Example of multi-family housing (duplex) which appears as a single family dwelling.

Mortality Differences: Comparison to Houston Study

Mortality Differences

The mortality difference is a measure of the agreement between the expected rate for each block group by age group, and the observed rate by age group. This difference is then used as the dependent variable, rather than crude death rates. By taking these differences by ages we are controlling for both age and population vagaries, allowing any differences in the resulting rate to be explained by the chosen independent variables.

The results for Houston were much stronger than for Galveston. The R square for Houston was .70 while for Galveston it was only .34. In the Houston equation, the census variables explained more of the variance, while in the Galveston equation the reverse was true. (7 out of 10 were land use variables).

Open space figures as an explanatory variable both for Galveston and for Houston. In the Houston equation, green space, accounted for 3% of the variance and in Galveston it counted for 5% of the variance. Single family residential areas acted as common predictors in each equation as well.

It would appear from the data in both Houston and Galveston that overall mortality does not strongly reflect socio-economic differences, either in quality of residential areas or in value of owner occupied homes or in rents. While in Houston the <u>number</u> of rental units explained 15% of the variance in mortality differences, in Galveston this variable did not appear at all. We assumed in the Houston study that rental housing implied lower income status, but this assumption does not necessarily hold for Galveston due to the large numbers of duplex and garden apartments distributed city-wide. Perhaps the mixed income distribution among rental uses in Galveston prevented this variable from entering the equation.

The following table compares the results of both the Houston and Galveston studies in measuring mortality differences. This model was not included in the ten models listed for the Galveston study and was run separately for comparison purposes only.

TABLE 22

COMPARISON

MORTALITY DIFFERENCES

HOUSTON			GALVESTON		
SIGN	VARIABLE	R^2	SIGN	VARIABLE	R^2
+	% RENT	.15	−	SQ. FT./DWELL. UNIT.	.05
−	TOTAL POPULATION	.28	−	% BLACK	.09
+	SCHOOLS/CHURCHES	.41	−	COMMERCIAL	.15
(∓)	CH.	.49	−	POPULATION/DWELL. UNIT	.188
−	% 1 PERSON HOUSEHOLDS	.54	(±)	% OVER 62	.22
(±)	POPULATION/DWELL. UNIT.	.58	+	OPEN SPACE	.267
−	OWN. OCC. DWELL. UNIT.	.61	+	AVE. VALUE OWN. OCC. D.U.	.287
+	GREEN SPACE	.64	+	SINGLE FAMILY	.30
(∓)	RES. EXCELLENCE	.67	(∓)	1 PERSON HOUSEHOLDS	.32
(∓)	RES. MED. GOOD	.70	(∓)	VACANT	.347

F = 3.24

Sig. at. .005

CHAPTER VII

SUMMARY AND CONCLUSIONS

The city is a mirror. Within its urban form the texture and character of its neighborhoods reflects the socioeconomic and cultural characteristics of its inhabitants. Looking deeper into the mirror, one sees the city as a setting for the interaction of these characteristics with the health, and ill health, of these inhabitants.

The epidemiological model of agent, vector and host has expanded in this half century to include this urban setting as the environment, physical, social, psychological; the framework in which episodes of morbidity and mortality take place. Human ecology and epidemiology are thus beginning to merge as researchers seek to unravel the intricate causal strains of disease.

What are the implications of this merger for research? One implication, alluded to above, is that the physical environment of the city, acting as a mirror for the social environment, must be re-examined and continually monitored. Since we do not know as yet the real impact of the physical city on its inhabitants and their health and disease patterns, it behooves us to investigate the city from this perspective.

One mode of investigation is to use modern technology to examine this age-old association between the physical city and the people with whom it interacts, focusing specifically on ill-health. Because the city is a mirror and in its physical form manifests the varied life styles of its residents, a natural tool for capturing this mirror image is the photograph, and space technology has given us a highly sophisticated form of the photograph, remote sensing.

Remote sensing is an ideal method for looking at the city in its vast 20th century form. The great span and complexity of our metropolitan areas call for just this kind of methodology, which enables us to view the city as the sum of its parts and as sectors and neighborhoods as well. Therefore, we are able to obtain a macro and a micro view simultaneously.

By examining patterns of ill health and mortality in the same spatial frame, we can then merge the photograph with health patterns and begin to investigate any possible associations which may present themselves to us.

The use of remote sensing to evaluate the physical urban environment does not preclude the buttressing of the information thus obtained, with additional socio-demographic data. Both are necessary, and should act in a complementary fashion. While a photograph can reveal quite clearly the obvious correlates of poverty, social indicators organized in similar spatial configurations, can confirm these correlates. A surfeit of information is not a problem here, as long as the correlates for analysis are carefully chosen, spatially arranged and then interrelated in a precise and logical manner.

Acting within the conceptual framework mentioned above, this project then has attempted to accomplish two things:

1. To determine the applicability of remote sensing in urban public health by investigating and identifying the spatial distribution of physical environmental characteristics in urban areas which are postulated to be associated with health problems.
2. To compare this applicability in turn to the more common usage of census data as the usual correlates selected for association with health problems.

The first step in this research project was to identify the indicator variables to be used in assessing the urban physical environment. The remote sensing literature yielded valuable guidelines in this regard, and the selection of these variables was greatly facilitated by what had been previously accomplished. Not only did the literature advise as to which indicator variables were best suited to the unique properties of remote sensing and the ensuing image analysis, but within the broad range of those variables themselves we were able to ascertain those which would appear to be most suited to an investigation of urban health patterns, as they relate to the physical environment.

Our indicator variables were divided into two basic groups; types of land use and residential quality indicators. We then attempted to quantify both groups, seeking to determine if the amount as well as the distribution of these indicator variables, had an affect on urban health.

The land use indicator variables were as follows:

Community Facilities
Open Space
Commercial
Industrial
Vacant and Unimproved
Streets and Parking Lots*
Water**

Residential
- Single Family
- Multi-Family (1-3 Story)
- Multi-Family (Over 3 Story)

The quality indicator variables were as follows:

Foliage and Green Lawn
Sidewalks
Driveway and Garage
Street Width Over 30 Ft.
Paved Street
Curbs and Gutters
Litter

Frontage of Lots
- Over 90 Ft.
- 50 to 90 Ft.
- Less than 50 Ft.

Size of House
- Over 2000 Sq. Ft.
- Between 1200 and 2000 Sq. Ft.
- Less than 1200 Sq. Ft.

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*Streets were later integrated into the block measurements and quality variables, leaving only parking lots in this category.

**Water was eventually eliminated from analysis due to relatively sparse distribution.

The second step taken was to determine which morbidity indices to use. The pilot project in Houston had selected tuberculosis, hepatitis/meningitis, shigella/salmonella (in combination), mental health, and juvenile delinquency with the latter two being commonly viewed today as indicators of ill-health in the social fabric of the city. It was intended to replicate these choices in the Galveston follow-up study, but the existence of data proved to be a problem for the latter two, and therefore, three new indices were selected; venereal disease, hypertension and a combination of cardiac arrest and myocardial infarction (as a measure of the commonly named "heart attack"). The addition of chronic diseases in the latter two selections was felt to be called for inasmuch as chronic disease has supplanted communicable disease as the most frequently occurring in the population. Mortality was used in both studies as a gross measure, rather than by specific cause of death. (See Chapter III for more detailed explanations).

The third important step taken in the research program was the decision to sample the study area rather than attempt image analysis for the entire city. The intention was to be able to generalize to the entire city from the sample, which had not been done before in remote sensing studies. If successful, it was felt that this would further enhance the utility of remote sensing in urban studies in that time saved would be substantial while essential accurracy would be preserved.

The methodology used in the sampling procedure was to divide the city into "natural areas" based on similar land use and residential quality characteristics (using the same indicator variables as given above) and then sample from these natural areas, ignoring census tract boundaries.

It was felt that census tracts did not necessarily yield homogenous characteristics and that a simple windshild survey of the city would provide a better sampling frame. (Further details concerning the sampling process are given in Chapter IV).

<u>Hypotheses Formulated for Testing</u>

After reviewing the significant remote sensing literature dealing with poverty neighborhoods, (Mumbower, Donoghue, 1967; Tuyahov, Davies, Holz, 1973); with land use and housing surveys (Mullens, 1970; Wellar, 1968), and the association of both with public health (Mullens, 1969), it appeared that the results of these studies could be evolved into one central empirical generalization, which could be stated as follows:

LAND USE AND RESIDENTIAL QUALITY ARE ASSOCIATED WITH AND ACT AS AN INFLUENCE UPON HEALTH AND PHYSICAL WELL BEING.

This empirical generalization in turn yielded six subsequent hypotheses which could be tested. These six are stated as follows:

1. Variations in levels of health and in health status, as reflected in morbidity and mortality rates, are associated with and can be explained by land use and residential quality.
2. Variations in levels of health and health status, as reflected in morbidity and mortality rates, are associated with and can be explained by socio-economic and housing indices as given in the census.
3. When combining land use, residential quality and census variables, in order to explain variations in mortality and morbidity rates, the land use and residential quality variables will account for a higher level of association than will the census variables.
4. Residential quality alone, independent of density and other land uses is associated with and can explain variations in mortality and

morbidity rates.

5. Residential density alone, independent of density and other land uses, both measured internally and externally, is associated with and can explain variations in mortality and morbidity rates.

6. Neighborhoods of mixed land uses are more strongly associated with poor levels of health than are purely residential neighborhoods.

These hypotheses were tested by means of a step-wise regression program (BMD-02R), in which ten different models were devised. The results of eight of these models are given in this report (see Chapter VI, and Appendices). The health variables acted as dependent variables, with land use and residential quality, and census indicators, as independent variables.

The overall results showed a statistically significant association between the combination of land use and residential quality and health, with all of the dependent variables reaching statistical significance levels of .001 except two which were significant at .05*. In addition, for eight of the 10 dependent health variables there was a higher level of association with the independent land use and quality variables than with the census variables. In other words, for 80% of the variables, land use and quality indicators were better predictors of mortality and morbidity than census indicators.

Looked at more closely, the two dependent variables TB and VD showed by far the strongest association with land use and residential quality,

*What this means is that one can be reasonably certain that if there is an association between land use, residential quality and health, then 99.9% of the time (for an .01 level of significance) and 95% of the time (for an .05 level of significance), the resulting data would not have been obtained if in fact that association did not hold.

with 82% of the variance of TB explained and VD registering 74% in the step-wise regression analysis. When the residential quality variables were removed, and land use was run as a separate model, a predictive level of 67% was attained for both dependent variables. The neighborhood profile generated from the individual variables for these two diseases was quite similar, in that both showed high levels of these diseases occurring in typical urban poverty areas, confirming long time associations between poverty and TB and VD as seen in the literature.

The other dependent health variables did not show quite so striking an association with land use and residential quality as did TB and VD. However, five of them attained an R^2 measure of association of over 40%; these were Mortality Under 18, Mortality between 18-61, hypertension, cardiac arrest/myocardial infarction and shigella/salmonella. Therefore, while 40 to 50% of the variation in rates for these five health variables may be due to other causes, it remains that the physical environment should be taken into account in any exploration of the ecology of these morbidity and mortality indices.

The strength of the land use and residential quality variables shows up again when they are combined with census variables. A comparison was made taking the first five independent variables which appeared in the regression equation, and comparing these first five for all ten of the dependent variables. Of the total 50 variables compared (10 dependent multiplied by 5 independent in each equation) 30 were land use variables. This model was the model which was analyzed for land variables only. In the second model, which was that which combined land use and quality, out of the first 50 variables, 35 were land use variables. That is, 60%

of the variables in the first model which combined census data as independent variables and land use as independent variables, turned out to be land use variables rather than census. And in the second model, where quality was also added, 70% of the variables were land use and quality variables. In both cases then, the land use and quality variables outperformed the census variables.

However, when the land use variables were run in a model by themselves against the dependent health variables, and when the residential quality variables were also run in a model by themselves, neither showed the predictive strength which was achieved when they were combined. Aside from TB and VD, with a previously mentioned R^2 of 67%, the other dependent variables did not achieve higher than 31% of the variance explained for any one dependent variable. The quality variables by themselves made an even weaker showing. It was quite evident that land use without quality measures, and vice-versa, is not sufficient for a strong association with health.

When examining the individual land use and quality variables by themselves, in relation to each dependent health variable, it is interesting to note that there is no consistent pattern of association with any dominant land use characteristic. Instead, there is a great deal of variety with each disease index showing its own particular and unique relationships with land use and quality. Thus, while both TB and VD are associated with a profile of a poverty neighborhood, the special characteristics of those neighborhoods differ somewhat. For instance, while TB shows an association with industrial land uses and to a lesser extent with commercial uses, unpaved streets is one of the strongest variables appearing through all of the models, as well as a low ratio of dwelling units to total square footage. VD on the other hand shows a consistently high relationship with industrial land uses, multi-family housing and litter. One would assume that the neighborhoods in which these diseases are located would have similar characteristics appearing in the regression equation but such is not the case. One can only conclude that of the many characteristics of poverty neighborhoods, there are some which are unique to each disease index. (The census variable "% Black" appeared prominently in the VD equation as well.)

The other interesting observation, which is actually a corollary to the above, is that certain disease indices show a totally different neighborhood setting, based on the independent variables entering the regression equation. Hypertension does not appear to occur in a neighborhood which is predominantly black, but rather in a middle class neighborhood characterized by single family homes with wide lot frontages, shrubs and trees, paved streets, driveways and garages and generally high quality overall. The same holds true for "heart attacks" (cardiac arrest/myocardial infarction) except that the neighborhood profile includes some neighborhood commercial uses and a higher ratio of dwelling units to total square footage of the block, indicating somewhat older homes. In both cases however, there is a sharp contrast to VD and TB, and a decided difference as well between these neighborhoods and those associated with hepatitis, meningitis and shigella/salmonella, (which generally appear to be older inner city neighborhoods, with higher densities, multi-family housing and a lower level of quality).

Land Use and Quality Complement Census

The degree to which the land use and quality variables act as a complement to the census variables, and enhance the validity of both in terms of logical associations, is revealed in the simple correlation matrix. The highlights of these associations are given below, for those census variables which correlated with land use and quality variables at the .001 level of significance. The actual correlations with their signs are given to indicate the strength of the associations numerically. A perusal of these correlations confirms the fact that indeed the city is a mirror, reflecting internal housing and social characteristics which are generally not thought to be attainable other than through household surveys.

For example, the census variable commonly associated with over-crowding, "more than 1.01 persons per room", showed a strong association across the board with variables which indicated poor residential quality (with both positive and negative associations):

More than 1.01 persons per room: Simple Correlations

Litter	Foliage	Driveways	Lot Frontage	Multi-Family
+.463	-.489	-.601	-.473	+.467

The census variable which indicates the value of owner occupied dwelling units showed a consistently high correlation with positive values of quality as well:

Value of Owner Occupied Dwelling Units: Simple Correlations

Foliage	Driveways	Lot Frontage
+.608	+.768	+.674

In addition, areas which were predominately owner occupied showed the same patterns:

Foliage	Driveways	Single Family	Industrial
+.527	+.471	+.599	-.406

The entire simple correlation matrix may be found as Appendix XVII. The important correlations are affixed with an asterisk to facilitate location.

Investigation of Density Patterns

The long association of density and overcrowding with social and physical pathologies received additional focus from Galle in a recent publication (see Galle et al, 1972) and from Stokols (1972) who differentiated between density as a physical condition limiting space, and crowding as the results of this restriction as perceived by the individual. Both went on to re-assert the negative aspects of density (or crowding), both psychological and physiological. Galle found that the number of rooms per dwelling units was a strong predictor of admissions to mental hospitals, and that persons per room was the most important determinant of overall pathology, both psychological and physiological.

In an attempt to measure the effect of density on mortality and morbidity, seven different density measures were employed as separate indicators of both external and internal phenomenon of density. (See Chapter VI). No attempt was made to combine these measures, in that the effect of each as a discrete variable, was desired. While the total variance explained was similar to that for the individual quality variables and was not as high as had been anticipated, there were two interesting results. First, the traditional measure of density, "more than 1.01 persons per room" emerged as a strong predictor for only 3 of the 10 dependent variables. The size of the house emerged as the other strong predictor. These two variables are both complementary and different; they are different in that the first measures internal density while house size measures external density. However, house size can be looked at both externally and internally depending upon the number of rooms in the dwelling unit and the number of people in those rooms; in this way, house size is complementary to the overcrowding measure.

Although the density patterns investigated did not show the strength of association which had been predicted, an extensive investigation of this association was not performed, inasmuch as only one computer model was used for this investigation. A more varied manipulation of the measures employed might yield a subsequently stronger association in further investigations.

Mixed Land Uses

The purpose of land use regulation has long been to separate out incompatible uses in order to insure the "health and welfare" of the residents of a city. Land use regulations have also been used to maintain class and socio-economic differences in cities between the well to do neighborhoods and the rest of the city. Thus, those single family residential areas which have little commercial and no industrial uses contiguous to housing, and in turn have parks and open space, and a number of community facilities, are generally upper and upper middle income areas. Those neighborhoods where residential uses are located in close proximity to commercial and industrial uses, or vacant, untended areas, are generally less desirable residential locations.

Whether this kind of segregated land use pattern has any effect on health or disease patterns as well has been questioned. Any association between heavily mixed land use areas and higher mortality and morbidity rates could be misinterpreted to mean that land uses causes ill health whereas in truth, land use could be considered merely an intervening variable between disease and poor socio-economic and cultural conditions. It was felt that a brief investigation of the mixed land use association with poor health might be desirable.

Chapter VI (Testing of Hypotheses) gives a detailed account of the results of the computer model testing this association. Briefly, a generally stronger predictive level resulted from this model, which selected out those block groups with substantial amounts of mixed land uses for analysis. In one case, that for hepatitis, the R^2 increased almost four-fold, from 28% of the variance explained to 80% of the variance explained. Other variables also increased substantially; shigella/salmonella from 42% to 63% of the variance explained; CA/MI (heart attack) from 45% to 66% of the variance explained and Mortality Over 62 from 26% to 52% of the variance explained. As expected, dependent variables such as "Mortality Over 62" showed an association with compatible mixed uses such as community facilities, while hepatitis showed an association with incompatible land uses such as industrial uses.

Heart attacks (CA/MI) showed a much stronger association with commercial land uses (positive) and parking lots (negative) than in the model for the total city. However, this was a matter of degree only; the same variables entered both equations among the first three. A like phenomenon occurred for shigella/salmonella, with the same associations indicated (with open space and vacant as positive and community facilities as negative) but with these associations showing up much stronger in the mixed use model than in the total city model.

We can say then that to some extent, neighborhoods with mixed land uses show a stronger association with ill health than neighborhoods of both mixed and purely residential land uses combined in a model for the whole city. We cannot say that they show a greater association than do neighborhoods of purely residential land use, because we did not test this proposition. However, the conclusion is interesting and bears further investigation.

A Taxonomy of Land Uses and Attendant Problems

There are two main problems in the use of remote sensing to evaluate land uses and to put them into an appropriate taxonomy. These are:

1. Developing categories which share a common language and utility between urban planners and image analysts so that the image analyst is comfortable with traditional categories evolving from ground surveys.
2. Breaking down this taxonomy in such a way as to avoid possible conflicting interpretations.

An explanation is in order. The first problem deals with a general taxonomy of land uses which is compatible for both urban planners and image analysts and mutually beneficial to both. Thus the traditional urban planning category of "public utility" or "public use" would not be compatible to an image analyst because that utility could take the form of an office building, an electric generating plant or a golf course, all three are discreet and different land uses in the vocabulary of the image analyst. However, if the planner were to feel this kind of category was essential, he could then break it down in such a way as to include each of these uses as a discreet entity under the overall caption "Public Use". Thus both planner and analyst would find a solution mutually acceptable.

These two major problems generate component problems in that often an image analyst simply cannot tell from his perspective whether a large multi-story building is a bank, a hospital or an office building. Sometimes the kind and amount of parking or foliage will be helpful as a clue. Often however, even parking and foliage would be similar for all three of these buildings. Of the three building types, two would generally be considered commercial in urban planning terms, and one would be considered a community facility (the hospital).

This project encountered problems similar to this. In one case, a nursing home/retirement home, was classified as a commercial use when it probably belonged in the community facility category. It could also have been classified as multi-family housing, from the air. Another frequent problem in this project was the inability to distinguish between some multi-family units and commercial uses; this happened several times in the process of image analysis. Finally, it is very difficult for the analyst to distinguish between open space, meant as developed recreation area, and vacant areas which are neglected and undeveloped. In all of these cases, there are very definite implications for health depending upon the classification used.

However, this problem with the taxonomy of land uses occurs only on a micro basis and when all land uses are added up to present an overall picture of the city on a macro basis, they diminish in importance. Often these errors can be caught by the alert analyst or noted when a classification decision is made. If noted at the time, these questions can be answered through ground verification very quickly, or simply through knowledge of the important characteristics of the city itself on the part of the investigator.

A third major problem which touches on the two mentioned above, is the difficulty in distinguishing and counting multi-family units from single family units. (See Lingdren, 1971). This is particularly difficult in areas of duplexes or two story houses where the upper floor is one unit and the lower floor another. (It is also difficult to distinguish commercial uses on ground floors of residential dwellings. See Ayre, Adolphus, Amiel, 1970). Galveston as the research area for this project is characterized by many such dwelling unit combinations, increasing the difficulty of classification. The level of error between single family/multi family and between multi-family/commercial was generally higher than for other land use classification discrepancies. (See Chapter V, Reliability and Validity).

All of these problems argue for a thorough and extensive ground verification in areas where there are questionable classifications. This does not necessarily add to the time involved in the remote sensing process, because it can be done simultaneously with it. Therefore, the efficacy of remote sensing as a time saver in land use analysis is retained. With the development of the IDECS scanner (See Anderson & Anderson 1973) time saved will be multipied; however the problems of classification will remain.

Problems of Residential Quality Evaluation

Finally, a consistent problem which does not involve a taxonomy per se but which does reflect judgement problems of the image analyst, is the problem of evaluation of residential quality. Because in the Houston pilot study an overall subjective measurement was used for housing quality, there was no way to determine which variables were utilized for the quality measure. This was changed in the Galveston project, but the subjective category was maintained for comparison purposes, in order to determine the differences, if any, between "quality" as broken down into component variables, and "quality" as rendered through the overall subjective judgement of the analyst.

Chapter II discusses these quality categories more thoroughly. Briefly, there were 8 individual variables or factors which made up a Quality Index; the 9th factor was the subjective quality category, with distinctions between excellent, good, and poor and the percentages of same in each city block. The individual variables were also scaled in this fashion, giving a basic scale of 1 to 3 for quality (with one as low and three as high).

There was a consistent bias revealed when the numerical average for the Quality Index was compared against the numerical rating on the subjective quality judgement. This bias was measured using both the 8 Factor Index and the 4 Factor Index. (See Chapter V, Reliability and Validity). Inasmuch as the 4 Factor Index was adjudged to be closer to the subjective measurement in terms of the elements which the image analyst considered when looking at quality (eliminating streets and street characteristics), the 4 Factor Index was compared to the subjective

Quality judgement to determine differences, using the Spearman Rank Correlation Test. The results using the Four Factor Index showed that the subjective and objective measurements were correlated at the .01 level of significance. The Eight Factor Index also showed a similar correlation. In view of these results, it appears that an impressionistic evaluation of neighborhood residential quality shows the same relative accuracy as using discreet indicant variables and cumulating them in an index. This is an interesting conclusion in view of the resulting time saved in a remote sensing inventory. For research purposes one must still use discreet indicants. But for monitoring purposes, a subjective evaluation would appear to suffice.

A Note About The Ecological Fallacy

The question of the "ecological fallacy" arises whenever one undertakes studies involving aggregates of individuals in circumscribed spatial units. Briefly, the "ecological fallacy" simply means that "associations found at the individual level may differ in sign (direction as well as magnitude (correlation) from those based on corresponding group data."* The risk of the "ecological fallacy" is that the researcher may assume that the associations he has found at the group level, such as those involved in this study, are also occurring in the same manner at the individual level. This study makes no such assumptions.

However, this study does not intend to draw cause and effect relationships from the data and results we have assembled. In the words of Allardt (1969) "it is typical of survey studies (of which this is one) that we cannot draw causal inferences with any degree of certainty. This can only be done with controlled experiments. We can however, on the

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*Bice, Thomas & Kalimo, Esko, 1971.

basis of experience, existing explanatory hypotheses, and other available information, make causal interpretation.*

Suffice it to point out that the associations derived from the regression model used here are:

1. Applicable only at the block group territorial level and not for individuals residing within that territory
2. Not attributable to direct cause and effect relationships but only associations which can be predicted with some certainty that they are not caused by chance.

Utility of Remote Sensing

The utility of remote sensing as an analytic tool in data gathering and in providing an accurate "mirror" or image of the urban environment has been verified in this study. When one recognizes the need for an almost continual monitoring of the physical environment, neighborhood by neighborhood, to service the data needs of the many public agencies involved in program planning and resource allocation, it is almost a truism that remote sensing is a superior methodology to other assessment techniques in terms of time and manpower considerations.

As stated in Chapter II, the time spent by the image analyst on a block by block basis averaged out to roughly 12 to 15 minutes per block. This included identifying land uses, determining the square footage of each type of land use, determining the amount and type of each quality factor and filling in a coding sheet containing all of this information. The comparable task followed in the ground verification procedure, utilizing two people, took about 15 minutes per block also, not including

*Allardt, Erik, 1969, p. 43.

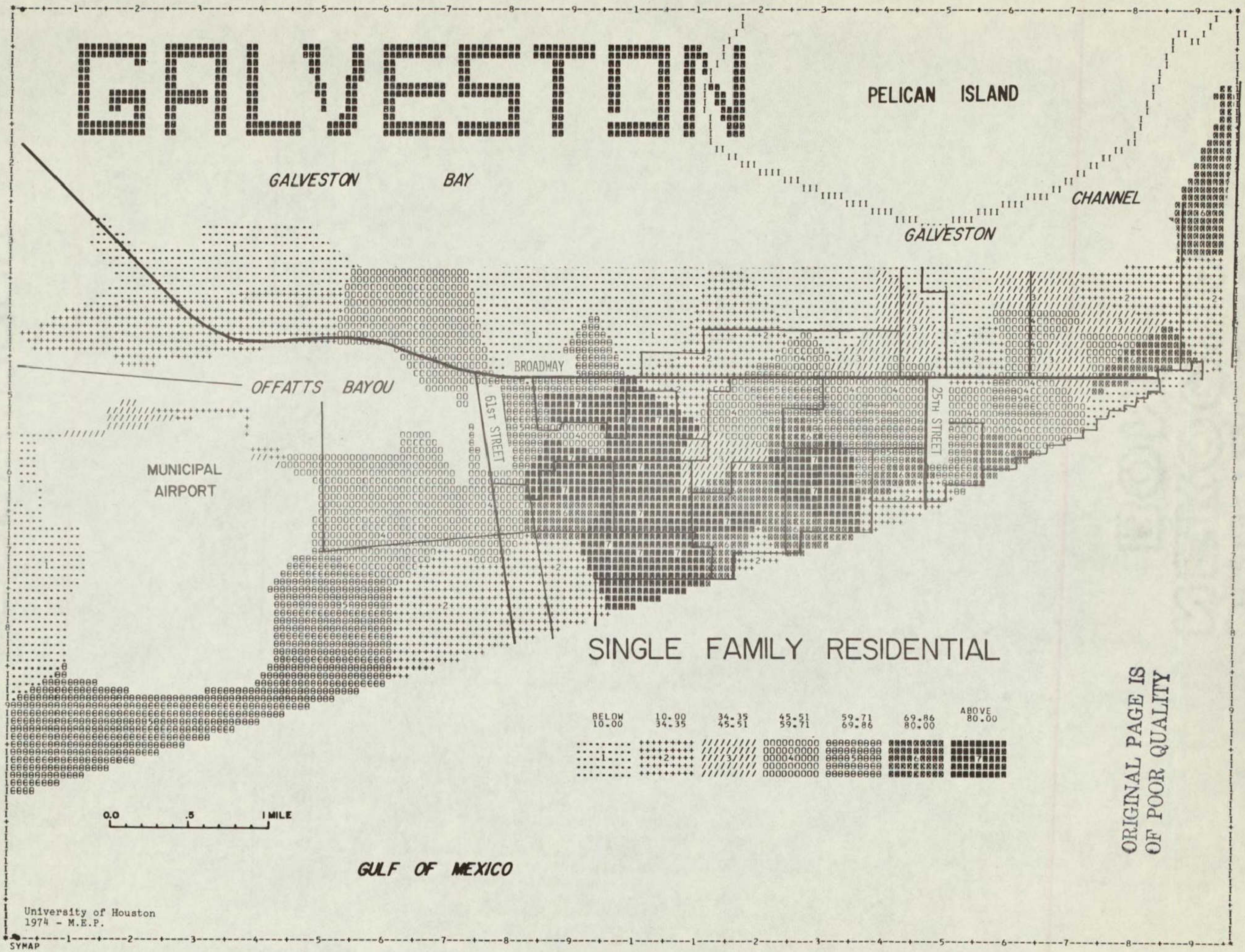
the square footage measurements which would have had to be done from a map, probably doubling the ground verification time for the same block.

The total number of blocks analyzed in this project was about 1300. Once the image analyst became familiar with the coding sheet and with the city and the procedure of analysis, he was averaging about 20 blocks per day or 100 blocks per week, working about a four hour day on the analysis itself. Therefore, the whole project could have been completed in 13 weeks. This is a considerably shorter time period than would have been taken for the comparable task by one person in a ground survey.

The additional advantage of remote sensing in this kind of study is that it can be done intercensually. Now that we know the predictive value of land use and residential quality data as compared to the census, we can be more confident that information generated by remote sensing will prove most useful in the decade between census periods. Again, it should be emphasized that remote sensing will never be a substitute for census data or any other social indicators; but rather a complement to them, as well as an effective monitoring device to keep up with change in the years when the census loses its initial accuracy due to our extreme population mobility.

Once initial baseline data is gathered for an urban area, via remote sensing and census and social indicators, then remote sensing can continue to monitor change, compare it against the baseline, and give an annual or biannual account of what is happening to the city's neighborhoods. Indicators of upward and downward mobility should be facilitated by employing some of the variables utilized in this research. It should be remembered that although about 20% of our urban population moves every year (most of these moves being intra rather than inter-city) the inhabitants of a neighborhood which maintains its essential characteristics will be similar to one another, even if they are not inhabited by the same people. Therefore, a basic typology of neighborhoods constructed from the initial baseline data, can be accompanied by a rough typology of the inhabitants of those neighborhoods as well. If the neighborhood remains essentially the same in the inter-censal decade, it can be assumed that the population characteristics are roughly the same. If the neighborhood changes, the type of neighborhood it becomes will also have a characteristic population of a different sort, based on the typology. Thus, whether a neighborhood shifts or remains constant, the population inhabiting it can generally be assessed, and then supplemented with other municipal data indices for verification (i.e. school records, welfare lists, etc.).

In addition, the monitoring of health data by location, when coupled with the remote sensing neighborhood profiles, will give municipal decision makers a good start on determining points of intervention with health programs, be they education, preventive or remedial.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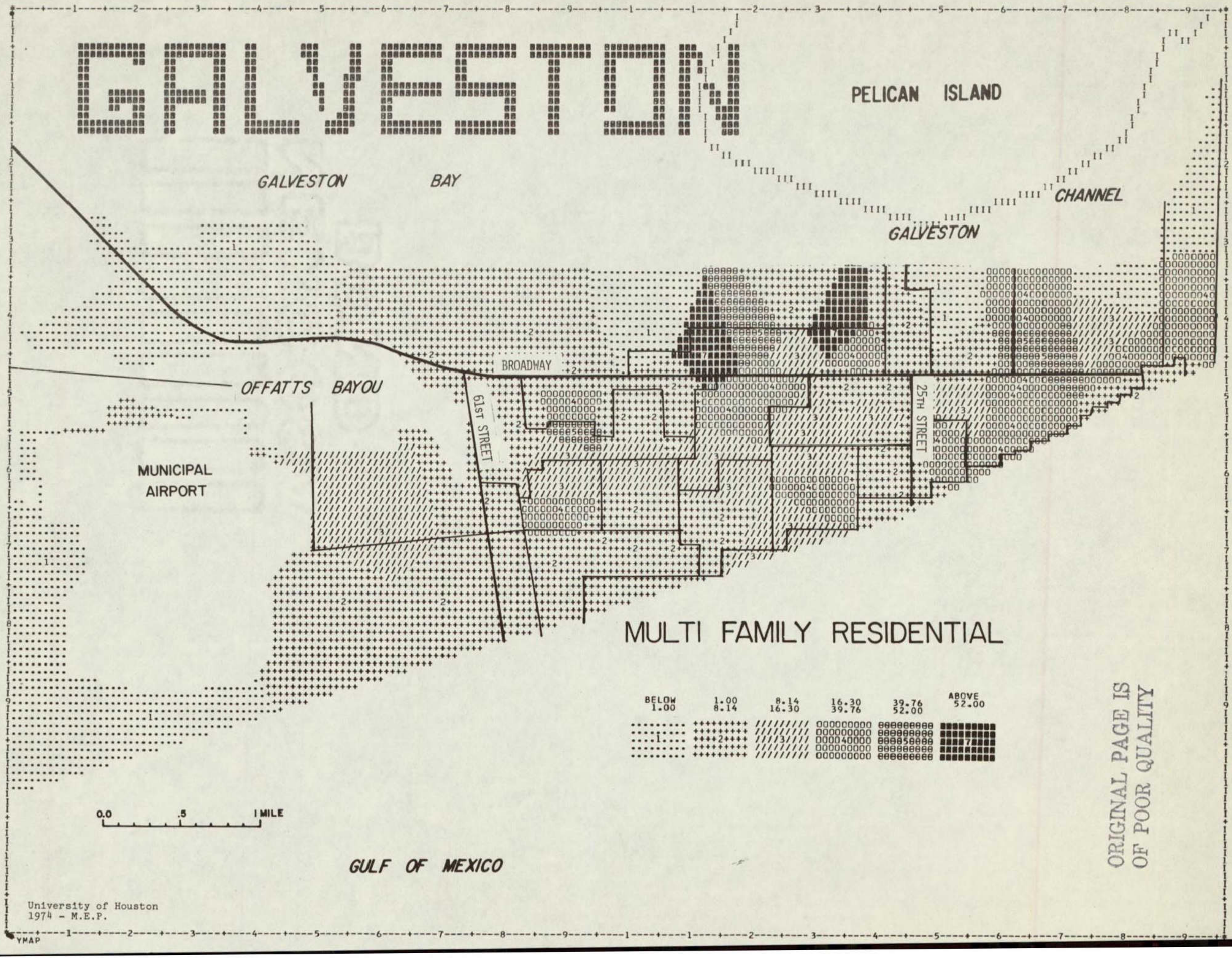

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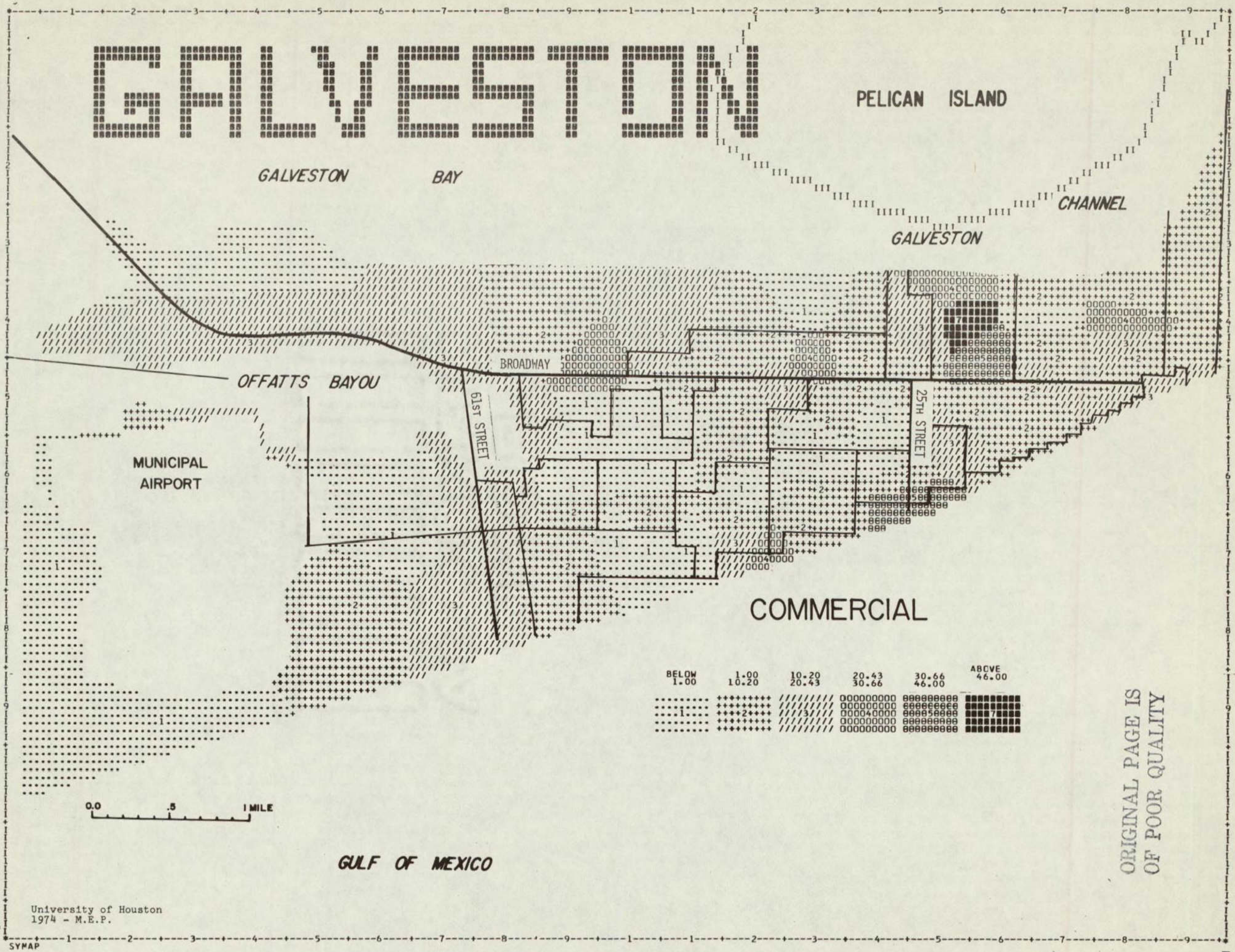

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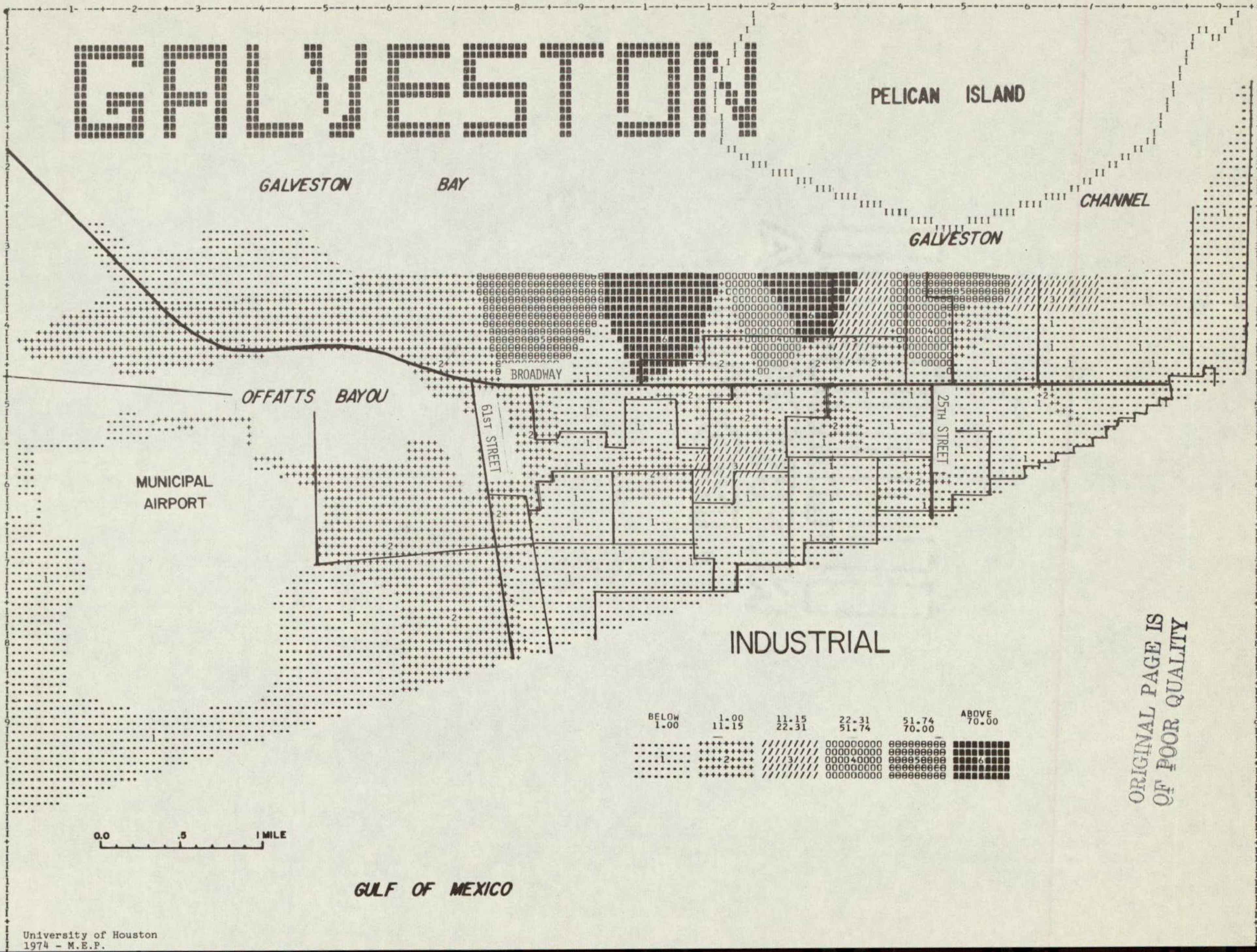
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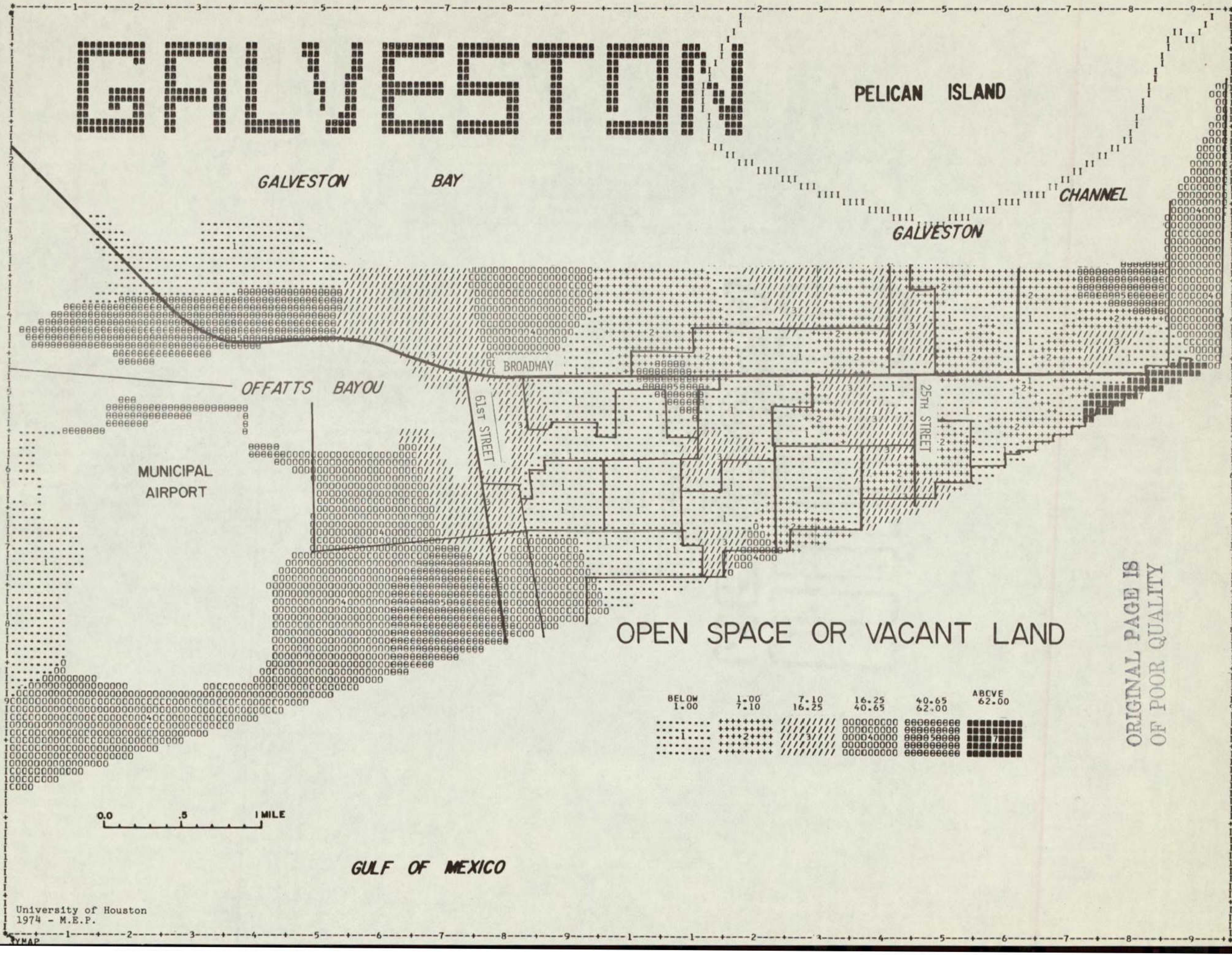
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7.10 16.25
16.25 40.65
40.65 62.00
ABCVE 62.00
0.0 .5 1 MILE
GULF OF MEXICO
University of Houston
1974 - M.E.P.
SYMAP

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BLOCK NO. 1247 BLOCK GROUP NO. 123 LAND USE CATEGORIES CENSUS TRACT NO.____

Total Sq. Ft.: 100,000

CODE	AREA SQ. FT.
F-Community Facilities	
1-School	
2-Churches	
3-Fire & Police Stations	
4-Developed rec. areas	
5-Civic Buildings	
6-Hospitals & Medical	
O-Open Space & Rec. Areas	
1-Parks & Playgrounds	
2-Country Clubs	
3-Baseball, Football	
4-Freeway & Grassy Basements	
5-Cemeteries	
W-Water	
1-Lakes	
2-Bayous & Rivers	
3-Reservoirs	
S-Streets Parking Lots	
C-Commercial	
1-Retail Outlets	
2-Motels & Hotels	
3-Office & Other	
I-Industrial	
1-Large Manufacturing	
2-Light Industrial	
3-Wholesale & Warehouse	
V-Vacant & Unimproved	

NO. OF HOMES 14 AREA SQ. FT. 100,000
Nearest 10%

	Low Less than 25%	Med 25-75%	High Over 75%
R - Residential			
R - 1-Single Family			100
H - 2-Multi Family 1-3 Story			
A - 3-Multi Family Over 3 Story			
A-Amount of Foliage & Green Lawn		✓	
B-Presence of Sidewalks			✓
C-Presence of Driveway & Garage			✓
D-Street Width Over 30 Ft.			✓
E-Paved Street			✓
F-Curbs & Gutters			✓
G-Litter	Yes or No		
H-Frontage of Houses			
a-Over 90 Ft.			
b-50 to 90 Ft.			
c-Less than 50 Ft.			✓
I-Size of Houses			
a-Large (over 2000 sq. ft.)			✓
b-Medium (1200-2000 sq. ft.)			
c-Small (1200 or less sq. ft.)			
J-Quality			
a-Exc		✓	
b-Good		✓	
c-Poor			

	AREA SQ. FT.	REMARKS:
T - Trailer Parks		

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APPENDIX II

AGE-ADJUSTED MORTALITY RATES - 1971

Census Tract	Age Groups <18 Years	18-61 Years	≥62 Years
1231			
1	0	5.49	77.77
2	0	2.02	72.29
1232			
1	5.52	1.52	28.99
2	5.92	2.84	37.97
3	0	1.99	34.48
4	0	4.10	71.90
5	0	0	40.65
6	3.37	3.93	46.05
7	0	6.64	60.00
8	0	8.13	34.48
1233			
1	11.81	5.44	21.74
2	0	4.52	53.03
3	7.33	6.22	29.33
4	2.46	1.82	22.98
5	2.69	6.99	69.52
6	6.78	2.28	53.69
1234			
1	0	10.75	0
2	0	4.18	120.80
3	0	3.62	48.00
1235			
1	0	2.20	5.35
2	0	4.95	48.95
3	0	10.58	15.04
1236			
1	0	8.95	32.26
2	4.67	7.56	25.00
3	3.16	4.46	30.30
4	2.96	12.27	49.18
5	0	2.5	39.06
1237			
1	0	8.47	30.30
2	0	9.71	38.22
3	0	1.86*	49.38*

APPENDIX II Continued

	<18 Years	18-61 Years	≥62 Years
1238			
1	0	9.58	62.50
1240			
1	1.04	6.72	14.93
2	10.00	9.38	18.35
3	0	8.93	24.59
4	11.03	18.69	41.10
5	2.82	5.80	52.63
1241			
1	0	3.45	30.30
2	3.27	7.21	40.94
3	0	1.95	46.98
1242			
1	0	8.79	41.67
2	3.82	7.33	32.09
3	0	6.40	61.07
1243			
1	2.78	4.79	35.02
2	0	6.79	22.90
3	0	4.26	28.17
1244			
1	0	0	35.71
2	12.50	0	22.47
3	0	0	38.96
4	0	3.13	85.11
1245			
1	4.41	3.74	31.11
2	0	1.74	30.00
1246			
1	0	3.98	65.57
2	0	9.41	28.17
3	0	1.73	53.57
1247			
1	0	3.65	22.60
2	0	3.55	33.56
3	0	3.69	79.55
4	0	11.31	31.01

APPENDIX II Continued

AGE-ADJUSTED MORTALITY RATES - 1972

Census Tract	<18 Years	18-61 Years	≥62 Years
1231			
1	0	3.66	22.22
2	0	4.04	72.29
1232			
1	0	0	28.99
2	0	5.67	31.65
3	0	1.99	13.79
4	0	0	45.75
5	0	3.46	48.78
6	0	3.93	26.32
7	0	11.06	40.00
8	0	6.50	27.59
1233			
1	0	1.81	36.23
2	0	2.26	53.03
3	0	12.45	48.00
4	0	5.47	17.24
5	2.69	13.99	26.74
6	0	2.28	60.40
1234			
1	0	21.51	3.57
2	0	4.18	102.38
3	0	0	48.00
1235			
1	0	8.81	26.74
2	0	4.95	27.97
3	0	15.87	60.15
1236			
1	0	2.24	59.14
2	0	5.04	41.67
3	0	6.70	30.30
4	0	6.13	43.72
5	0	0	46.88
1237			
1	0	33.89	60.61
2	0	19.42	101.91
3	11.50	1.86*	12.35*

*Subject to correction

APPENDIX II Continued

	<18 Years	18-61 Years	≥62 Years
1248			
1	0	0	40.00
2	9.39	7.41	18.69
3	7.63	10.00	49.69
1249			
1	45.05	7.49	35.29
2	0	7.94	0
3	1.92	7.77	21.58
4	0	29.70	250.00
1250			
1	6.69	11.36	40.00
2	0	3.61	145.45
3	0	2.38	57.14
4	0	17.54	285.71
1251			
1	0	6.25	0
2	0	4.94	19.42
3	0	6.10	24.39
4	0	4.87	84.51

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APPENDIX II Continued

	<18 Years	18-61 Years	≥62 Years
1238			
1	3.95	11.49	37.50
1240			
1	2.08	8.40	59.70
2	0	25.00	36.70
3	0	5.95	32.79
4	3.68	18.69	41.10
5	4.24	13.54	32.89
1241			
1	0	12.09	45.45
2	0	1.80	23.39
3	0	3.91	73.83
1242			
1	4.33	8.79	65.48
2	0	0	16.04
3	0	6.40	22.90
1243			
1	0	6.38	19.45
2	0	4.52	45.80
3	0	8.51	35.21
1244			
1	0	3.71	35.71
2	0	7.14	11.24
4	0	3.12	106.38
1245			
1	0	3.74	35.56
2	0	5.23	25.00
1246			
1	3.09	0	49.18
2	0	4.71	56.34
3	2.79	5.18	35.71
1247			
1	0	3.65	39.55
2	0	0	26.85
3	0	3.69	79.55
4	0	9.69	15.50

APPENDIX II Continued

	<18 Years	18-61 Years	$\geq$62 Years
1248			
1	0	6.04	13.33
2	0	4.94	65.42
3	0	5.71	31.06
1249			
1	0	3.75	58.82
2	0	15.87	0
3	0	5.83	28.78
1250			
1	0	9.09	26.67
2	0	2.40	36.36
5	0	14.29	0
9	20.00	17.54	142.86
1251			
2	0	2.47	38.83
3	0	6.10	60.98
4	0	4.87	56.34

APPENDIX III

V.D. INCIDENCE RATES, BY BLOCK GROUPS, GALVESTON TEXAS

RATES PER 1000 POPULATION

Census Tract	Block Group	Rounded Cr. Rate
1231	1	5.31
	2	4.14
1232	1	3.30
	2	2.90
	3	7.24
	4	7.09
	5	7.23
	6	4.17
	7	15.40
	8	15.69
1233	1	7.42
	2	15.90
	3	8.84
	4	11.51
	5	10.61
	6	5.66
1234	1	0.00
	2	12.36
	3	9.03
1235	1	5.72
	2	18.46
	3	10.44

Census Tract	Block Group	Rounded Cr. Rate
1236	1	32.45
	2	21.88
	3	16.22
	4	20.79
	5	28.77
1237	1	12.90
	2	8.56
	3	26.82
1238	1	72.90
1240	1	48.73
	2	34.97
	3	14.41
	4	81.19
	5	48.07
1241	1	11.47
	2	15.50
	3	6.76
1242	1	3.51
	2	4.66
	3	3.59

APPENDIX III Continued

Census Tract	Block Group	Rounded Cr. Rate
1243	1	2.41
	2	0.00
	3	6.00
1244	1	2.28
	2	0.00
	3	0.00
	4	1.64
1245	1	2.02
	2	1.91
1246	1	0.00
	2	0.00
	3	4.76
1247	1	1.71
	2	1.84
	3	5.96
	4	0.97
1248	1	14.26
	2	20.68
	3	20.21
1249	1	57.49
	2	32.14
	3	26.36
	4	0.00
1250	1	2.45
	2	0.63
	3	0.00
	5	0.00
	9	8.77
1251	1	0.00
	2	0.71
	3	2.11
	4	1.22

APPENDIX IV

TB PREVALENCE RATES, BY BLOCK GROUPS, GALVESTON, TEXAS

RATES PER 1000 POPULATION

Census Tract	Block Group	Rounded Cr. Rate
1231	1	2.12
	2	.70
1232	1	2.20
	2	.97
	3	3.62
	4	2.36
	5	1.80
	6	8.35
	7	7.10
	8	8.22
1233	1	9.54
	2	4.54
	3	10.62
	4	4.42
	5	7.07
	6	9.07
1234	1	
	2	2.36
	3	4.02
1235	1	4.58
	2	7.39
	3	3.91
1236	1	5.07
	2	2.73
	3	4.63
	4	5.94
	5	3.60
1237	1	45.16
	2	15.00
	3	9.75
1238	1	27.59
1240	1	3.70
	2	7.95
	3	2.88
	4	1.35
	5	8.93
1241	1	3.82
	2	5.66
	3	4.51
1242	1	1.17
	2	6.54
	3	2.40

APPENDIX IV Continued

Census Tract	Block Group	Rounded Cr. Rate
1243	1	3.21
	2	
	3	4.80
1244	1	2.28
	2	
	3	2.43
	4	
1245	1	3.04
	2	1.91
1246	1	1.92
	2	2.69
	3	5.71
1247	1	3.44
	2	1.84
	3	0.00
	4	.98
1248	1	7.92
	2	5.51
	3	3.6

Census Tract	Block Group	Rounded Cr. Rate
1249	1	6.97
	2	42.86
	3	11.05
	4	0.00
1250	1	1.23
	2	.63
	3	0.00
	5	0.00
	9	8.77
1251	1	3.50
	2	1.42
	3	3.18
	4	4.88

APPENDIX V

HEPATITIS INCIDENCE RATES, BY BLOCK GROUPS, GALVESTON, TEXAS

RATES PER 1000 POPULATION

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1231			4	
	1	941	1	1.06
	2	1449	3	2.07
1232			16	
	1	909	2	2.20
	2	1032	0	.00
	3	828	1	1.21
	4	846	0	.00
	5	553	2	3.61
	6	958	3	3.13
	7	844	2	2.37
	8	1338	6	4.48
1233			7	
	1	943	0	.00
	2	880	2	2.27
	3	1130	1	.88
	4	1129	0	.00
	5	1131	1	.88
	6	882	3	3.40
1234			2	
	1	184	1	5.43
	2	647	1	1.54
	3	996	0	.00

APPENDIX V Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1235			4	
	1	874	2	2.29
	2	1083	1	.92
	3	766	1	1.30
1236			6	
	1	986	0	.00
	2	731	3	4.10
	3	863	1	1.16
	4	1010	1	1.00
	5	834	1	1.20
1237			1	
	1	155	0	.00
	2	467	1	2.44
	3	410	0	.00
1238			3	
	1	1015	3	2.95
1240			15	
	1	1621	6	3.70
	2	629	2	3.18
	3	694	0	.00
	4	666	1	1.50
	5	1377	6	4.35

APPENDIX V Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1241			4	
	1	1046	0	.00
	2	1032	3	2.90
	3	887	1	1.12
1242			9	
	1	854	4	4.68
	2	858	3	3.49
	3	834	2	2.40
1243			11	
	1	1244	2	1.60
	2	787	2	2.54
	3	833	7	8.40
1244			0	
	1	438	0	.00
	2	309	0	.00
	3	412	0	.00
	4	609	0	.00
1245			3	
	1	987	1	1.01
	2	1042	2	1.92
1246			3	
	1	948	2	2.10
	2	743	0	.00
	3	1050	1	.95

APPENDIX V Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1247			4	
	1	582	2	3.43
	2	542	2	3.70
	3	503	0	.00
1248			4	
	1	631	2	3.17
	2	725	1	1.38
	3	1385	1	.72
1249			4	
	1	574	0	.00
	2	280	1	3.57
	3	1176	3	2.55
	4	166	0	.00
1250			7	
	1	814	3	3.68
	2	1584	3	1.89
	3	741	1	1.35
1251			2	
	1	286	0	.00
	2	1404	1	.71
	3	944	1	1.06
	4	819	0	.00

APPENDIX VI

MENINGITIS INCIDENCE RATES, BY BLOCK GROUPS, GALVESTON, TEXAS

RATES PER 1000 POPULATION

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1241				
	1	1046	1	.95
	2	1059	0	0
	3	887	0	0
1242				
	1	854	1	1.17
	2	917	0	0
	3	834	2	2.40
1243				
	1	1244	2	1.60
	2	787	1	1.27
	3	833	2	2.40
1244				
	1	438	0	0
	2	309	0	0
	3	412	0	0
	4	609	0	0
1245				
	1	987	1	1.01
	2	1042	2	1.92
1246				
	1	948	3	3.16
	2	743	0	0
	3	1050	2	1.90

APPENDIX VI Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1231				
	1	941	0	0
	2	1449	1	.70
1232				
	1	909	0	0
	2	1032	1	.96
	3	828	0	0
	4	846	0	0
	5	553	1	1.80
	6	958	1	1.04
	7	844	3	3.55
	8	1338	5	3.74
1233				
	1	943	0	0
	2	880	1	1.13
	3	1130	0	0
	4	1129	0	0
	5	1131	0	0
	6	882	0	0
1234				
	1	184	1	5.43
	2	647	0	0
	3	996	1	1.0

APPENDIX VI Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1235				
	1	874	0	0
	2	1083	1	.92
	3	766	1	1.30
1236				
	1	986	2	2.03
	2	731	3	4.10
	3	863	2	2.32
	4	1010	2	1.98
	5	834	2	2.40
1237				
	1	155	0	0
	2	467	0	0
	3	410	1	2.44
1238				
	1	1015	2	1.97
1240				
	1	1621	1	.62
	2	629	1	1.59
	3	694	0	0
	4	739	3	4.06
	5	1456	3	2.06

APPENDIX VI Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1247				
	1	582	0	0
	2	542	0	0
	3	503	0	0
	4	1024	0	0
1248				
	1	631	0	0
	2	725	1	1.37
	3	1385	3	2.16
1249				
	1	574	1	1.74
	2	280	0	0
	3	1176	2	1.70
	4	166	0	0
1250				
	1	8.4	0	0
	2	1584	0	0
	3	741	0	0
	5	117	0	0
	9	114	0	0
1251				
	1	286	0	0
	2	1404	1	.71
	3	944	0	0
	4	819	1	1.22

APPENDIX VII

SHIGELLA/SALMONELLA INCIDENCE RATES, BY BLOCK GROUPS, GALVESTON, TEXAS

RATES PER 1000 POPULATION

C.T. #	C.T. Pop	Block Group #	BG Pop	# Cases by Blk Group	Blk Grp Rate
1231					
		1	941	1	1.06
		2	1449	0	0
1232					
		1	909	1	1.10
		2	1032	1	.97
		3	828	1	1.21
		4	846	3	4.68
		5	553	1	1.81
		6	958	1	1.04
		7	844	1	2.37
		8	1338	1	.75
1233					
		1	943	2	2.12
		2	880	3	3.41
		3	1130	1	.88
		4	1129	2	1.77
		5	1131	1	.88
		6	882	1	1.13
1234					
		1	184	2	10.86
		2	647	0	.00
		3	996	3	3.01
1235					
					5.72

APPENDIX VII Continued

C.T. #	C.T. Pop	Block Group #	BG Pop	# Cases by Blk Group	Blk Cap Rate.
1235		2	1083	1	.92
		3	766	0	0
1236					
		1	986	1	1.01
		2	731	3	4.10
		3	863	0	.00
		4	1010	0	.00
		5	834	0	.00
1237					
		1	155	0	.00
		2	467	0	.00
		3	410	0	.00
1238					
		1	1015	1	.98
1240					
		1	1621	1	.61
		2	629	0	.00
		3	694	1	1.44
		4	739	3	4.06
		5	1456	2	1.37
1241					
		1	1046	0	.00
		2	1059	2	1.89
		3	887	2	2.25

APPENDIX VII Continued

C.T. #	C.T. Pop	Block Group #	BG Pop	# Cases by Blk Group	Blk Grp Rate
1242					
		1	854	1	1.17
		2	917	0	.00
		3	834	0	.00
1243					
		1	1244	0	.00
		2	787	2	2.54
		3	833	2	2.40
1244					
		1	438	0	.00
		2	309	1	3.23
		3	412	0	.00
		4	609	0	.00
1245					
		1	987	0	.00
		2	1042	2	1.92
1246					
		1	948	1	1.05
		2	743	1	1.34
		3	1050	0	.00
1247					
		1	582	0	.00
		2	542	0	.00
		3	503	1	1.98
		4	1024	1	.97

APPENDIX VII Continued

C.T. #	C.T. Pop	Block Group #	BG Pop	# Cases by Blk Group	Blk Grp Rate
1248					
		1	631	0	.00
		2	725	0	.00
		3	1385	5	3.61
1249					
		1	574	3	5.23
		2	280	0	.00
		3	1176	3	2.55
		4	166	0	.00
1250					
		1	814	3	3.68
		2	1584	1	.63
		3	741	1	1.35
		5	117	0	.00
		9	114	0	.00
1251					
		1	286	0	.00
		2	1404	1	.71
		3	944	1	1.06
		4	819	2	2.44

APPENDIX VIII

HYPERTENSION INCIDENCE RATES, BY BLOCK GROUPS, GALVESTON, TEXAS

RATES PER 1000 POPULATION

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1231			36	
	1	941	27	28.69
	2	1449	9	6.21
1232			43	
	1	409	3	3.30
	2	1032	7	6.78
	3	828	6	7.24
	4	846	2	2.36
	5	553	7	12.65
	6	958	7	7.30
	7	844	7	8.29
	8	1338	4	2.98
1233			57	
	1	943	6	6.36
	2	880	13	14.77
	3	1130	19	16.81
	4	112	11	9.74
	5	1131	7	6.18
	6	882	1	1.13
1234			22	
	1	184	1	5.43
	2	647	10	15.45
	3	996	11	11.04

APPENDIX VIII Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1235			22	
	1	874	8	9.15
	2	1083	5	4.61
	3	765	9	11.74
1236			39	
	1	986	9	9.12
	2	731	8	10.94
	3	863	7	8.11
	4	1010	9	8.91
	5	834	6	7.19
1237			10	
	1	155	3	19.35
	2	467	3	6.42
	3	410	4	9.75
1238			11	
	1	1015	11	10.83
1240			46	
	1	1621	8	4.93
	2	629	5	7.94
	3	694	7	10.08
	4	739	13	17.59
	5	1456	13	8.92

APPENDIX VIII Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1241			35	
	1	1046	15	14.34
	2	1059	13	12.27
	3	887	7	7.89
1242			25	
	1	854	10	11.70
	2	917	9	9.81
	3	834	6	7.19
1243			28	
	1	1244	13	10.45
	2	787	6	7.62
	3	833	9	10.80
1244			43	
	1	438	17	38.81
	2	309	10	32.36
	3	412	12	29.12
	4	69	4	5.62
1245			26	
	1	987	18	18.23
	2	1042	8	7.67
1246			21	
	1	948	6	6.32
	2	743	4	5.38
	3	1050	11	10.47

APPENDIX VIII Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1247			30	
	1	582	13	22.33
	2	542	9	16.60
	3	503	2	3.97
	4	1024	6	5.85
1248			17	
	1	631	5	7.92
	2	725	2	2.75
	3	1385	9	6.49
1249			12	
	1	574	3	5.52
	2	280	2	7.14
	3	1176	5	4.25
	4	166	2	12.04
1250			26	
	1	814	12	14.74
	2	1584	10	6.31
	3	741	1	1.34
	5	117	1	8.54
	9	114	2	17.54
1251			22	4.88
	1	286	2	6.99
	2	1404	11	7.83
	3	944	5	5.29
	4	819	4	

APPENDIX IX

CARDIAC ARREST & MYOCARDIAL INFARCTION INCIDENCE RATES, BY BLOCK GROUPS, GALVESTON, TEXAS

RATES PER 1000 POPULATION

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1247				
	1	582	5	8.59
	2	542	11	20.29
	3	503	10	19.88
	4	1024	10	9.76
1248				12.67
	1	631	8	12.67
	2	725	4	5.51
	3	1385	5	3.61
1249				
	1	574	1	1.74
	2	280	1	3.57
	3	1176	10	8.50
	4	166	4	24.09
1250				
	1	814	8	9.80
	2	1584	14	8.83
	3	741	4	5.39
	5	117	1	8.54
	9	114	3	26.31
1251				
	1	286	0	0
	2	1404	7	4.98
	3	944	6	6.35
	4	[illegible]		

APPENDIX IX Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1231				
	1	941	7	7.43
	2	1449	6	4.14
1232				
	1	909	1	1.10
	2	1032	7	6.78
	3	828	9	10.86
	4	846	7	8.17
	5	553	8	14.46
	6	958	4	4.17
	7	844	15	17.77
	8	1338	12	8.96
1233				
	1	943	10	10.60
	2	880	6	6.81
	3	1130	17	15.04
	4	1129	10	8.85
	5	1131	11	9.72
	6	882	18	20.40
1234				
	1	184	3	16.30
	2	647	25	38.63
	3	996	12	12.04

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APPENDIX IX Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1235				
	1	874	7	8.00
	2	1083	5	4.61
	3	766	10	13.05
1236				
	1	986	5	5.07
	2	731	9	12.31
	3	863	8	9.26
	4	1010	5	4.95
	5	834	4	4.79
1237				
	1	155	0	0
	2	467	8	17.13
	3	410	3	7.31
1238				
	1	1015	5	4.92
1240				
	1	1621	1	.60
	2	629	6	9.53
	3	694	6	8.64
	4	666	2	3.00
	5	1377	8	5.80

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OF POOR QUALITY

APPENDIX IX Continued

Census Tract	Block Group	Total Population	No. Cases By Blk. Group	Crude Rate
1241				
	1	1046	17	16.25
	2	1032	13	12.59
	3	887	8	9.01
1242				19.90
	1	854	17	19.90
	2	858	6	6.99
	3	834	14	16.78
1243				
	1	1244	5	4.01
	2	787	6	7.62
	3	883	12	13.59
1244				
	1	438	3	6.84
	2	309	2	6.47
	3	412	3	7.28
	4	609	5	8.21
1245				
	1	987	16	16.21
	2	1042	9	8.63
1246				
	1	948	7	7.38
	2	743	8	10.76
	3	1050	9	8.57

Appendix X

See Map 5, Page 88 a

APPENDIX XI -A

CONGRUENCY OF SAMPLE OF THE CITY WITH TOTAL CITY BASED ON TYPE AND PERCENT OF LAND USE. COMPARISON BY BLOCK GROUPS WITHIN CENSUS TRACTS

CT	BG		R	H	I	C	V/O
1240	1	Sample	8.0	67.0	12.5	5.0	4.0
		Total	12.3	57.0	17.1	10.8	0.9
	2	Sample	39.0	17.0	1.0	5.0	3.0
		Total	45.8	11.6	0.48	18.2	1.7
	3	Sample	54.0	9.0	7.0	28.0	0.0
		Total	65.2	12.7	3.3	16.3	2.6
	4	Sample	13.6	51.5	33.0	2.0	0.0
		Total	40.4	30.3	16.9	2.7	7.7
	5	Sample	20.0	66.0	4.0	4.0	5.0
		Total	25.8	53.1	3.2	9.5	4.0
1241	1	Sample	60.0	18.0	0.0	12.0	0.0
		Total	59.8	16.1	0.0	11.3	1.8
	2	Sample	83.0	12.0	0.0	0.0	0.0
		Total	62.7	13.4	9.5	2.3	0.0
	3	Sample	79.5	11.0	0.0	0.0	0.0
		Total	60.5	8.3	8.1	5.6	6.1
1242	1	Sample	83.0	12.0	0.0	0.0	0.0
		Total	84.7	12.0	0.0	0.0	0.0
	2	Sample	81.0	18.0	0.0	1.0	0.0
		Total	87.9	11.8	0.0	0.5	0.0
	3	Sample	73.0	13.0	0.0	8.0	6.0
		Total	81.7	11.4	0.0	3.7	2.9
1243	1	Sample	79.5	11.0	0.0	0.0	0.0
		Total	78.9	8.9	0.9	0.1	0.0
	2	Sample	89.0	8.0	0.0	3.0	0.0
		Total	82.2	7.6	0.0	10.2	0.0
	3	Sample	75.0	2.0	0.0	12.0	0.0
		Total	81.7	5.2	0.0	6.3	0.8

APPENDIX XI-A Continued

1244	1	Sample	94.0	6.0	0.0	0.0	0.0
		Total	94.0	4.6	0.0	1.4	0.0
	2	Sample	93.5	6.5	0.0	0.0	0.0
		Total	95.2	4.8	0.0	0.0	0.0
	3	Sample	85.0	7.0	0.0	0.0	0.0
		Total	90.7	4.8	0.0	0.0	0.0
	4	Sample	29.0	1.0	0.0	2.0	30.0
		Total	47.0	1.1	0.0	2.3	22.6
1245	1	Sample	81.0	12.0	5.0	0.0	0.0
		Total	86.4	9.3	1.8	1.9	0.0
	2	Sample	88.0	8.0	0.0	3.0	0.0
		Total	88.02	10.4	0.0	4.1	0.0
1246	1	Sample	90.0	10.0	0.0	0.0	0.0
		Total	89.7	8.5	0.0	0.0	1.7
	2.	Sample	90.0	10.0	0.0	0.0	0.0
		Total	91.0	9.0	0.0	0.0	0.0
	3	Sample	79.0	17.0	0.0	3.0	0.0
		Total	84.4	9.8	0.0	2.8	0.0
1247	1	Sample	92.0	8.0	0.0	0.0	0.0
		Total	96.1	3.9	0.0	0.0	0.0
	2	Sample	94.0	6.0	0.0	0.0	0.0
		Total	93.8	4.1	0.0	0.0	2.1
	3	Sample	56.0	44.0	0.0	0.0	0.0
		Total	60.8	7.7	0.0	1.1	15.2
	4	Sample	60.0	6.0	2.0	13.0	13.0
		Total	23.5	2.3	0.6	4.7	5.1
1248	1	Sample	24.5	1.0	9.0	4.0	48.0
		Total	29.9	1.0	6.3	6.1	32.3
	2	Sample	68.0	7.0	0.0	24.0	0.0
		Total	67.8	4.9	0.0	26.3	1.1
	3	Sample	83.0	17.0	0.0	0.0	00.0
		Total	90.0	10.0	0.0	0.0	0.0

KEY: CT: Census Tracts; BG: Block Groups; R: Single Family; H: Multi-Family; I: Industrial; C: Commercial; V/O: Vacant & Open Space

APPENDIX XI -B

COMPARISON OF SAMPLE TO TOTAL SAMPLING AREAS

BASED ON TYPE & PERCENTAGE OF LAND USES

	CT	BG		R	H	I	C	V/O
SAMPLE AREA 1	1236	1	Sample	95.6	4.4			
			Remainder	75.1	6.5		14.4	4.0
			Total	77.5	6.2		12.8	3.5
		2	Sample	57.0	21.9		0.3	20.9
			Remainder	81.9	9.1		9.0	
			Total	60.8	19.1		1.6	17.7
		3	Sample	80.0	20.0			
			Remainder	72.7	9.8		17.6	
			Total	76.3	14.9		8.8	
		4	Sample	77.9	10.6		0.5	11.0
			Remainder	86.4	13.6			
			Total	81.9	12.0		0.3	5.8
		5	Sample	75.1	5.7		10.2	9.0
			Remainder	78.2	4.5	4.0	5.2	8.1
			Total	76.6	5.2	1.9	7.8	8.5
SAMPLE AREA 2	1236	3	Sample	86.2	7.8		6.0	
			Remainder	83.1	7.9		1.0	8.0
			Total	84.1	7.9		2.7	5.3
	1241	1	Sample	60.2	23.2		14.6	2.0
			Remainder	78.4	7.7		14.0	
			Total	67.3	17.1		14.4	1.2
		2	Sample	49.3	20.6	7.5	22.6	
			Remainder	83.2	1.1	12.6	3.1	
			Total	62.0	13.3	9.4	15.3	
		3	Sample	26.7	4.0		42.6	26.8
			Remainder	83.6	7.2		9.2	
			Total	44.9	5.0		31.9	18.2
	1242	1	Sample	88.4	11.2		0.4	
			Remainder	93.4	6.6			
			Total	91.1	8.7		0.2	
		2	Sample	82.0	17.3		0.7	
			Remainder	97.2	2.8			
			Total	87.9	11.7		0.4	

APPENDIX XI-B Continued

	CT	BG		R	H	I	C	V/O
SAMPLE AREA 2 (Continued)	1242	3	Sample	77.4	8.4		7.4	6.8
			Remainder	89.6	10.0		0.4	
			Total	82.8	9.1		4.3	3.8
	1243	1	Sample	88.2	11.6		0.1	
			Remainder	66.3	28.9	3.5	1.4	
			Total	82.1	16.5	1.0	0.5	
		2	Sample	88.1	9.6		2.4	
			Remainder	72.7	6.3		21.0	
			Total	82.0	8.3		9.7	
		3	Sample	79.2	2.4		18.4	
			Remainder	90.7	7.2		7.3	1.4
			Total	86.5	5.5		7.1	0.9
	1248	1	Sample	13.0	1.0		8.0	76.5
			Remainder	96.0	3.0			
			Total	17.0	1.0		3.0	282.6
SAMPLE AREA 3	1240	1	Sample	76.9		12.8	57.7	44.9
			Remainder	18.0	24.5	38.8	18.8	
			Total	56.9	8.3	21.6	10.2	3.0
		2	Sample	60.3	26.5	1.2	7.6	4.4
			Remainder	65.9	2.5		31.6	
			Total	63.4	13.4	0.5	20.8	2.0
		3	Sample	50.6	8.9		40.5	
			Remainder	67.2	13.9	4.9	10.1	3.9
			Total	62.9	12.6	3.6	18.0	2.9
		4	Sample	13.8	51.6	32.8	2.0	
			Remainder	72.7	80.8	2.5	2.5	16.7
			Total	15.4	45.0	25.1	3.2	11.4
		5	Sample	67.8	5.1	19.3	3.3	4.4
			Remainder	46.5	8.0		45.5	
			Total	63.7	5.7	15.5	11.5	3.5
	1248	1	Sample	96.2	3.8			
			Remainder	61.0		4.0	30.0	5.0
			Total	79.6	2.0	1.9	14.1	2.4
	1249	1	Sample	42.1	0.6	40.3		16.9
			Remainder	90.0	10.0			
			Total	47.0	1.6	36.2		15.2

APPENDIX XI-B Continued

	CT	BG		R	H	I	C	V/O
SAMPLE AREA 3 (Continued)	1249	2	Sample	65.0				3.5
			Remainder	100.0				
			Total	82.5				17.5
SAMPLE AREA 4	1248	2	Sample	75.0	11.6		13.8	
			Remainder	80.0	1.3	1.3	17.1	
			Total	77.0	6.6	0.6	15.4	
		3	Sample	75.3	24.7			
			Remainder	98.6	1.4			
			Total	85.4	14.6			
SAMPLE AREA 5	1241	3	Sample	69.6	11.4		19.0	
			Remainder					
			Total	69.6	11.4		19.0	
	1245	1	Sample	82.2	12.2	2.5	3.0	
			Remainder	90.2	9.1		7.7	
			Total	87.1	10.3	0.9	1.6	
		2	Sample	89.9	8.5		1.6	
			Remainder	88.9	6.5		4.6	
			Total	89.4	7.4		3.1	
	1246	1	Sample	89.8	10.2			
			Remainder	94.3	5.7			
			Total	91.5	8.5			
		2	Sample	90.0	10.0			
			Remainder	91.7	8.3			
			Total	91.0	9.0			
		3	Sample	78.1	17.2		4.7	
			Remainder	84.6	6.5		4.5	4.5
			Total	81.0	12.3		4.6	2.0
	1247	1	Sample	89.4	10.6			
			Remainder	100.00				
			Total	94.7	5.2			
		2	Sample	93.2	6.8			
			Remainder	97.6	2.4			
			Total	95.7	4.3			
		3	Sample	68.4	8.7		1.5	21.3
			Remainder	95.0	5.0			
			Total	72.9	8.1		1.3	17.7
		4	Sample	100.0				
			Remainder	100.0				
			Total	100.0				

<u>APPENDIX XI-B Continued</u>

	CT	BG		R	H	I	C	V/O
SAMPLE AREA 6	1244	1	Sample	91.8	8.2			
			Remainder	94.2	3.3		2.5	
			Total	92.9	6.0		1.1	
		2	Sample	92.1	7.9			
			Remainder	100.0				
			Total	93.7	6.3			
		3	Sample	85.1	7.5		7.5	
			Remainder	99.2	0.8			
			Total	90.7	4.8		4.5	
		4	Sample	47.3	3.0		6.4	43.3
			Remainder	100.0				
			Total	61.1	2.2		4.8	32.0
SAMPLE AREA 7	1250	1	Sample	28.8	7.6	2.0	34.3	27.3
			Remainder					
			Total	28.8	7.6	2.0	34.3	27.3
	1251	2	Sample	90.0	10.0			
			Remainder					
			Total	90.0	10.0			
		3	Sample	64.0	4.2	2.5	3.0	26.3
			Remainder	87.9	2.1		6.3	3.8
			Total	66.9	3.9	2.2	3.4	23.5
		4	Sample	62.3	6.5	7.2	13.3	10.8
			Remainder	74.0	3.1	0.4	11.4	11.0
			Total	67.4	5.0	4.2	12.5	10.9

KEY:

CT: Census Tract
BG: Block Number
R: Single Family
H: Multi-Family
I: Industrial
C: Commercial
V/O: Vacant & Open Space

APPENDIX XII

VALIDITY TEST: PHOTO INTERPRETATION
AND CITY PLANNING DEPT. GROUND SURVEY
CITY BLOCKS USED IN TEST

Tract 1232

Sample #	Census Block	City Map Block
1	108	672
2	113	552
3	201	492
4	208	484
5	209	424
6	309	304
7	311	307
8	316	312
9	405	248
10	412	190
11	413	191
12	504	196
13	606	318
14	608	377
15	609	376
16	611	374
17	702	434
18	703	435
19	706	438
20	709	496
21	804	556
22	805	557
23	806	558
24	814	674
25	816	676

APPENDIX XII Continued

Tract 1233

Sample #	Census Block	City Map Block
1	510	20SE
2	104	130
3	107	133
4	110	136
5	113	139
6	114	140
7	202	83
8	204	81
9	207	77
10	208	76
11	211	73
12	213	71
13	215	69
14	216	68
15	301	9
16	314	22
17	315	23
18	408	21NW
19	604	45SE
20	515	19SW
21	603	45SW
22	601	44SW
23	606	46SE
24	611	69NW
25	613	69SE

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