A SIMULATION MODEL OF THE DEVELOPMENT PROCESS IN AN URBAN CORE

BY

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A B S T R A C T

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M. ROBERT KIRBY

Submitted to the Department of Architecture and Planning on June, 1970 in partial fulfillment of the requirement for the degree of Master of Architecture (Urban Design).

The dissertation is intended as a preliminary investigation into constructing a simulation model of the physical development process in an urban core.

The development of this model has required an understanding of the basic determinates that operate in reality and an editing of these determinants to obtain a reasonable representation that can be explicitly defined.

Chapter III describes the factors that are used as the content of the model and a brief explanation of the roles and relationships between the principal actors involved in environmental decision making at the urban scale.

Chapter IV deals with an explanation of the basic theoretical structure of the model and the assumptions behind the formulation of the approach taken.

A description of the operative model as developed to date is given in Chapter V. This describes the major components of the model, their criteria, and definitions, and the sequence of events leading to a developmental decision.

Chapters VI and VII graphically illustrate and describe the results and conclusions that can be derived from the model output.

The reasons for this dissertation and development of this model have grown out of an interest and conviction that indirect intervention into the urban environment are perhaps the most effective way that one can operate to affect change and innovation into the quality of the urban experience.

This model represents a beginning into understanding urban physical development and how it might be indirectly effected through public policy to achieve a higher quality of enjoyment in urban life.

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The development of the Discourse language by Professor William Porter and Wren McMains has provided the necessary interest and means by which the author was able to realize the construction and execution of this study.

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I PROBLEM DEFINITION

The main thrust of this study consists of developing a computer simulation model that will represent the consequences of urban core growth guided by varied public policies. The study area to be modelled is a downtown core of a metropolitan area with a population of half a million people (it is hoped that the development of this model would be adaptable to other urban areas). Appendix B contains description of the study area.

The theoretical and operative model formulated in this study will be aimed at producing a future state, or prediction model of an existing urban center.

The scale of the modelled environment will be such that it will hopefully generate a simulated picture of an environment that will give some insight into the consequences of public policy and its influence in determining the quality of environment. This model could be classified as an urban growth or development model in that it is concerned with the processes of urban physical development,but because of its generation from an existing urban state it could perhaps be more precisely termed a transformation model.

SPECIFIC PROBLEM

The specific interest of this study will be in examining some of the following aspects of urban physical development:

1. What determinates are instrumental in the choice of a specific location for a specific activity in an urban area?

2. How can these determinates be modelled?
3. What measures in public policy can be taken to effect the quality of results?
4. What influences does the present pattern of activity have on future patterns?

The intention will be to construct a representation of those criteria that play an effective role in determining development decisions. Development decisions will include those aspects such as use, spatial location, and magnitude that affect the pattern and quality of urban environment.

II PURPOSE

The principal concern of this study will be to determine the underlying principals used to construct a model of reality and apply this to the development of a computer simulated model.

The model will be constructed to simulate the physical development of future growth in an urban downtown core.

Its purpose will be to predict the possible future activity patterns and generate a picture of their possible physical characteristics.

It is also hoped that further development of this model could result in a useful instrument for testing urban growth policies and hypotheses.

In order to construct the model it will first be necessary to examine the determinates and processes that are to be modelled.

III DEVELOPMENT DETERMINATES

INTRODUCTION

This study will be concerned with the ability to use prediction as a means of aiding the formulation of public growth policies. Therefore, it will first be necessary to describe the point of view and the limitations that are used to form the basis for structuring the model. The intent of this section will be to identify the components and their relationships that are used to describe the urban content of this model. It will also be necessary to describe the processes that are used to determine the resultant state of that content.

Development and growth of the urban area will be viewed as a mutual relationship between two distinct and sometimes opposed sets of urban actions: (1) actions taken by the Private Realm and (2) actions taken by the Public Realm. Each of these actions are concerned with and motivated by different values, and each have different underlying motivations and behavioral characteristics that determine the scope and make up of their consequent decisions.

PRIVATE REALM will be defined as being concerned and motivated by individual (person, firm, institution) interests that represent the values of that individual and the PUBLIC REALM will be defined as being concerned and motivated by community (city, city district) interests that represent the values of the total community. Urban

activities and their spacial distribution as determined by the interplay are the basic elements of concern in this model between public policy and private actions. How urban activites are located, and by what criteria this locational decision is made will be considered to be a factor that is manipulated by the Private Realm. It will be the task of this model to simulate the behavioral aspects determining private actions in the physical environment and to identify what areas of public policy can enhance and guide this growth and what area of public policy must be regulatory.

The model will focus on seven basic types of human activities, ranging from small or secondary manufacturing to residential, each being defined only as its response to location, for example, the size and characteristics of a residential development will be determined by the characteristics of the land costs, size of land parcel and a measure of the intensity that a specific location must economically absorb.

Activity use will be viewed and explained in terms of economic behavior of land users or land developers operating in the market place. Although economic determinants are viewed as the primary behavior determinant, it will be hard to isolate and neglect the influence of cultural, social and personal values and attitudes that in some cases underlie and modify a pure economic decision. Because of such influences as symbolic or historical importance of specific locations, land costs do not always accurately reflect true market value.

ECONOMIC FACTORS INFLUENCING PRIVATE LAND DEVELOPMENT

There are two basic economic forces shaping urban land use development and the patterns of that development. (1) EXTERNAL forces such as decisions of government or private corporations to invest or develop in a local community effect the make-up and vitality of that local economy and effect the internally (locally) focused processes of the urban land market. External forces influence how much and to a large degree the rate at which land goes into development. (2) INTERNAL operation of land development is dependent on the degree of external financial support and a desire to supply a need and to service a demand. It is largely (from the developer's point of view) a function of the cost incurred in making land productive and the anticipated income or return realizable by the development of that land. Most decisions to develop urban land can be regarded as an opportunity to maximize a return on invested capital.

Urban land then can be considered to possess economic value because of its potential for producing income. But, market value of land varies according to its specific location, and it is this difference of location of land and its economic market value that produces variation in land use pattern. This variation of market value has a historical base that over time as development actions are taken produce areas that are more desirable because of the degree of convenience, degree of amenity or degree of accessibility to locations. When we view land values as a whole or in aggregate we are more interested in its economic function as it relates to the community as a whole.

Land use patterns are the culmination of many individual market place decisions over a period of time. Land users tend to bid for

spatial location in relation to activity needs, for example, retail locates on high land cost areas near highly accessible locations in anticipation of high volume sales. Residential locations are chosen on the basis of dollar value versus amenity benefit. The structure of land values in the urban core reflects its worth as a focus for business transactions and retail activity by the high dollar value of land and the degree of intensity of development patterns.

SPATIAL PATTERNS

Land values directly influence the intensity of land use but development intensity can also be influenced by such diverse factors as transportation and methods of conducting business or retailing activities.

There are five factors that tend to generate intensity nodes of development.

1. Some activities have a need for close physical proximity, because of their reinforcing nature and their interdependence on one another.
2. Some activities tend to aggregate together because it is mutually profitable to capitalize on an aggregation of their users.
3. Some activites tend to collect together because of their relationship and need for a common facility that services them.
4. Some activities tend to relate closely to one another because of symbolic or cultural traditions or attractions.

5. Some activities tend to aggregate together because of social or personal desire for segregation from other activities or other similar activities of a different status.

LOCATIONAL ASPECTS OF DEVELOPMENT

The relationship of spatial location pattern to economic activity has two effects:

1. Economic activity at a specific geographic location affects economic activities carried out at adjacent spacial locations.
2. Spacial locations between interdependent activities affect the costs incurred in moving persons or goods between them.

These two aspects create a partial logic of active spatial relationships in an urban area. Economic location is concerned with the allocation and equilibrium of space, as achieved by market competition. Economic allocation of land and the structure of land uses are determined by the economics of accessibility to needed resources (people, goods, status, or raw material, etc.). All locations where an economic activity is technically possible we term to be <u>feasible</u> locations, and all locations that satisfy all criteria for location of an activity can be called <u>desirable</u> locations.

If any one requirement is dominant over all other criteria, an activity is said to be <u>oriented</u> toward that requirement, for example, commercial retail activity is oriented toward consumers as a resource. The feasibility of location may also depend on the proximity to other economic activities. Among all possible locations

for an economic activity there will be a few or one that is optimal. Optimality for an economic activity means that this location will provide for maximizing profits,and for a consumption activity it means that utility is maximized. In our economic organization based on profit motive, optimal activity location will always exert an attraction and try to overcome inertia of past actions or present obstacles, for whether the activity is productive or consuming, it will pay a price for nonoptimal location choice.

For the purpose of this study locational choices will be viewed to be governed by the desire to maximize profits or utility.

The following tables describe the activities to be modelled and some of their locational needs, characteristics, and their influence on attracting other activity:

1. LIGHT INDUSTRY

- required access to handling services for heavy goods
- large concentration of low and semi-skilled workers
- do not serve general public
- requires downtown site only because of existing supporting functions
- no longer dependent on railway
- large percentage of light industry decentralizing

functions: produce, package, distribution and installation of small consumer goods

time: 8:00 A.M. to 5:00 P.M. (Monday through Friday)
radial functions: quick food outlets
: equipment, service and repair shops
: wholesaling and warehousing facilities

2. WHOLESALING

- requires easy access by buyers
- requires good handling services
- requires access to rail and trucking lines

functions: sell bulk goods, display marketable goods
time: 8:00 A.M. to 5:00 P.M. (Monday through Saturday)
radial functions: quick food outlets
: equipment and repair shops
: meeting halls and show rooms
: hotels

3. COMMERCIAL RETAIL

a. department store:

- requires heavy consumer traffic
- requires good handling services
- has widest variety of participants
- has individual, tandem and family shoppers

functions: sell goods and services, display marketable goods, fashion center, food services, center of leisure activity of browsing.
time: 9:00 A.M. to 9:00 P.M. (Monday through Saturday)
radial functions: specialty shops
ladies lounges and clubrooms
short-term nursery
art displays
fashion shows
information center, tourists, politics
person-oriented services
repair shops
specialty shops

b. specialty shops

- tend to locate near source of consumers (department stores, business district)
- customers are specialized and, in some cases, established
- tend to supplement and support department stores

functions: sell goods and services
time: 9:00 A.M. to 5:00 P.M. (Monday through Saturday)
radial functions: crafts and art shops
: ethnic shops
: small offices
: small educational and vocational institutes

4. OFFICES

a. corporation offices:

- workshops for white collar workers
- have large concentration of professional people
- do not serve general public
- require downtown site for prestige and personal communication within and between offices

functions: workshop, business center of the city
time: 9:00 A.M. to 5:00 P.M. (Monday through Friday)
radial functions: specialty shops
: club rooms
: meeting halls and show rooms
: dining facilities
: entertainment
: recreation
: equipment and service shops

b. professional service offices

- scattered throughout project area
- tend to locate near source of serviced consumers
- serve general public and corporation offices

function: serve public, eg. doctors, lawyers, engineers
time: 9:00 A.M. to 5:30 P.M. (Monday through Friday)

radial functions: specialty shops
: dining facilities
: clubs
: recreation
: entertainment

5. HOTELS

a. convention

- serve large groups of businessmen
- people on expense accounts
- short-term housing

function: housing and meeting, personal contact for inter- and intra-city groups
time: full-time
radial functions: display center
: dining facilities
: recreation
: entertainment
: shopping
: art and cultural centers

b. tourists

- serve individuals, families and small groups
- people on their own budget
- short-term housing

6. GOVERNMENT OFFICES

- a public service requiring good vehicular and pedestrian access
- requires a number of offices, some of which directly serve the general public

function: public service and general office work
time: 9:00 A.M. to 5:00 P.M. (Monday through Friday)
radial functions: other government offices and agencies
: dining facilities
: specialty shops

7. HOUSING (in downtown area)

- caters to single persons and families with few children and usually the wealthy and middle class
- short-term residents
- people who work in the area
- people who extensively use the downtown facilities

function: housing
time: full-time
radial functions: specialty shops
service shops
entertainment
recreation
work place

PUBLIC INTEREST AS A MEANS OF INFLUENCING LAND DEVELOPMENT

Public actions that are taken on the behalf of effecting private development actions are done so because of a concern for both urban economics and for reasons of urban physical qualities, desired or interpreted to be desired by the community. Intervention into the private development process involves the notion of protecting or preserving public held values. Public involvement in urban growth is done by means of controls or regulatory measures that are meant to guide growth by performance specifications. By their nature these means are usually done in a negative and indirect fashion.

There are five basic purposes that land use controls are meant to serve:

1. Guide the use of land
2. Prevent the misuse of land
3. Prevent the nonuse or underuse of land
4. Guide the redevelopment of land
5. Protect developments of social or traditional value

Land use controls are made operational by means of specifying regulations that must be adhered to by private actions. These specifications are concerned with:

1. ECONOMY OF LAND USE PATTERNS

Land use patterns have a direct effect on municipal expenditures and municipal tax resources. Public economic vitality is directly

dependent on the general economic conditions of the urban area it services. Land use patterns in terms of activity locations and relationships between activity location can directly affect municipal revenues and municipal costs. Intensity of development has the further effect of contributing to municipal revenues by reducing distances and increasing taxes in proportion to degree of increased density of development. But public policy must also be concerned with the quality of environment and the convenience of that environment for its citizens.

It is then the public responsibility to balance out a land use policy that has on the one hand efficiency and the least cost of operation and on the other satisfaction of citizen values and attitudes.

2. DEVELOPMENT LOCATIONS

The location of a new development has a direct effect on municipal expenditures by its:

(1) relationship to previously developed utilities and facilities such as roads, sewers, etc.
(2) relationship to existing public services such as schools, parks, playgrounds, etc.
(3) proximity to complementary functions
(4) degree of compatibility with surrounding development

3. DEVELOPMENT INTENSITY

The degree of intensity of an activity development also effects municipal expenditure by:

(1) permitting reduced expenditures for service facilities as

they relate to distance (footage of hydro, roads, water and sewage lines) intensity of development can also incur an increased cost by placing an overly large demand on utilities and public facilities causing increases in costs for providing services; and

(2) providing increased revenues for a given spatial area since taxes relate to building and land assessments.

If public expenditures can be reduced it will directly release more capital for investment into private development and this in turn may produce a more intense development.

Land use intensity must be looked at in terms of community values. It may be that a community is willing to acquire increased taxes to acquire such physical attributes as more open space, more personal property and the resultant privacy and reduced congestion that this attribute may bring. But sound urban economics should be responsive to spatial efficiency as this not only effects public spending, but has a tremendous impact on the quality of the urban environment.

4. CONVENIENCE AND COMFORT

One of the purposes of land use controls is to provide a means of satisfying basic human environmental needs. As we give up a portion of our individual freedom to live in proximity to others, we must find means to permit enjoyment of this urban experience on a

collective basis. The decisions of where an activity will be located and in what relationship spatially this activity is with every other activity to a large degree determines the way in which the environment will be used. Convenience can be judged in terms of how well the relationship between different uses respond to desired and established activity patterns:

- distances between different activity destinations
- ease of movement to activity destination
- degree of accessibility provided
- degree of quality of experience obtained from use of the environment.

RELATIONSHIP BETWEEN PUBLIC AND PRIVATE INTEREST REALMS

If we consider the growth of the urban environment to be largely the consequence of decisions governed by private economic motivations we must explain the relationship between the impact of public policy on those private actions and the reciprocal impact of private actions on formulating public policy. An economic model of spatial structure views development as being organized by the state of the market supply and demand relationship and the history of spatial decisions, both locational and quantitative. These decisions are seen as the reasons for the patterns generated. The relationship between the market place dominated processes, and the municipal, political and legal processes, are the two means by which urban form is finally generated.

It is the task of the public realm to provide the harmony between these two sometimes opposed systems. The role it plays is one of initiation that must both guide and encourage growth. Public policy must provide the necessary strategy of actions that indirectly influence the course of development events that produce the subsequent patterns of the urban area.

Two purposes have been presented for public policies - one is seen as a positive process of providing the opportunity for full realization of development potential and the other is a more negative role of constraint, to protect the values of the public from private exploitation. How these purposes are used and in fact which one is effective to bring about some degree of convergence of the public and private interest realms is one of the main concerns of this study.

The simulation model is designed to help determine the relevance and to test the consequences of various public proposals which seek to guide individual development into patterns that will achieve desired public goals. To be effective in achieving its desired goals, public policy must be responsive to individual development decisions and the economic criteria that motivates those decisions. The purpose of this model will be to identify what areas of the private interest realms are sensitive and what areas can be manipulated to achieve desired public environmental values. The degree to which indirect public actions can achieve their goals will constitute its measure of success.

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IV THEORETICAL STRUCTURE

METHODOLOGY

INTRODUCTION

This section will describe the basic decisions that have been made in regard to the development of the model's structure. Models are conceptual or mathematical formulations related to real objects and the relationship between those objects that can be expressed in statements or formulas. Unlike models, simulation is expressed in terms of processes that can be combined with a model to imitate reality. A simulation process is a manipulation of conceptual or mathematical models that contain a model of process.

The structure of the models contained in a simulation process depend directly upon the objects being modelled, the information available about the objects and the intended purpose of the simulation.

MODEL STRUCTURE - BEHAVIORAL APPROACH

Individual decisions regarding development have produced the collective environment of urban settings. Each urban area contains its own historical sequence of decision events that have produced its own uniqueness of form. If these processes and sequences of decision could be documented such that each action could be understood in terms of its rational basis, we could conceivably reconstruct a model of the relationships (causes and effects) between these many actions that happen over a period of time. In this respect the model

would become a documentation of the behavior of many actors to a changing environmental situation.

The conceptual development of the model works on the premise that an urban development process is a rational one that can be identified and made explicit. The structure of this model is based on the assumption that growth in the urban area can be simulated to represent the way that urban development decisions are made. In this respect the model is behavioral in that it responds to development by determining events through interaction with previous actions, and allocates resources based on individual circumstances.

The principle underlying this method relies on specifying a preference system that can be structured to simulate the order and priorities for determining individual choice under varied situations.

Further classification of the model's structure can be made by defining the methods used to describe the environment and manipulate its represented variables. This model can be classified as being analytic in that it explicitly details the relationships involved in development decisions and their sequence. An analytic model specifies cause and effect relationships. A second classification that can be made is that this model is a partial model in that it only structures a limited part of an environment and is only concerned with the immediate effect of an action on the environment.

Because the model contains a representation of the individual or individual-type decision maker, this structure can also be classified as microanalytic. Microanalytic models are based on theories of individual competition or interaction as opposed to macromodels

which are constructed on aggregate levels of individual decisions.

A fourth distinction can be made as to how the model treats time and change. Since urban process and decision-making deal with change to an existing environment, some form of dynamic model is required. A prediction model attempts to represent the outcome of a process beginning with the state of the relevant world at a time T and reports to us the possible state of the world at time T + N. The method of building in time and change in this model has been approximated by iterative effects to endogenous variables and to locational variables occurring after each 'run'. The results of these changes then become the input for the next sequence and so on to completion.

This classification can be termed pseudo-dynamic.

This model is also structured to be deterministic in that a 'run' results in a unique set of results. The model's variables and relationships are rigidly defined and there is no inclusion of random factors as structured in a probabilistic model.

A sixth classification can be identified in the structure of the model's algorithms. The determination or selection of values are structured on an iterative causative ases a step at a time. This is classified as a sequential operating model. Sequential models appear in a program as a series of sub-routines in which each step provides input for the next operation. This building-block approach has been taken to allow flexibility in construction and provide for alterations after initial completion.

B. BASIC ASSUMPTIONS AND REQUIREMENTS

1. ASSUMPTIONS

The model structure is based on the following assumptions which help to limit and simplify the model's structure:

1. Development decisions and actions will be treated as a linear process.
2. Development decisions will be determined by the development process algorithms and sequence of algorithms.
3. The model will be structured to focus on a limited and general classification of activities.
4. The model will treat development as the needed magnitude of activity for a specific location at a specific time and will not specify the actual physical requirements, eg. new growth, rehabilitation, expansion of existing facilities.

2. REQUIREMENTS

- The model must be structured on a logical, consistent conceptual framework based on existing theory or rational observation of the process being modelled.
- The model's structure must have a positive relationship to those processes in the environment being modelled that can be measured.
- The model structure must take into account the passage of time.
- The structure must be capable of adapting to the feedback of its own processes.

D. PROCESSES TO BE MODELLED

The following are the processes considered in the structure of this model:

1. Aggregate growth of activities produced by external and internal forces (population increase, technological, life style, etc.)
2. Internal shifts in activity location preferences.
3. Locational decisions for activities.
4. Assembly of physical space.
5. Magnitude of activity development.
6. Effects of development on surrrounding environment.

1. AGGREGATE GROWTH OF ACTIVITIES PRODUCED BY EXTERNAL AND INTERNAL FORCES

The process of activity growth of an urban area is directly proportional to its population and/or economic expansion, which relies on the state of the external forces acting on it. The magnitude of these forces will have a direct influence on the city's demand or need for growth in activities and to some extent influence their distribution within the urban area. For purposes of the model, aggregate growth of the urban area will be related to its direct effect on the state of future activity needs (see market projections). Projection figures of spaces become a means of providing a resource input for the model processes to operate on. In this respect the market projections will constitute a given condition - exogenous to the operative model. Modification to its initial state will be accomplished by individual actions taken in the following processes:

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2. INTERNAL SHIFTS IN ACTIVITY LOCATION PREFERENCES

Because of changing technological, social and economic conditions of the urban setting, activity patterns usually transform to coincide. Changes in land values or changes in an activity's internal demands have effects on locational selection choices. This process of change in location preference will be treated as an exogenous variable and incorporated into the initial state of the non-locational data.

3. LOCATIONAL DECISIONS FOR ACTIVITIES

Locational decisions will be based on a competition for:

a. The availability of locational space.
Because of the nature of the study area physical space needs for new activity development will involve the displacement of existing activities. Availability of land area will be measured in terms of its readiness for release to the market (see locational data).

b. The desirability of locational space.
Every physical location has specific attributes that contribute to its desirability for specific activity placement, the availability of service, its relation to other activites, its accessibility to varying degrees of network needs, or its visual and status ratings. Each attribute reflects the degree to which it will meet the needs of a specific activity. Location selection for any specific activity will be influenced by the degree that a specific location satisfies that activity.

c. Physical accessibility of the location.

Each activity displays a unique need in regard to its accessibility to and from other locations. The degree of accessibility and the characteristics of the network system greatly influence locational choice.

d. Cost of locational space.

Because of the degree of urbanization already existing in the study area cost of physical space must be calculated to reflect 'true' cost of obtaining and occupying that space. Land costs plus additional costs of existing building facilities will reflect a more exact cost of space.

4. ASSEMBLY OF PHYSICAL SPACE

The process of determining the bulk or size of a new development is dependent on:

1. market needs and demands
2. economic factors of land and construction
3. ability to finance
4. relationship of land parcel to building program
5. zoning and building regulations
6. technological conditions and abilities

If we assume that land values in the study area are such that every decision regarding size will be on the basis of optimizing the relationship between physical development and site, we can approximate the decisions of building size by equating land costs to needed economic building size. This process will determine the size that

has to be developed for a specific activity at a specific location. This process will represent the needed economic magnitude of development but not necessarily its 'true' size.

6. EFFECTS OF DEVELOPMENT ON SURROUNDING ENVIRONMENT

The process of implementing a new development action will be assumed to have the following effects:

1. Because like developments tend to collect around a given source, the presence of an activity will tend to attract like activities or activities that are supportive in nature or complementary.

2. The presence of a new development has an immediate effect on the surrounding land values increasing in value in relation to proximity to the new development.

3. Employee population and/or consumer population has an impact on increasing traffic in the network system.

E. DATA REQUIREMENTS:

1. INITIAL CONDITION

Initial state of data will describe the magnitude of all relevant variables at the present time. Variables used for describing model will be of two types:

1. Non-location specific data.
   Those variables that have values that are independent of a specific location (NOTE: some of these variables may have different values in different cities but are considered constant for the present study area).

2. Location specific data
   Those variables that have unique values for a specific geographic location.

2. EXOGENOUSLY SPECIFIED DATA

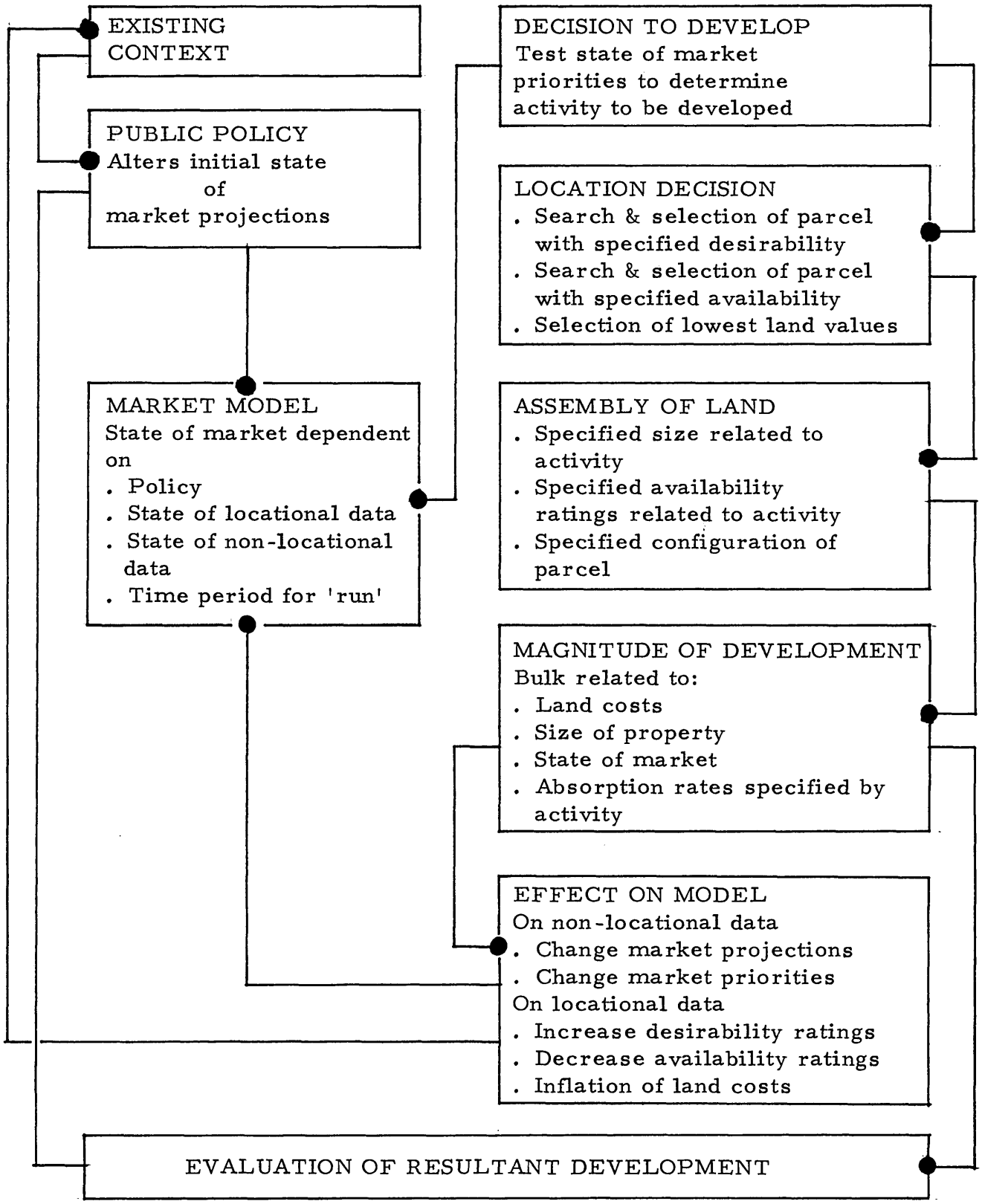
Exogenous data is specified to the models initial state and effect on the development process by specifying a set of predetermined rules. Public policy decisions, zoning bylaws, incentive programs to attract specific activities are all examples of exogenous data that are used to set the model's initial conditions.

3. THE ELEMENT OF TIME

This model is intended to represent the outcome of various development processes that take place over a specified period of time. The

initial condition represents the state of the relevant variables at time 1970 and projects the activity space needs forward to a future state of the model at time 1970 + 10. The process of moving from the initial state to the future state is left unspecified as to exact time sequence. The need for specified sequence of time is not of importance since the interest in this study is the ultimate consequence of the prediction and the sequence of events that took place need not be specific as to their exact timing.

FIGURE 1 DIAGRAM OF THEORETICAL DEVELOPMENT PROCESS



VI DESCRIPTION OF OPERATIVE MODEL

A. INTRODUCTION

This chapter will deal with describing the operation of the computer model, its data base, sequence of operations, algorithms, and output as they relate to determining a possible future pattern of urban development. Economic considerations play a large part in motivating many of man's decisions and actions, especially in societies where this is sanctioned and encouraged as a mode of operating. It would seem conceivable that if information regarding how past economic decisions were made for a particular problem and what reasons or criteria guided those decisions, predictions could be made as to the probability of decisions in the future.

This description will include:

1. The assumption and criteria as established in Chapter III related to land development determinants.
2. Projection figures for establishing future space needs.
3. Explanation of calculations and data used for projecting resultant land development's physical and economic characteristics.

B. STRUCTURE OF MODEL

MAJOR COMPONENTS

The operational model is structured so that it contains three distinct components:

1. The first contains all the variables that are locational specific. These describe the characteristics of the environment to be modelled.
2. The second consists of definitions of all variables that are not locational specific. These are used to test and manipulate locational data into useable form.
3. The third component of the model contains the necessary algorithms to simulate the behavioral decisions and sequence of decisions in a private development action.

These three interdependent components make up the operative model.

The attempt in developing these elements has been to reduce and simplify reality to a degree that still satisfies the objectives for the model.

1. LOCATION-SPECIFIC DATA

Locational data consists of model variables that are locational specific. Locations are determined by a grid or matrix that is superimposed to coincide with the surveyed street network and land parcels of the study area (see map #1).

The grid used for locational data has a size of 34 rows and 42 columns. Each grid represents a 120' square with an area of 14,400 sq. ft. Ten of these grids make up a typical city block of land 2 wide by 5 long.

The three attributes used to specify locational data are:

a. COST: (cost incurred in acquiring a parcel of land for new

development). Land costs were obtained from recent land transactions and assessment figures for all property and building in the study area.* Where assessment figures were used a factor of 2.5** was multiplied by that figure to approximate its market value. Building size and condition were used to determine additional cost in acquiring property. Values for the variable costs are assigned to parcels on a represented square foot basis which can then be translated into a total cost of property.

b. AVAILABILITY represents the degree of 'hardness' or 'softness' of the existing physical environment. Availability rating are dependent on the existing state of development at a specific location, and the geographical position of that location in relationship to adjacent locations.

Availability ratings for a specific location are determined by an aggregation of:

. existing land use*
. intensity of use of land*
. condition, size and age of physical building presently occupying the location*
. present investment or value of development*
. degree of intertia of present activity (ability to maintain validity for occupying location)

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* Source. Metropolitan Corporation, Winnipeg Downtown Survey, 1967.

** Ratio used to convert land value to assessment value.

Availability ratings assigned locations provide an indication of the opportunity for new development to occur over time. In this regard, availability ratings become a classification that suggest future potential. For purposes of simplification availability ratings were weighted on a numerical scale from 1 to 10, providing a possible two-year increment per unit of value.

c. DESIRABILITY: Like availability ratings, this data classification is an aggregation of specific collectable and observable data. Desirability ratings represent the degree of attractiveness of a location for a given activity. A desirability rating for a given activity. A desirability rating for a given location indicates that this location satisfies activity needs to the amount specified on a numeric scale. To avoid the necessity of providing a desirability rate for each activity type, commercial retail was used as a base for establishing ratings. All other activities are related to retail ratings by selection of a progressively lower 'entry point' into the scale, for example, a rating of '90' for desirability would only enter commercial activity into location testing, whereas a rating of '60' would allow retail, offices, government and hotel activities into locational testing. There is also included a lower level of exclusion for each activity just as there is an upper level of entry.

Desirability ratings for a specific location are determined by an aggregation of:

. geographical position within the study area (relationship to major thoroughfare)
. relationship of location to existing activity patterns

. relationship of activity to adjacent activities

. cost of land parcel

Like availability ratings, desirability indicates potential for new development. Desirability data is dependent on the characteristics of the physical environment for establishing ratings, but independent from the time element. (See effects for description of changes to desirability ratings.) Its major purpose is to establish criteria for determining the opportunity for activity location.

2. NON-LOCATION SPECIFIC DATA

This section of the model is structured to define and quantify all needed data that is independent of geographic location. This file contains the definitions and quantities for the locational and assembly algorithms, and the criteria for generating the characteristics of the physical development for a specific location.

The initialization of a 'run' is established by manipulation of the criteria contained in this file, to approximate the expected operational effects of a given public policy on the decisions made by a private developer. (For example, a public policy attempting to encourage growth of a specific activity would have to provide a direct economic incentive or indirect effect on costs incurred by a developer for developing that activity). The initialized state of this file is then considered to be the operative model for a given public policy 'run'.

This file contains the following data:

a. ACTIVITY SELECTION

(1) Projected space needs for a twenty year period for the study area.*

(2) Priority ratings for projected space needs.*

b. LAND SELECTION AND ASSEMBLY

(1) Desirability rating related to activities (upper and lower limits of ratings) criteria for locational testing.

(2) Availability ratings related to activities (upper limits of ratings) criteria for locational testing.

(3) Size of land parcel required for activity types (based on observation of recently completed and proposed developments in the study area).

(4) Availability ratings used to determine feasibility of land assembly around selected location.

c. EFFECTS OF DEVELOPMENT

(1) Availability incremental decrease to land effected by adjacent new development. (Approximates the pressure exerted on surrounding land for quicker release to market created by new development locating in immediate area.)

(2) Desirability incremental increase to land effected by adjacent new development (approximates propinquity) and increased marketability for land development.

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* Source: Urban Renewal Area #2, Reid Crowler & Associates 1967 "Downtown Development Plan", Planning Department Metropolitan Corporation of Greater Winnipeg

(3) Cost incremental increase to land affected by adjacent development (approximates increase in market price land can demand and provide a means of incrementally increasing land costs over time).

d. ACTIVITY DEVELOPMENT AND DEVELOPMENT CHARACTERISTICS

(1) Cost of construction related to land costs (absorption rates). This represents the dollar value of land cost per unit (sq. ft.) that can feasibly be paid for each unit (sq. ft.) of building constructed to ensure an economically feasible development.

Example: Absorption rates are determined from present and proposed developments in the study area.

Example: Residential development

. An average apartment unit size is approximately 700 to 800 sq. ft. (averaging bachelor, 1 and 2 bedrooms)

.. The cost of land that can be paid per apartment unit is approximately 1400 to 1600 dollars. This represents a figure based on land costs incurred in relation to gross physical units constructed and does not take into account servicing costs, mechanical or elevator costs, etc. which represent further cost variables that must be calculated against proposed development to ensure feasibility.

. Absorption rates for residential development can therefore be calculated per unit sq. ft. as $\frac{1600 \text{ dollars}}{800 \text{ sq. ft.}} = \pm \$2.00$ per sq. ft.

(2) Population generated from new development ratio of square feet per person for a given activity type.

(3) Income generated by development in terms of income per person.

(4) Number of cars generated by development ratio of population to vehicles for a given activity type.

(5) Mill rate for a given activity type.

(6) Incremental reduction to priority ratings. This represents the change incurred to space needs after development of an activity is completed.

(7) Information represents the physical and economic characteristics to be calculated for each development action.

(8) Total represents the aggregated sum of all physical and economic calculations for all development actions for complete run.

e. TEMPORARY VARIABLES

(1) TLIST 2. represents all land that satisfies the availability and desirability algorithm tests.

(2) TLIST 3. represents the final selection of location from all land represented on TLIST 2.

3. ALGORITHMS

The algorithm file contains the arithmetic, relational and logical operative functions for manipulating the location and non-locational data to achieve the desired results of the model.

The following is an explanation of the sequence and procedures contained in this file, reference to specific labelling in the file will be done to provide a means of cross-relating this description to the file contained in Appendix C (file develop)

a. LOCATIONAL DECISIONS

(1) Determine Location

The first algorithm establishes the activity type that will be used for the 'run'. This is done by search and selection of the highest priority value currently assigned to the seven activity categories. Assignment of values to an activity are redesignated after each 'run' (see effects). The choice of a specific activity assigns the correct category of variables related to that activity, this appears as a qualification to all activity related variables designated as 'work'.

(2) Determine Location

In order to determine a site for the selected activity, feasible locations must meet three specifications:

- Parcel locations must be within the allowable desirability rating specified for that activity.
- Parcel locations must be chosen that contain the lowest availability ratings; this specification changes incrementally as the development runs proceed.
- Final selection of parcel is completed by testing each parcel for land cost values and selecting parcel with the lowest value. Search procedures are progressively reduced by intersecting temporary lists, each containing one test - to obtain only location that progressively satisfies all criteria.

b. ASSEMBLY OF LAND

The process of assembling the needed land for development is usually a difficult task when the area is already heavily built-up. As a consequence of already intense development and high land cost, land assembly for development in the downtown is usually

held to the minimum land necessary to support the proposed physical development.

PROCEDURE:

(i) Selection of land around chosen location - land surrounding the chosen location is tested for its availability rating. If availability rating of surrounding land meets specification, it is selected for assembly and search proceeds to the next contiguous parcel until specified size of land is assembled.

(ii) Land assembly procedures are simulated to represent a progressive search - testing and selection of all parcels surrounding the chosen site. A BLOCK statement is used to confine search to immediate area surrounding location, and a CIRCLE statement is used to initiate search to right or left or top or bottom of chosen location. This procedure for search produces land assemblies of contiguous usable land configurations for activity developments.

(iii) Assignment of normalized land values. When land assembly is completed land values for assembled sites are normalized, to give a collective value to assembled land, in dollars per square feet.

(iv) Exclusion from market. Land that has successfully been assembled is excluded from any future location or assembly procedure by deletion of those variables used for selection.

c. ACTIVITY DEVELOPMENT

The process of generating a possible configuration of activity development characteristics is based on projections of minimum economic feasibility requirements. Development characteristics are therefore pictured as the possible consequence of economic

necessity. The resultant picture of the environment is a projection based on the minimum physical intervention necessary to produce an economically feasible development from a developer's viewpoint.

PROJECTIONS OF PHYSICAL DEVELOPMENT CHARACTERISTICS

A. MAGNITUDE OF DEVELOPMENT

The amount of development to be constructed is determined by land values and the relationship of absorption rates to a specific activity.

$$\text{TOTAL BUILDING AREA} = \frac{\text{Land costs per unit}}{\text{Absorption rates per unit}} \times \text{total units of land}$$

B. BUILDING DENSITY

Building density represents the relationship of the amount of building construction to the amount of land. This is commonly termed as a building floor-area-ratio and describes the bulk of a building, it is a good indicator of development intensity, especially if land area of site is also known.

$$\text{F.A.R.} = \frac{\text{Total building area}}{\text{Total land area}}$$

C. POPULATION OF DEVELOPMENT

Population figures for the predicted development are generated from established space per person ratios.* These figures are assumed to remain constant over the study period. The projected

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*Source: Planning Department, Metropolitan Corporation, Greater Winnipeg

population figures for a new development give an indication of the influence of the development on generating 'life' into the study area and further given an indication of the impact of the development on existing service facilities.

$$\text{POPULATION} = \frac{\text{Total building area}}{\text{Ratio of floor space per person}}$$

D. INCOME GENERATED BY DEVELOPMENT

Income generated by new development provides an indication of the potential sales dollars that can be attracted to the downtown commercial area. Income is based on employee wages and does not include the profits generated by the activity's processes. Incomes are based on average dollars earned for a given activity type. Residential category is assigned a value equivalent to an average of the other activities.

INCOME = Total population x Average wages per person for a given activity

E. INVESTMENT

The amount of investment incurred by a development action provides a dollar value measure that can be evaluated as to the degree of success that a given policy has had in attracting development. The investment cost of a development also provides a measure of the success in providing a sound economic tax base.

INVESTMENT = Total building area x Cost per unit sq. ft. for a given activity

F. NUMBER OF CARS GENERATED BY DEVELOPMENT

Each new development occuring in the study area contributes to the problem of providing adequate storage space and adequate access space on the network system. The number of automobiles directly generated by a new development can be projected by providing a ratio of the number of cars per person for the various activities based on past standards and zoning requirements.

NUMBER OF CARS = Population x ratio of persons per car for a given activity

G. POPULATION DENSITY

$$\text{POPULATION DENSITY} = \frac{\text{Total building area}}{\text{Total population}}$$

H. ASSESSMENT

Assessment value of property is the value assigned property and building for taxation purposes. Assessment values provide a measure by which a city's tax base can be evaluated. Land that is underdeveloped or a development that has depreciated in value provides little tax support to the municipality. Taxes based on assessment values for new development are usually considered in development capital since no revenue will be derived during construction period.

ASSESSMENT = 40% building cost + land cost

I. TAXES ON DEVELOPMENT

Taxes for a development are calculated by multiplying the assessment value of a development by the Mill rate established by the

municipality for a given activity.

$$TAX = \frac{\text{Assessment x Mill Rate}}{1000}$$

d. EFFECTS OF DEVELOPMENT ACTION

(1) On Non-Locational Data

Each development action initiated and executed is structured to change the initial data base as the 'run' progresses.

- After each action has been calculated the results of the magnitude of the development are subtracted from the projected space needs contained in the market.
- The activity type selected for the completed 'run' is then used to reduce its priority rate by an amount specified for that particular activity. These changes are merely used as accounting devices to continuously record the state of the market projections as the run progresses.

(2) On Locational Data

The changes made to locational data are a method of approximating the impact a new development has on the environment surrounding its location.

The existence of a new activity affects the surrounding environment in three ways:

- Desirability ratings for the surrounding land are increased to approximate the impact a new development has on attracting future developments.
- Availability rating on land parcels surrounding development are reduced to simulate the pressure exerted on surrounding development for quicker release to the market for redevelopment.

. Land costs are increased to:

(i) approximate natural inflation of land values over time, and

(ii) provide a means of approximating the increases of land values in surrounding area once a new development has occurred.

These changes to the data base have a direct effect on the possible sequence of development events. The process of locational decisions will be altered and selection-procedures must test the advantage of increased desirability and decreased availability ratings against the disadvantages of the increase in land costs.

e. OUTPUT PROCEDURES

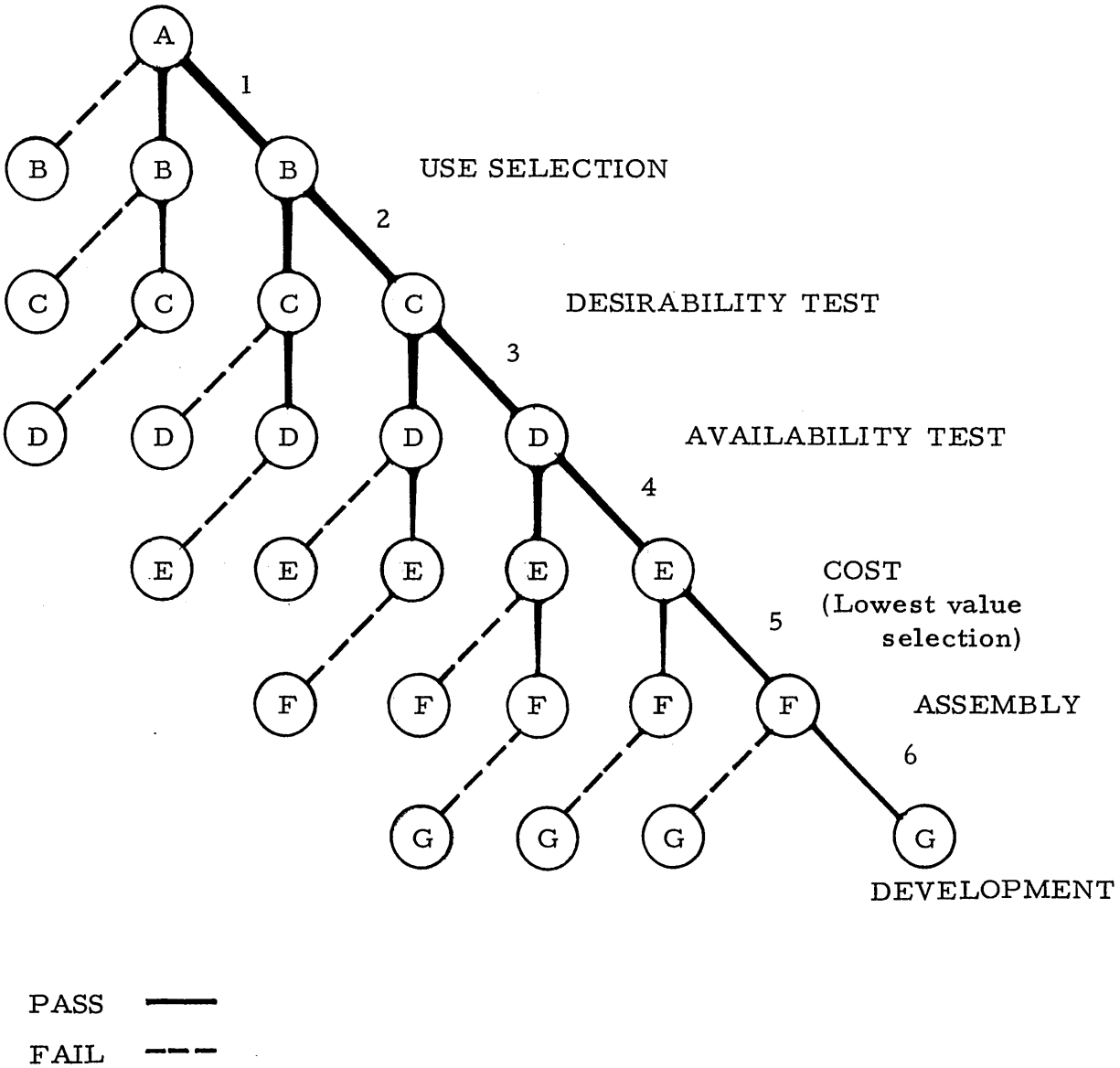
(1) Mapping of Location and Assembly Decisions

Maps are generated to indicate the location, size and shape of selected sites for each action. As the 'runs' progress a record of the past development is progressively mapped to enable a graphic observation of the development pattern being generated.

(2) Listing of Development Characteristics

Each action is recorded by listing its physical and economic characteristics. These characteristics can then be used to compile a profile of the success of a total 'run'.

FIGURE 2: SCHEMATIC DIAGRAM OF POSSIBLE DEVELOPMENT DECISION CONFIGURATION



MARKET PROJECTIONS

INTRODUCTION

The purpose of this section will be to develop a representation of some of the future activity needs for the downtown core area. Market projections will be used as a 'resource' for the prediction procedure of the development model. The purpose of the market projects will be to:

- identify the priority of activity space needs for a 0 year period,
- determine the magnitude of each activity for a 0 year period, and
- determine the number of employees required for each activity.

The market projections will perform as the information recording and retrieving system of the development model. Decisions to develop will be monitored by the state of the market projections at any point in the 'run'.

In order to develop a simplified representation of future needs it will first be necessary to analyze and make projections of the existing market activities, their patterns of distribution and their quantities; from the projections it will then be possible to construct a simplified version that will provide the initial input to the model.

Base for future projection figures:

The base for determining projection will include only those activities that constitute a significant proportion of the existing core area and

will be represented by aggregate headings to limit the size of classification.

Methods of projection will vary with each classification of activity but all figures will have a relationship to population projections prepared by Metropolitan Winnipeg Area Transportation Study for the year 1990. This study estimated the population of Winnipeg to be 780,000 in 1990 or a 2.2% increase per year and 44% increase for the purpose of this study.

ACTIVITY, FLOOR SPACE AND EMPLOYEE PROJECTION

LIGHT INDUSTRY

. existing floor space = 733,166
. existing number of employees = 3,180
. existing square feet per person = 230

a. ASSUMPTIONS REGARDING FUTURE GROWTH

(1) Light industry will continue to decline as space users in downtown at rate 1/2% per year.

. increasing proportion of sales in outside central city
. increased use of trucking
. requires more highly skilled labor force

b. CALCULATION (based on employment)

(1) Employment

. light industry = 20 (4804 - 1/2%) = 4341

(2) Floor Space

Assumed floor space per employee ratios will stay constant over study period.

. light industry	Employment	Sq. ft. per employee	Estm. space
	4341	195	846,495

c. PROJECTION = 113,329

CONCLUSION

The estimated projections indicate that there will be virtually no growth but a possible significant rearrangement of industries located in the study area which could result in new buildings being required because of the obsolescence of the buildings in the central manufacturing area.

WHOLESALING AND WAREHOUSING

. existing floor space = 1,230,000
. existing number of employees = 3,090
. existing square feet per person = 416

a. ASSUMPTION REGARDING FUTURE GROWTH

(1) Winnipeg expanding as distributing center
(2) Preference to be close proximity to related manufacturing firm.
(3) Some advantages in being close to central retailing area.
(4) Accommodation for buyers in central area
(5) Proximity to competitors

b. CALCULATIONS (based on employment)

(1) Employment

. relationship wholesaling employment to total labor force constant for fifteen years at 8.5% with 39% participation rate.

. assumed this ratio will continue

.·. therefore number of wholesale employees = 780,000 x 39.085 = 25,800

.·. estimated 10% in study area = 2,580

(2) Floor Space

. assumed floor space per employee ratio will stay constant over study period.

. Therefore floor space = 2,580 x 416 = 1,032,000

c. PROJECTION = 198,000

CONCLUSIONS

Small increase in space requirements. It is likely that some of this expansion will be achieved by converting existing space at wholesaling uses.

RETAILING

. existing floor space 4,665,217

. existing number of employees 19,323

. existing square feet per person 241

a. ASSUMPTIONS REGARDING FUTURE GROWTH

(1) nature of retailing in C. B. D. changes as city increases in size.

(2) intensified competition from suburban shopping centers.

(3) easy access to downtown provided by proposed freeway network.

(4) mobility in C. B. D. network is good and there is adequate parking.

(5) growing downtown labor force by growth of financial and administrative centers provides captive market.

(6) public concern for downtown's vitality.

b. CALCULATIONS (based on sales dollars)

(1) Floor space

. population 1970 = 780,000

. disposable income = $2,111,000,000 (1965 dollar value)

. personal consumption = 94% = 1,990,000,000

. proportion sales in C. B. D. = 22%*

. annual dollar sales per square foot of floor space = $750

. total floor space = 6,012,000

(2) Employment = (constant square footage per employee) = 6,012,000/214 = 24,900 employees

c. PROJECTION = 2,347,000

*Source: E. M. Horwood and R. R. Boyce, "Studies of the Central Business District and Urban Freeway Development" (1959)

CONCLUSIONS

There will be a substantial increase in retail space required in the C. B. D., but much of this may be incorporated into large scale multi-use developments, thus making it more complex to establish locational distribution in model.

COMMERCIAL OFFICES

- existing floor space 4,910,613
- existing number of employees 19,739
- existing sq. ft. per person 260

a. ASSUMPTIONS REGARDING FUTURE GROWTH

(1) Winnipeg continues to be a dominant financial and administrative center for the prairies.

(2) Inner city location flexibility = propinquity

(3) Outer city location flexibility = land costs, rents or environmental conditions.

(4) As cities grow larger, office space in the downtown increases at a faster rate than population

b. CALCULATIONS

(1) Floor Space

- existing = 10.2 sq. ft. commercial floor space per capita
- estimated 10.5 sq. ft. commercial floor space per capita
- therefore for population of 780,000 = 8,190,000 sq. ft.

(2) Employment = 8,190,000/2 = 31,162

c. PROJECTION = 3, 279, 387

HOTELS

. existing floor space = 1, 228, 530
. existing number of employees = 1, 260
. existing square feet per person = 956

a. ASSUMPTIONS REGARDING FUTURE GROWTH
(1) business visitors used as an index of hotel growth
(2) therefore, growth will be in direct proportion to the total downtown employment population

b. CALCULATIONS (based on % growth C. B. D.)
(1) Floor space
. estimated that downtown employment will grow by 36%
. therefore there will be .36 x 1, 228, 529 = 1, 670, 800 sq. ft.

(2) Employment (constant sq. ft. per employee)
1, 670, 800/956 = 1748 employees

c. PROJECTION = 442, 270

GOVERNMENT

. existing floor space = 1, 928, 300
. existing number of employees = 6, 983
. existing square footage per person = 390

a. ASSUMPTIONS REGARDING FUTURE GROWTH

(1) space requirements for municipal administration will grow proportionately as population to be served.

(2) Federal and Provincial offices grow in accordance with the Economic Council of Canada(projections for government employment = 2.8% for next five years)

(3) downtown Winnipeg has a large government sector - Metro, municipal, provincial and federal offices

(4) as society becomes more affluent, government usually grows at more rapid rate

b. CALCULATIONS

(1) Employment

. growth rate estimated at 3% per year

. 6,983 x 3% x 20 = 12,600

(2) Floor space (constant sq. ft. per employee)
12,600 x 390 = 4,914,000 sq. ft.

(3) percentage in study area = 75% = 3,595,100

c. PROJECTIONS = 1,667,800

HOUSING

. existing floor space = 360,000 sq. ft.

. existing number of residents = 12,000

. existing sq. ft. per person = 300

a. ASSUMPTIONS REGARDING FUTURE GROWTH

(1) increased rate of household formation

(2) economic council estimates growth rate 6.2% per year

(3) future of C.B.D. as residential area depends largely on public policy

(4) if public policy made residential development attractive 10% of the city's residential growth could be attracted to the area.

b. CALCULATIONS (based on % residential growth)

(1) number of residential units

. total number of residential units = 1800 per year

. 10% developed in core = 20(10% of 1800) = 3600

(2) number of square feet

. assumed that each unit = 800 sq. ft. (average bachelor and one bedroom)

. therefore = 3,680,000 sq. ft.

c. PROJECTION = 3,320,000

VII CONCLUSIONS AND RESULTS

A. RESULTS

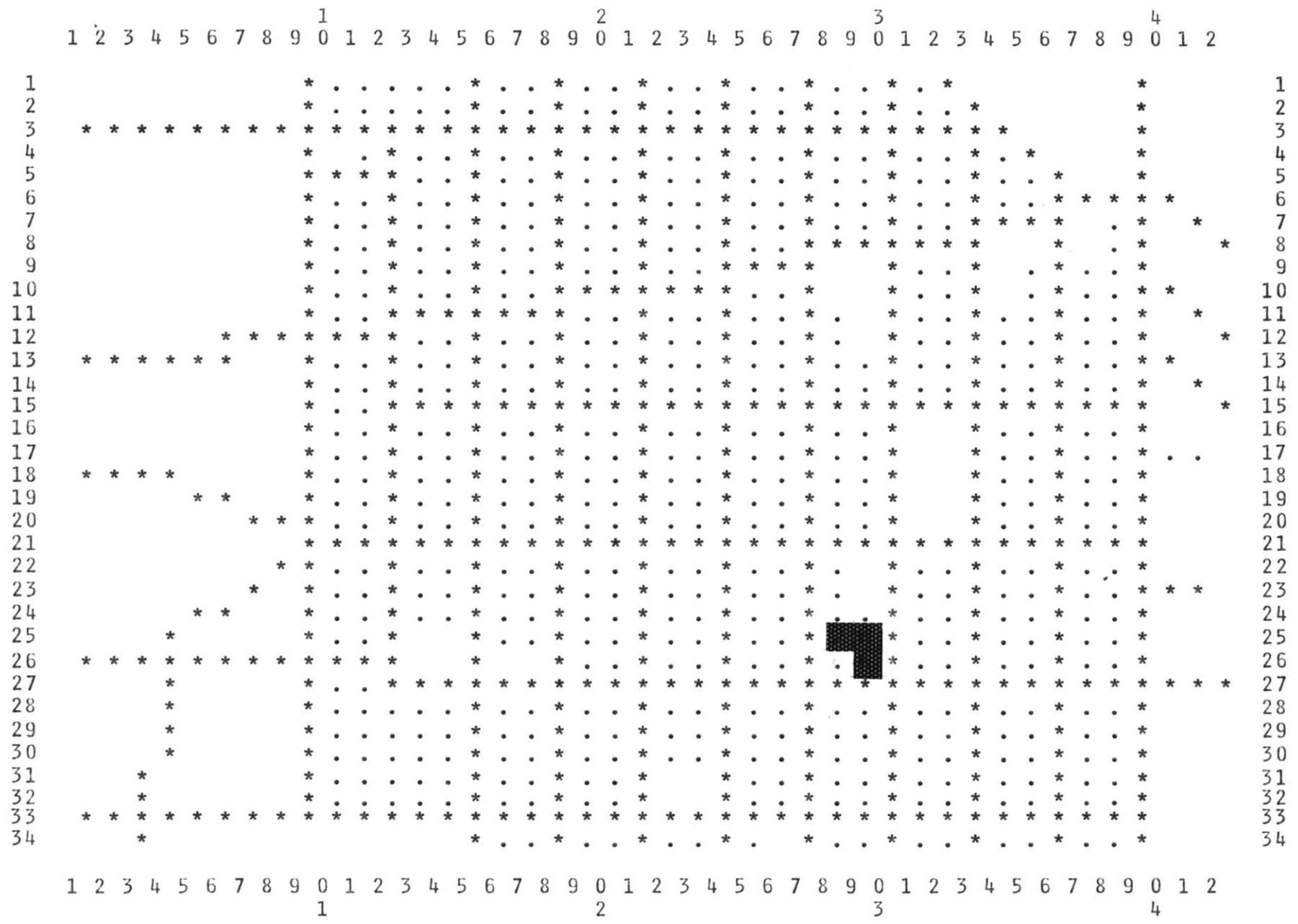
EXAMPLES OF OUTPUT

Figures 3 and 4 graphically show two intermediate stages in location selection. Figure 3 represents land searched for determining a residential location and Figure 4 indicates land searched for locating a commercial office. Each activity has its unique search patterns and these patterns constantly change as the run progresses. Changes are incurred in search by:

1. change initiated by new development effects
2. change in the algorithm availability rating test

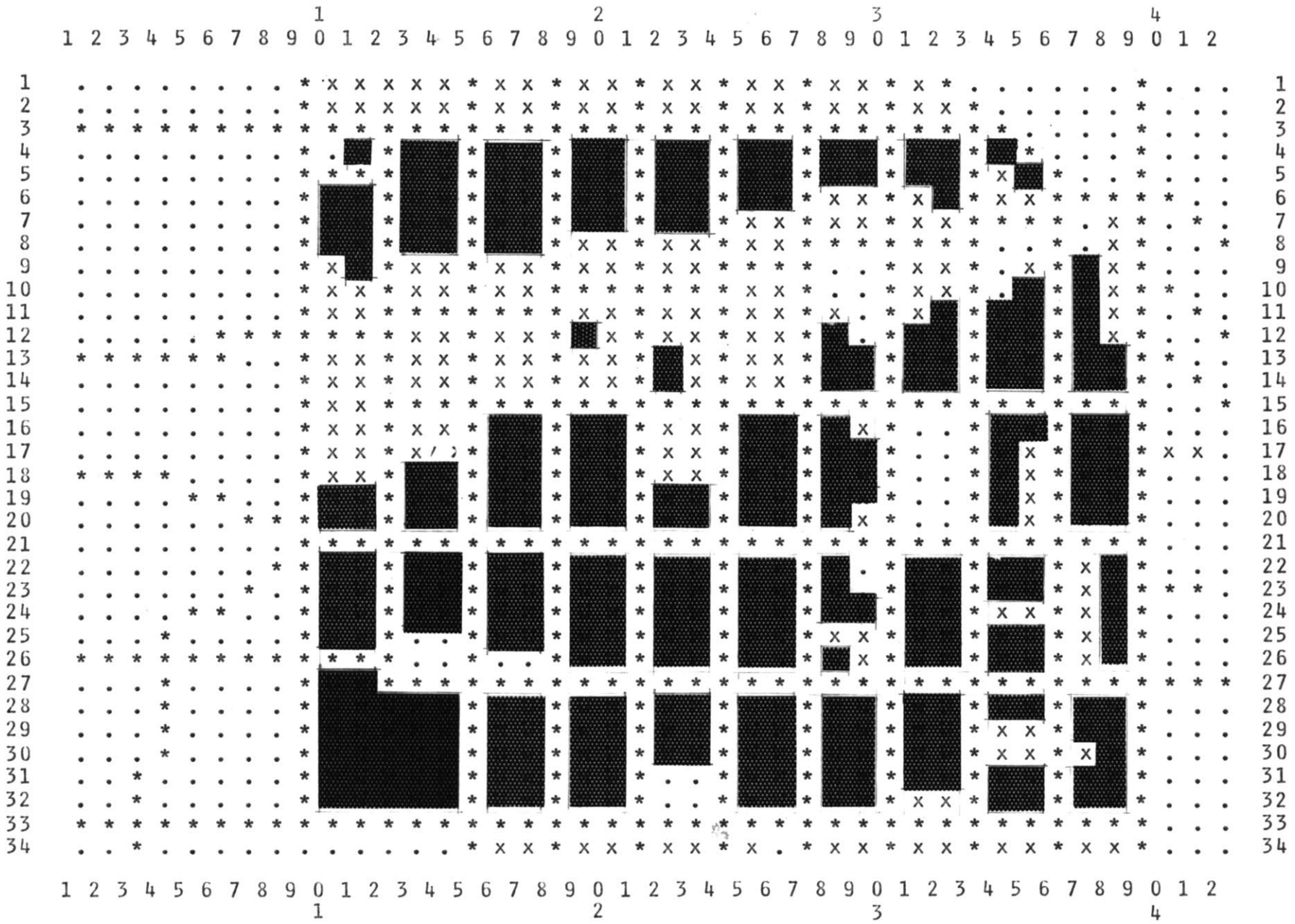
FIGURES 3 and 4: four temporary steps

a. final selection
b. parcels selected for desirability search
c. parcel selected for availability search
d. parcel effected by development



LEGEND: FIGURE 1a. H O U S I N G FINAL SELECTION AND ASSEMBLY

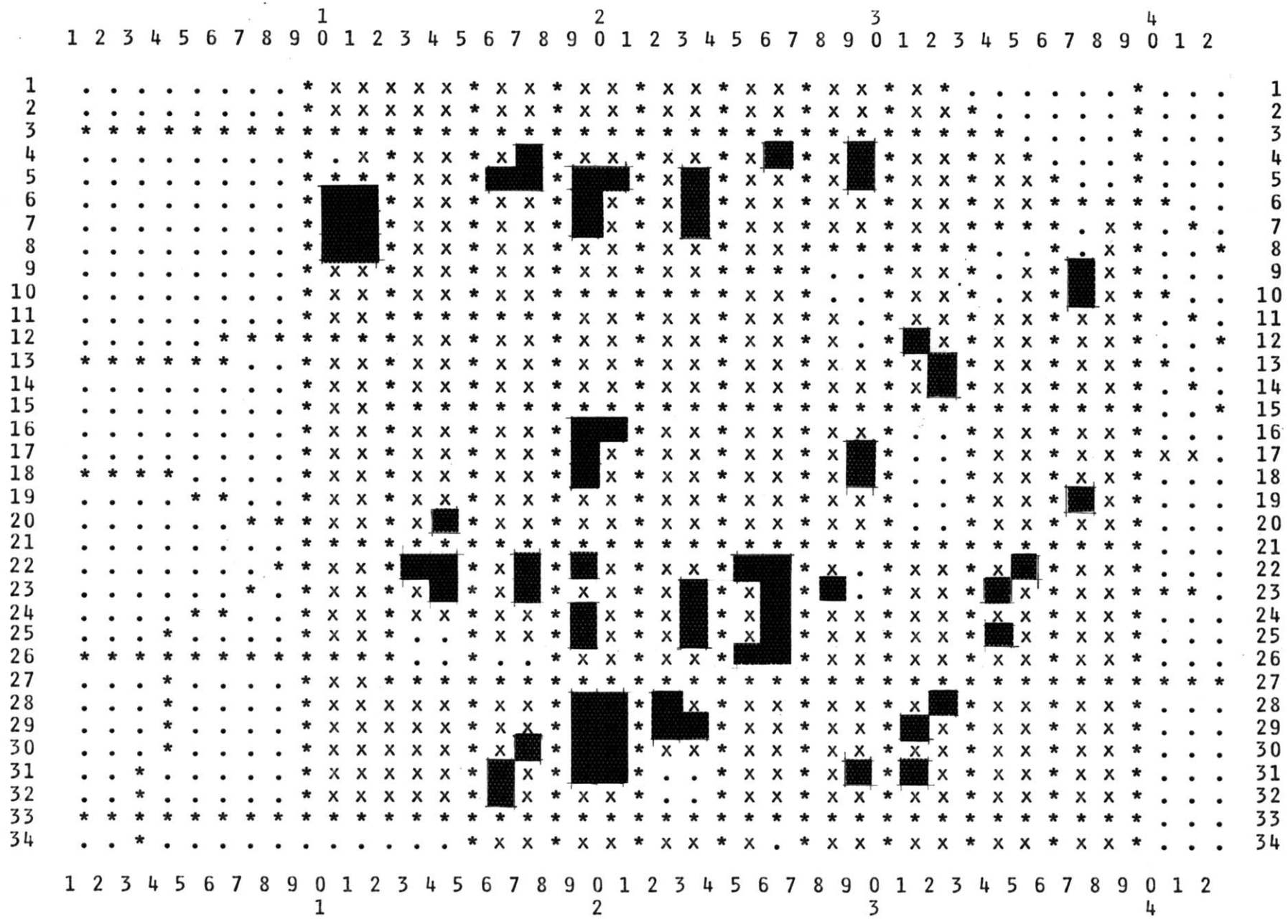
PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = TLIST3(23); '*' = STREET(3); '.' = PARCEL(2); ' ' = NOTAV(4)



LEGEND: FIGURE 1b. H O U S I N G ALL PARCELS THAT HAVE PASSED DESIRABILITY TEST

PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = TLIST1(29); '*' = STREET(3); '.' = NOTAV(4)

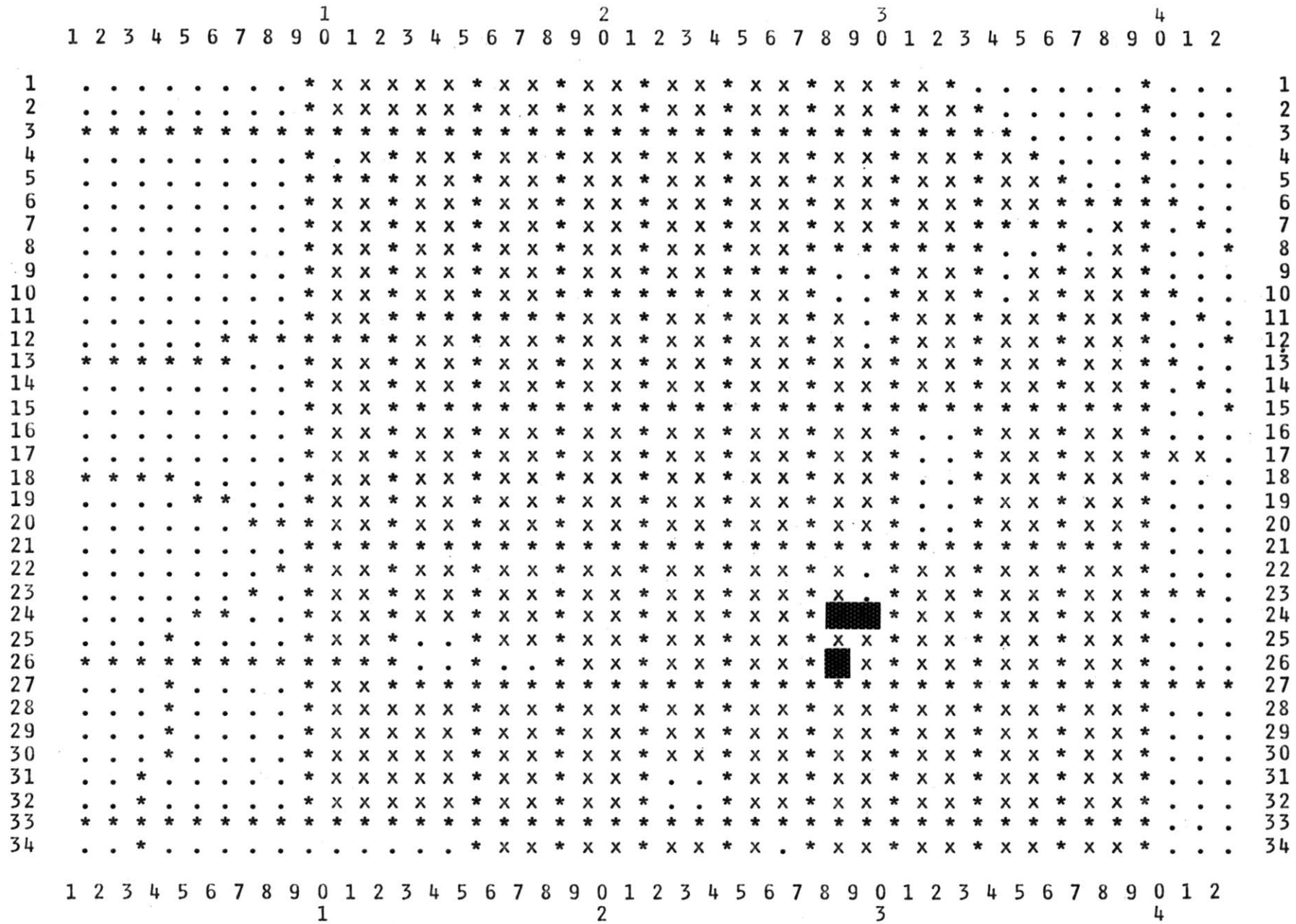
'x' = NON EMPTY LAND



LEGEND: FIGURE 1c. H O U S I N G ALL PARCELS THAT PASSED AVAILABILITY

PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = TLIST2(22); '*' = STREET(3); '.' = NOTAV(4)

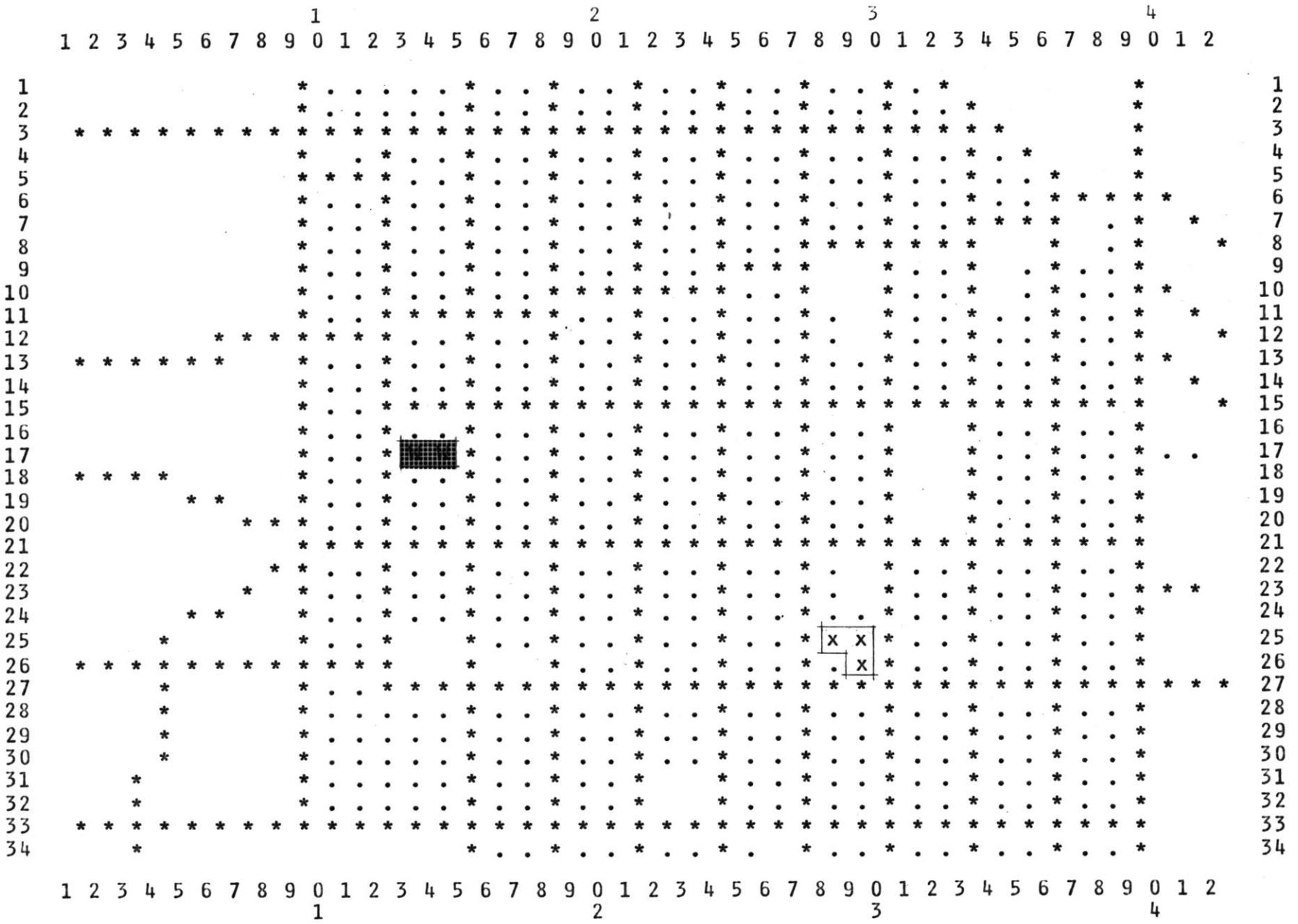
'x' = NON EMPTY LAND



LEGEND: TABLE 1d. H O U S I N G ALL PARCELS AFFECTED BY DEVELOPMENT

PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = SURROUND(33); '*' = STREET(3); '.' = NOTAV(4)

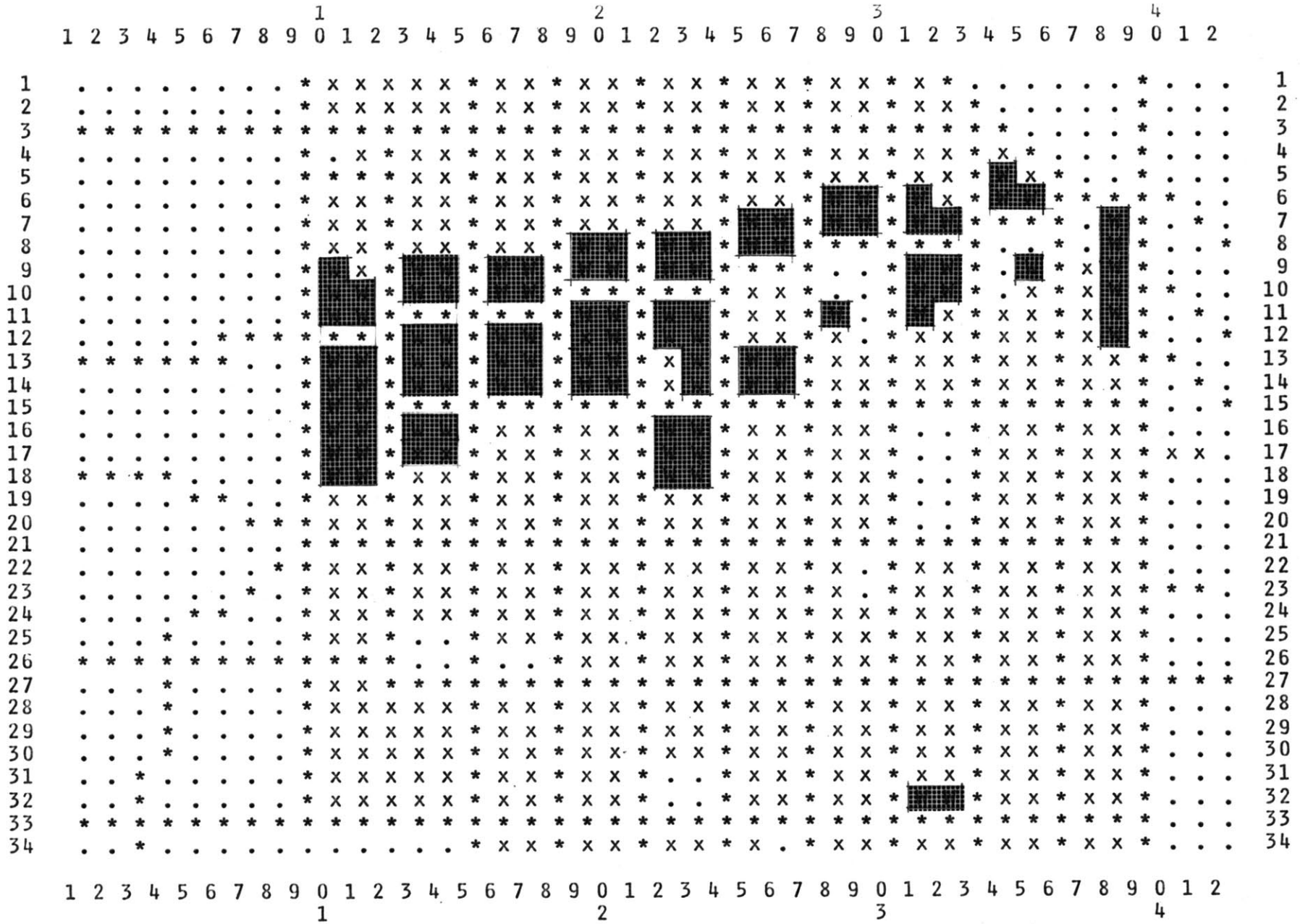
'x' = NON EMPTY LAND



LEGEND: FIGURE 2a. O F F I C E FINAL SELECTION AND ASSEMBLY

PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = TLIST3(23); '*' = STREET(3); '.' = PARCEL(2); ' ' = NOTAV(4)

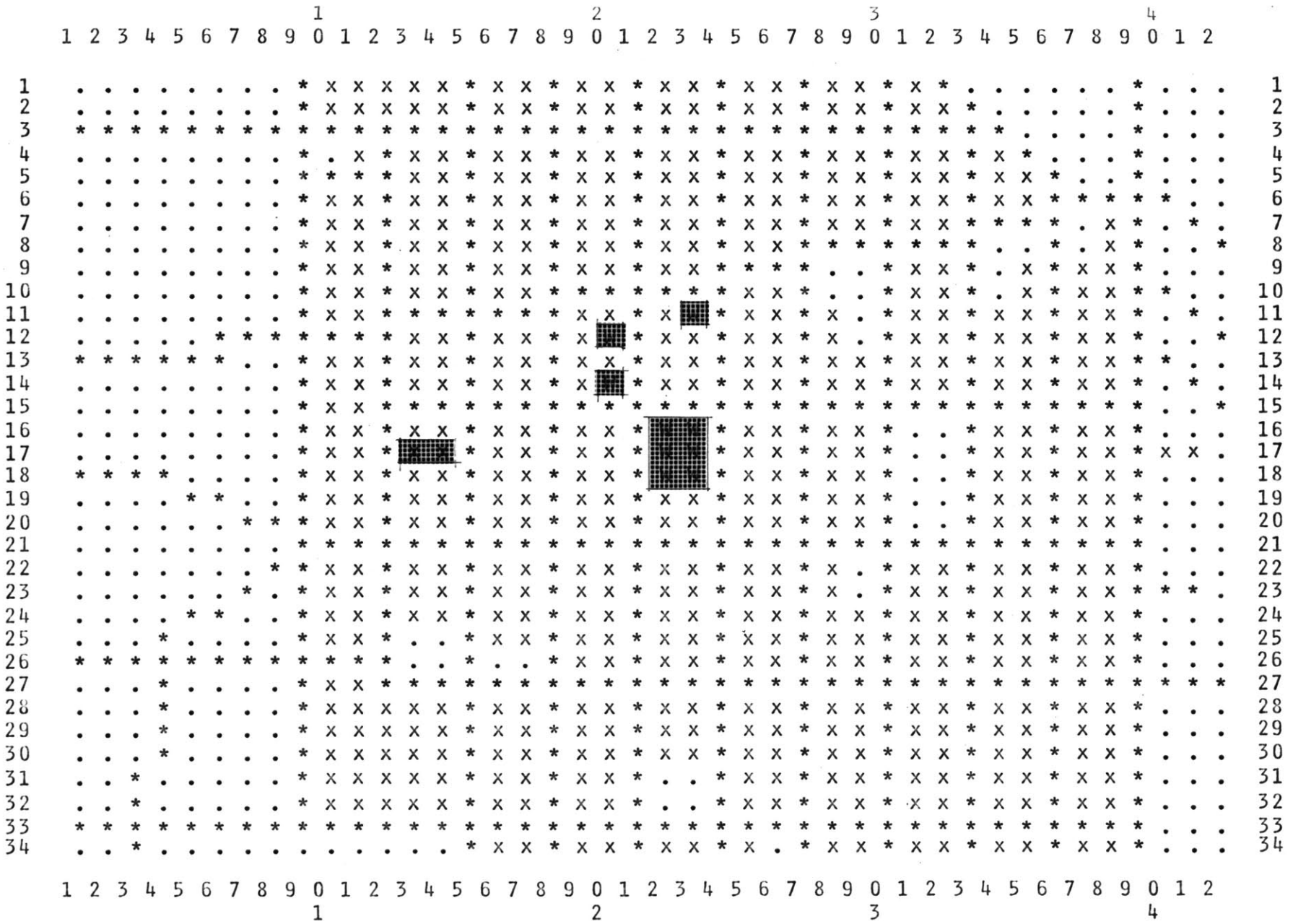
'x' = NON EMPTY LAND



LEGEND: FIGURE 2b. O F F I C E ALL PARCELS THAT PASSED DESIRABILITY TEST

PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = TLIST1(29); '*' = STREET(3); '.' = NOTAV(4)

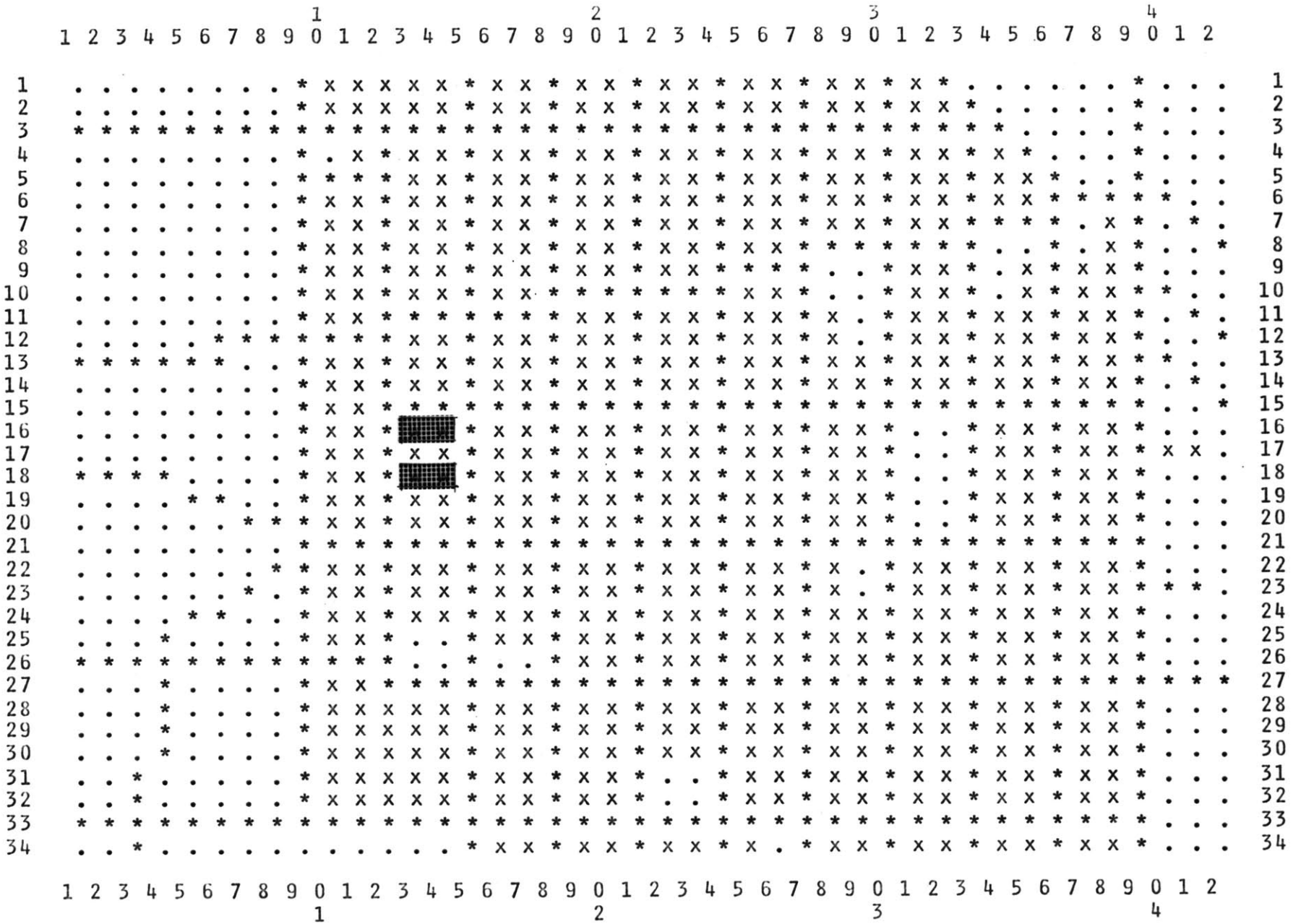
'x' = NON EMPTY LAND



LEGEND: FIGURE 2c. O F F I C E ALL PARCELS THAT PASSED AVAILABILITY TEST

PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = TLIST2(22); '*' = STREET(3); '.' = NOTAV(4)

'x' = NON EMPTY LAND



LEGEND: FIGURE 2d. O F F I C E ALL PARCELS AFFECTED BY DEVELOPMENT

PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = SURROUND(33); '*' = STREET(3); '.' = NOTAV(4)

'x' = NON EMPTY LAND

DESCRIPTION OF STUDY AREA

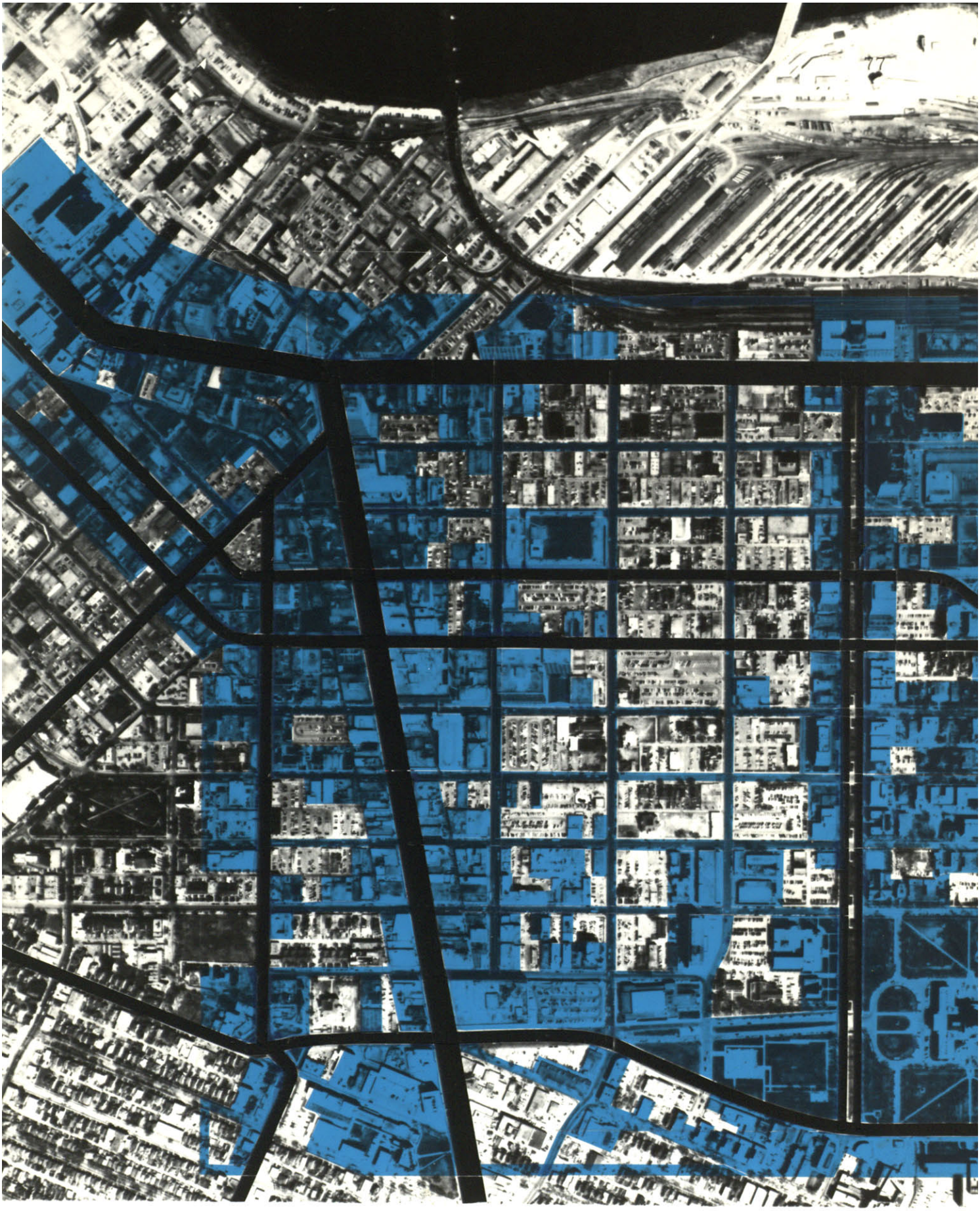
The following maps briefly illustrate the existing physical state of the study area.

Appendix II: Contains an explanation of some of the historical events that have contributed to determining the existing urban patterns and contributed to some of its physical problems.

Map #1	Aerial Photo and Study Area
Map #2	Intensity of Existing Development
Map #3	Block Designation
Map #4A	Existing Land Use Patterns
Map #4B	Existing Assessed Value

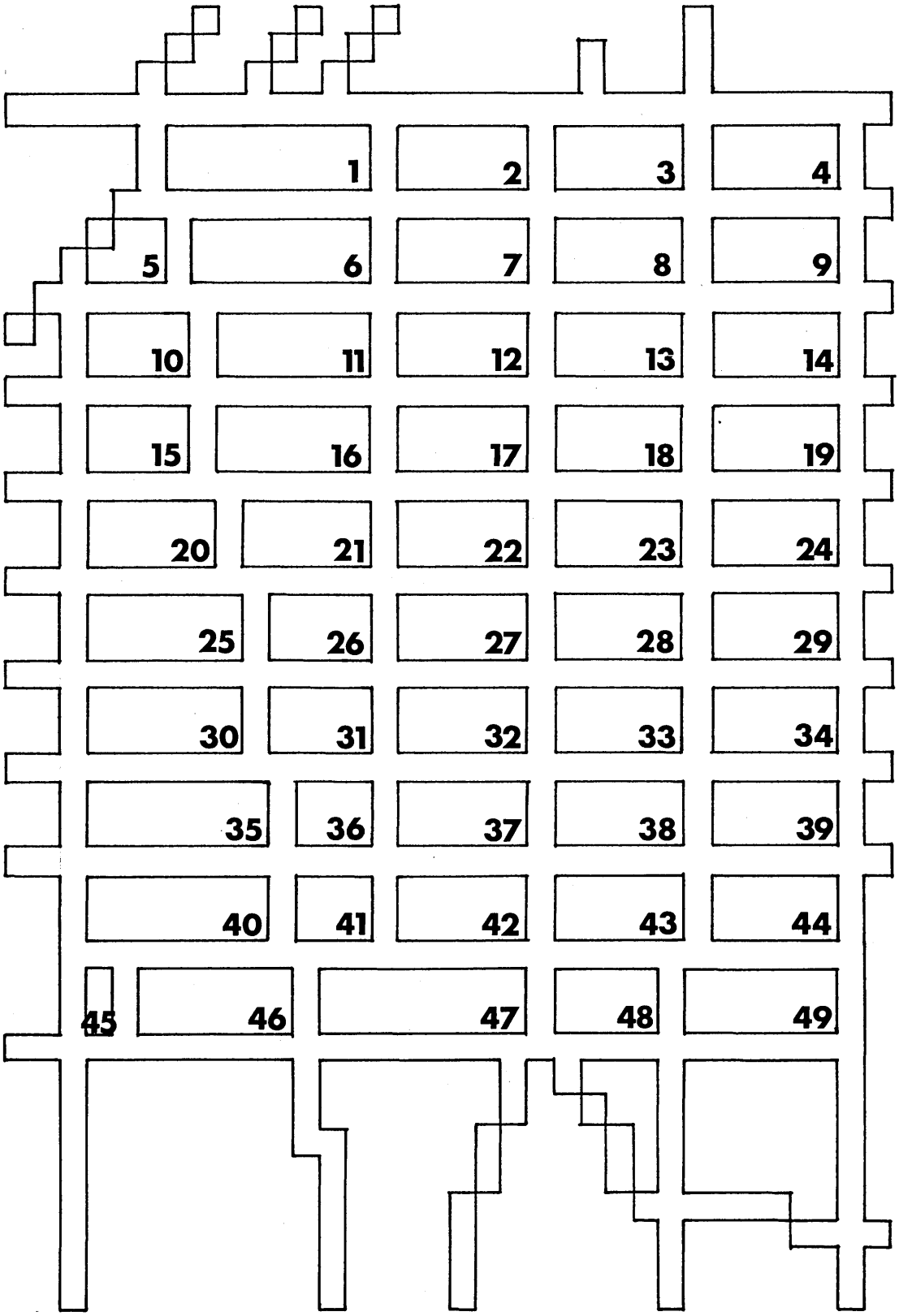
MAP #1

AERIAL PHOTO: STUDY AREA: WINNIPEG MANITOBA



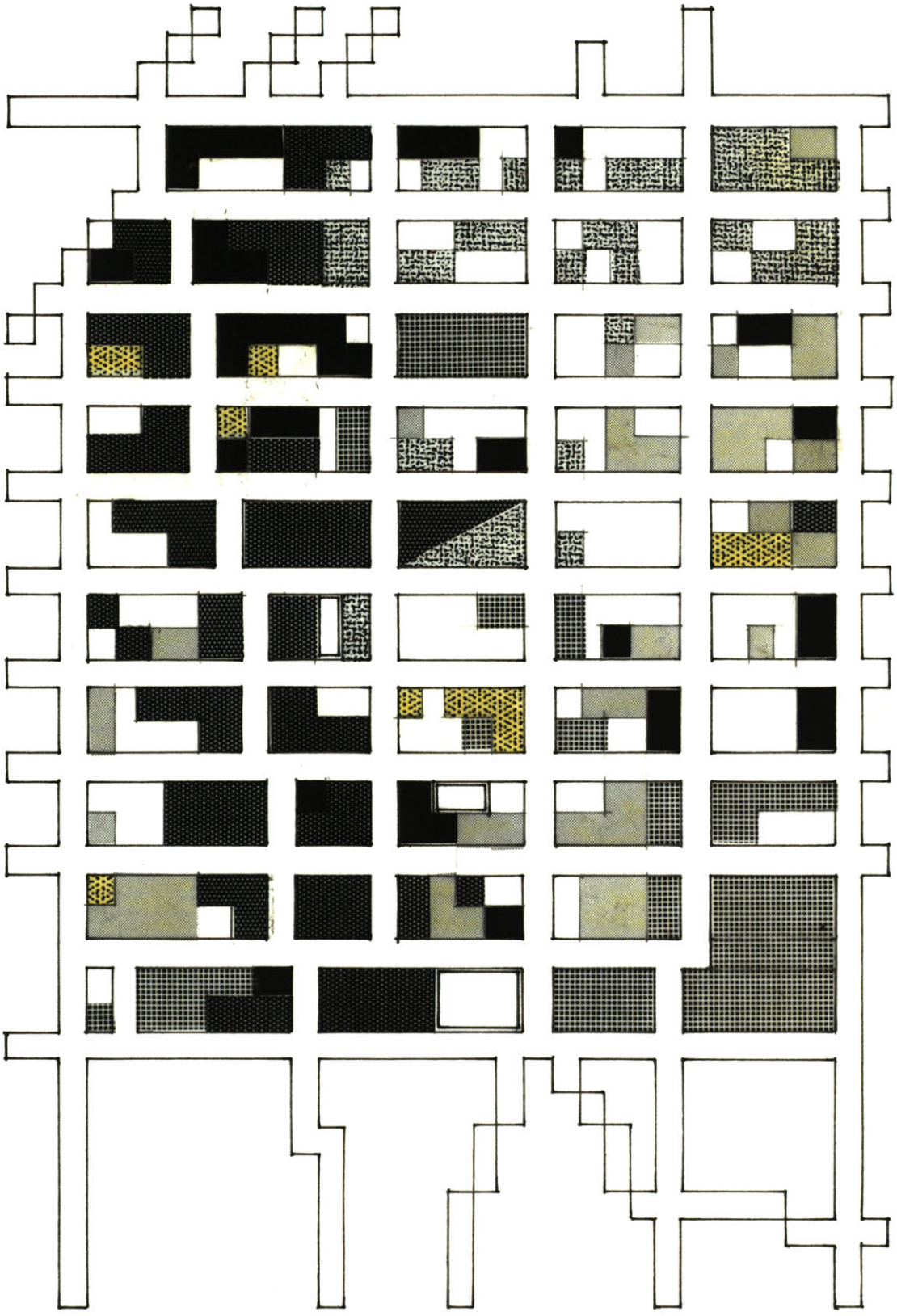
MAP #2

INTENSITY OF EXISTING DEVELOPMENT



MAP #3

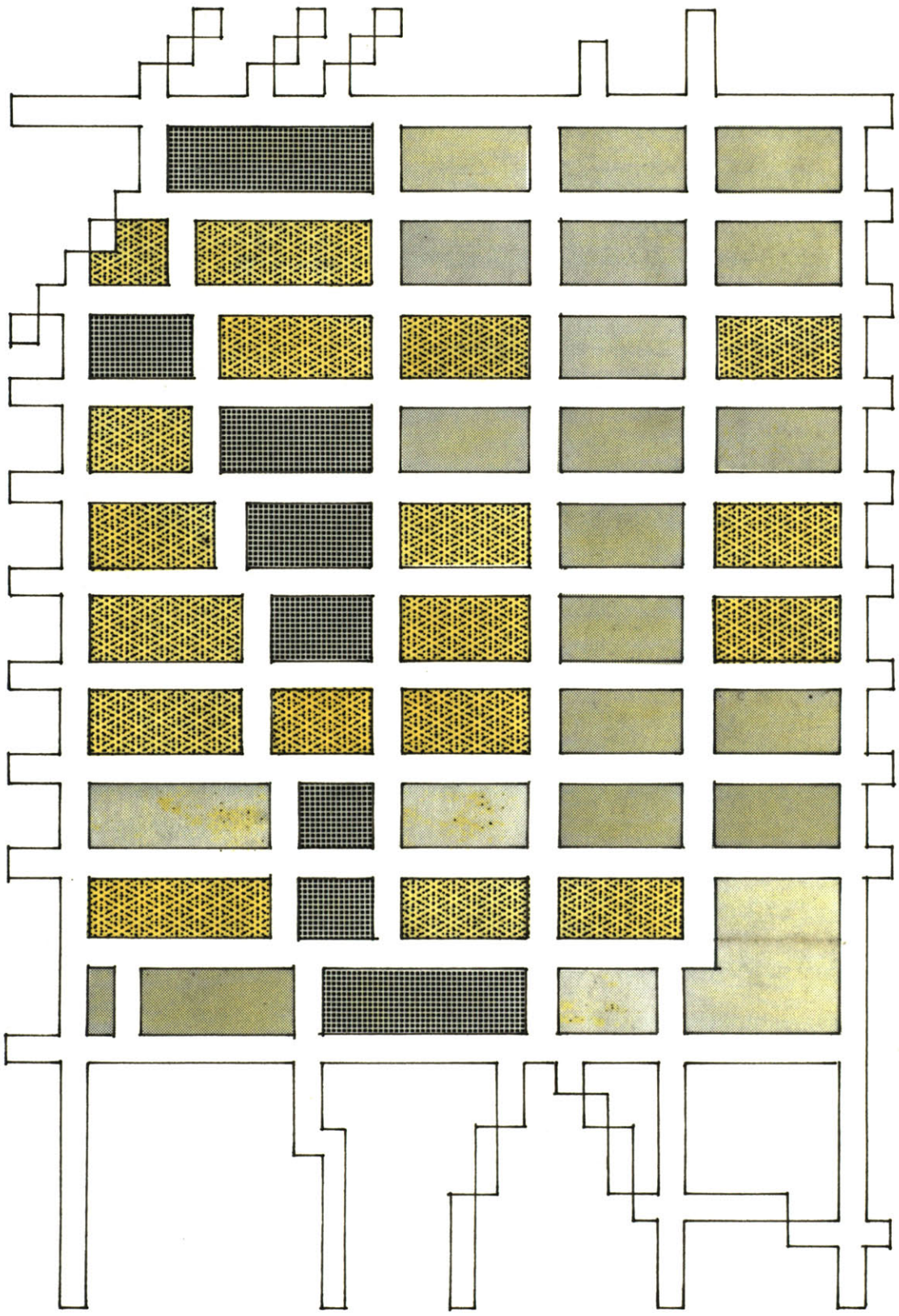
BLOCK DESIGNATION



Office
Commercial
Institutional
Industry & Warehous.
Hotel
Residential

MAP #4 A

EXISTING LAND USE PATTERNS



10-20
21-30
31-40
41-50
50+

MAP #4B

EXISTING ASSESSED VALUE

BLDG AND LAND $ PER SQ. FT.

PROGRAM RUNS

Each run is preprogrammed to either approximate a desired urban objective or represent an urban public development policy. This program flexibility allows the model to be used repeatedly to 'test' hypothesis or the effectiveness of public policy, regarding urban development. The results of a run can then be evaluated to determine the consequences of the program on the resultant urban spacial organization.

PROGRAM RUN A

The first complete run (A) was used primarily to establish a basis for comparison for future runs and provide a final test as to the model's workability and effectiveness.

Its secondary purpose was to determine the possible spacial pattern generated from:

POLICY A

. the use of downtown land for residential development as a means of constructing a viable urban core and encouraging other types of private development.

FEASIBILITY

. there were 3,000 apartment units built in 1968. It is estimated that one third could be diverted to central city locations by providing construction and taxation incentives.*

---

* Planning Department, Metropolitan Corporation of Greater Winnipeg

The potential of creating housing as a large component of the downtown development does not depend directly upon increases in population growth or attracting large amounts of outside investment. If housing could be encouraged to locate in the downtown it would mean a relocation of present resources that are now operating in the metropolitan region and at the same time provide a wider choice of residential locations and types to residents of Metropolitan Winnipeg.

The development of a large in-town residential district would hopefully provide an incentive for commercial and service activities to locate in the downtown.

PROGRAM RUN B

This run is intended to alter the results of run A to illustrate the model's capacity as an instrument for testing urban development hypothesis:

Policy B used for this second run is a proposal currently being considered in Downtown Winnipeg as a possible means of encouraging private development to this area.

POLICY B

. a controlled environmental pedestrian system as a means of encouraging commercial development.

The development of a public initiated all-weather elevated pedestrian system would have the advantage of providing a

movement system protected from the harsh weather conditions of Winnipeg's weather and hopefully provide for an intensity of year-round economic commercial activity, and a high degree of comfort and amenity to users. The shift to upper level commercial locations would require a slow and possibly staged development, dependent firstly on new development and secondly on adaption of existing development to the system.

This proposal would in effect create a downtown "shopping center" in the traditional manner of an enclosed movement system lined with shops with two "magnets" located at either end. This proposal is intended to attract new commercial development to the downtown area and result in a more concentrated commercial core.

This policy will also attempt to determine the pattern of residential growth as in Policy A but will allow for a higher density of construction per site by specifying a smaller parcel size in the assembly algorithm.

RESULTS

PROGRAM A

The model's distribution of activities in the first run were greatly influenced by the existing pattern of underused land and their lower land values (CONSISTANT WITH ALGORITHMS). The process of influencing development patterns by the 'effects'

algorithm contributed to the final pattern, but the strength of lower land values determined location selection for most of the earlier predicted residential development.

Predicted residential development produced a scattered pattern closely reflecting the present condition of vacant land, on grade parking and underdeveloped land.

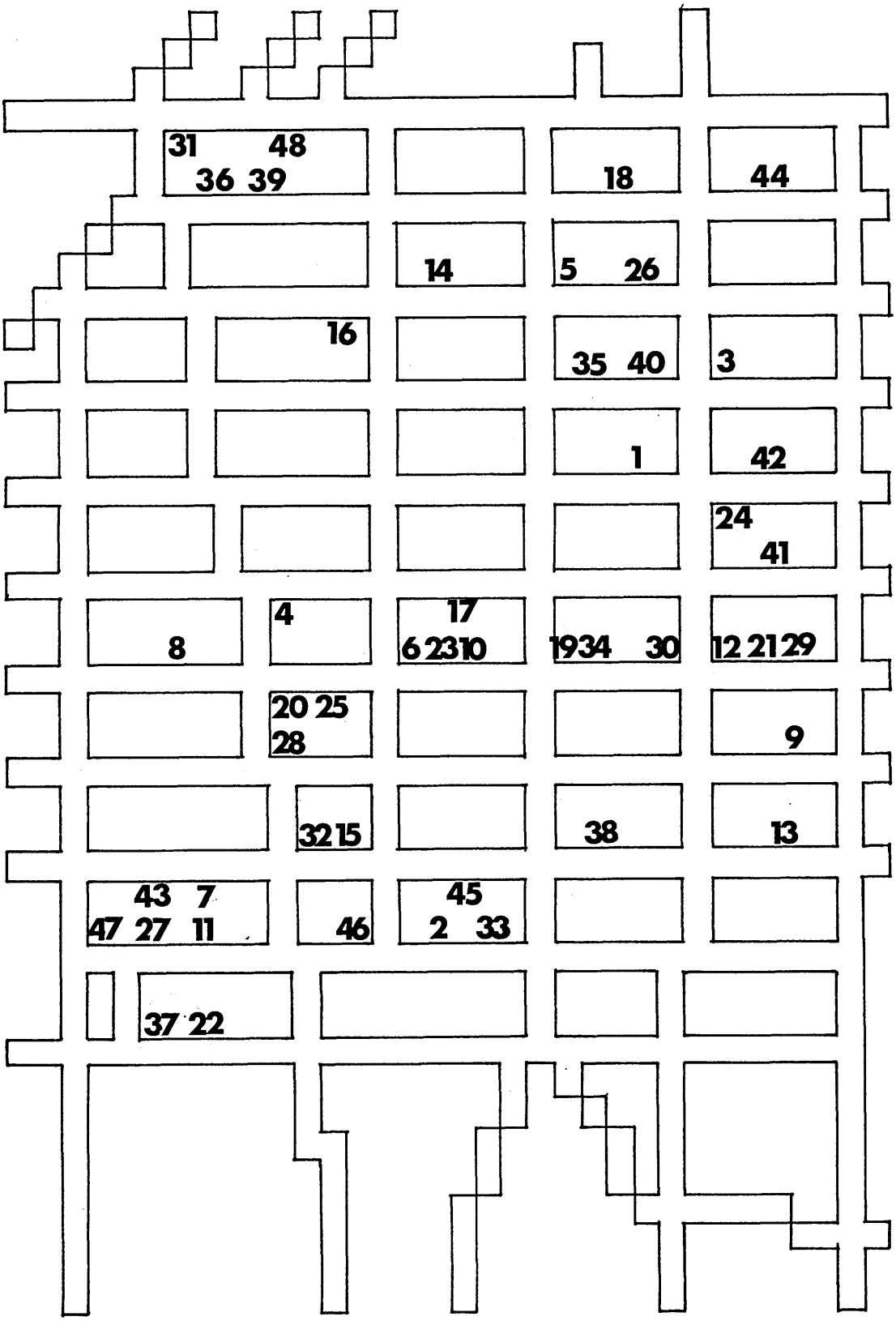
The model's inability to influence a stronger influence on sequence could be partially contributable to the program's present inability to 'cross-over streets' to reflect an influence on adjacent land.

Commercial office and institutional activities tended to reinforce and widen the commercial area especially at the upper and lower boundary of the area. This reinforcing pattern occurred later in the run and is a result of existing underutilized land at desirable locations.

Light industry and warehousing activities exhibited difficulty in achieving development and where they were successful they reinforced or replaced existing facilities.

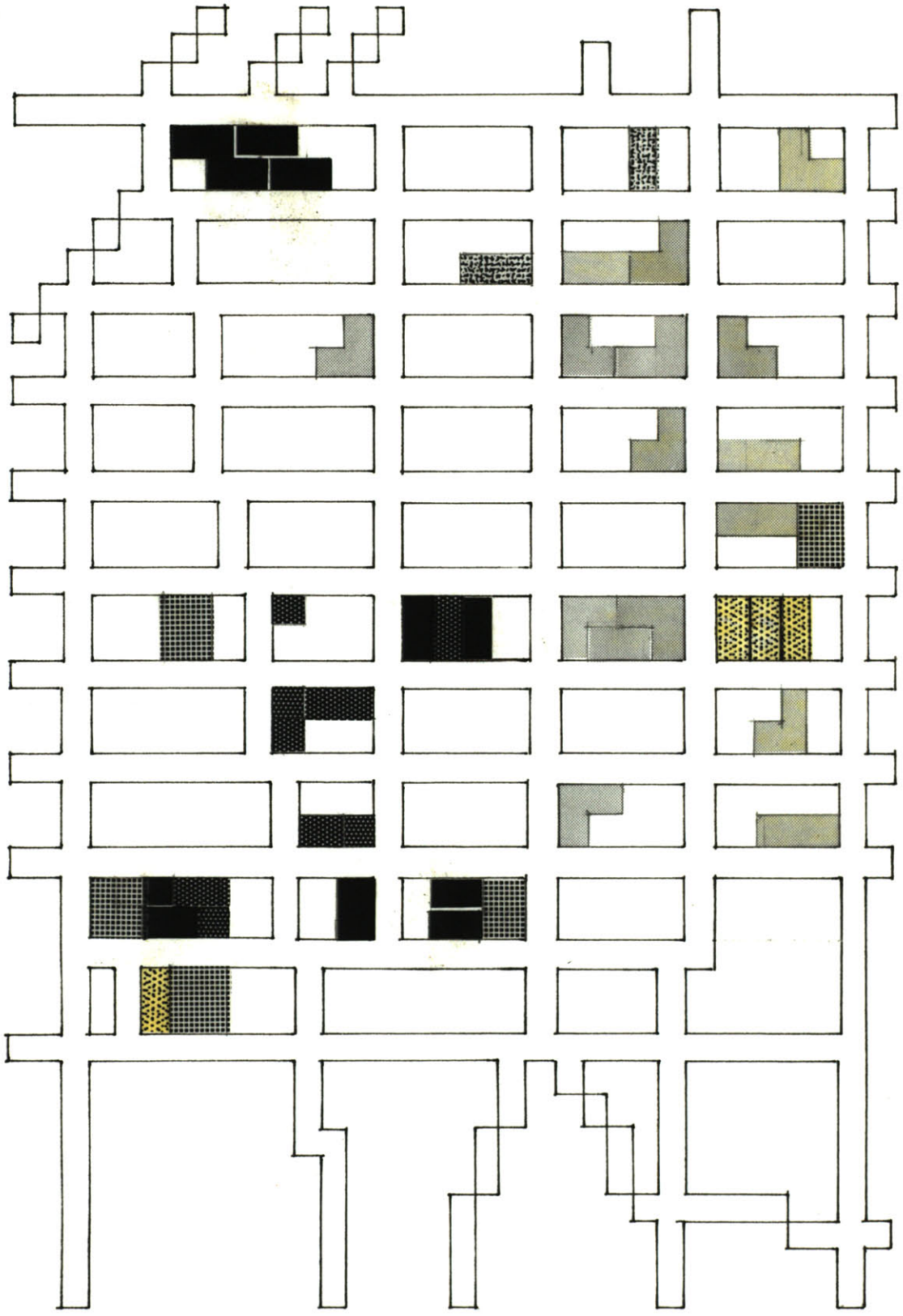
The predicted hotel development proved to be one instance where the effects on surrounding land tended to attract like development repeatedly to the same location. Either this is a likely possible event for that location or the weighting assigned to the attraction of this activity is incorrect.

Maps #5A and 5B illustrate the predicted sequence of developments location and the resultant land use pattern.



MAP #5A

SEQUENCE OF PREDICTED DEVELOPMENT



MAP # 5B

PREDICTED GROWTH LAND USE

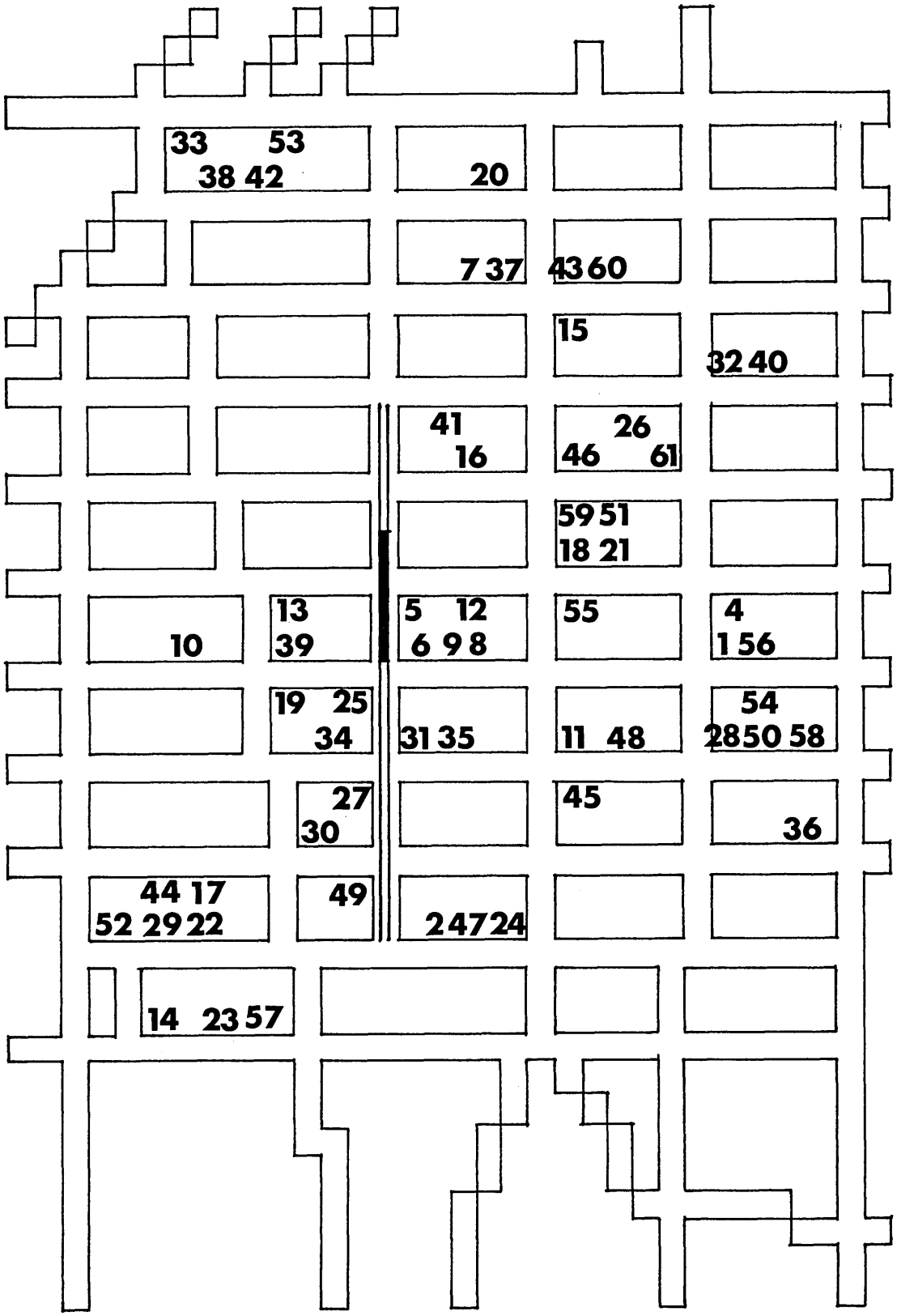
PROGRAM B

This program run exhibited a much stronger ability to influence development patterns. The proposed predestrian system was programmed to begin developed near a large department store and then be encouraged to develop along the street as development was attracted to the area. Its weighting attraction was held constant with that of commercial development to limit its impact on the area. The results indicate that within the projected time period this proposal was not successful enough to complete the total system.

The portion of the system complete had a marked effect on attracting predicted commercial office and institutional development in the immediate area. The development of the upper and lower edges of the study area were almost identical to Program A results.

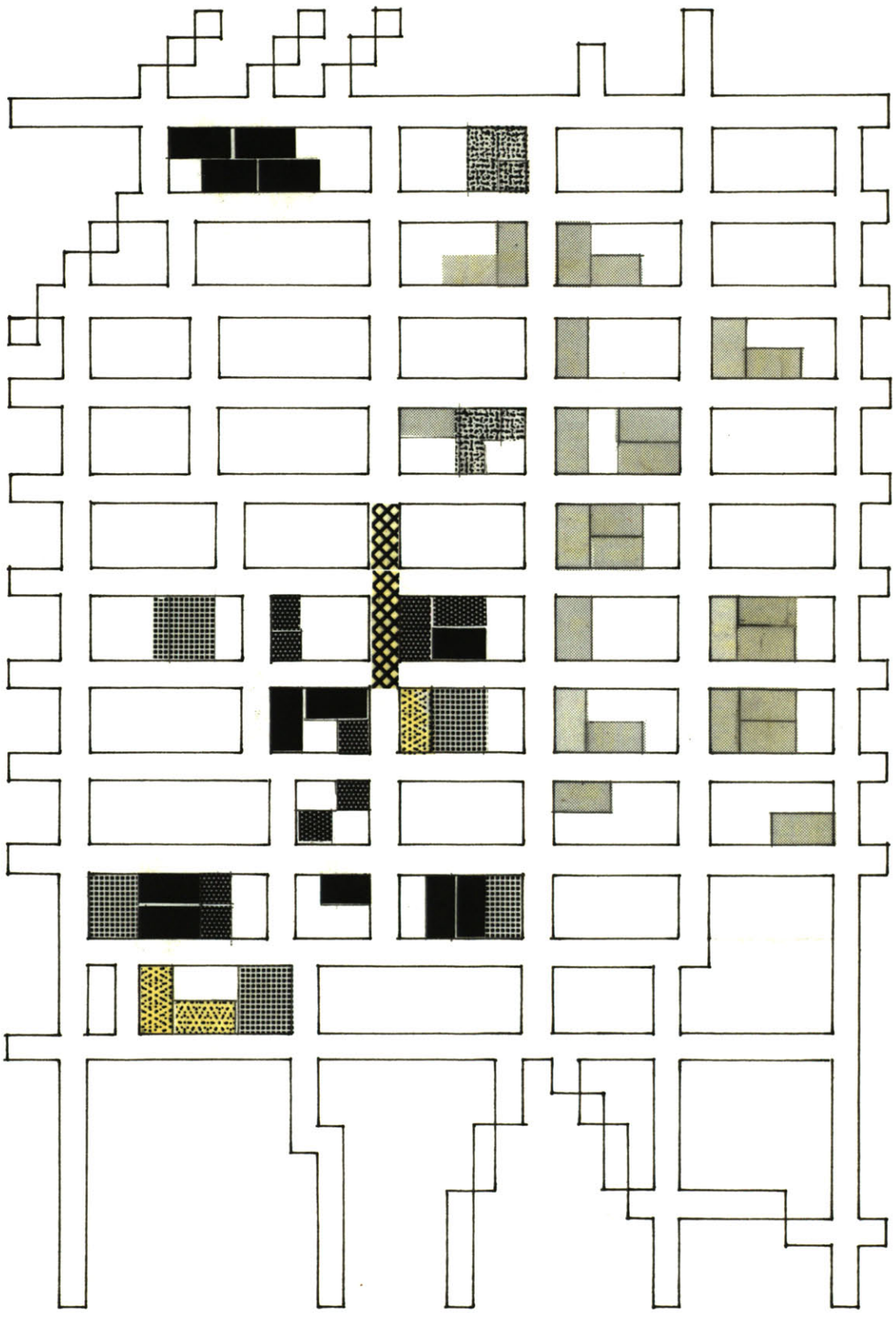
The removal of density constraints by reducing site specification contributed to a more uniform and concentrated residential development. The sequence for predicted residential development did not follow a strong linear pattern indicating that land values still influenced early location selections. However, the contiguity effect did produce a more concentrated pattern at the end of the run.

Maps 6A and 6B illustrate the results of the predicted sequence of development locations and the resultant land use patterns.



MAP #6A

SEQUENCE OF PREDICTED DEVELOPMENT



MAP #6B

PREDICTED GROWTH: LAND USE

EXAMPLES OF PREDICTED DEVELOPMENT CHARACTERISTICS

Each predicted development action is programed to generate information pertaining to the development's probable physical and economic characteristics. These characteristics are generated to obtain a more complete picture of the consequences of any public policy in order to evaluate its effectiveness in guiding urban growth.

The following are some examples of Predicted Development Characteristics:

FIGURE 5: Sample of the information output related to each development action.

TBA	Total Building Area
POP	Building Population
INCOME	Total Wages Generated by Development
INVEST	Dollar Value of Development
CARS	Vehicles Requiring permanent or Temporary Storage
PDENSITY	Square Feet per Person
ASSEST	Assessed Value of Property
TAX	Initial Tax on Property
WORK	Classification of Activity Type by Number (7 = Residential)
MARKET RA	State of Residential Market Projections
PRIORITY RAP	State of Residential Priority Rate

FIGURE 6: Example of mapping procedures for information related to specific locations.

FIGURE 5

```
rd develop kirby


N=4
PLEASE TYPE MAP TITLE ON NEXT LINE
INFO<TBA 29,23> = 113759.9

INFO<FAR 29,23> = 3.95

INFO<POP 29,23> = 316.

INFO<INCOME 29,23> = 63199.95

INFO<INVEST 29,23> = 2502718.

INFO<CARS 29,23> = 379.2

INFO<PDENSITY 29,23> = 360.

INFO<ASSEST 29,23> = 1001087.

INFO<TAX 29,23> = 65971.62

WORK = 7.

MARKET<RA> = 3112640.

PRIORITY<RAP> = 84.

ALL NON-MACRO LABELS REMOVED
R 12.30/44.15
```

FIGURE 6

```
rd table2 kirby (10,30)
THIS IS A F.A.R. TABLE:
```

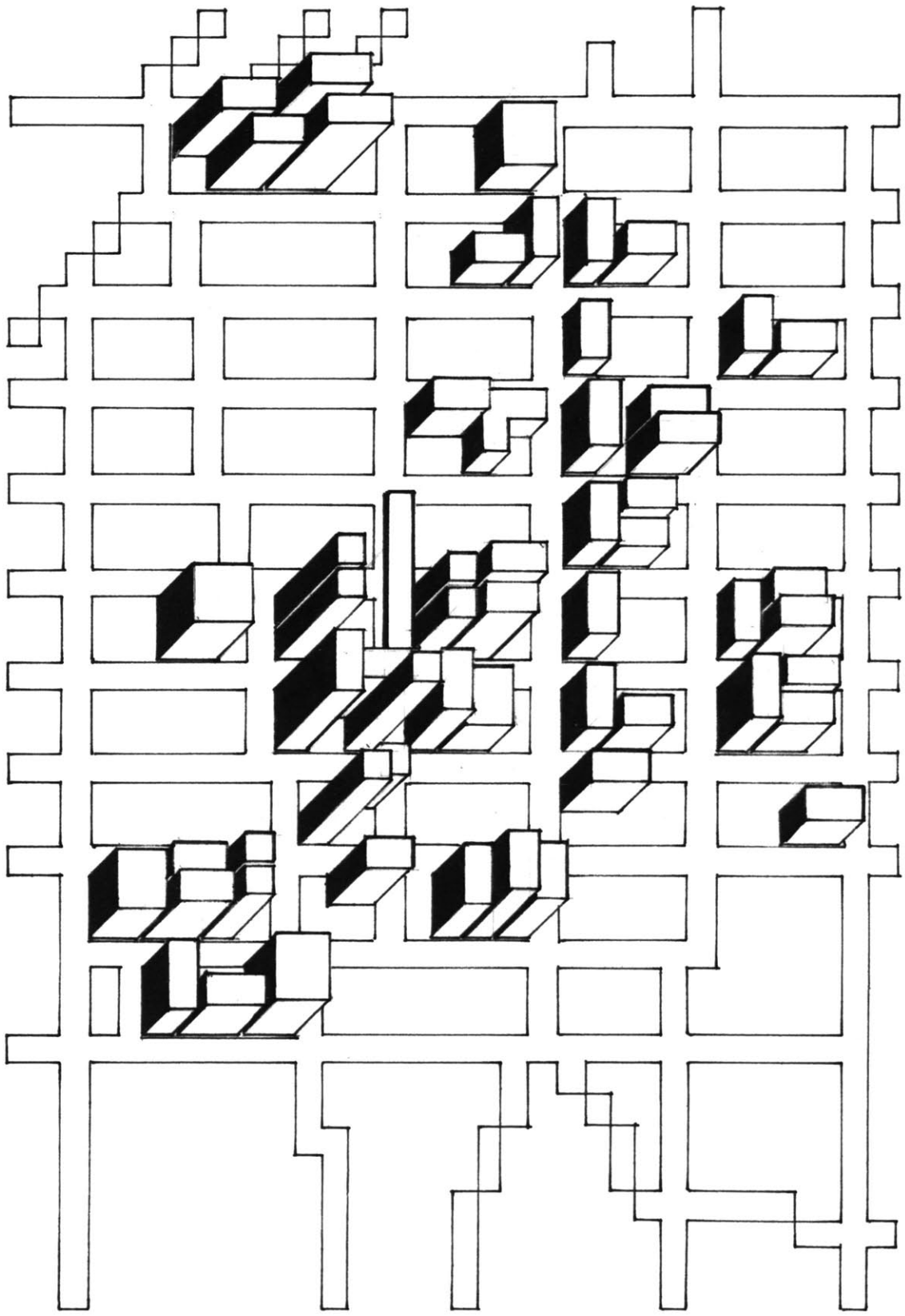
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	5.2	0.0	0.0	6.7	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	5.2	0.0	0.0	6.7	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	7.9	0.0	0.0	0.0	0.0	0.0	0.0
8	5.4	5.4	0.0	7.6	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	7.9	0.0	0.0	0.0	0.0	0.0	0.0
9	6.7	6.7	0.0	7.6	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	6.7	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0	12.4	12.9	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.0	0.0	0.0	11.0	0.0	12.4	12.9	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.0	0.0	12.9	12.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	6.5	0.0	6.4	0.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	6.5	0.0	6.4	0.0	0.0	0.0	6.7	0.0	0.0	0.0	6.0	6.0	10.5	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	7.0	0.0	7.1	7.1	0.0	0.0	10.5	0.0	0.0	0.0
17	0.0	0.0	0.0	6.0	6.0	0.0	0.0	0.0	0.0	6.4	6.4	0.0	8.6	8.6	0.0	0.0	0.0	0.0	0.0	4.1
18	0.0	0.0	0.0	8.0	8.0	0.0	0.0	0.0	0.0	6.4	6.4	0.0	8.2	9.4	0.0	0.0	0.0	0.0	0.0	4.1
19	0.0	0.0	0.0	6.6	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	9.4	0.0	0.0	0.0	0.0	8.3	8.3
20	0.0	0.0	0.0	6.6	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	8.3
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	4.2	4.2	0.0	0.0	0.0	0.0	4.0	0.0	0.0	4.2	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	4.7	0.0	4.0	0.0	0.0	4.2	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	4.7	0.0	3.7	4.6	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	3.7	4.6	0.0	4.0	4.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	5.2	0.0	3.2	3.2	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	4.8	0.0	4.6	3.9	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	4.8	0.0	4.6	3.9	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

```
ALL NON-MACRO LABELS REMOVED
R 2.60/41.70
```

```
able2 kirby (30,42)
IS A F.A.R. TABLE:
```

	30	31	32	33	34	35	36	37	38	39	40	41	42
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	10.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	13.5	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	4.4	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	3.0	0.0	3.8	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	8.2	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	8.2	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	3.5	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

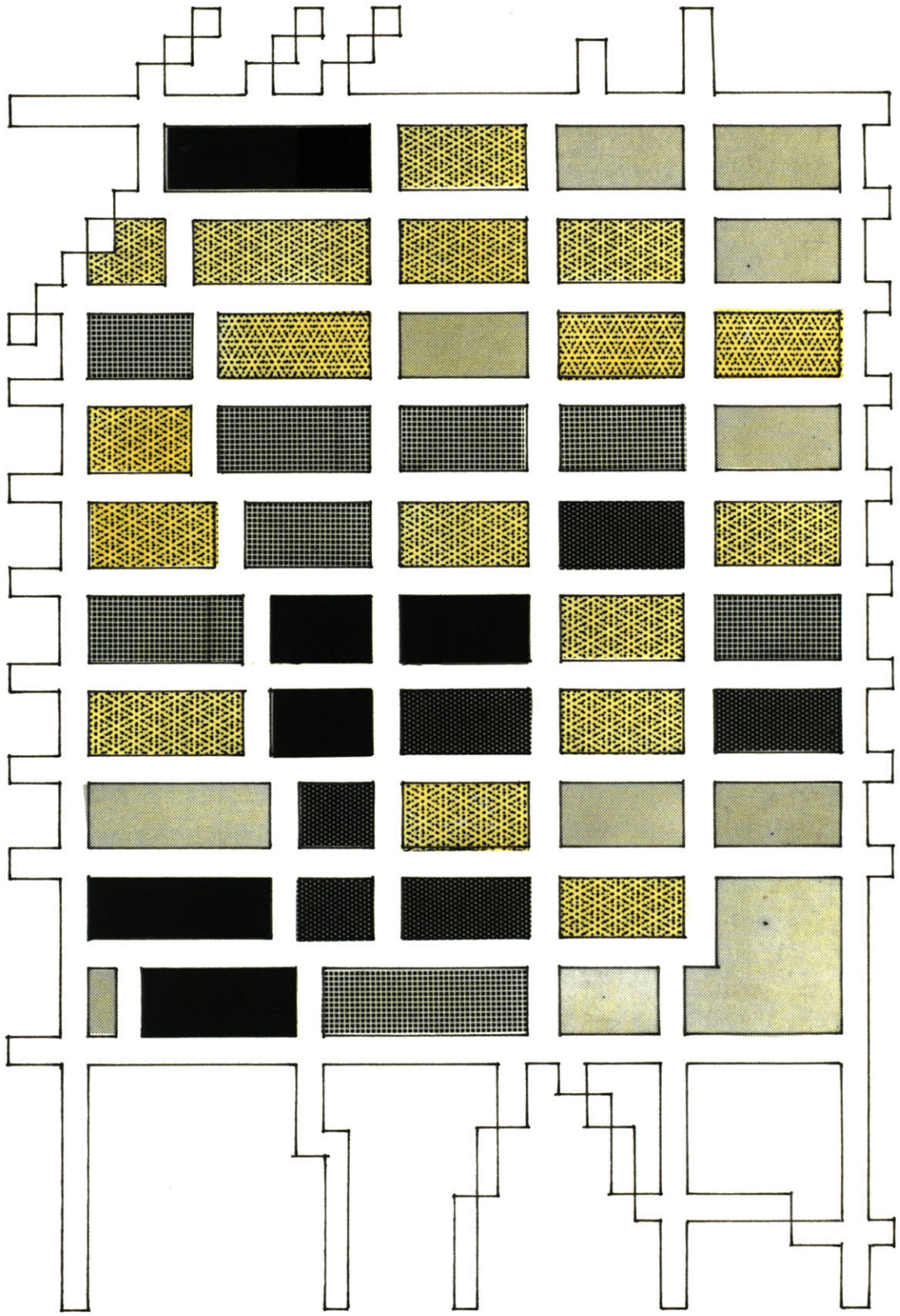
```
NON-MACRO LABELS REMOVED
82/43.52
```



SCALE: F.A.R.
FLOOR-AREA-RATIO = 2.0

MAP # 7

PREDICTED BUILDING DENSITY



MAP #8

PREDICTED ASSESSED VALUE

BLDG. & LAND $ PER SQ. FT.

10-20

21-30

31-40

41-50

50+

CONCLUSIONS:

STRUCTURE OF THE MODEL

Although the main concern of this study has been toward construction of the model it would be useful to evaluate its effectiveness from the results to-date. It has already been mentioned that there are difficulties involved in testing the validity of this type of model.

EFFICIENCY OF THE MODEL PROGRAM

Efficiency deals with how well a program performs a prescribed role.

The original intention of dividing the model into subcomponents allowed great flexibility;breaking down naturally in use to allow for changes. Changes can be made in one section without effecting the others. The "editing mode" incorporated in the Discourse language provided an efficient method for file manipulation to effect the desired program changes during program construction.

The computer time necessary for a program run was highly variable because of the large number of "fail" possibilities built into the algorithms;on an average each run required 16 to 18 seconds. In program 'run' A 48 'runs' were required to represent the growth prediction for the 10 year period.

The large percentage of "fails" began to occur half-way through the program 'run' as a result of the difficulties incurred in the

assembly test for residential locations. It was anticipated that computer time for execution would diminish as the run progressed but the iteration necessary to complete assembly test caused each run time to be irregular.

EFFECTIVENESS OF MODEL

Effectiveness of model program deals with how well the model fits into a worthwhile research activity and how valid its results are.

The intention of this study has been to develop a simulation program that would be a first attempt at construction of a useful research instrument capable of aiding the urban designer, by modelling partial factors underlying urban development and simulating development processes to predict future development patterns. This ability to predict the possible future urban environment would give insights into possible actions and policies that should be initiated in the present.

A second complementary 'role' for the program has proved useful. Because of the flexibility of the model structure and the capabilities of the Discourse language. Hypotheses testing is easily incorporated into the program by file manipulation. Minimal programming time is required to compile and execute an altered program incorporating the hypothesis to be tested.

It has become clear to me that the development and testing of models is a long-term process and that their validity will be

extremely hard to determine. But this attempt, if successful, provides a means of understanding system-wide impact of environmental interventions.

Like so many other attempts at model building the present value of this study lies mainly in the insight and guide-lines it offers for further research and development. A first attempt of this nature usually leads to disappointment; results usually fall short of expectations.

In its present form the model program has proved a valuable educational experience and provided useful insight into model building, and the determinants of spacial structure and the process of change.

PROBLEMS AND SUGGESTED ADDITIONAL RESEARCH

PROGRAM IMPROVEMENTS:

The algorithm test for selection and assembly of land was expected to be produced in a reduction of computer time as the 'run' progressed, instead of resulting in a falling time curve. The time for execution was dependent on difficulties incurred in passing land assembly tests.

In order to rectify this problem, and thus reduce time for execution, the assembled algorithm sequence should be structured to allow for more flexibility. This could be accomplished by entering a random factor into the parcel size specification. This

could be accomplished by entering a random factor into the parcel size specification. This would reduce assembly time in program run by 'softening' specification and possibly produce a more varied pattern of development sites for each activity.

It would also have been beneficial to construct a data base with a more complete description of the existing environment (equivalent to generated data characteristics of the prediction). This would provide a more effective picture of the "before' and "after" conditions.

DATA IMPROVEMENTS

As a means of improving the validity of the predicted pattern of development and the generated characteristics of that development data should be more empirically based. The results could be improved and reflect a more accurate description of all the variables could be verified by statistical research, or reliable source material. Because of time and intent, variables used in producing this study model are crude and in some cases reflect intuitive judgment and 'rule of thumb' figures.

It would also be desirable to include a larger sampling of retro-active data to provide a means of more accurately testing results and adjusting weights of the model.

Taking into consideration the requirements and the desirability of improving the model in the ways noted above, it may be concluded that the first full 'run' test of the model has demonstrated the

feasibility of programming a behavior simulated model for predicting distribution of future activity development.

Further refinement of the model could be expected to improve on the results and further hypothesis testing could be expected to shed light on its effectiveness as an instrument for urban physical growth policy analysis and evaluation.

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APPENDIX I

COMPUTER PROGRAM FILES

1. File: DATAW1
   - Location specific data

2. File: DATAW2
   - Changes to DATAW1 for program run 'B'

3. File: MARKET
   - Non-location specific data

4. File: DEVELOP
   - Algorithms

5. File: SKYWAY
   - Data file for program run 'B'

6. Computer Generated Maps

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21,33 21,34 21,35 21,36 21,37 21,38 21,39 22,8 22,9 22,12 22,15 22,18 '
22,21 22,24 22,27 22,30 22,33 22,36 22,39 23,7 23,9 23,12 23,15 23,18 '
23,21 23,24 23,27 23,30 23,33 23,36 23,39 23,40 23,41 24,5 24,6 24,9 '
24,12 24,15 24,18 24,21 24,24 24,27 24,30 24,33 24,36 24,39 25,4 25,9 '
```

```
25,12 25,15 25,18 25,21 25,24 25,27 25,30 25,33 25,36 25,39 26,1 26,2 '
26,3 26,4 26,5 26,6 26,7 26,8 26,9 26,10 26,11 26,12 26,15 26,18 26,21'
 26,24 26,27 26,30 26,33 26,36 26,39 27,4 27,9 27,12 27,13 27,14 27,15'
 27,16 27,17 27,18 27,19 27,20 27,21 27,22 27,23 27,24 27,25 27,26 27,'
27 27,28 27,29 27,30 27,31 27,32 27,33 27,34 27,35 27,36 27,37 27,38 '
27,39 27,40 27,41 27,42 28,4 28,9 28,15 28,18 28,21 28,24 28,27 28,30 '
28,33 28,36 28,39 29,4 29,9 29,15 29,18 29,21 29,24 29,27 29,30 29,33 '
29,36 29,39 30,4 30,9 30,15 30,18 30,21 30,24 30,27 30,30 30,33 30,36 '
30,39 31,3 31,9 31,15 31,18 31,21 31,24 31,27 31,30 31,33 31,36 31,39 '
32,3 32,9 32,15 32,18 32,21 32,24 32,27 32,30 32,33 32,36 32,39 33,1 '
33,2 33,3 33,4 33,5 33,6 33,7 33,8 33,9 33,10 33,11 33,12 33,13 33,14 '
33,15 33,16 33,17 33,18 33,19 33,20 33,21 33,22 33,23 33,24 33,25 33,'
26 33,27 33,28 33,29 33,30 33,31 33,32 33,33 33,34 33,35 33,36 33,37 '
33,38 33,39 34,3 34,15 34,18 34,21 34,24 34,27 34,30 34,33 34,36 34,39
DEFINE NOTAV 0:*
PUT NOTAV 1,1 1,2 1,3 1,4 1,5 1,6 1,7 1,8 1,33 1,34 1,35 1,36 1,37 1,'
38 1,40 1,41 1,42 2,1 2,2 2,3 2,4 2,5 2,6 2,7 2,8 2,34 2,35 2,36 2,37 '
2,38 2,40 2,41 2,42 3,35 3,36 3,37 3,38 3,40 3,41 3,42 4,1 4,2 4,3 4,4'
 4,5 4,6 4,7 4,8 4,10 4,36 4,37 4,38 4,40 4,41 4,42 5,1 5,2 5,3 5,4 5,'
5 5,6 5,7 5,8 5,37 5,38 5,40 5,41 5,42 6,1 6,2 6,3 6,4 6,5 6,6 6,7 6,8'
 6,41 6,42 7,1 7,2 7,3 7,4 7,5 7,6 7,7 7,8 7,37 7,40 7,42 8,1 8,2 8,3 '
8,4 8,5 8,6 8,7 8,8 8,34 8,35 8,37 8,40 8,41 9,1 9,2 9,3 9,4 9,5 9,6 9'
,7 9,8 9,28 9,29 9,34 9,40 9,41 9,42 10,1 10,2 10,3 10,4 10,5 10,6 10,'
7 10,8 10,28 10,29 10,34 10,41 10,42 11,1 11,2 11,3 11,4 11,5 11,6 11,'
7 11,8 11,29 11,40 11,42 12,1 12,2 12,3 12,4 12,5 12,29 12,40 12,41 13'
,7 13,8 13,41 13,42 14,1 14,2 14,3 14,4 14,5 14,6 14,7 14,8 14,40 14,'
42 15,1 15,2 15,3 15,4 15,5 15,6 15,7 15,8 15,40 15,41 16,1 16,2 16,3 '
16,4 16,5 16,6 16,7 16,8 16,31 16,32 16,40 16,41 16,42 17,1 17,2 17,3 '
17,4 17,5 17,6 17,7 17,8 17,31 17,32 17,42 18,5 18,6 18,7 18,8 18,31 '
18,32 18,40 18,41 18,42 19,1 19,2 19,3 19,4 19,7 19,8 19,31 19,32 19,'
40 19,41 19,42 20,1 20,2 20,3 20,4 20,5 20,6 20,31 20,32 20,40 20,41 '
20,42 21,1 21,2 21,3 21,4 21,5 21,6 21,7 21,8 21,40 21,41 21,42 22,1 '
22,2 22,3 22,4 22,5 22,6 22,7 22,29 22,40 22,41 22,42 23,1 23,2 23,3 '
23,4 23,5 23,6 23,8 23,29 23,42 24,1 24,2 24,3 24,4 24,7 24,8 24,40 24'
,41 24,42 25,1 25,2 25,3 25,5 25,6 25,7 25,8 25,13 25,14 25,40 25,41 '
25,42 26,13 26,14 26,16 26,17 26,40 26,41 26,42 27,1 27,2 27,3 27,5 27'
,6 27,7 27,8 28,1 28,2 28,3 28,5 28,6 28,7 28,8 28,40 28,41 28,42 29,1'
 29,2 29,3 29,5 29,6 29,7 29,8 29,40 29,41 29,42 30,1 30,2 30,3 30,5 '
30,6 30,7 30,8 30,40 30,41 30,42 31,1 31,2 31,4 31,5 31,6 31,7 31,8 31'
,22 31,23 31,40 31,41 31,42 32,1 32,2 32,4 32,5 32,6 32,7 32,8 32,22 '
32,23 32,40 32,41 32,42 33,40 33,41 33,42 34,1 34,2 34,4 34,5 34,6 34,'
7 34,8 34,9 34,10 34,11 34,12 34,13 34,14 34,26 34,40 34,41 34,42
T = 1BDF|
READ_CONSOLE
```

```
PUT PARCEL 15,12(5.,1.5.,99.) 15,13(5.,1.5.,99.) 15,14(5.,1.5.,99.) '
15,15(5.,1.5.,99.) 15,16(6.,2.,99.) 15,17(6.,2.,99.) '
15,18(6.,2.,99.) 15,19(6.,2.,99.) 15,20(6.,2.,99.) '
15,21(6.,2.,99.) 15,22(6.,2.,99.) 15,23(6.,2.,99.) '
15,24(6.,1.,99.) 15,25(6.,1.,99) 15,26(6.,1.,99.) '
15,27(6.,1.,99.) 15,28(5.,2.,99) 15,29(5.,2.,99.) '
15,30(5.,2.,99.)
DELETE STREET 15,12 15,13 15,15 15,16 15,17 15,18 '
15,19 15,20 15,21 15,22 15,23 15,24 15,25 15,26 '
15,27 15,28 15,29 15,30
READ_CONSOLE
```

```
FILE: MARKET   KIRBY    P1                MASSACHUSETTS INSTITUTE OF TECHNCI

COMMENT MARKET REPRESENTS THE PROJECTED SPACE NEEDS
COMMENT FOR A TWENTY YEAR PERIOD
DEFINE MARKET 0*8: '
IA=113329 '
WA=198000 '
CA=2347000 '
OA=3279390 '
HA=442270 '
GA=1667800 '
RA=3320000 '
SA=345000
COMMENT PRIORITY REPRESENTS THE RATING OF SPACE
COMMENT NEEDS (RELATED TO POLICY OBJECTIVES)
DEFINE PRIORITY 0*8: '
IAP=55 '
WAP=60 '
CAP=90 '
OAP=95 '
HAP=70 '
GAP=80 '
RAP=100 '
SAP=94
COMMENT DESIRABILITY HIGH RATING RELATED TO ACTIVITY
COMMENT (FOR DETERMINING LOCATIONAL POSSIBILITIES)
DEFINE GROUPD 0*8: '
G1=20 '
G2=30 '
G3=97 '
G4=90 '
G5=80 '
G6=75 '
G7=70 '
G8=100
COMMENT DESIRABILITY RATING LOW RELATED TO ACTIVITY
DEFINE GROUPD1 0*8: '
G1=10 '
G2=10 '
G3=85 '
G4=75 '
G5=65 '
G6=65 '
G7=40 '
G8=97
COMMENT AVAILABILITY RATING OF PARCEL
COMMENT (FOR DETERMINING LOCATIONAL POSSIBILITIES)
DEFINE GROUPA 0*8:  '
G1=2 '
G2=3 '
G3=6 '
G4=8 '
G5=6 '
G6=4 '
G7=6 '
G8=5
COMMENT AREA NEEDED BY ACTIVITY FOR ASSEMBLY OF PARCELS
```

```
DEFINE GROUPS 0*8: '
G1=4 '
G2=4 '
G3=2 '
G4=2 '
G5=2 '
G6=4 '
G7=2 '
G8=2
COMMENT AVAILABILITY RATING OF SURROUNDING PARCELS
COMMENT (FOR DETERMINING ASSEMBLY POSSIBILITIES)
DEFINE GROUPAA 0*8: '
G1=2 '
G2=3 '
G3=8 '
G4=7 '
G5=6 '
G6=5 '
G7=8 '
G8=3
COMMENT AVAILABLITY INCREMENTAL DECREASE
COMMENT (EFFECT ON SURROUNDING PARCELS)
DEFINE GROUPAX 0*8: '
G1=1 '
G2=1 '
G3=3 '
G4=3 '
G5=2 '
G6=2 '
G7=2 '
G8=3
COMMENT DESIRABILITY INCREMENTAL INCREASE
COMMENT (EFFECT ON SURROUNDING PARCELS)
DEFINE GROUPDX 0*8: '
G1=5 '
G2=5 '
G3=10 '
G4=8 '
G5=5 '
G6=5 '
G7=5 '
G8=10
COMMENT COST INCREMENTAL INCREASE
COMMENT (EFFECT ON SURROUNDING PARCELS)
DEFINE GROUPCX 0*8: '
G1=0.5 '
G2=0.5 '
G3=1.5 '
G4=1.5 '
G5=1.0 '
G6=1.0 '
G7=0.8 '
G8=0.0
COMMENT COST OF CONSTRUCTION RELATED TO LAND COSTS
COMMENT (ABSCRETION RATES FOR DETERMINING NEEDED
```

```
COMMENT ECONOMIC SIZE OF DEVELOPMENT)
DEFINE GROUPAE 0*8: '
G1=1.50 '
G2=1.20 '
G3=2.10 '
G4=2.00 '
G5=2.30 '
G6=2.20 '
G7=2.00 '
G8=1.00
COMMENT POPULATION GENERATED BY NEW DEVELOPMENT
DEFINE GROUPP 0*8: '
G1=195 '
G2=400 '
G3=150 '
G4=200 '
G5=100 '
G6=200 '
G7=360 '
G8=25
COMMENT INCOME GENERATED BY NEW DEVELOPMENT
DEFINE GROUPI 0*8: '
G1=7000 '
G2=5000 '
G3=10000 '
G4=12000 '
G5=6000 '
G6=9000 '
G7=200 '
G8=0
COMMENT NUMBER OF CARS GENERATED BY ACTIVITY TYPE
DEFINE GROUPC 0*8: '
G1=0.5 '
G2=0.5 '
G3=0.2 '
G4=0.2 '
G5=0.6 '
G6=0.4 '
G7=1.2 '
G8=0.0
COMMENT INVESTMENT GENERATED BY NEW DEVELOPMENT
DEFINE GROUPTI 0*8: '
G1=14. '
G2=12. '
G3=24. '
G4=30 '
G5=25. '
G6=32. '
G7=22. '
G8=14.
COMMENT INCREMENTAL REDUCTION TO PRIORITY RATES
DEFINE GROUPX 0*8: '
G1=15 '
G2=15 '
G3=10 '
```

```
G4=12 '
G5=20 '
G6=30 '
G7=8 '
G8=7
COMMENT GROUPMR REPRESENTS MILL RATE FOR TAX CALCULATION
DEFINE GROUPMR 0*8: '
G1=88.8 '
G2=78.8 '
G3=88.8 '
G4=88.8 '
G5=88.8 '
G6=55.9 '
G7=65.9 '
G8=0.0
DEFINE TLIST2 1:**
DEFINE TLIST3 0*1:NUMB=0.0*
COMMENT INFORMATION TO BE CALCULATED AND MAPPED
DEFINE INFO 9: '
TBA '
FAR '
POP '
INCOME '
INVEST '
CARS '
PDENSITY '
ASSEST '
TAX*
COMMENT TOTAL REPRESENTS THE AGGREGATION OF ALL INFORMATION
COMMENT FOR A COMPLETE 'RUN'
DEFINE TOTAL 0*7: **
COMMENT PL REPRESENTS RANKING OF PRIORITY LIST
DEFINE PL 1: **
DEFINE TEMP1 0*
DEFINE TEMP2 0*
READ_CONSOLE
```

```
FILE: DEVELOP  KIRBY    P1                MASSACHUSETTS INSTITUTE OF TECHNOL(

SUBSTITUTION ON
START$CONTINUE
FOR Q=1 1 8 PL<1 1,Q>=PRIORITY<Q>
THROUGH ZIP FOR I=,J=EACH RANKED HIGH PL<<1>>
WORK=J
IF PRIORITY<J> .EQ. 0 GOTO DONE
IF MARKET<WORK>.GEQ. 14400 GOTO NEXT
ZIP$ CONTINUE
DONE$ EXPAND +EXECUTION COMPLETE+
READ_CONSOLE
NEXT $ TLIST1*=*NULL
TLIST5*=NULL
FOR T=EACH PARCEL<<DES>> .LEQ. GROUPD<WORK> PUT TLIST1 T
FOR T=EACH PARCEL<<DES>> .GEQ. GROUPD1<WORK> PUT TLIST5 T
TLIST1*=*TLIST1 .AND. TLIST5
IF TLIST1.EQL.0. GOTO NOTPOS
TLIST2*=*NULL
A=1
COMM$ CONTINUE
THROUGH SL FOR T=EACH TLIST1
SL$ IF PARCEL<AV T>.EQL. A PUT TLIST2 T (PARCEL<COST T>)
IF TLIST2 .EQL. 0 GOTO T1
MAX=GROUPS<WORK>-1
THROUGH LAB FOR T2=EACH RANKED LOW TLIST2<<1>>
MINAV=15
TLIST3*=NULL
PUT TLIST3 T2
BLOCK 1 TEMP1<T2> *
T4=T2
THROUGH L1 FOR C=1 1 MAX
CIRCLE 1 TEMP2<T4> *
W1*= TEMP1 .AND. TEMP2 .ANDN. TLIST3 .AND. PARCEL
T3=T2
THROUGH X FOR T=EACH W1
IF PARCEL<AV T> .LES. GROUPAA<WORK> .AND.PARCEL<AV T> .GEQ. MINAV GOTO X
MINAV=PARCEL<AV T>
T3=T
X$ CONTINUE
PUT TLIST3 T3
IF TLIST3 .EQL. C GOTO LAB
L1$ T4=T3
GOTO FOUND
LAB$ CONTINUE
T1$ IF A .EQL. 9 GOTO EXP
A=A+1
GOTO COMM
EXP$ EXPAND +NOT POSSIBLE TO ASSEMBLE LAND/+
GOTO NOTPOS
FOUND$ CONTINUE
TCOST=0
THROUGH X1 FOR T=EACH TLIST3
X1$ TCOST=TCOST+PARCEL<COST T>
THROUGH FIX FOR T=EACH TLIST3
DELETE PARCEL T
DELETE TLIST1 T
```

```
FIX$ DELETE TLIST2 T
THROUGH ZAP FOR T=EACH TLIST3
INFO<TBA T>=TCOST/GROUPAB<WORK>*14400
INFO<FAR T>=INFO<TBA T>/(TLIST3*14400.)
INFO<POP T>=INFO<TBA T>/GROUPP<WORK>
INFO<INCOME T>=INFO<POP T>*GROUPI<WORK>
INFO<INVEST T>=INFO<TBA T>*GROUPII<WORK>
INFO<CARS T>=INFO<POP T>*GROUPC<WORK>
INFO<PDENSITY T>=INFO<TBA T>/INFO<POP T>
INFO<ASSEST T>=0.4*INFO<INVEST T>+PARCEL<COST T>
INFO<TAX T>=(INFO<ASSEST T>*GROUPMR<WORK>)/1000
ZAP$ CONTINUE
TEMPSUR*=NULL
FOR T=EACH TLIST3 BLOCK 1 TEMPSUR<1>
SURROUND*=TEMPSUR .AND. INFO .AND. STREET
MARKET<WORK>=MARKET<WORK>-INFO<TBA T>
PRIORITY<WORK>=PRIORITY<WORK>-GROUPX<WORK>
THROUGH X2 FOR T=EACH SURROUND
IF PARCEL<DES T> .LES. GROUPD1<WORK> PARCEL<DES T>=PARCEL<DES T> + '
GROUPDX<WORK>
IF PARCEL<AV T> .LES. GROUPA<WORK> '
PARCEL<AV T>=PARCEL<AV T>-GROUPAX
IF PARCEL<AV T>.IEQ. 0 PARCEL<AV T>=1
PARCEL<COST T>=PARCEL<COST T>+GROUPCX<WORK>
X2$ CONTINUE
EXPAND +N'=$3N/+
MAPSET STANDARD (1;W) (2;*) (3;.) (4; ) SMALL (9;X) SMALL
MAP* OFFLINE (TLIST3 STREET PARCEL NOTAV) 1-34 1-42
SAY MAP COMPLETED
FOR T=EACH TLIST3 GOTO Q2
Q2$SHOW INFO<1 T> INFO<2 T> INFO<3 T> INFO<4 T>'
INFO<5 T> INFO<6 T> INFO<7 T> INFO<8 T> INFO<9 T>
SHOW WORK MARKET<WORK> PRIORITY<WORK>
N=N+1
READ_CONSOLE
NOTPOS$ PRIORITY<WORK>=0
SAY CHOICE OF ACTIVITY IS BEING REEXAMINED
GOTO START
```

```
EXPAND +///THIS IS A F'.A'.B'. TABLE:///+
SET_DECIMAL_PLACES 1
EXPAND +$45*   +
FOR I=ARG1 1 ARG2  EXPAND +$3I*+
CARRIAGERETURN 2
THROUGH XG FOR I=1 1 34
EXPAND +$43$3I$45$1INFO<FAR I,ARG1>...INFO<FAR I,ARG2>/+
XG$CONTINUE
READ_CONSOLE
```

APPENDIX II

1. CONTEXT FOR MODEL

A. HISTORICAL GROWTH PATTERNS

The land use pattern in the central area of Winnipeg was generated by the establishment of a fur trading post located at the junction of two rivers - the Red flowing north from the U.S. and the Assiniboine flowing east from the foothills of the Rocky Mountains. This early settlement was later intensified by settlers locating along the rivers flowing to Indian trails now called Main Street and Portage Avenue. It was the junction of this trail that became the center of the settlement. Commerce related to the agricultural industry located at the crossing; industry, wholesaling and distribution located north of Portage Avenue and east of Main Street to the Red River. Commerce developed along both main streets and residential located between and surrounding the other land uses.

This original pattern expanded west and north along the two trails and early survey systemizes this pattern by following the early property lines of the river lots of the Selkirk settlers and generated a regular north-south grid in the central area which crossed Portage Avenue at acute angles. The railways reinforced and expanded this pattern, bringing span lines into the existing warehousing and manufacturing districts.

This original nucleus of growth essentially remained and exerts itself in the existing street network system, the location of major use patterns and the ownership and configuration of land parcels.

HISTORY OF WINNIPEG'S ECONOMY

Initially Winnipeg evolved as a transportation center through which goods and services flowed into and out of the agricultural hinterland of the prairies. The second important economic development began around the turn of the century, when a number of manufacturing and wholesaling activities were introduced. These activities were in the creation and the distribution of goods for use by the agricultural industry and in processing and distributing agricultural produce. As urban areas of the prairies grew in size and number, manufacturing diversified on a wider basis and by 1950, forty-five per cent of Winnipeg's labor force was engaged in manufacturing, transportation and wholesaling activities. The third aspect of Winnipeg's development has been the evolution of the service and trade industries. These activities had always tended to be passive elements, in the sense that they were the result rather than the cause of economic growth.

Since 1950 there has been a reduction in the rate at which manufacturing activities have grown in Winnipeg, partially contributed to the decline of growth in rural population and increased growth in other prairie urban centers.

There is now a change in consumption patterns in which a larger proportion of expenditures are for services and a smaller proportion for goods. While the services have been expanding since the city was founded, it has only recently become the primary base of economic growth.

EXISTING CONDITIONS

The urban study area used for this simulation model is going through the same changes that have affected most North American cities in this century -

. it has lost most of its residential population
. the people who remain are the older and poorer citizens
. it is losing its manufacturing and wholesaling activities, and
. it is losing retail trade to suburban locations.

Service industries are growing but the total volume and rate of new investment in the area is not sufficient to compensate for tax losses and the quality of built environment in the area. A number of early decisions by public and private realms have added to the problem and makes a reversal of these trends difficult:

1. Early anticipation of the growth potential of this city, generated an overly grand scale to what was considered to be the future downtown.

2. Major private retail developments establish locations for their premise at a sufficiently great distance from the early central focus on Main Street and these attracted other retail activities which spread thinly along Portage Avenue from the corner of Main Street.

3. The two railways established their terminals on fringes of the early downtown at two extreme ends and caused development to spread along Main Street at a low density.

4. In the early 1950's business developments began concentrating on offices to the south of the core on Broadway Avenue where land was less expensive and quality of environment more controlled than the decline, and blighted conditions of available land in the core.

5. Renewal attempts in the city each competed for available federal money and feasible development activities. These areas each tried to encourage large amounts of development, over large tracts of land in the frame area of the downtown.

6. The special renewal area for the Cultural Center Complex succeeded in developed a large homogenous complex north of the downtown area, but failed to attract private development to renew this area.

7. All attempts to reverse the central core's decline have done little to provide incentive to the private realm and as in some cases caused development to locate at our of center locations or out of city locations where there was some degree of stability to municipal plans and economic objectives.

The following maps graphically illustrate some of the present patterns and underuse of land in the downtown core.

APPENDIX III:

C. THE DEVELOPMENT PROCESS IN REALITY

The following table represents the possible process that must be considered when land is developed in reality.

1. ORIGIN:
   - A. Land already owned or options that show feasibility for capital return
   - B. Availability of capital resources and equity
   - C. Market demands that can be capitalized on
   - D. External factors: direct, client request
     indirect, competition for request

2. SEARCH PROCESS (dependent on origin):
   - A. Feasibility study to determine the degree of economic return
   - B. Search for financial (backing) support
   - C. Test feasibility of market need
   - D. Search for prime occupant
   - E. Search for desirable land

3. FORMALIZE POSSIBLE DEVELOPMENT INTO UNIFIED CONCEPT:
   - A. Processing and further elaboration of all available variables into complete package
   - B. Search for alternate routes - new site, new financing arrangements
   - C. Calculation to determine maximum profit combinations

D. Presentation to economically effected parties

E. Adjustments

F. Test for possible constraint alleviations (to either make development feasible or more profitable)

G. Acceptance or rejection of proposal by client or city

4. PROPOSAL FORMULIZATION:

A. Development of physical plans and specifications

B. Cost analysis

C. Contracts of legal and economic responsibility arrangements

D. Clarification and agreement on all public constraints

- zoning regulation
- building regulation
- rights of way
- property and air rights
- taxes, arrangements

E. Commitment of tenants

5. IMPLEMENTATION

A. Construction of development

B. Tenant leasing and inclusion of tenant responses

C. Detailed legal arrangements

```
FILE: SKYWAY   KIRBY    P1                    MASSACHUSETTS INSTITUTE OF TECHNOI

SETUP 1 34 1 42 40 40 0
DEFINE PARCEL 3: COST AV DES*
PUT PARCEL 1,10(99.,3.,1.) 1,11(99.,1.,1.) 1,12(99.,1.,1.) 1,13(99.,1.'
,1.) 1,14(99.,1.,1.) 1,16(99.,2.,1.) 1,17(99.,7.,1.) 1,19(99.,7.,1.) 1'
,20(99.,6.,1.) 1,22(99.,1.,1.) 1,23(99.,1.,1.) 1,25(99.,3.,1.) 1,26('
99.,6.,1.) 1,28(99.,5.,1.) 1,29(99.,4.,1.) 1,31(99.,1.,1.) 2,10(99.,4.'
,1.) 2,11(99.,1.,1.) 2,12(99.,1.,1.) 2,13(99.,1.,1.) 2,14(99.,1.,1.) 2'
,16(99.,1.,1.) 2,17(99.,7.,1.) 2,19(99.,4.,1.) 2,20(99.,6.,1.) 2,22('
99.,3.,1.) 2,23(99.,2.,1.) 2,25(99.,3.,1.) 2,26(99.,4.,1.) 2,28(99.,5.'
,1.) 2,29(99.,3.,1.) 2,31(99.,1.,1.) 2,32(99.,1.,1.) 4,11(18.,5.,50.) '
4,16(14.,2.,50.) 4,17(16.,1.,50.) 4,19(16.,3.,50.) 4,20(18.,3.,50.) 4,'
22(22.,3.,50.) 4,23(18.,3.,50.) 4,25(21.,2.,50.) 4,26(22.,1.,40.) 4,28'
(18.,3.,40.) 4,29(22.,1.,50.) 4,31(20.,9.,50.) 4,32(15.,6.,40.) 4,34('
27.,5.,70.) 5,16(12.,1.,40.) 5,17(11.,1.,40.) 5,19(14.,1.,50.) 5,20('
12.,1.,50.) 5,22(12.,3.,60.) 5,23(14.,1.,50.) 5,25(18.,3.,60.) 5,26('
17.,4.,40.) 5,28(22.,3.,70.) 5,29(22.,1.,70.) 5,31(18.,7.,70.) 5,32('
19.,9.,70.) 5,34(27.,4.,80.) 5,35(27.,4.,70.) 6,11(15.,1.,55.) 6,16('
12.,3.,40.) 6,17(14.,3.,40.) 6,19(15.,1.,50.) 6,20(14.,5.,60.) 6,22('
17.,3.,65.) 6,23(18.,1.,70.) 6,25(18.,4.,60.) 6,26(20.,4.,40.) 6,28('
21.,4.,80.) 6,29(21.,4.,80.) 6,31(30.,3.,80.) 6,32(30.,3.,70.) 6,34('
32.,4.,90.) 6,35(34.,4.,90.) 7,11(14.,1.,60.) 7,16(12.,3.,60.) 7,17('
12.,3.,60.) 7,19(16.,1.,50.) 7,20(15.,5.,70.) 7,25(28.,4.,80.) 7,26('
28.,4.,80.) 7,28(28.,4.,90.) 7,29(30.,4.,90.) 7,31(32.,3.,80.) 7,32('
32.,3.,80.) 7,37(3.,1.,16.) 8,16(15.,3.,60.) 8,17(14.,4.,60.) 8,19(18.'
,5.,80.) 8,20(18.,5.,80.) 8,25(32.,4.,90.) 8,26(34.,4.,90.) 9,10(13.,'
5.,80.) 9,11(13.,3.,65.) 9,16(18.,4.,90.) 9,17(17.,6.,90.) 9,19(23.,5.'
,90.) 9,20(21.,4.,90.) 9,22(27.,4.,80.) 9,23(26.,5.,80.) 9,31(26.,5.,'
90.) 9,32(27.,5.,80.) 9,35(28.,3.,80.) 9,38(32.5,3.,75.) 10,10(15.,4.,'
90.) 10,11(18.,6.,80.) 10,13(21.,4.,90.) 10,14(22.,4.,90.) 10,16(18.,'
4.,90.) 10,17(17.,6.,90.) 10,25(30.,7.,95.) 10,26(30.,7.,95.) 10,31('
24.,5.,80.) 10,32(21.,4.,80.) 10,35(20.,4.,50.) 11,10(15.,4.,90.) 11,'
11(18.,6.,90.) 11,19(26.5,3.,80.) 11,25(30.,7.,95.) 11,26(30.,7.,95.) '
11,28(25.,7.,80.) 11,31(27.,6.,80.) 11,32(22.,3.,60.) 11,34(23.,4.,50.'
) 11,35(22.,3.,50.) 11,37(33.,4.,76.) 12,13(28.,4.,90.) 12,14(28.,4.,'
90.) 12,17(28.5,5.,90.) 12,19(26.,4.,88.) 12,25(30.,7.,95.) 12,26(30.,'
7.,95.) 12,28(26.,7.,60.) 12,31(26.,1.,70.) 12,32(23.,3.,60.) 12,34('
22.,4.,50.) 12,35(22.,3.,50.) 12,37(26.5,4.,78.) 13,10(28.,9.,90.) 13,'
11(28.,9.,90.) 13,13(26.5,4.,80.) 13,14(25.5,4.,80.) 13,17(24.,4.,90.)'
13,22(27.,9.,90.) 13,23(27.,9.,90.) 13,25(28.,5.,90.) 13,26(28.,5.,'
90.) 13,28(18.,6.,60.) 13,29(18.,6.,60.) 13,31(24.,8.,70.) 13,32(20.,'
1.,60.) 13,34(22.,6.,50.) 13,35(22.,6.,50.) 13,37(24.5,4.,78.) 13,38('
26.5,3.,78.) 14,10(28.,9.,90.) 14,11(28.,9.,90.) 14,13(26.5,3.,80.) 14'
,17(21.,4.,90.) 14,19(24.,5.,90.) 14,22(24.,6.,70.) 14,23(24.,6.,90.) '
14,25(28.,5.,100.) 14,26(28.,5.,100.) 14,28(18.,6.,70.) 14,29(18.,6.,'
70.) 14,31(24.,8.,60.) 14,32(20.,1.,50.) 14,34(22.,3.,60.) 14,35(22.,'
5.,60.) 14,37(23.,2.,70.) 14,38(22.,3.,70.) 15,10(28.,9.,90.) 15,11('
28.,9.,90.) 15,12(5.,1.,99.) 15,13(6.5,1.,99.) 15,15(8.,1.,99.) 15,17('
7.5,1.,99.) 15,18(7.,1.,99.) 15,19(8.5,1.,99.) 15,21(10.,1.,99.) 15,22'
(7.5,1.,99.) 15,23(7.5,1.,99.) 15,27(6.,1.,99.) 15,28(5.,1.,99.) 15,29'
(5.,2.,99.) 15,30(5.,2.,99.) 16,10(28.,9.,90.) 16,11(28.,9.,90.) 16,13'
(18.,6.,80.) 16,14(21.,4.,80.) 16,16(23.5,6.,80.) 16,17(24.5,5.,80.) '
16,25(15.,5.,80.) 16,28(12.8,3.,40.) 16,29(12.8,2.,35.) 16,34(12.,4.,'
50.) 16,35(13.,3.,50.) 16,37(10.,2.,40.) 16,38(10.,3.,60.) 17,10(28.,'
9.,80.) 17,11(28.,9.,80.) 17,16(18.,6.,50.) 17,17(10.,7.,60.) 17,25('
10.,5.,70.) 17,26(10.,5.,70.) 17,28(10.8,3.,40.) 17,34(9.8,3.,50.) 17,'
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35(8.8,1.,35.) 17,37(12.,3.,30.) 17,38(12.,3.,60.) 17,40(99.,0.,1.) 17'
,41(99.,0.,1.) 18,10(15.,9.,80.) 18,11(15.,9.,80.) 18,16(13.,4.,50.) '
18,17(12.,7.,50.) 18,25(15.,5.,50.) 18,26(15.,5.,50.) 18,28(11.3,3.,'
40.) 18,35(9.8,4.,35.) 18,37(11.,4.,40.) 18,38(12.,4.,60.) 19,10(15.,'
9.,70.) 19,11(15.,9.,70.) 19,16(12.,4.,40.) 19,17(12.,7.,40.) 19,19('
13.,5.,55.) 19,20(19.,7.,55.) 19,25(15.,5.,60.) 19,26(15.,5.,60.) 19,'
35(10.6,3.,40.) 19,37(11.,1.,40.) 19,38(12.,4.,60.) 20,10(15.,9.,70.) '
20,11(15.,9.,70.) 20,16(11.,3.,40.) 20,17(10.,7.,40.) 20,19(7.,4.,50.) '
20,20(18.,7.,50.) 20,22(21.,7.,66.) 20,23(21.,7.,66.) 20,25(10.,5.,'
60.) 20,26(10.,5.,60.) 20,37(10.,3.,40.) 20,38(12.,3.,60.) 22,10(20.,'
6.,70.) 22,11(20.,6.,70.) 22,13(13.,1.,50.) 22,14(10.,1.,50.) 22,16('
10.8,2.,50.) 22,22(8.8,2.,50.) 22,23(11.8,2.,50.) 22,26(9.8,1.,50.) 22'
,29(0.8,1.,5.) 22,31(9.8,5.,50.) 22,37(7.,4.,30.) 22,38(12.,5.,50.) 23'
,10(20.,6.,70.) 23,11(20.,6.,70.) 23,13(11.,3.,50.) 23,14(10.,1.,50.) '
23,16(8.8,2.,50.) 23,19(13.6,3.,50.) 23,20(9.6,2.,60.) 23,22(12.8,2.,'
40.) 23,26(10.4,1.,50.) 23,29(0.8,1.,5.) 23,31(7.8,3.,50.) 23,34(9.8,'
1.,40.) 23,35(9.8,3.,50.) 23,37(8.5,1.,30.) 23,38(12.5,5.,40.) 24,10('
20.,6.,70.) 24,11(20.,6.,70.) 24,13(9.,4.,60.) 24,14(10.,4.,50.) 24,16'
(8.8,3.,40.) 24,17(9.8,4.,50.) 24,20(8.8,2.,50.) 24,22(11.8,3.,40.) 24'
,28(13.6,7.,60.) 24,29(11.6,3.,50.) 24,31(6.8,3.,50.) 24,32(7.8,4.,40.'
) 24,34(8.,4.,30.) 24,35(10.,3.,30.) 25,10(20.,6.,70.) 25,11(20.,6.,'
70.) 25,16(20.,3.,40.) 25,17(20.,2.,50.) 25,20(7.8,2.,40.) 25,22(10.8,'
2.,40.) 25,23(12.8,1.,50.) 25,31(9.,3.,50.) 25,32(9.,3.,40.) 25,34(10.'
,1.,50.) 25,35(9.,2.,50.) 26,19(10.8,4.,50.) 26,20(10.8,5.,50.) 26,22('
11.,2.,60.) 26,23(12.,2.,60.) 26,25(10.6,1.,60.) 26,26(10.6,1.,60.) 26'
,28(12.8,2.,50.) 26,29(9.8,1.,50.) 26,31(12.,4.,40.) 26,32(9.,2.,40.) '
26,34(9.,4.,40.) 26,35(10.,2.,40.) 26,37(13.5,3.,30.) 26,38(12.5,4.,'
40.) 27,10(9.,5.,40.) 27,11(9.,5.,40.) 28,10(9.,5.,40.) 28,11(9.,5.,'
40.) 28,12(9.,3.,40.) 28,13(9.,3.,40.) 28,14(6.,3.,40.) 28,16(12.,6.,'
40.) 28,17(14.,6.,40.) 28,25(12.,8.,60.) 28,26(8.,2.,50.) 28,28(7.,3.,'
60.) 28,29(6.,3.,60.) 28,34(7.,3.,50.) 28,35(7.,3.,50.) 28,37(7.,3.,'
40.) 28,38(12.,6.,50.) 29,10(9.,5.,50.) 29,11(9.,5.,50.) 29,12(9.,3.,'
50.) 29,13(6.,3.,50.) 29,14(6.,3.,50.) 29,16(10.,6.,50.) 29,17(7.,6.,'
60.) 29,25(9.,8.,60.) 29,26(10.,2.,60.) 29,28(7.,3.,50.) 29,29(7.,6.,'
50.) 29,32(16.6,6.,50.) 29,34(7.,3.,30.) 29,35(10.,3.,30.) 29,37(12.,'
4.,40.) 29,38(12.,6.,50.) 30,10(6.,5.,50.) 30,11(6.,5.,50.) 30,12(6.,'
6.,50.) 30,13(30.,6.,50.) 30,14(30.,6.,70.) 30,16(7.8,3.,60.) 30,17('
10.8,1.,60.) 30,25(7.,4.,60.) 30,26(10.,5.,50.) 30,28(10.,3.,50.) 30,'
29(10.,2.,40.) 30,32(15.8,6.,40.) 30,34(10.,3.,30.) 30,35(10.,4.,30.) '
30,37(12.,4.,30.) 30,38(10.,3.,50.) 31,10(6.,5.,70.) 31,11(6.,5.,50.) '
31,12(6.,6.,50.) 31,13(30.,6.,50.) 31,14(30.,6.,50.) 31,17(12.8,4.,60.'
) 31,19(9.6,1.,50.) 31,20(11.6,1.,50.) 31,22(1.6,1.,10.) 31,23(1.6,1.,'
10.) 31,25(12.,4.,70.) 31,26(12.,4.,60.) 31,28(13.,3.,60.) 31,29(12.,'
1.,60.) 31,31(12.8,1.,50.) 31,32(16.8,4.,60.) 31,34(15.,3.,50.) 31,35('
15.,3.,50.) 31,37(10.,3.,60.) 31,38(15.,5.,60.) 32,10(6.,5.,50.) 32,11'
(6.,5.,50.) 32,12(6.,6.,50.) 32,13(30.,6.,50.) 32,14(30.,6.,50.) 32,17'
(12.8,4.,60.) 32,19(16.,9.,60.) 32,20(9.,9.,60.) 32,25(12.,4.,60.) 32,'
26(12.,4.,70.) 32,28(13.,6.,60.) 32,29(13.,7.,70.) 32,31(12.,6.,80.) '
32,32(16.,4.,80.) 32,34(15.,3.,70.) 32,35(15.,3.,70.) 32,37(10.,3.,60.'
) 32,38(15.,5.,60.) 34,16(10.,1.,1.) 34,17(10.,1.,1.) 34,19(10.,4.,1.)'
34,20(10.,7.,1.) 34,22(10.,4.,1.) 34,23(10.,6.,1.) 34,25(10.,6.,1.) '
34,28(10.,5.,1.) 34,29(10.,8.,1.) 34,31(10.,5.,1.) 34,32(10.,5.,1.) 34'
,34(10.,7.,1.) 34,35(10.,7.,1.) 34,37(10.,5.,1.) 34,38(10.,3.,1.)
DEFINE STREET C:*
PUT STREET 1,9 1,15 1,18 1,21 1,24 1,27 1,30 1,32 1,35 2,9 2,15 2,18 2'
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FILE: SKYWAY KIRBY P1 MASSACHUSETTS INSTITUTE OF TECHNOL

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,21 2,24 2,27 2,30 2,33 2,39 3,1 3,2 3,3 3,4 3,5 3,6 3,7 3,8 3,9 3,10 '
3,11 3,12 3,13 3,14 3,15 3,16 3,17 3,18 3,19 3,20 3,21 3,22 3,23 3,24 '
3,25 3,26 3,27 3,28 3,29 3,30 3,31 3,32 3,33 3,34 3,39 4,9 4,12 4,15 4'
,18 4,21 4,24 4,27 4,30 4,33 4,35 4,39 5,9 5,10 5,11 5,12 5,15 5,18 5,'
21 5,24 5,27 5,30 5,33 5,36 5,39 6,9 6,12 6,15 6,18 6,21 6,24 6,27 6,'
30 6,33 6,36 6,37 6,38 6,39 6,40 7,9 7,12 7,15 7,18 7,21 7,24 7,27 7,'
30 7,33 7,34 7,35 7,36 7,39 7,41 8,9 8,12 8,15 8,18 8,21 8,24 8,27 8,'
28 8,29 8,30 8,31 8,32 8,33 8,36 8,39 8,42 9,9 9,12 9,15 9,18 9,21 9,'
24 9,25 9,26 9,27 9,30 9,33 9,36 9,39 10,9 10,12 10,15 10,18 10,19 10,'
20 10,21 10,22 10,23 10,24 10,27 10,30 10,33 10,36 10,39 10,40 11,9 11'
,12 11,13 11,14 11,15 11,16 11,17 11,18 11,21 11,24 11,27 11,30 11,33 '
11,36 11,39 11,41 12,6 12,7 12,8 12,9 12,10 12,11 12,12 12,15 12,18 12'
,21 12,24 12,27 12,30 12,33 12,36 12,39 12,42 13,1 13,2 13,3 13,4 13,5'
 13,6 13,9 13,12 13,15 13,18 13,21 13,24 13,27 13,30 13,33 13,36 13,39'
 13,40 14,9 14,12 14,15 14,18 14,21 14,24 14,27 14,30 14,33 14,36 14,'
39 14,41 15,9 15,14 15,31 15,32 15,33 15,34 15,35 15,36 15,37 15,38 15'
,39 15,42 16,9 16,12 16,15 16,18 16,21 16,24 16,27 16,30 16,33 16,36 '
16,39 17,9 17,12 17,15 17,18 17,21 17,24 17,27 17,30 17,33 17,36 17,39'
 18,1 18,2 18,3 18,4 18,9 18,12 18,15 18,18 18,21 18,24 18,27 18,30 18'
,33 18,36 18,39 19,5 19,6 19,9 19,12 19,15 19,18 19,21 19,24 19,27 19,'
30 19,33 19,36 19,39 20,7 20,8 20,9 20,12 20,15 20,18 20,21 20,24 20,'
27 20,30 20,33 20,36 20,39 21,9 21,10 21,11 21,12 21,13 21,14 21,15 21'
,16 21,17 21,18 21,19 21,20 21,21 21,22 21,23 21,24 21,25 21,26 21,27 '
21,28 21,29 21,30 21,31 21,32 21,33 21,34 21,35 21,36 21,37 21,38 21,'
39 22,8 22,9 22,12 22,15 22,18 22,21 22,24 22,27 22,30 22,33 22,36 22,'
39 23,7 23,9 23,12 23,15 23,18 23,21 23,24 23,27 23,30 23,33 23,36 23,'
39 23,40 23,41 24,5 24,6 24,9 24,12 24,15 24,18 24,21 24,24 24,27 24,'
30 24,33 24,36 24,39 25,4 25,9 25,12 25,15 25,18 25,21 25,24 25,27 25,'
30 25,33 25,36 25,39 26,1 26,2 26,3 26,4 26,5 26,6 26,7 26,8 26,9 26,'
10 26,11 26,12 26,15 26,18 26,21 26,24 26,27 26,30 26,33 26,36 26,39 '
27,4 27,9 27,12 27,13 27,14 27,15 27,16 27,17 27,18 27,19 27,20 27,21 '
27,22 27,23 27,24 27,25 27,26 27,27 27,28 27,29 27,30 27,31 27,32 27,'
33 27,34 27,35 27,36 27,37 27,38 27,39 27,40 27,41 27,42 28,4 28,9 28,'
15 28,18 28,21 28,24 28,27 28,30 28,33 28,36 28,39 29,4 29,9 29,15 29,'
18 29,21 29,24 29,27 29,30 29,33 29,36 29,39 30,4 30,9 30,15 30,18 30,'
21 30,24 30,27 30,30 30,33 30,36 30,39 31,3 31,9 31,15 31,18 31,21 31,'
24 31,27 31,30 31,33 31,36 31,39 32,3 32,9 32,15 32,18 32,21 32,24 32,'
27 32,30 32,33 32,36 32,39 33,1 33,2 33,3 33,4 33,5 33,6 33,7 33,8 33,'
9 33,10 33,11 33,12 33,13 33,14 33,15 33,16 33,17 33,18 33,19 33,20 33'
,21 33,22 33,23 33,24 33,25 33,26 33,27 33,28 33,29 33,30 33,31 33,32 '
33,33 33,34 33,35 33,36 33,37 33,38 33,39 34,3 34,15 34,18 34,21 34,24'
 34,27 34,30 34,33 34,36 34,39
DEFINE NOTAV 0:*
PUT NOTAV 1,1 1,2 1,3 1,4 1,5 1,6 1,7 1,8 1,33 1,34 1,35 1,36 1,37 1,'
38 1,40 1,41 1,42 2,1 2,2 2,3 2,4 2,5 2,6 2,7 2,8 2,34 2,35 2,36 2,37 '
2,38 2,40 2,41 2,42 3,35 3,36 3,37 3,38 3,40 3,41 3,42 4,1 4,2 4,3 4,4'
 4,5 4,6 4,7 4,8 4,10 4,36 4,37 4,38 4,40 4,41 4,42 5,1 5,2 5,3 5,4 5,'
5 5,6 5,7 5,8 5,37 5,38 5,40 5,41 5,42 6,1 6,2 6,3 6,4 6,5 6,6 6,7 6,8'
 6,41 6,42 7,1 7,2 7,3 7,4 7,5 7,6 7,7 7,8 7,37 7,40 7,42 8,1 8,2 8,3 '
8,4 8,5 8,6 8,7 8,8 8,34 8,35 8,37 8,40 8,41 9,1 9,2 9,3 9,4 9,5 9,6 9'
,7 9,8 9,28 9,29 9,34 9,40 9,41 9,42 10,1 10,2 10,3 10,4 10,5 10,6 10,'
7 10,8 10,28 10,29 10,34 10,41 10,42 11,1 11,2 11,3 11,4 11,5 11,6 11,'
7 11,8 11,29 11,40 11,42 12,1 12,2 12,3 12,4 12,5 12,29 12,40 12,41 13'
,7 13,8 13,41 13,42 14,1 14,2 14,3 14,4 14,5 14,6 14,7 14,8 14,40 14,'
42 15,1 15,2 15,3 15,4 15,5 15,6 15,7 15,8 15,40 15,41 16,1 16,2 16,3 '
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FILE: SKYWAY KIRBY P1 MASSACHUSETTS INSTITUTE OF TECHNCI

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16,4 16,5 16,6 16,7 16,8 16,31 16,32 16,40 16,41 16,42 17,1 17,2 17,3 '
17,4 17,5 17,6 17,7 17,8 17,31 17,32 17,42 18,5 18,6 18,7 18,8 18,31 '
18,32 18,40 18,41 18,42 19,1 19,2 19,3 19,4 19,7 19,8 19,31 19,32 19,'
40 19,41 19,42 20,1 20,2 20,3 20,4 20,5 20,6 20,31 20,32 20,40 20,41 '
20,42 21,1 21,2 21,3 21,4 21,5 21,6 21,7 21,8 21,40 21,41 21,42 22,1 '
22,2 22,3 22,4 22,5 22,6 22,7 22,29 22,40 22,41 22,42 23,1 23,2 23,3 '
23,4 23,5 23,6 23,8 23,29 23,42 24,1 24,2 24,3 24,4 24,7 24,8 24,40 24'
,41 24,42 25,1 25,2 25,3 25,5 25,6 25,7 25,8 25,13 25,14 25,40 25,41 '
25,42 26,13 26,14 26,16 26,17 26,40 26,41 26,42 27,1 27,2 27,3 27,5 27'
,6 27,7 27,8 28,1 28,2 28,3 28,5 28,6 28,7 28,8 28,40 28,41 28,42 29,1'
 29,2 29,3 29,5 29,6 29,7 29,8 29,40 29,41 29,42 30,1 30,2 30,3 30,5 '
30,6 30,7 30,8 30,40 30,41 30,42 31,1 31,2 31,4 31,5 31,6 31,7 31,8 31'
,22 31,23 31,40 31,41 31,42 32,1 32,2 32,4 32,5 32,6 32,7 32,8 32,22 '
32,23 32,40 32,41 32,42 33,40 33,41 33,42 34,1 34,2 34,4 34,5 34,6 34,'
7 34,8 34,9 34,10 34,11 34,12 34,13 34,14 34,26 34,40 34,41 34,42
DEFINE MARKET 0:* 8: IA = -357070.7 WA = -281999.9 CA = -138716.2 OA ='
 -18210. HA = -64860.5 GA = 90345.56 RA = 623600.2 SA = -130200.
DEFINE PRIORITY 0:* 8: IAP = 55. WAP = 45. CAP = 90. OAP = 35. HAP = '
70. GAP = 20. RAP = 19. SAP = 100.
DEFINE GROUPD 0:* 8: G1 = 20. G2 = 30. G3 = 97. G4 = 90. G5 = 80. G6 ='
 75. G7 = 70. G8 = 99.
DEFINE GROUPD1 0:* 8: G1 = 10. G2 = 10. G3 = 85. G4 = 75. G5 = 65. G6 '
= 65. G7 = 40. G8 = 97.
DEFINE GROUPA 0:* 8: G1 = 2. G2 = 3. G3 = 6. G4 = 8. G5 = 6. G6 = 4. '
G7 = 6. G8 = 5.
DEFINE GROUPS 0:* 8: G1 = 4. G2 = 4. G3 = 2. G4 = 2. G5 = 2. G6 = 4. '
G7 = 2. G8 = 2.
DEFINE GROUPAA 0:* 8: G1 = 2. G2 = 3. G3 = 8. G4 = 7. G5 = 6. G6 = 5. '
G7 = 8. G8 = 3.
DEFINE GROUPAX 0:* 8: G1 = 1. G2 = 1. G3 = 3. G4 = 3. G5 = 2. G6 = 2. '
G7 = 2. G8 = 3.
DEFINE GROUPDX 0:* 8: G1 = 5. G2 = 5. G3 = 10. G4 = 8. G5 = 5. G6 = 5.'
 G7 = 5. G8 = 10.
DEFINE GROUPCX 0:* 8: G1 = 0.5 G2 = 0.5 G3 = 1.5 G4 = 1.5 G5 = 1. G6 ='
 1. G7 = 0.8 G8 = 0.
DEFINE GROUPAB 0:* 8: G1 = 1.5 G2 = 1.2 G3 = 2.1 G4 = 2. G5 = 2.3 G6 ='
2.2 G7 = 2. G8 = 1.
DEFINE GROUPP 0:* 8: G1 = 195. G2 = 400. G3 = 150. G4 = 200. G5 = 100.'
 G6 = 200. G7 = 360. G8 = 25.
DEFINE GROUPI 0:* 8: G1 = 7000. G2 = 5000. G3 = 10000. G4 = 12000. G5 '
= 6000. G6 = 9000. G7 = 200. G8 = 0.
DEFINE GROUPC 0:* 8: G1 = 0.5 G2 = 0.5 G3 = 0.2 G4 = 0.2 G5 = 0.6 G6 ='
 0.4 G7 = 1.2 G8 = 0.
DEFINE GROUPTI 0:* 8: G1 = 14. G2 = 12. G3 = 24. G4 = 30. G5 = 25. G6 '
= 32. G7 = 22. G8 = 14.
DEFINE GROUPX 0:* 8: G1 = 15. G2 = 15. G3 = 10. G4 = 12. G5 = 20. G6 ='
 30. G7 = 8. G8 = 7.
DEFINE GROUPMR 0:* 8: G1 = 88.8 G2 = 78.8 G3 = 88.8 G4 = 88.8 G5 = '
88.8 G6 = 55.9 G7 = 65.9 G8 = 0.
DEFINE TLIST2 1: 1*
PUT TLIST2 4,17(16.) 4,26(22.) 4,29(22.) 5,16(12.) 5,17(11.) 5,19(14.)'
 5,20(12.) 5,23(14.) 5,29(22.) 6,11(15.) 6,19(15.) 6,23(18.) 7,11(14.)'
 7,19(16.) 12,31(26.) 13,32(20.) 14,32(20.) 19,37(11.) 22,13(13.) 22,'
14(10.) 22,26(9.8) 23,14(10.) 23,26(10.4) 23,34(9.8) 25,23(12.8) 25,34'
(10.) 26,25(10.6) 26,26(10.6) 26,29(9.8) 30,17(10.8) 31,19(9.6) 31,20('
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FILE: SKYWAY   KIRBY    P1                    MASSACHUSETTS INSTITUTE OF TECHNOL(

11.6) 31,29(12.) 31,31(12.8)
DEFINE TLIST3 0:* 1: NUMB = 0.
PUT TLIST3 29,22 30,22
DEFINE INFO 9: TBA FAR POP INCOME INVEST CARS PDENSITY ASSEST TAX*
PUT INFO 4,13(373090.8,6.48,1865.45,1.678907007,1.193891007,746.18,'
200.,4775563.,266953.9) 4,14(373090.8,6.48,1865.45,1.678907007,'
1.193891007,746.18,200.,4775563.,266953.9) 5,13(373090.8,6.48,1865.45,'
1.678907007,1.193891007,746.18,200.,4775563.,266953.9) 5,14(373090.8,'
6.48,1865.45,1.678907007,1.193891007,746.18,200.,4775563.,266953.9) 6,'
10(150260.9,5.22,1502.61,9015651.,3756521.,901.57,100.,1502608.,'
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FILE: SKYWAY KIRBY P1 MASSACHUSETTS INSTITUTE OF TECHNOL

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396.,360.,1045440.,68894.44) 18,34(100800.,3.5,280.,56000.,2217600.,'
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2534400.,384.,360.,1013760.,66806.75) 23,28(122400.,4.25,340.,68000.,'
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132479.9,4.6,368.,73599.94,2914558.,441.6,360.,1165823.,76827.69) 25,'
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FILE: SKYWAY   KIRBY    P1                    MASSACHUSETTS INSTITUTE OF TECHNOL

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65971.56) 29,31(106559.9,3.7,296.,59199.95,2344318.,355.2,360.,'
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PUT TEMP1 28,21 28,22 28,23 29,21 29,22 29,23 30,21 30,22 30,23
DEFINE TEMP2 0:*
PUT TEMP2 28,22 29,21 29,22 29,23 30,22
DEFINE TLIST1 0:*
PUT TLIST1 4,11 4,16 4,17 4,19 4,20 4,22 4,23 4,25 4,26 4,28 4,29 4,31'
 4,32 4,34 5,16 5,17 5,19 5,20 5,22 5,23 5,25 5,26 5,28 5,29 5,31 5,32'
 5,35 6,11 6,16 6,17 6,19 6,20 6,22 6,23 6,25 6,26 6,32 7,11 7,16 7,17'
 7,19 7,20 8,16 8,17 9,11 10,35 11,32 11,34 11,35 12,28 12,31 12,32 12'
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FILE: SKYWAY   KIRBY    P1                    MASSACHUSETTS INSTITUTE OF TECHNCL

 6,32 6,34 6,35 7,11 7,16 7,17 7,19 7,20 7,25 7,26 7,28 7,29 7,31 7,32'
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25 31,26 31,28 31,29 31,31 31,32 31,34 31,35 31,37 31,38 32,10 32,11 '
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32 32,34 32,35 32,37 32,38
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PUT W1 30,22
DEFINE TEMPSUR 0:*
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21 31,22 31,23
DEFINE SURROUND 0:*
PUT SURROUND 31,22 31,23
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Q = 9.
I = 1.
J = 7.
WORK = 7.
A = 1.
MAX = 1.
T2 = 1761|
MINAV = 3.
T4 = 1833|
C = 2.
T3 = 1833|
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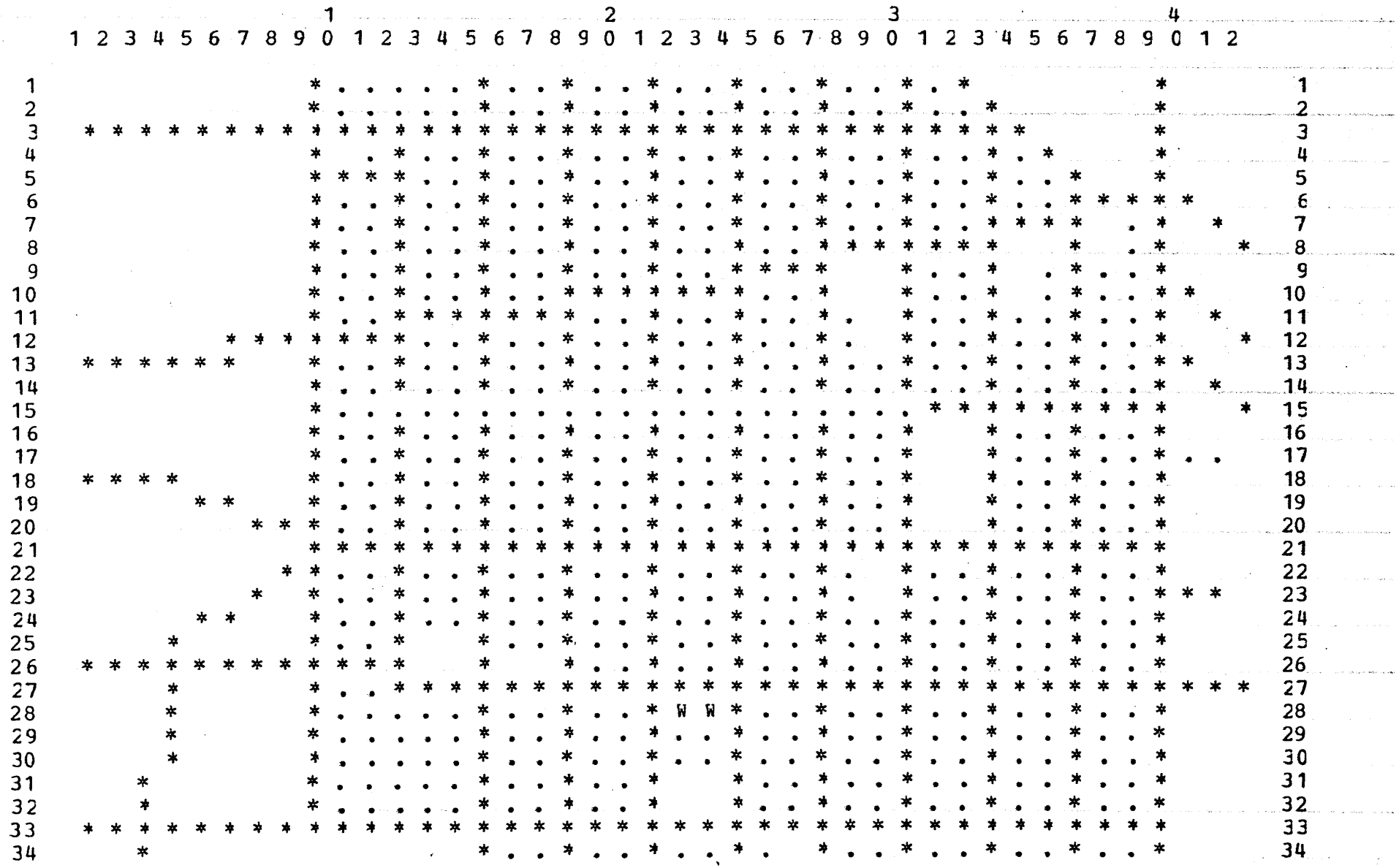
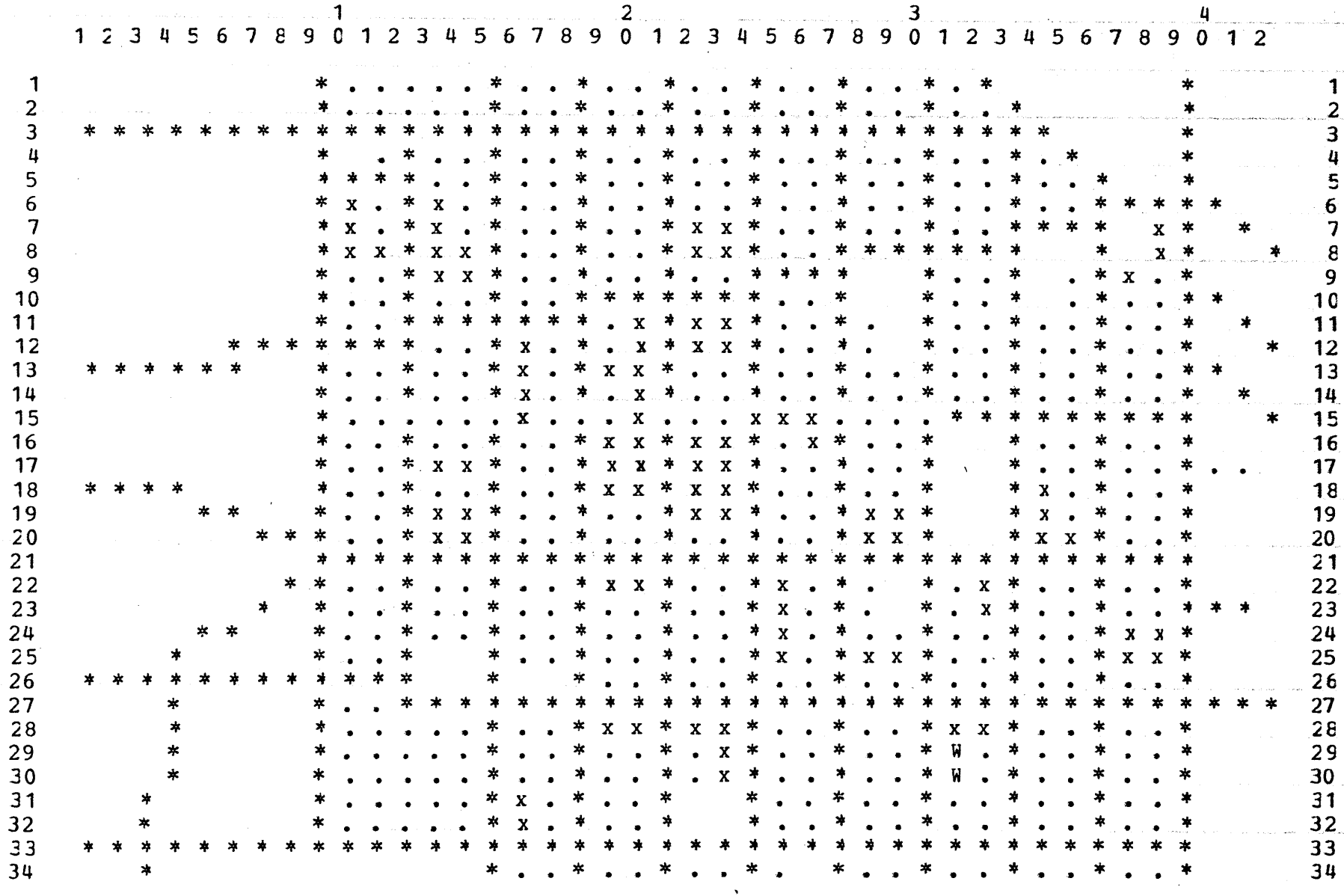


LEGEND: DEVELOPMENT LOCATION #1

PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = TLIST3(23) ; '*' = STREET(3) ; '.' = PARCEL(2) ; ' ' = NOTAV(4)

'.' = *, . 'x' = NON EMPTY LAND



LEGEND: DEVELOPMENT LOCATION #58

PRIMARY ATTRIBUTE ASSIGNMENTS - - 'W' = ILIST3(23); '*' = STREET(3); '.' = PARCEL(2); ' ' = NOTAV(4)

'.' = *, . ' ' = ., 'x' = NON EMPTY LAND