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An Analysis of Bus Ridership Potential to Oregon Health Sciences University Using a Geographic Information System Approach

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AN ANALYSIS OF BUS RIDERSHIP POTENTIAL TO OREGON HEALTH SCIENCES UNIVERSITY USING A GEOGRAPHIC INFORMATION SYSTEMS APPROACH

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ABSTRACT

GIS address-matching and overlay techniques can be used in the analysis of specialized transportation problems. These techniques enhance the spatial resolution of transportation services relative to the locations of potential users of the service. This allows planners to evaluate accessibility issues for identifiable user groups and thus make decisions about the feasibility of adjusting routes or schedules, or providing new services for these users. A case study focused on the commuter base of Oregon Health Sciences University is presented as an example of such an application.

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INTRODUCTION

Geographic Information System (GIS) technology potentially offers a powerful tool for transportation planning and analysis. In addition to use for pathfinding and allocation problems common to transportation network analysis (Lupien et.al, 1987;Shaw, 1989), GIS can be used as a decision support tool in planning applications that ask more basic questions about transportation services. Specifically, GIS is well suited to the preliminary tasks of identifying the spatial relationships between the location of existing or proposed services, and the locations of potential users of a service. Particularly when a large, identifiable commuter group traveling to the same destination can be identified.

In dealing with the preliminary locational aspects of this type of transportation problem, GIS address-matching and overlay functions, rather than the network commands mentioned above, are of primary interest. GIS address-matching allows the analyst to match the locations of potential users of a service from an employee database, or other source, to the street network of a study area. Once the potential users are spatially referenced, GIS overlay commands allow for combination with other coverages representing existing or proposed services. Evaluations can then be made as to the numbers of potential riders with easy access to an existing service. Feasibility studies for new services can also be initiated using this approach.

The research and case study presented in this report documents the application of these techniques using ARC/INFO GIS software on a personal computer. The fact that the research was carried out on a PC platform is evidence of the speed that GIS technology is moving within reach of individual analysts.

RESEARCH EXAMPLE

Transportation Problems at OHSU

The focus of the research centers around the transportation and parking problems at Oregon Health Sciences University (OHSU) in Portland, Oregon. OHSU is a major employer in the metropolitan area with over 5000 employees and approximately 2500 students (Hannum, 1989). The transportation and parking problems inherent with a commuter base of this size, are compounded by the site and situation of OHSU. The facility is perched on Marquam Hill at the southwest edge of downtown Portland, is surrounded by residential neighborhoods with little room for growth, and has limited vehicular access by two-lane roads (Figure 1). Recent changes in zoning laws have further aggravated the parking problems by prohibiting employee parking in the surrounding neighborhoods (Hannum, 1989).

Tri-Met, Portland's mass transit agency, enlisted the help of Portland State University, Center For Urban Studies, to assist in analyzing the potential for increased mass transit usage on the part of the OHSU community. The question asked by Tri-Met at the beginning of study was how the location of OHSU employees meshed with existing bus routes, and whether or not route or schedule adjustment might encourage greater use of public transportation to the "hill". Tri-Met also proposed analyzing the demographics of potential ridership for direct-service vans along four possible alternatives, and from the current park and ride locations scattered within the study area.

In general, little was known about the distribution of employees relative to existing services, and whether or not "spatial accessibility" was a factor limiting employee usage of mass transit. The study was carried out using employee data that was downloaded from the OHSU employee database one time only. No provisions were made to update the employee data during the study period, nor was historical data researched to provide for analysis of past distribution trends.

Study Area Delineation

The study was started by tabulating and mapping the OHSU employee database by zip code using ATLAS mapping software. Zip code mapping involved much less effort than address-matching techniques used subsequently. This step was undertaken to limit the study area to a manageable size for processing on a PC-based system (limiting the number of street segments), and in the hope that concentrations of employees might be identified on which to focus the GIS analysis. The results of this mapping effort showed a wide distribution of employees across the entire metro region (Figure 2).

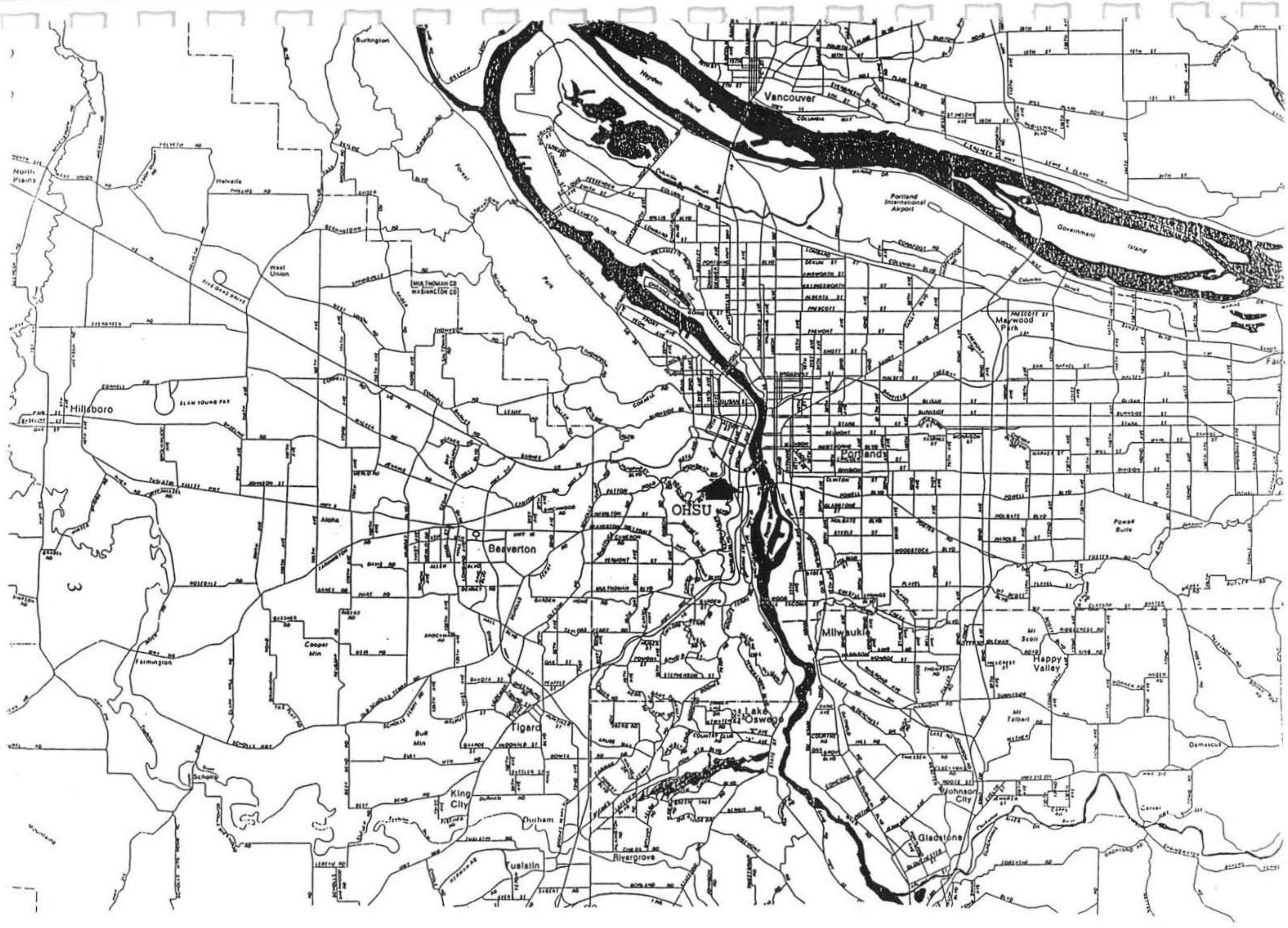


FIGURE 1. LOCATION OF OHSU AT THE SOUTHWEST EDGE OF DOWNTOWN PORTLAND.

OHSU EMPLOYEES BY ZIP CODE AREA

FOCUS ON AREAS ⟩ 100 EMPLOYEES

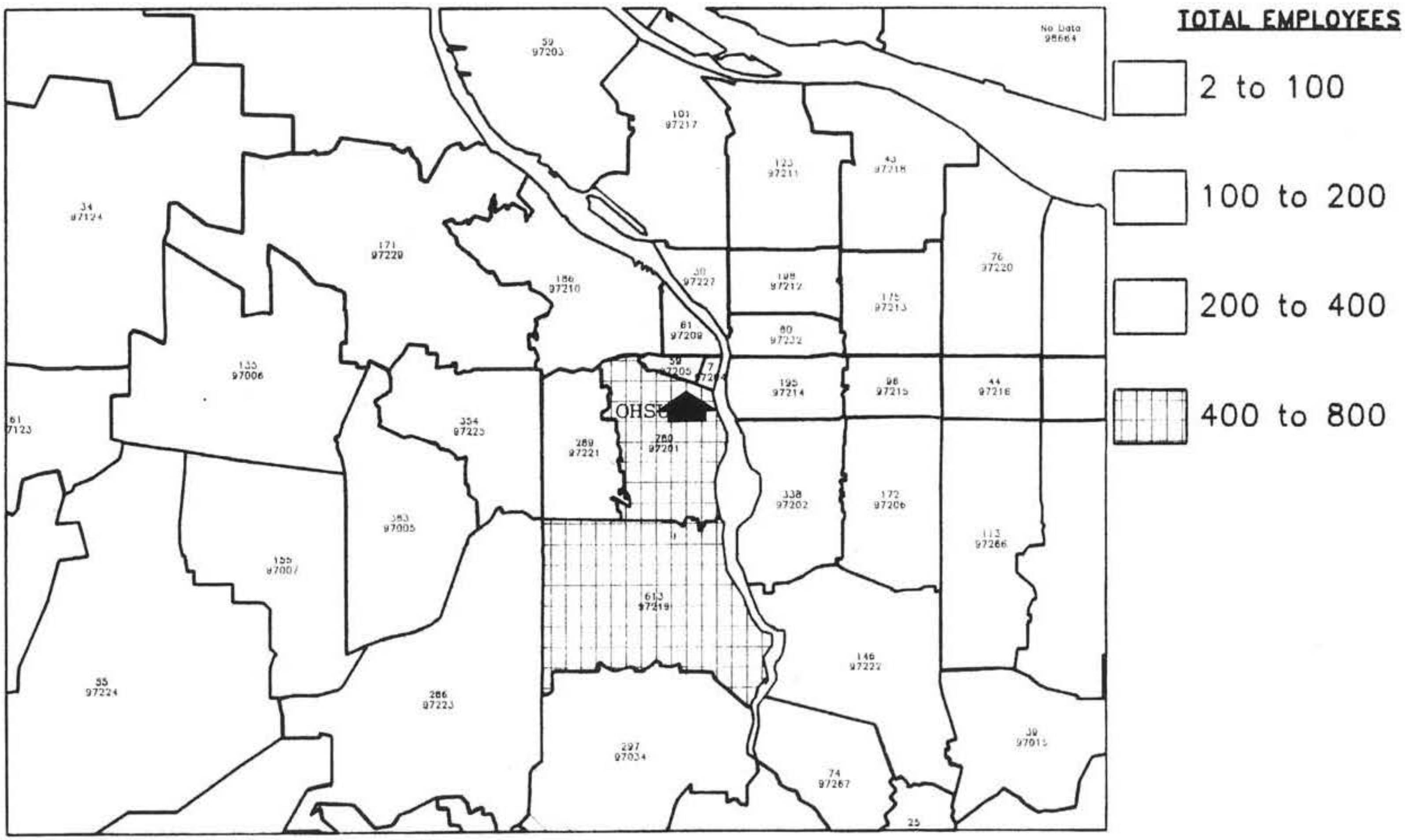


FIGURE 2. AN EXAMPLE OF THE CHOROPLETH MAPPING
UNDERTAKEN AT THE BEGINNING OF THE STUDY.

Although this did not provide an easy method for limiting the study area, it was nevertheless enlightening in that it immediately discounted some of the subjective opinions held by OHSU that certain areas of the city represented larger proportions of employees which could easily be targeted for mass transportation. Tri-Met subsequently selected a study area ranging from the southeast side of Portland, across the Willamette River from OHSU, to the southwestern suburbs of Beaverton and Tigard, based on the relatively high numbers of employees and students in these areas, and on proximity to OHSU (Figure 3).

Address Matching

Address matching of attribute information from a tabular data file, such as an employee database, requires a geocoded street network with address ranges associated with each arc in the network file. The street network can be manually digitized and geocoded, but for the purposes of this study a preliminary copy of the U.S. Bureau of the Census TIGER (Topologically Integrated Geographic Encoding and Referencing) file was utilized.

After loading the TIGER file street network into the GIS, the employee database was address matched and the results were evaluated for the number of matches and rejects. Approximately 90 percent of the employee records were matched without further processing (See Table 1). Upon examination of the rejects file, it was concluded that data quality problems in the OHSU employee database was by far the largest reason for rejection. Specific problems noted were those related to P.O. box addresses and other street-name data-entry errors. A slightly lower rate of matching success was observed in the suburban areas due to the preliminary nature of the TIGER file. In these areas, the newer streets were not yet address-ranged; a problem that was to be corrected by release of updated versions of the file after this research was completed.

Initial Overlay Analysis

The bus routes covering the study area had to be manually digitized and registered to the street network before the actual overlay analysis could be started. It was recommended by Tri-Met that a buffer of approximately two city blocks be used around the bus routes as an acceptable walking distance to a bus line for most riders (Figure 4). The creation of buffer zones around points or lines is a function easily carried out by a GIS system. For this study

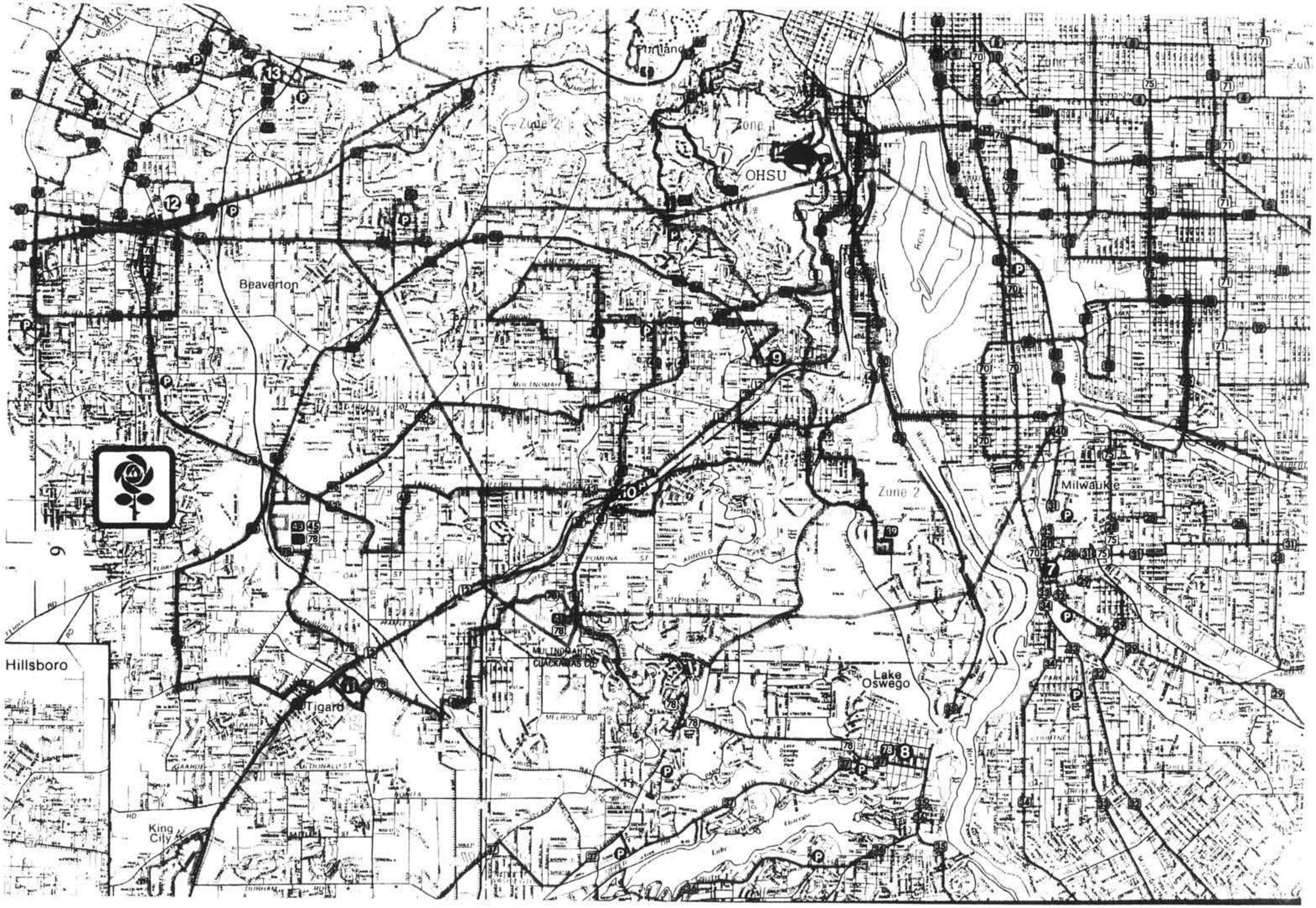


FIGURE 3. STUDY AREA WITH BUS ROUTES.

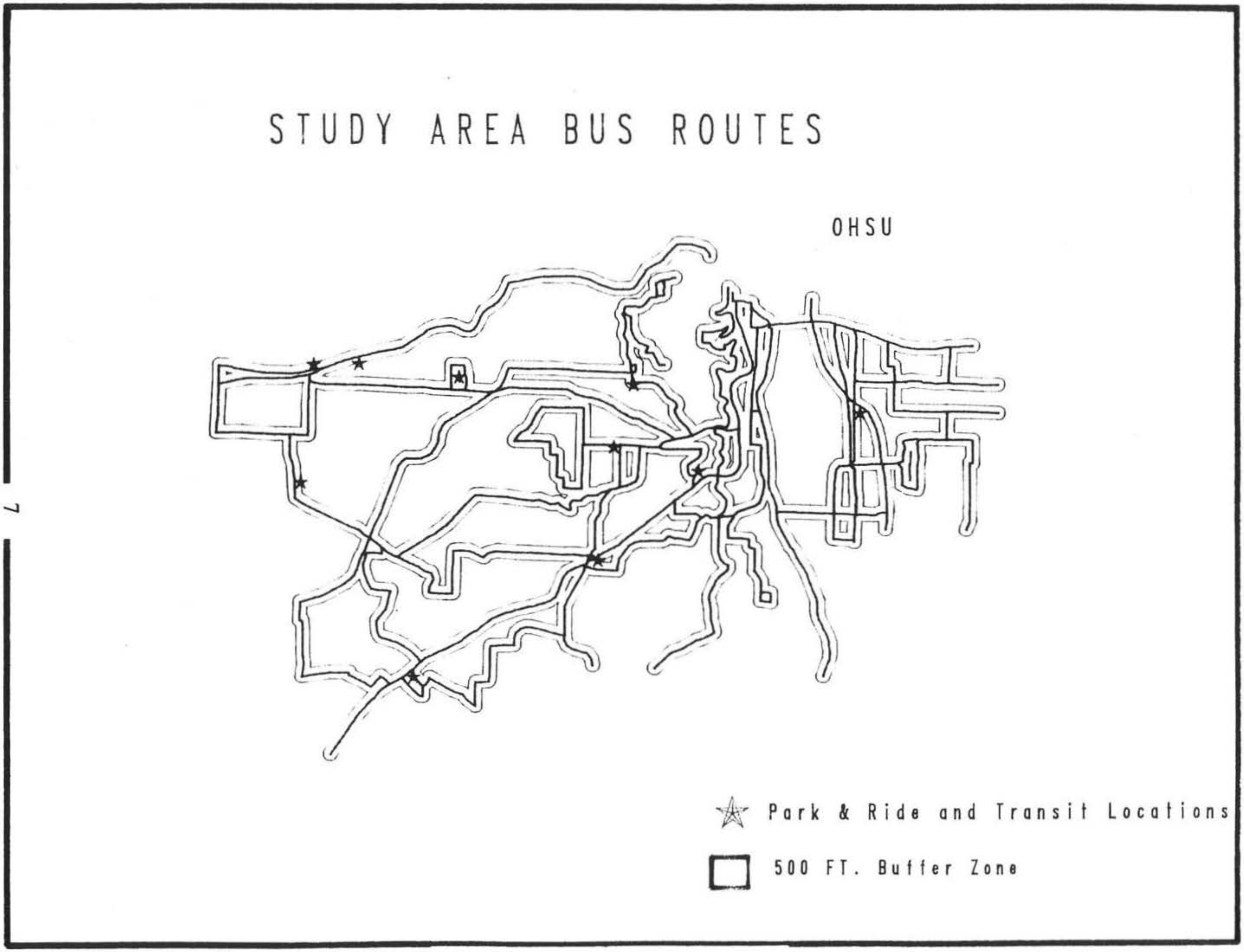

STUDY AREA BUS ROUTES
OHSU
Park & Ride and Transit Locations
500 FT. Buffer Zone

FIGURE 4

TABLE 1. EVALUATION OF ADDRESS MATCHING SUCCESS

ZIP	LOCATION	STATUS*	TOTAL RECORDS	RECORDS MATCHED	PERCENT MATCHED
97202	SE	COMPLETE	337	307	91.1%
97219	SW	COMPLETE	612	535	87.4%
97223	TIGARD	COMPLETE	285	220	77.2%
97221	WEST HILLS	PARTIAL	288	240	83.3%
97005	BEAVERTON	PARTIAL	382	286	74.9%
97201	SW (OHSU)	PARTIAL	779	455	58.4%
97225	BEAVERTON	PARTIAL	353	175	49.6%
97224	KING CITY	PARTIAL	54	26	48.1%
97206	SE WOODSTOCK	PARTIAL	171	72	42.1%
97204	DOWNTOWN	PARTIAL	6	1	16.7%
97205	DOWNTOWN	PARTIAL	58	8	13.8%
97222	MILWAUKIE	PARTIAL	145	13	9.0%
97215	SE	PARTIAL	95	5	5.3%
97034	LAKE OSWEGO	PARTIAL	296	11	3.7%
97214	SE	PARTIAL	194	2	1.0%

*STATUS REFERS TO THE EXTENT TO WHICH THE ZIP CODE AREA WAS INCLUDED WITHIN THE CENSUS TRACTS EXTRACTED FROM THE TIGER FILE. IN MOST CASES PART OF THE ZIP CODE AREA FELL OUTSIDE OF THE CENSUS TRACTS. SINCE THE EMPLOYEE DATA IS SUMMARIZED BY ZIP CODE, ADDRESS-MATCHING SUCCESS FOR THESE AREAS CANNOT BE EVALUATED.

EXAMINATON OF THE REJECT RECORDS (UNMATCHED) REVEALED THAT DATA QUALITY PROBLEMS IN THE OHSU EMPLOYEE FILE WERE RESPONSIBLE FOR MOST OF THE REJECTS. PROBLEMS INCLUDED: POST OFFICE BOX ADDRESS DESCRIPTIONS; STREET NAME MISSPELLING; STREET NAMES FROM OTHER PARTS OF TOWN WITH THE WRONG ZIP CODE; AND STREET NAME STRUCTURE PROBLEMS.

THE PRELIMINARY NATURE OF THE TIGER FILE IN SUBURBAN AREAS, WHERE NEW STREETS HAVE NOT YET BEEN ADDRESS-RANGED, ACCOUNTED FOR THE REMAINING REJECTS.

constant-distance buffers were employed, but a GIS system can also selectively buffer based on selection criteria defined by the user.

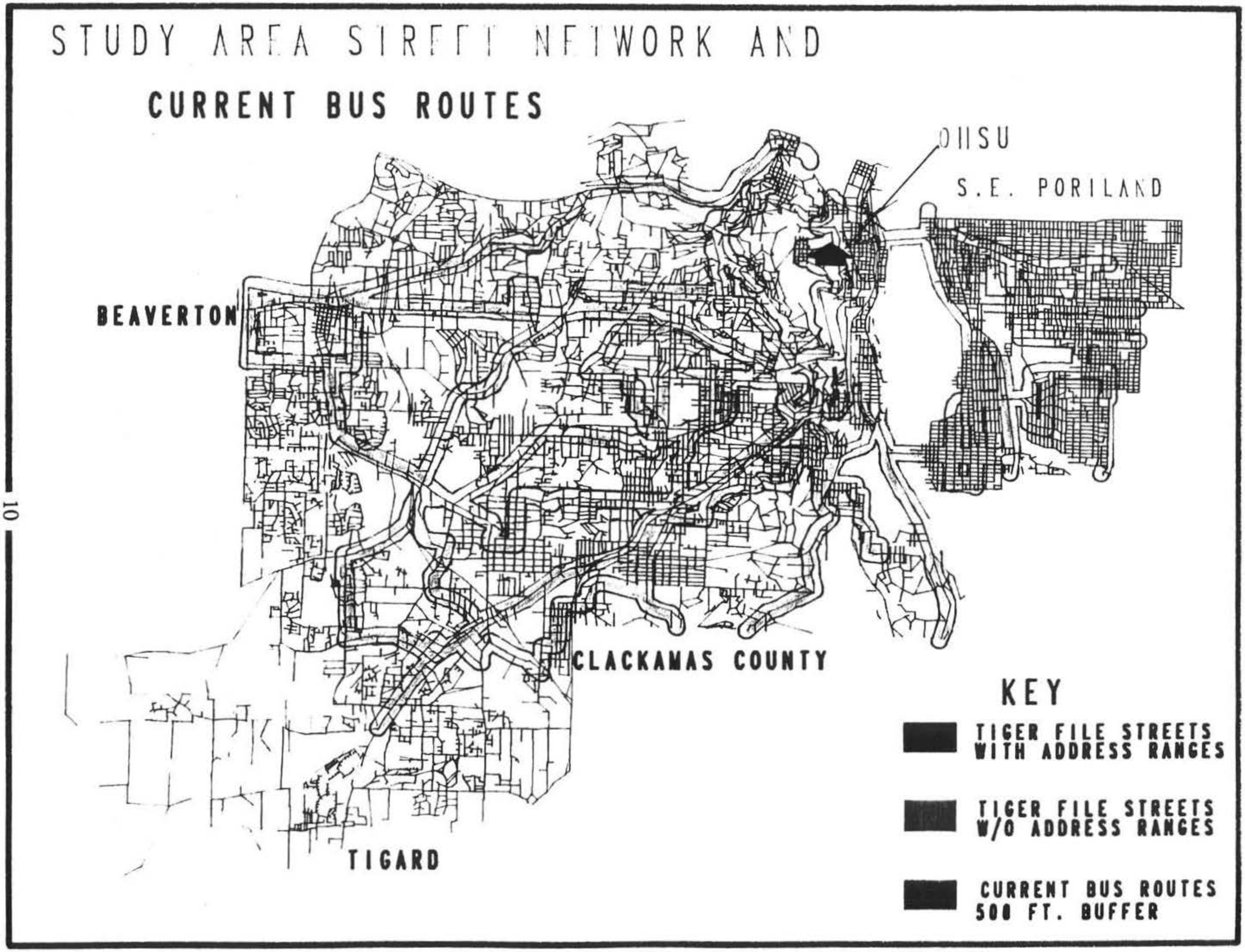
After the bus routes had been buffered, map overlays of the street network, employee locations, and bus routes were created for visual inspection. The first example, Figure 5, shows the detail of the street network from the TIGER file with streets without address ranges in red, streets with address ranges in black, and the buffered bus routes in blue. The second example, Figure 6, is a density map of employee locations in comparison to the bus route network. In this case the street network was filtered during the mapping process. In the third example, Figure 7, a zoom-plot of an area in close proximity to OHSU was plotted to demonstrate the power of a GIS system in selectively displaying varying degrees of detail for analysis.

GIS functionality does not end with the production of overlay mapping products. One of its major strengths is its capability to perform complicated spatial intersections of two coverages to produce new coverages with only the data subsets of interest. For this study, intersection processing was performed with the buffered bus-routes and employee location coverages. The intersection results were tabulated by zip code for evaluation of the total number of employees falling within the 500 foot buffer.

The results from this intersection (See Table 2) revealed that over 40% of all employees were within 500 feet of a bus line. Discussions with Tri-Met about these findings, and in review of the density map (Figure 6), resulted in the decision to abandon the idea of adjusting regular bus routing or scheduling in an effort to pick up more riders for OHSU. It was felt that the small numbers did not warrant changes in mainline services aimed at increasing ridership by one user group.

<u>**Analysis of Direct-Service Alternatives**</u>

After concluding that adjusting mainline routes or schedules was of questionable benefit to the OHSU problem, Tri-Met officials then suggested analyzing the demographics of potential ridership for new direct-service van lines servicing the OHSU location. In addition, it was decided to look at park and ride locations as potential pick-up points for this service. Four



STUDY AREA STREET NETWORK AND
CURRENT BUS ROUTES
OHSU
S.E. PORTLAND
BEAVERTON
CLACKAMAS COUNTY
TIGARD
KEY
TIGER FILE STREETS WITH ADDRESS RANGES
TIGER FILE STREETS W/O ADDRESS RANGES
CURRENT BUS ROUTES 500 FT. BUFFER

FIGURE 5

OHSU EMPLOYEES AND CURRENT BUS ROUTES

DAY AND VARIABLE SHIFT ONLY

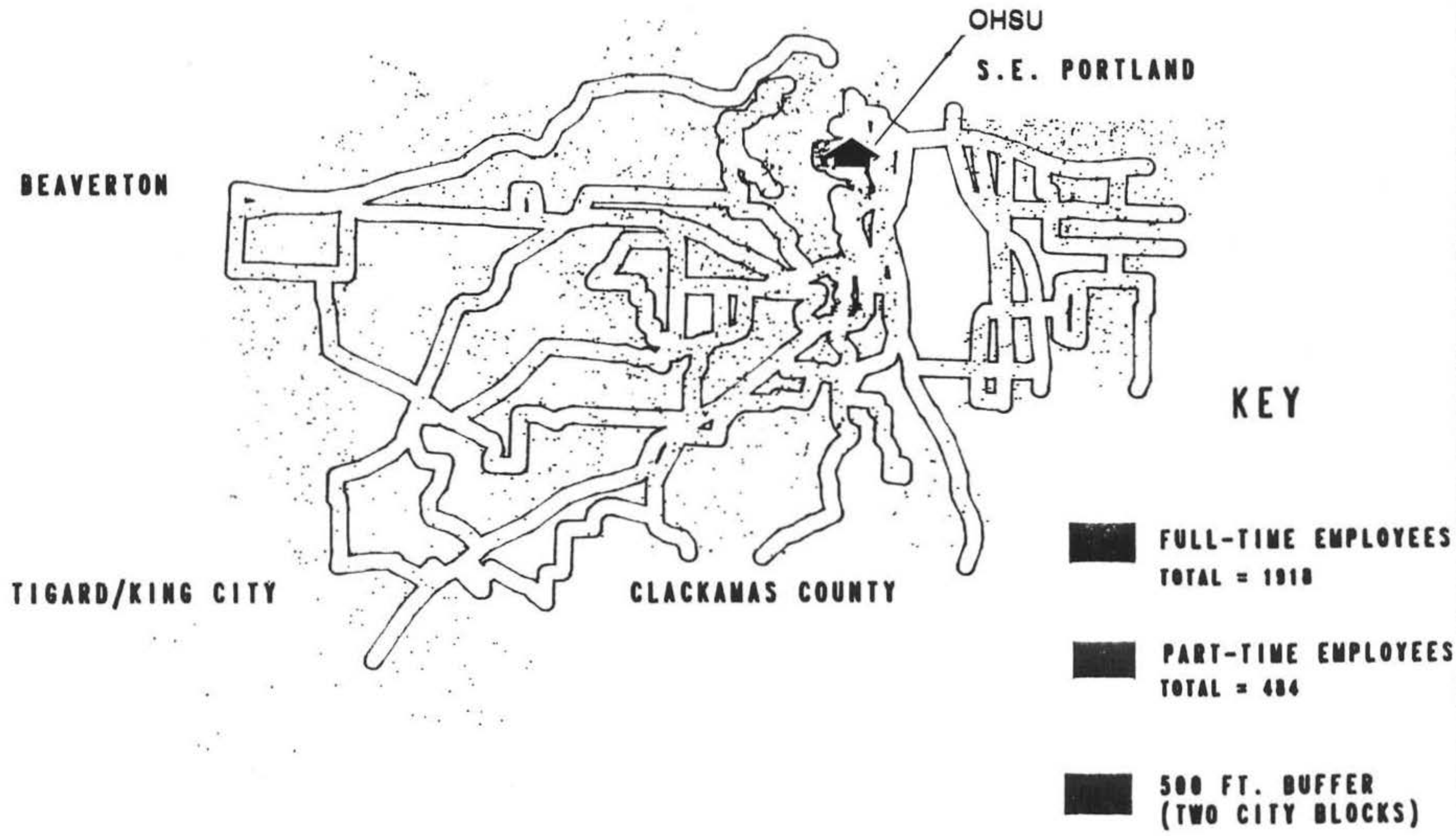


FIGURE 6

SOUTHWEST OF STUDY AREA
ALL DAY AND VARIABLE SHIFT EMPLOYEES

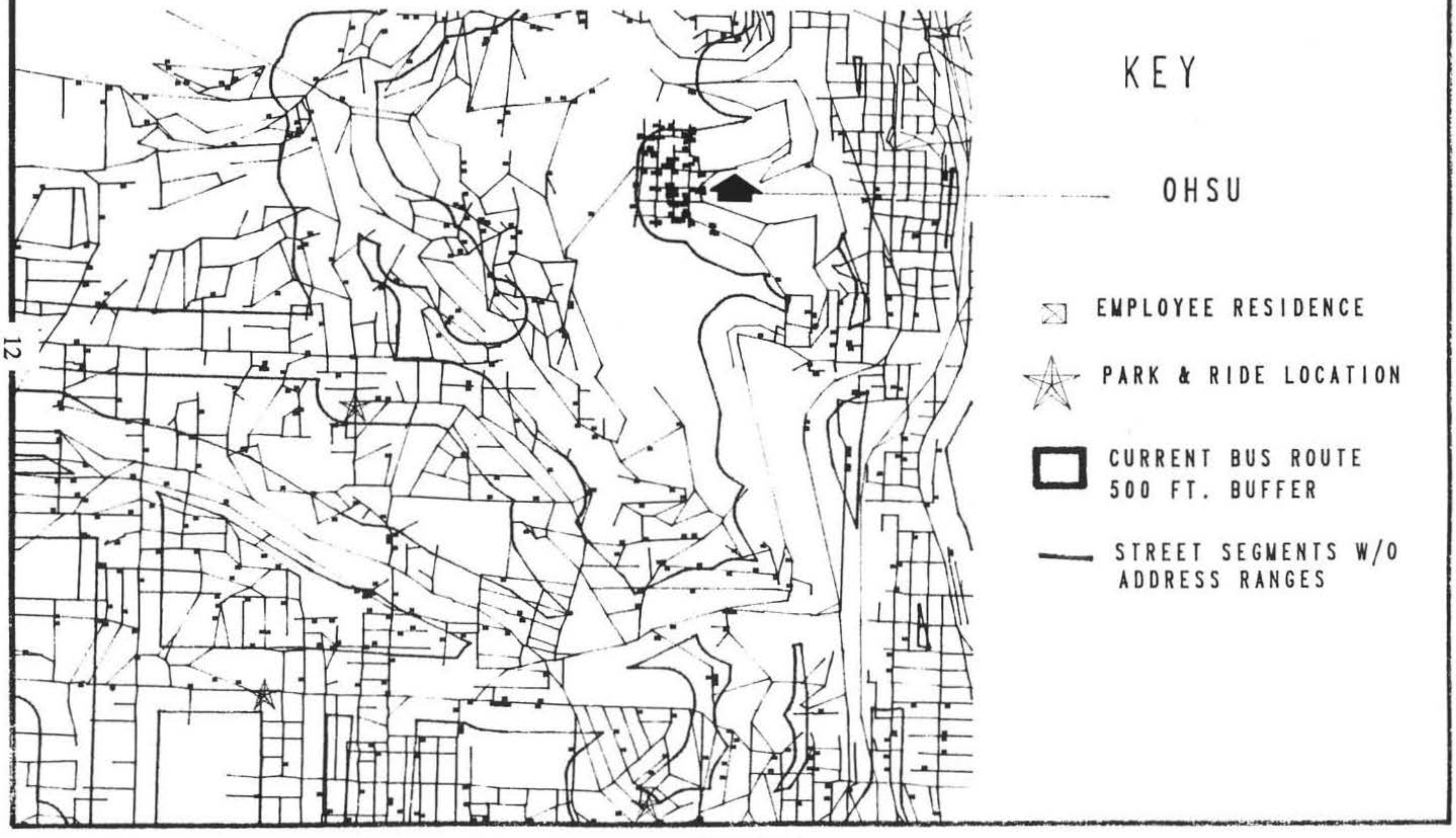


FIGURE 7

TABLE 2. INTERSECTION OF ADDRESS-MATCHED RECORDS WITH 500 FT. BUFFER.

ZIP	LOCATION	STATUS*	ADDRESS MATCHED RECORDS	ADDRESS MATCHED RECORDS IN BUFFER	PERCENT MATCHED IN BUFFER
97202	SE	COMPLETE	307	131	42.7%
97219	SW	COMPLETE	535	234	43.7%
97223	TIGARD	COMPLETE	220	90	40.9%
97221	WEST HILLS	PARTIAL	240	111	46.3%
97005	BEAVERTON	PARTIAL	286	129	45.1%
97201	SW (OHSU)	PARTIAL	455	199	43.7%
97224	KING CITY	PARTIAL	26	9	34.6%
97225	BEAVERTON	PARTIAL	175	74	42.3%
97206	SE WOODSTOCK	PARTIAL	72	27	37.5%
97204	DOWNTOWN	PARTIAL	1	1	100.0%
97205	DOWNTOWN	PARTIAL	8	4	50.0%
97222	MILWAUKIE	PARTIAL	13	6	46.2%
97215	SE	PARTIAL	5	2	40.0%
97034	LAKE OSWEGO	PARTIAL	11	5	45.5%
97214	SE	PARTIAL	2	1	50.0%

*SEE DISCUSSION OF STATUS WITH TABLE 1.

major commuter corridors (Figure 8) and seven park and ride locations (Figure 9) were selected for review and tabulation.

As above, the route alternatives and park and ride lots were digitized, buffered and intersected with the address-matched employee coverage. The map seen in Figure 10 shows the results of the route-alternative intersections using a quarter-mile buffer. A one-mile buffer was used as the intersection criteria around the park and ride lots (Figure 11).

Cross-tabulations of the intersected employee records by four major employee-attribute categories were completed for each route alternative and park and ride lot (See Tables 3 and 4). The variables tabulated included: Work Period; Job Classification; Car Pool Participation; and Parking Seniority.

Tri-Met officials reacted favorably to the results of this analysis as it graphically and numerically seemed to support the idea of implementing, at least on a trial basis, a dedicated van service along one of the first three alternatives. Of particular interest was the fact that a large number of the total employees along these routes could be identified as having no parking seniority. In effect, they did not qualify for the limited number of parking permits available at OHSU.

It was noted by Tri-Met that implementation of any direct service to OHSU would probably have to be subcontracted to a private carrier with lower overhead expenses than those of a public transit authority. The applicability and need for private sector involvement in public transportation problems such as those seen in OHSU situation are discussed by Farkas and De Rouville (1988).

Whether or not this type of service is pursued will require cooperation between Tri-Met and OHSU. As of the writing of this report, OHSU officials had independently consulted with a private carrier over the feasibility of providing services to OHSU. The exact nature and extent of these services is not known.

With the attribute data maintained by the GIS it would be possible to conduct a survey of the employees identified within the corridor for further delineating the numbers of potential riders interested in transit services. This was not attempted as part of the GIS focus of this research.

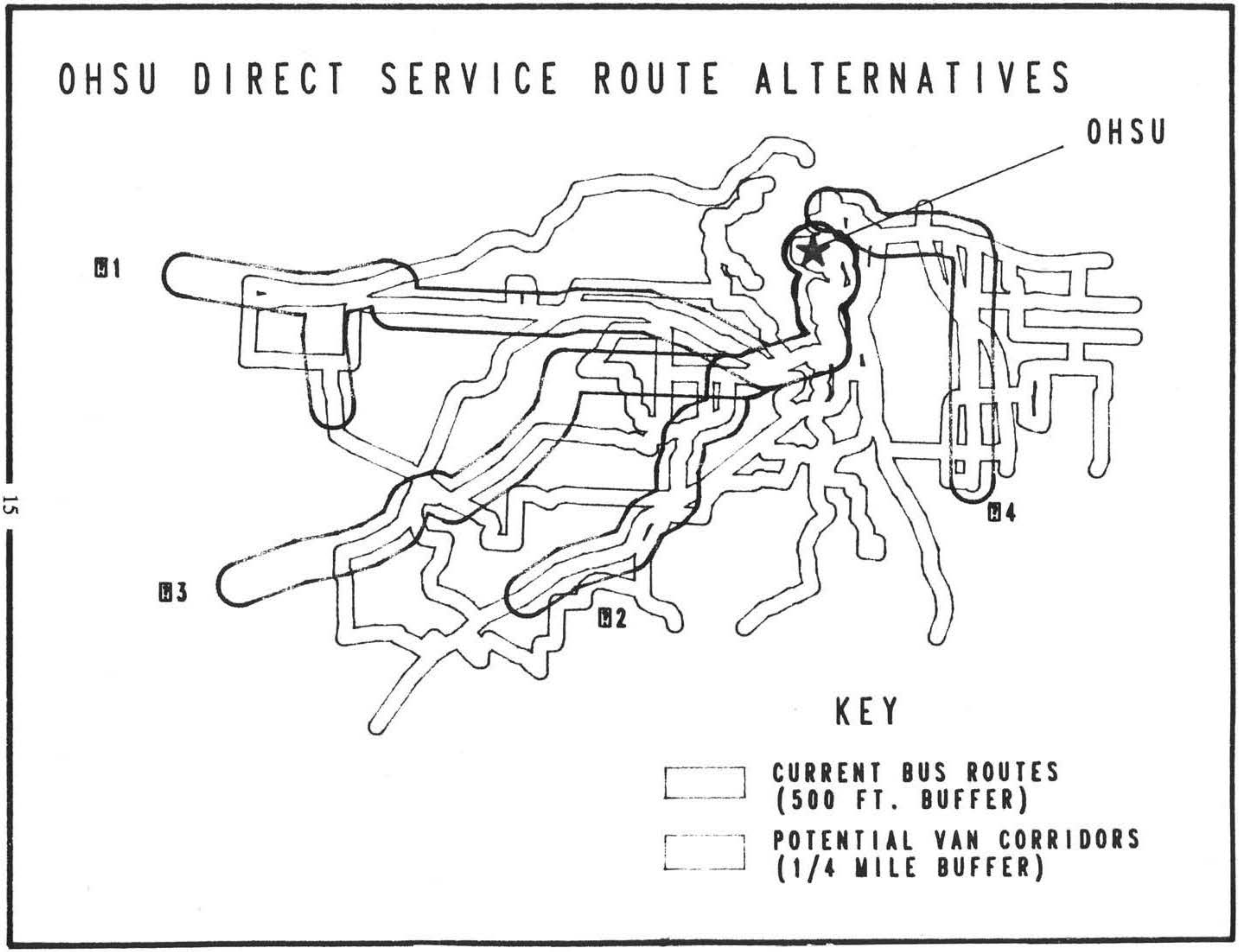

OHSU DIRECT SERVICE ROUTE ALTERNATIVES
OHSU
1
2
3
4
KEY
CURRENT BUS ROUTES
(500 FT. BUFFER)
POTENTIAL VAN CORRIDORS
(1/4 MILE BUFFER)

FIGURE 8

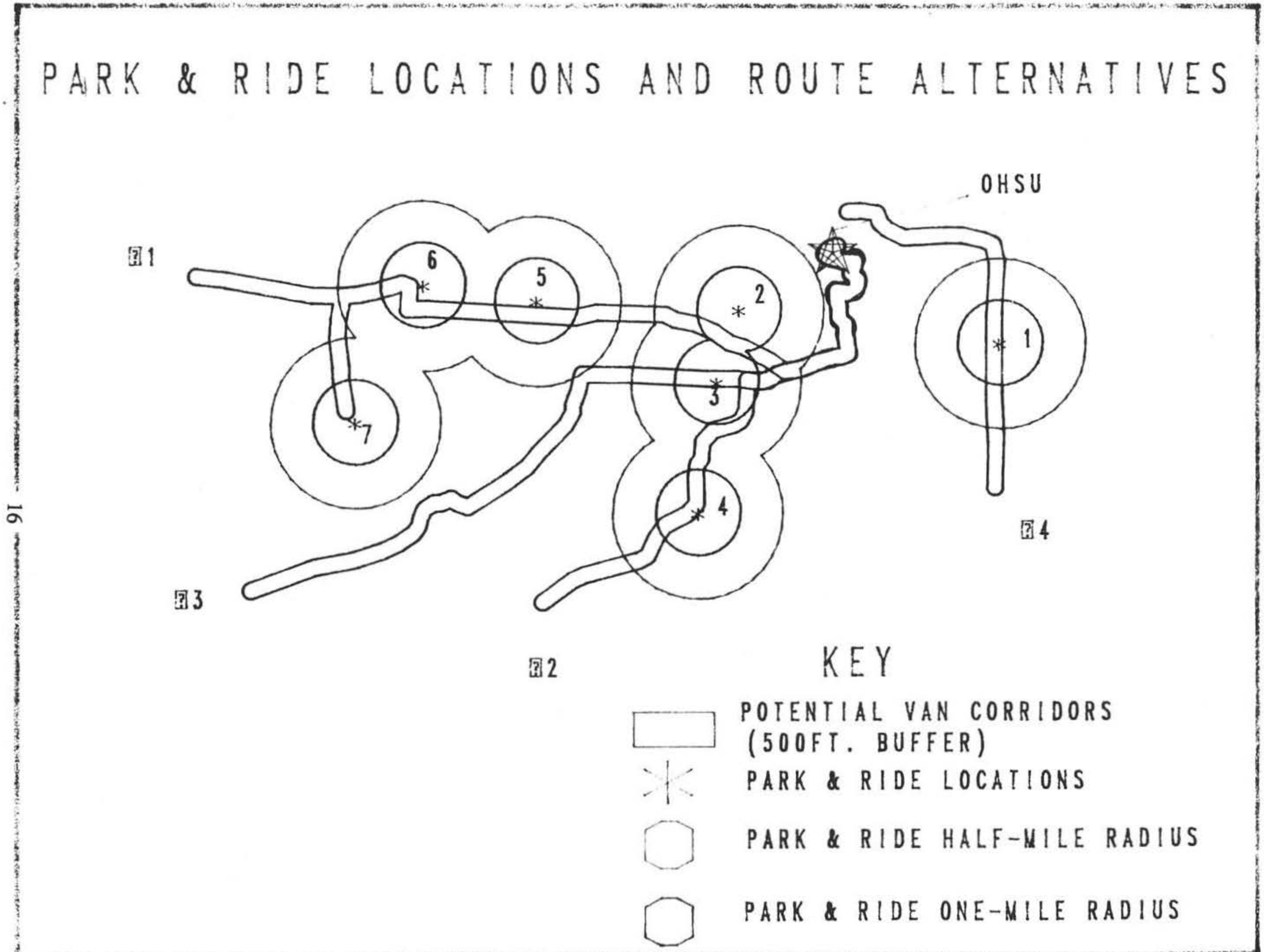

PARK & RIDE LOCATIONS AND ROUTE ALTERNATIVES
OHSU
1
2
3
4
5
6
7
KEY
POTENTIAL VAN CORRIDORS (500FT. BUFFER)
PARK & RIDE LOCATIONS
PARK & RIDE HALF-MILE RADIUS
PARK & RIDE ONE-MILE RADIUS

FIGURE 9

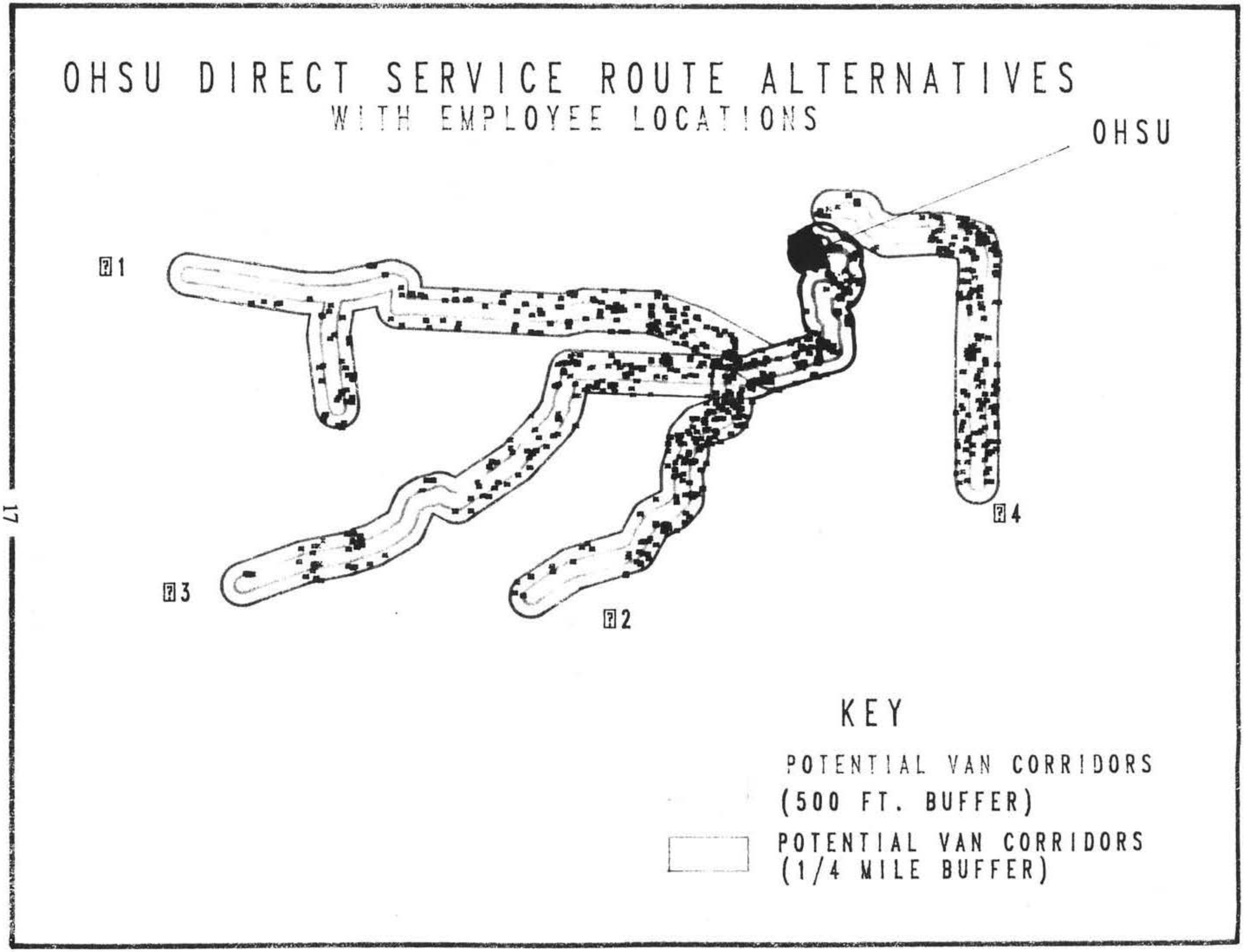

OHSU DIRECT SERVICE ROUTE ALTERNATIVES
WITH EMPLOYEE LOCATIONS
OHSU
1
2
3
4
KEY
POTENTIAL VAN CORRIDORS
(500 FT. BUFFER)
POTENTIAL VAN CORRIDORS
(1/4 MILE BUFFER)

FIGURE 10

PARK & RIDE LOCATIONS AND ROUTE ALTERNATIVES WITH EMPLOYEE LOCATIONS

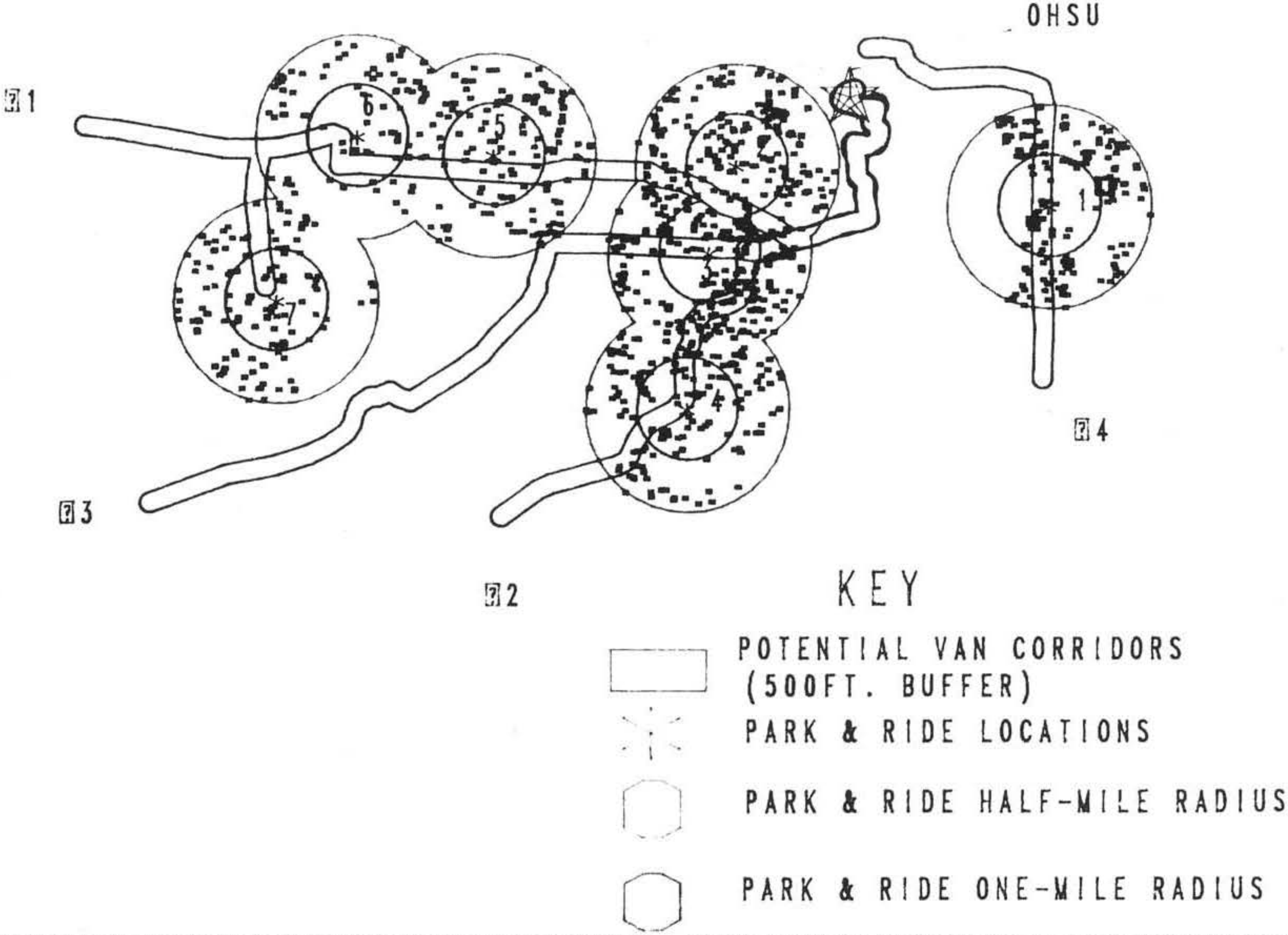


FIGURE 11

TABLE 3. EMPLOYEE DEMOGRAPHICS FOR PARK & RIDE LOCATIONS (1 MILE BUFFER*).

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7
TOTAL EMPLOYEES**	68	244	256	151	114	64	83
WORK PERIOD							
Day	25	93	108	66	54	30	37
Variable	15	77	73	41	32	22	23
Night	1	3	4	2	3	1	2
Swing	6	7	7	4	4	1	7
Null	21	64	64	38	21	10	14
CLASSIFICATION							
Classified	21	40	63	41	26	18	35
Faculty & Management	8	54	34	23	33	11	15
Residents & Interns	3	37	50	24	9	4	8
Students	9	14	20	18	13	7	8
Others	27	99	89	45	33	24	17
CAR POOL PARTICIPATION							
Car Pool	4	7	16	6	8	3	9
No Car Pool	64	237	68	145	106	61	74
PARKING SENIORITY							
ParkSen=0	25	67	71	46	23	13	19
ParkSen<=2	24	53	73	38	31	21	29
ParkSen<=5	14	79	76	43	33	17	18
ParkSen>5	5	45	36	24	27	13	17

*USING A ONE-MILE BUFFER OVERLAP OCCURS BETWEEN MOST PARK & RIDE LOTS. NO ADJUSTMENT FOR THIS OVERLAP HAS BEEN CALCULATED AT THIS TIME.

**THE TOTAL NUMBER OF EMPLOYEES REPRESENTS ALL EMPLOYEE RECORDS ADDRESS MATCHED, INCLUDING THOSE WITH INCOMPLETE ATTRIBUTE DATA.

TABLE 4. EMPLOYEE DEMOGRAPHICS FOR DIRECT ROUTE ALTERNATIVES (1/4 MILE BUFFER*)

	ALT. #1		ALT. #2		ALT. #3		ALT. #4
TOTAL EMPLOYEES**	416		392		389		85
WORK PERIOD							
Day	128		123		117		33
Variable	110		86		94		23
Night	2		2		1		2
Swing	6		4		7		5
Null	169		177		169		22
CLASSIFICATION							
Classified	62		70		66		33
Faculty & Management	51		36		41		4
Residents & Interns	61		53		48		8
Students	42		38		38		12
Others	200		195		196		28
CAR POOL PARTICIPATION							
Car Pool	16		13		10		3
No Car Pool	399		379		378		82
PARKING SENIORITY							
ParkSen=0	182		193		180		25
ParkSen<=2	111		98		100		26
ParkSen<=5	89		73		79		27
ParkSen>5	33		28		29		7

*THIS DATA REPRESENTS THE TOTAL POTENTIAL RIDERSHIP OF EACH ALTERNATIVE EVEN THOUGH ALTERNATIVES 1-3 PARTIALLY COVER THE SAME ROUTE IN APPROACHING OHSU FROM THE SOUTHWEST.

**THE TOTAL NUMBER OF EMPLOYEES REPRESENTS ALL EMPLOYEE RECORDS ADDRESS MATCHED, INCLUDING THOSE WITH INCOMPLETE ATTRIBUTE DATA.

Overall, Tri-Met planners were pleased with the results of the analysis. The primary benefit resulting from the research was the identification of employee locations. Tri-Met was able to conclude that their current mainline services provided acceptable access to OHSU commuters. Furthermore, the distribution of employees did not show any large groups that could be cost-effectively serviced by Tri-Met (See Appendix A). Any efforts to increase services to the employee base of OHSU will most likely require a joint effort by the private and public sector services.

DISCUSSION OF GIS METHODOLOGY

The substantive results presented above demonstrate the applicability of GIS to the problem of preliminary spatial referencing of transportation services. The automation of address-matching through a GIS system allows for an increased level of detail that would not normally be available to an analyst dealing with this type of question.

However, it must be noted that the detail does not come without a cost. The time involved in setting up the system with the TIGER file street network, address-matching, digitizing, buffering, intersecting, and data tabulation is quite extensive as it is with all GIS applications. In the best of worlds many of these time investments would be a one time expense and could be recovered in subsequent utilization.

Assuming this to be the case, it is easy to see how a GIS system could be used to carry out "what-if" analyses for recurring transportation questions dealing with proposed changes in transit services. Furthermore, the same street network used for address-matching and other preliminary locational referencing, could be enhanced with network attributes necessary for pathfinding or allocation undertakings.

As a final procedural comment it should be noted that when address-matching, a major emphasis must be given to data quality in the address database. In this study the reasons behind the rejection of records was investigated, but correction of these problems was not undertaken. In applications that demand stricter accounting of individuals this would not be acceptable and would require additional time for correction.

CONCLUSIONS

GIS technology can enhance the spatial resolution of employee locations relative to transportation services and thus offers a powerful tool for transportation planners. The increased spatial resolution can serve to delineate accessibility to existing services and to aid in feasibility analysis for new services. It can also be used as the starting point for targeting potential users of a service.

The GIS techniques involved in implementing studies of this type center around address-matching and overlay commands common to GIS systems. The more sophisticated algorithms involved in traditional network analysis can be incorporated into the implementation of such studies, but they are not necessary in the preliminary stages of analysis.

The results of the OHSU case study presented in this paper demonstrates how these techniques can be applied. The increased spatial resolution imparted by GIS allowed planners to look at the access to existing and alternative services, and thus increased objectivity in the preliminary stages of planning.

Further refinement and selection of service alternatives, using the GIS techniques demonstrated, or other spatial analysis methodology, would be of benefit. The application could also be enhanced by access to bus ridership data for the employee group being analyzed, both for the current time frame and for past years. In the case of the OHSU employee base, this information was not available but it could be developed by follow-up research.

Tri-Met, in considering the institutional issues of GIS implementation, will hopefully address the importance of maintaining archives of digital route networks and ridership data in order to preserve historical perspectives for future analysis and planning. Ideally, Tri-Met will also provide for integration of their GIS applications with a link to the transportation data collected by the Metropolitan Service District (the Portland regional government authority) which collects periodic origin-destination surveys of trips to work. These additional provisions will enhance future planning and analysis endeavors using GIS technology.

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