METHODOLOGY FOR THE PLACEMENT OF MAINTENANCE AREA HEADQUARTERS

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

A methodology for strategically locating Virginia Department of Highways and Transportation maintenance area headquarters throughout the state was developed and pilot tested in the Charlottesville Residency (Albemarle and Greene counties).

In the developmental phase, many parameters and work load indicators were examined for their effect on the optimal location of an area headquarters. From the examinations, it was concluded that the one work load indicator to be assigned the greatest weight was the travel time from the headquarters to the work sites. The methodology generates travel time contours around any number of area headquarters within a given area; thus allowing the contours for several headquarters to be examined for overlap and areas not reached within the established travel time to be identified. Consequently, the need for headquarters to be added, eliminated, or reduced to subarea status can be established.

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GENESIS AND PURPOSE OF STUDY

The Virginia Department of Highways and Transportation's policy manual for the Maintenance Division states that "the basic objectives of the maintenance function of the Department are to maintain and operate the highway system in a manner such that:

A. Comfort, convenience, and safety are afforded the public.

B. The investment in roads, bridges, and appurtenances is preserved or enhanced.

C. The aesthetics and the compatibility of the highway system with the environment are preserved or enhanced.

D. The necessary expenditure of resources is accomplished with continuing emphasis on economy."

In addition, it is stated that "First priority in all maintenance work shall be that work directed specifically to the immediate safety of the traveling public."

In order to fulfill the objectives of the maintenance function in an economical and efficient manner and to provide for the safety of the traveling public, maintenance work forces need to be located near the areas where major maintenance activities are conducted. Therefore, the Department's maintenance area headquarters need to be located strategically throughout the state.

While over the last 30 to 40 years the network of roads maintained by the Virginia Department of Highways and Transportation has changed considerably, the distribution of maintenance area headquarters has remained virtually unchanged. Although the locations of the headquarters have been suitably matched with the work load over this period of time, it is possible now that the boundaries of the areas served by some of the facilities should be adjusted, or that some facilities should be eliminated or reduced to a subarea status.

In consideration of these possibilities, the Maintenance Division and the Joint Legislative Audit and Review Commission, the latter of which has been studying various facets of the Department's maintenance operations since 1981, requested an evaluation of the need for the present number of area headquarters and the suitability of their locations. As part of this evaluation, it was necessary to develop a methodology for determining how area headquarters should be sited throughout the state to best enable the Department to meet its objectives.

Therefore, the purpose of this study was to develop a methodology for determining what locational distribution of area headquarters within the boundaries of a residency would best promote achievement of the objectives set forth in the policy manual of the Department's Maintenance Division. In addition, it was proposed to pilot test this methodology in the Charlottesville Residency.

PRELIMINARY ACTIVITIES

Because of the complexity and sensitivity of this study, a "brain-storming" seminar with other researchers at the Research Council and several smaller meetings with selected individuals were held. In these meetings, many approaches to the study were discussed, and the author was made aware of locational studies in related fields, such as those for fringe parking lots.

A literature search revealed that most of the locational studies used a branch and bound algorithm or a warehouse problem approach to siting a new facility that would serve a number of highways or to determine which one of several facilities would serve which highway at the least total cost. The most relative and significant publications reviewed are listed in the Selected Bibliography.

SELECTION OF FACTORS TO BE CONSIDERED

In preparing the working plan for the evaluation, the following parameters and work load indicators were selected as being the ones to be given the most weight in determining the optimal location of an area headquarters.

1. Type of roadway (interstate, primary, secondary)

2. Miles of each type

3. Distance to the activity

4. Terrain (flat, mountainous, hilly)

5. Acres of right-of-way

6. Square yards of pavement

7. Population of area

8. Number of vehicles

9. Type of vehicles (weight, size, etc.)

10. Number of employees supervised by the area superintendent

11. Type of activity

    a. Snow removal

    b. Grass cutting

    c. Ditching

    d. Pavement patching

    e. Roadway shaping

    f. Other

12. Performance standards for the various maintenance activities

13. Equipment downtime (repairs)

14. Response time

15. Miscellaneous responsibilities

    a. Rest area maintenance

    b. Guardrail replacement

    c. Tree trimming

    d. Sign replacement and cleaning

Later, on the basis of the information and opinions obtained from the literature search and several discussions with Department officials,

it was concluded that the one work load indicator to be assigned the greatest weight would be the travel time from the headquarters to work sites. It was reasoned that 1 mile of road 15 miles from a headquarters should cost the same to maintain as 1 mile of road of similar design right next to the headquarters, except for the cost of travel time. Other indicators -- such as miles of road, acres of right-of-way, square yards of pavement, span of control of the superintendent, and type of activity -- were taken to be more closely related to the number of workers and their level of productivity than to the location of the headquarters. The remaining indicators -- population of the area, number of vehicles, type of vehicles, and equipment downtime -- were felt to be unrelated to the location of the headquarters or to have an influence on travel time.

OTHER CONSIDERATIONS

In addition to the many factors evaluated for this methodology (previous section), the following items will need to be considered during implementation of the methodology in Virginia. The research was focused on adjusting the boundaries of the areas served by the existing headquarters to achieve optimal locations, since the Department has 236 area headquarters representing such a substantial investment in land and buildings as to make the construction of many new facilities economically infeasible, and because Commissioner King has stated that no land will be condemned for the construction of a new highway facility. In addition, Department personnel indicated that every county should have a maintenance headquarters.

THE LOCATIONAL METHOD DEVELOPED

Therefore, in light of the above cited factors and considerations, it was decided that the locational methodology must focus on the generation of travel time contour lines or boundaries of the area to be served by a headquarters. In addition, it should indicate areas needing an area headquarters and facilities that could be eliminated or reduced to a subarea status.

To develop the contour lines used in the methodology, dynamic programming is used.

Each intersection within the region being investigated is numbered, as are the area headquarters locations for which travel time contours are desired. The distances between the intersections are determined, as well as the class of the roads. The roads are divided into eight

classes depending upon the type of road, the traffic conditions, the topography, the alignment, and the riding surface (Table 1).

Table 1

Classes of Roads Used in Methodology

Class	Description
1	Any interstate road
2	Any rural primary road or any primary road with little traffic control
3	A suburban primary road, a primary road with some traffic control, or a primary road with many horizontal or vertical curves
4	An urban primary road, a primary road with frequent traffic controls, or a steep primary road
5	A paved, relatively flat, smooth, and straight secondary road
6	A paved secondary road with either horizontal or vertical curves, or a rough secondary road
7	An unpaved, relatively flat and straight secondary road
8	An unpaved secondary road with either horizontal or vertical curves

For each class of road average speeds are established for travel under normal conditions and for snowy or icy conditions, the latter because snow and ice maintenance activities consume a large part of the state's maintenance budget. In addition, the travel speed should reflect the primary mode of travel of the Department's field forces, the dump truck. The average travel speed should be the same in different areas of the state for the different classes of roads (see later section on Proposed Work).

Using the above information and the maximum travel time desired as input for the computer program used in the locational methodology, travel time contours for both weather conditions can be generated around the area headquarters in the region under investigation. Contours can be generated for any maximum travel time desired.

Once a maximum one-way travel time (see later section on Proposed Work) is established, then boundaries for the area headquarters can be set with minor adjustments. Since this methodology is only a tool to assist in setting headquarters boundaries, adjustments will generally be required. The methodology will show overlapping contours indicating where a headquarters might be eliminated or reduced to a subarea facility. Conversely, it will show areas that cannot be reached in the maximum travel time established, and thus the need for an additional headquarters or a subarea facility. In addition, travel time contours for both weather conditions can assist in determining the placement of sand and chemical piles for use in snow and ice control.

PILOT TEST

The desired methodology was used to generate travel time contours (15, 20, 25, and 30 minutes) for the four headquarters in Albemarle County (Boyd Tavern, Keene, Yancey Mill, and Free Union), the one headquarters in Greene County, and the headquarters in Albemarle County closed by the Department in 1983 (Batesville). As an example of the information generated, the contours for 20- and 30-minute travel time under normal conditions are shown in Figures 1 through 4. In this pilot test the average travel speeds for the various classes of roads were obtained from Charlottesville Residency personnel (Table 2). From the Department's maps of Albemarle and Greene County and USGS 7.5 minute quadrangle maps, the intersections were located and numbered, the distances between intersections were determined, and the classes of roads were defined.

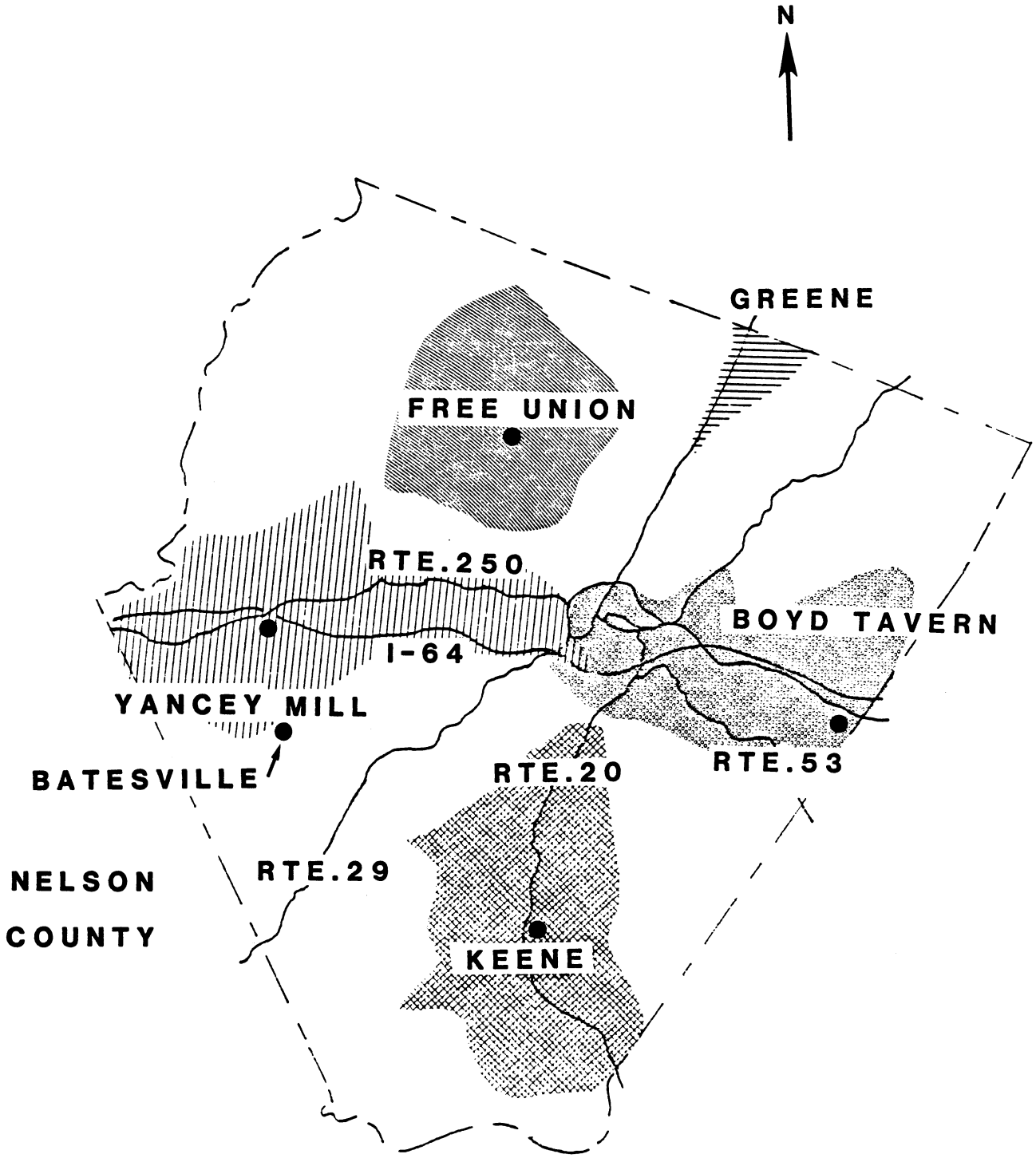

Figure 1. Twenty-minute contours under normal conditions for Albemarle County.

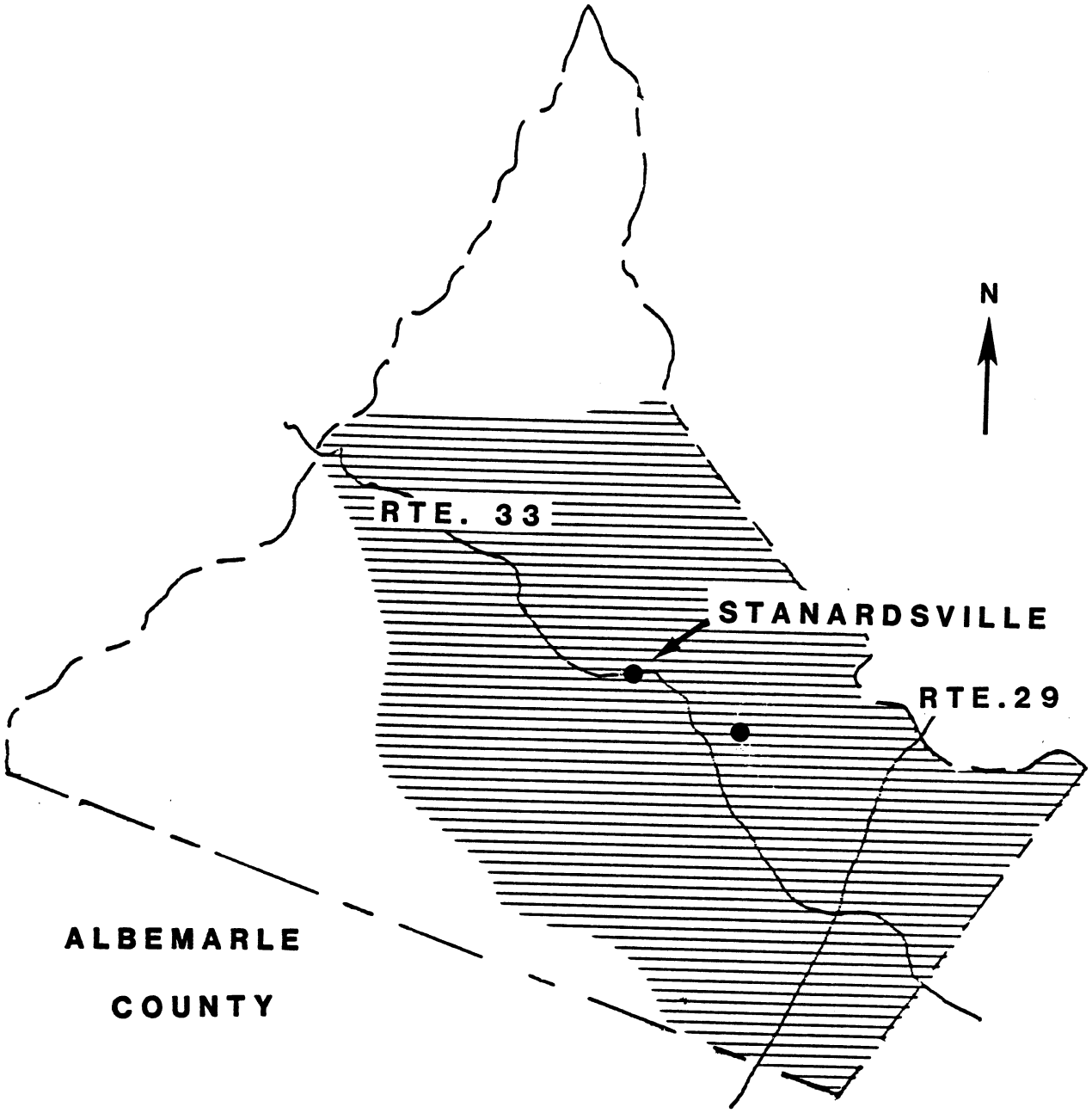

Figure 2. Twenty-minute contour under normal conditions for Greene County.

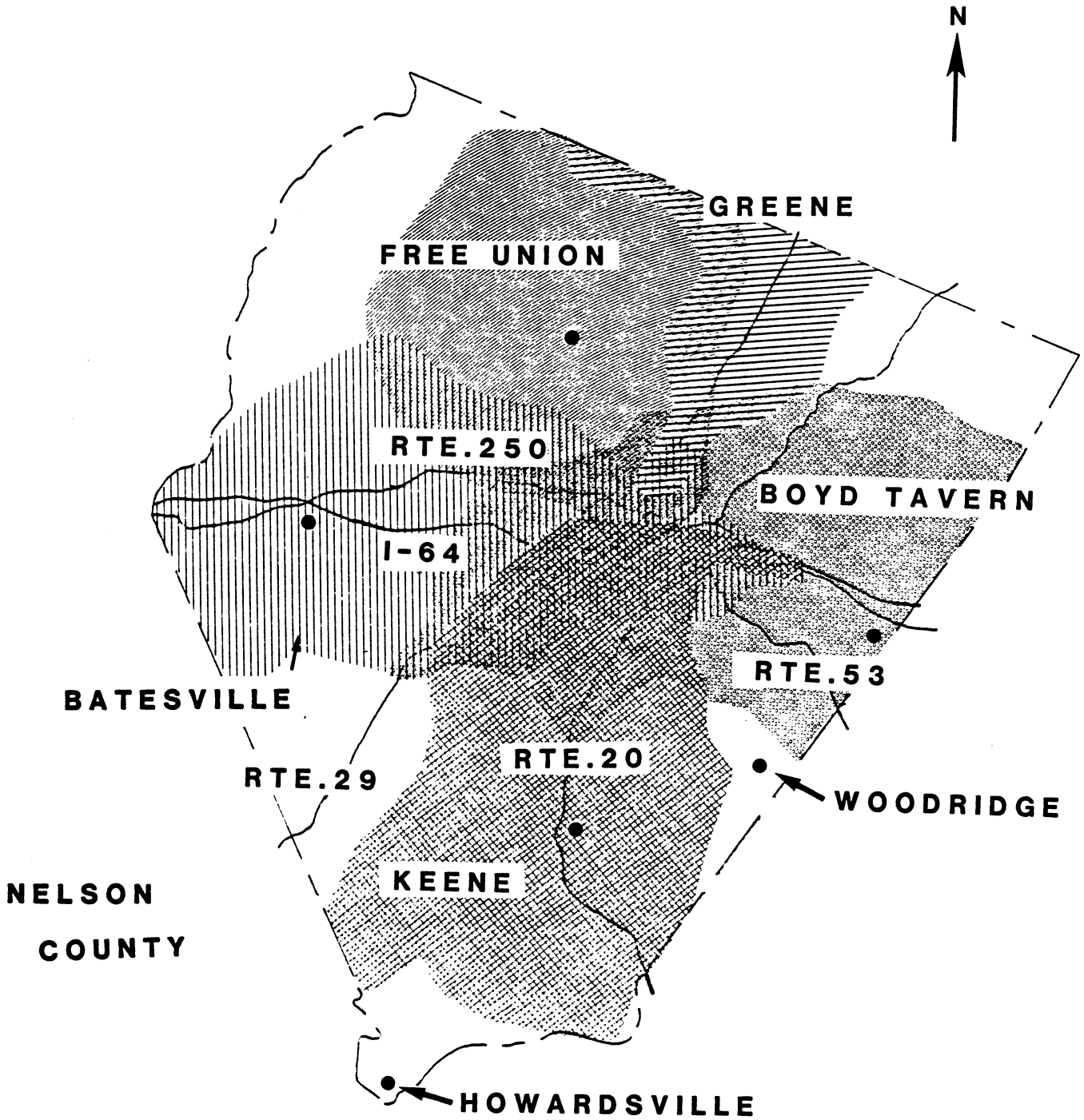

Figure 3. Thirty-minute contours under normal conditions for Albemarle County.

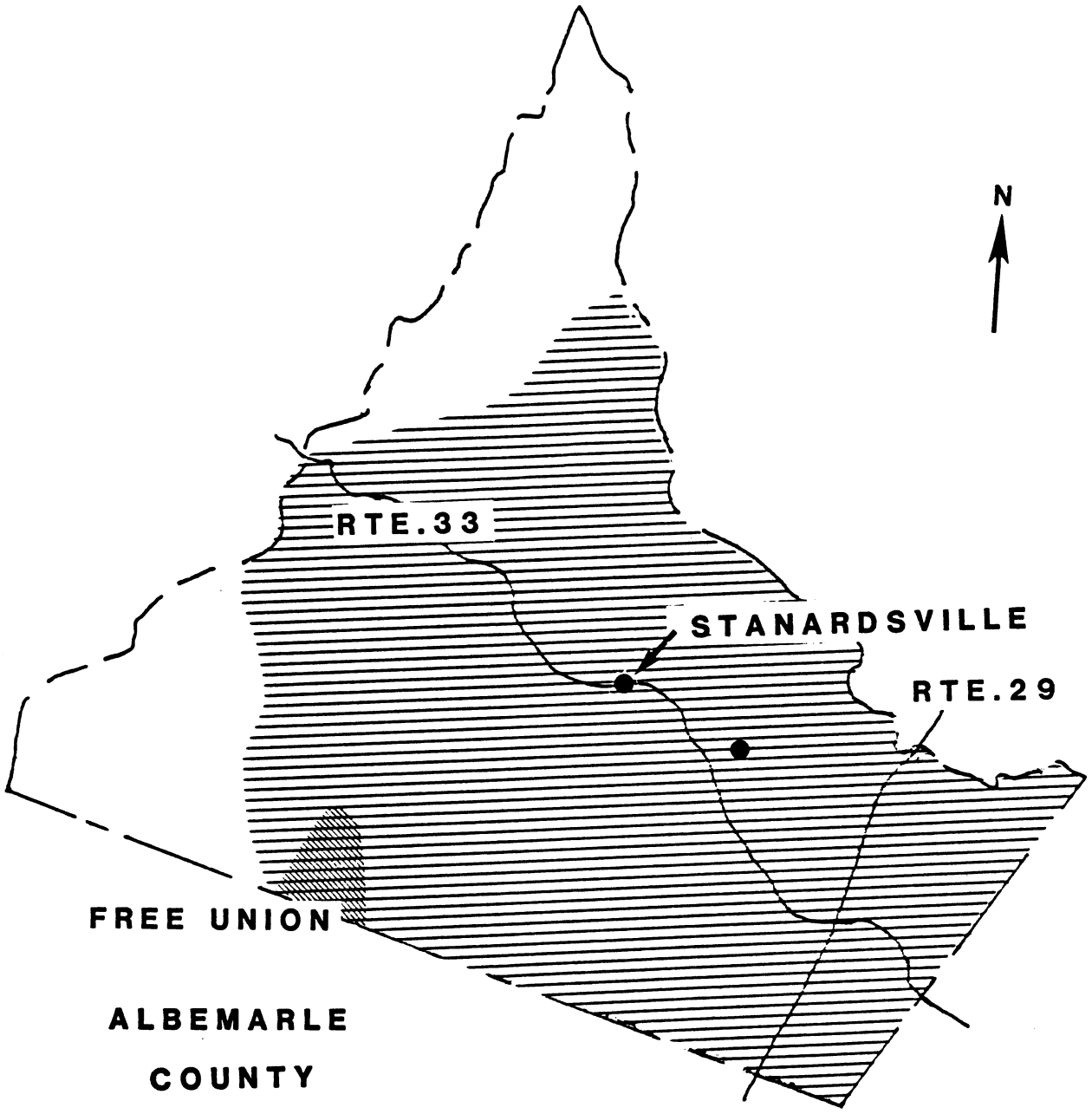

Figure 4. Thirty-minute contour under normal conditions for Greene County.

Table 2

Average Travel Speeds Provided by
Charlottesville Residency

Class of Road	Average Travel Speed	
	Snow and Ice	Normal Conditions
1	20	45
2	20	40
3	20	30
4	15	25
5	20	35
6	15	20
7	20	30
8	15	20

Travel time contours for the Batesville headquarters were determined to lie mainly within the Yancey Mill headquarters contours for all four travel time contours generated in this study. The methodology developed would indicate that one of the two headquarters should be eliminated if the Department establishes a maximum travel time of 15, 20, 25, or 30 minutes. As noted previously, the Batesville headquarters was closed in 1983, and the methodology developed in this study seems to support that decision.

In Figure 1 the contours for Yancey Mill, Boyd Tavern, and Keene converge around Charlottesville and the first two overlap slightly. The overlap is insignificant, but there are extremely large areas between the contours that the maintenance work forces cannot reach within the prescribed travel time of 20 minutes. The 20-minute contour for Greene covers the major part of that county and extends into the northern part of Albemarle along Route 29 (Figure 2). If the Department should establish a maximum travel time of 20 minutes, to provide effective maintenance several subarea headquarters or area headquarters would be needed in the area not within the contours.

As the travel time is increased to 30 minutes (Figures 3 and 4), the contour lines for all headquarters overlap a significant amount around Charlottesville. Still, some areas around Route 29 south near the Nelson County line, Howardsville, and Woodridge, and in the northeastern parts of Albemarle County and the western part of Albemarle and Greene counties cannot be reached within 30 minutes from any of the headquarters. If the 30-minute travel time contour map is used as a guide, and for the Department to provide effective maintenance coverage, area headquarters or subarea facilities would need to be established or

the computer derived boundaries of the existing area headquarters will need to be adjusted. If the latter is done, then the Yancey Mill and Keene headquarters could cover the areas on Route 29 south near the Nelson County line, Howardsville, and Woodridge if their coverages terminated at the western and southern boundaries of Charlottesville, respectively, rather than crossing town. The areas relinquished by the Yancey Mill and Keene headquarters near Charlottesville could be covered by the Boyd Tavern headquarters. To complete the adjustments would require that Boyd Tavern maintain the roads in the northeastern part of Albemarle County, while Free Union would take on the additional western areas of the county. The Greene County headquarters would then cover only the roads in that county.

To determine if it would be more feasible to establish new headquarters or subarea facilities, an economic analysis of the two alternatives must be made. Several factors that must be considered are cost of the new facility, frequency of work in the areas of concern, and travel time and its cost.

Close examination of the contour lines for the various travel times and headquarters shows that they follow the higher class roads, since the average travel speeds on these roads are higher than on the lower class roads.

When the methodology is applied to the Charlottesville Residency for the travel speeds during icy or snowy conditions, a separate set of travel time contours are generated. As examples, the travel time contours for the Free Union area headquarters are shown in Figures 5 and 6 for 20 and 30 minutes, respectively. As shown on the figures, the contours encompass less area than those for normal weather conditions; because the travel speed is slower. As the maximum travel time is increased (Figure 6), there is more difference between the contours for the two weather conditions. By comparing the contours for the two weather conditions for all the headquarters in Albemarle County, one could determine if a subarea facility or a stockpile would be needed during inclement weather conditions.

Figure 7 indicates the boundaries of the five area headquarters in the Charlottesville Residency (four in Albemarle County and one in Greene County). By comparing these boundaries with the computer generated travel time contours, it can be seen that the existing boundaries are similar to the 30-minute contours (Figures 3-4) with the adjustments suggested by the author to cover the areas outside of the contours. These results seem to indicate that even without this travel time methodology, Department personnel have established a maximum travel time of 30 minutes under normal weather conditions in the Charlottesville Residency and balanced out the area of responsibility of each headquarters. However, as indicated earlier, this methodology can

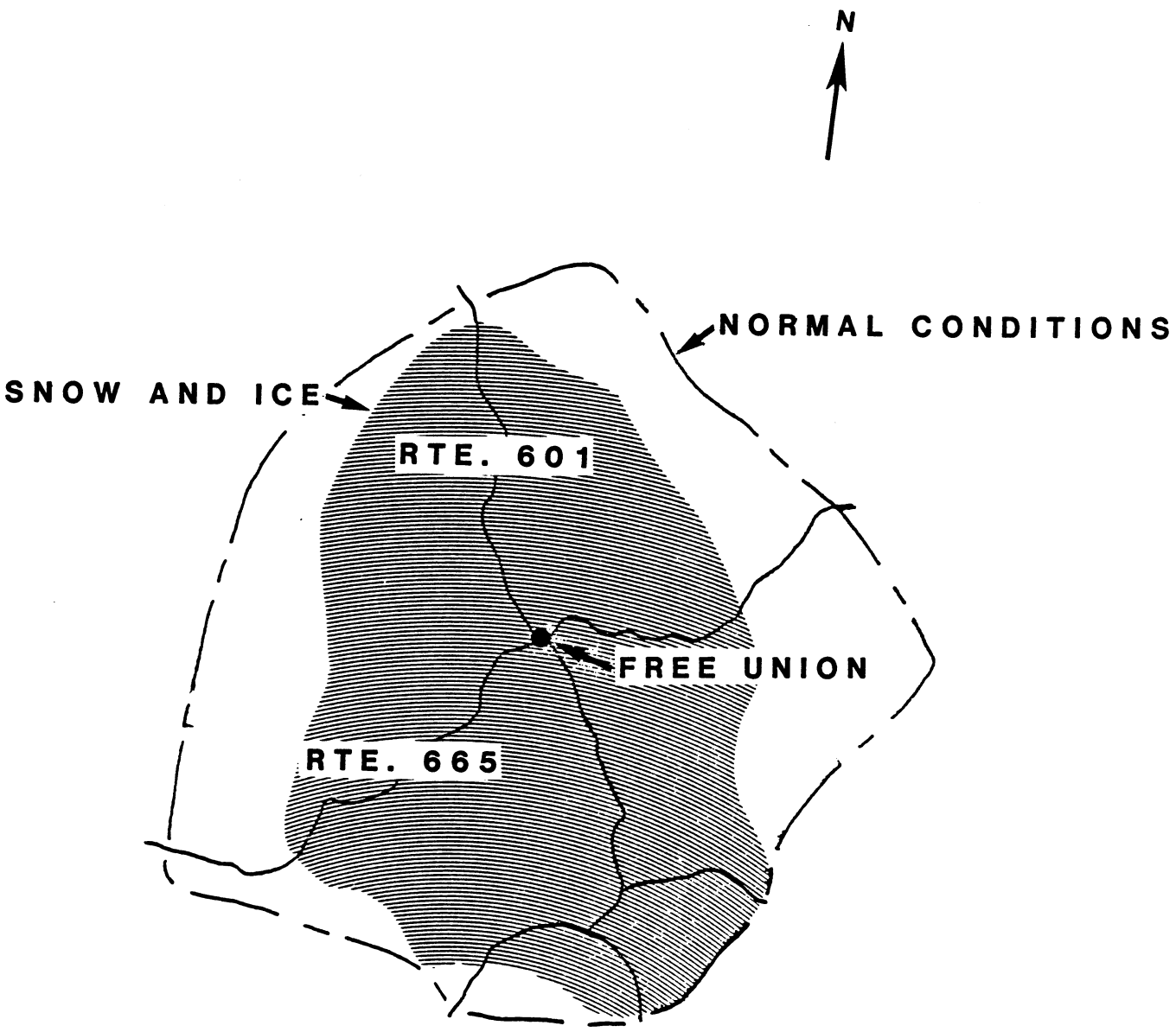

Figure 5. Twenty-minute contour for Free Union.

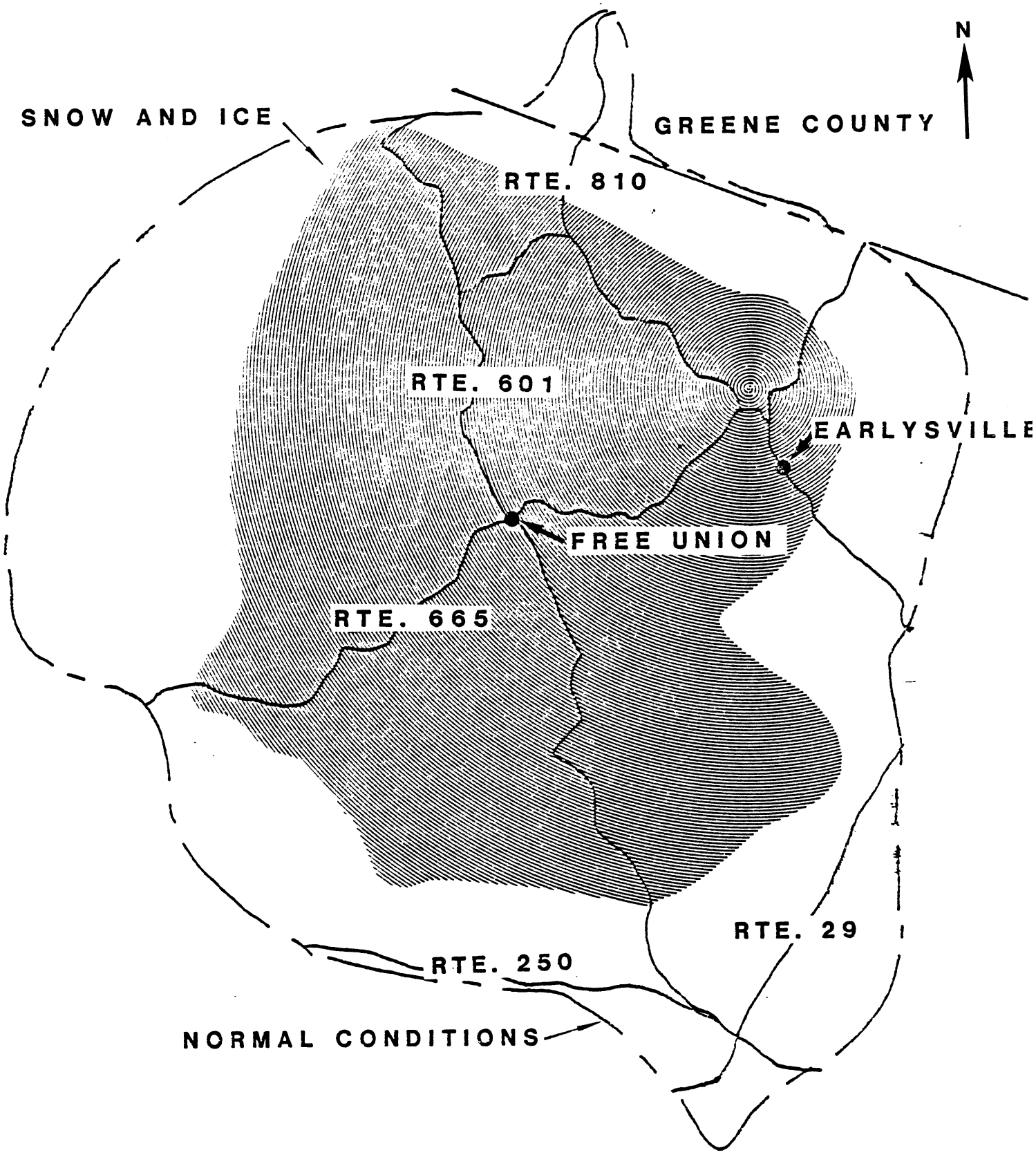

Figure 6. Thirty-minute contour for Free Union.

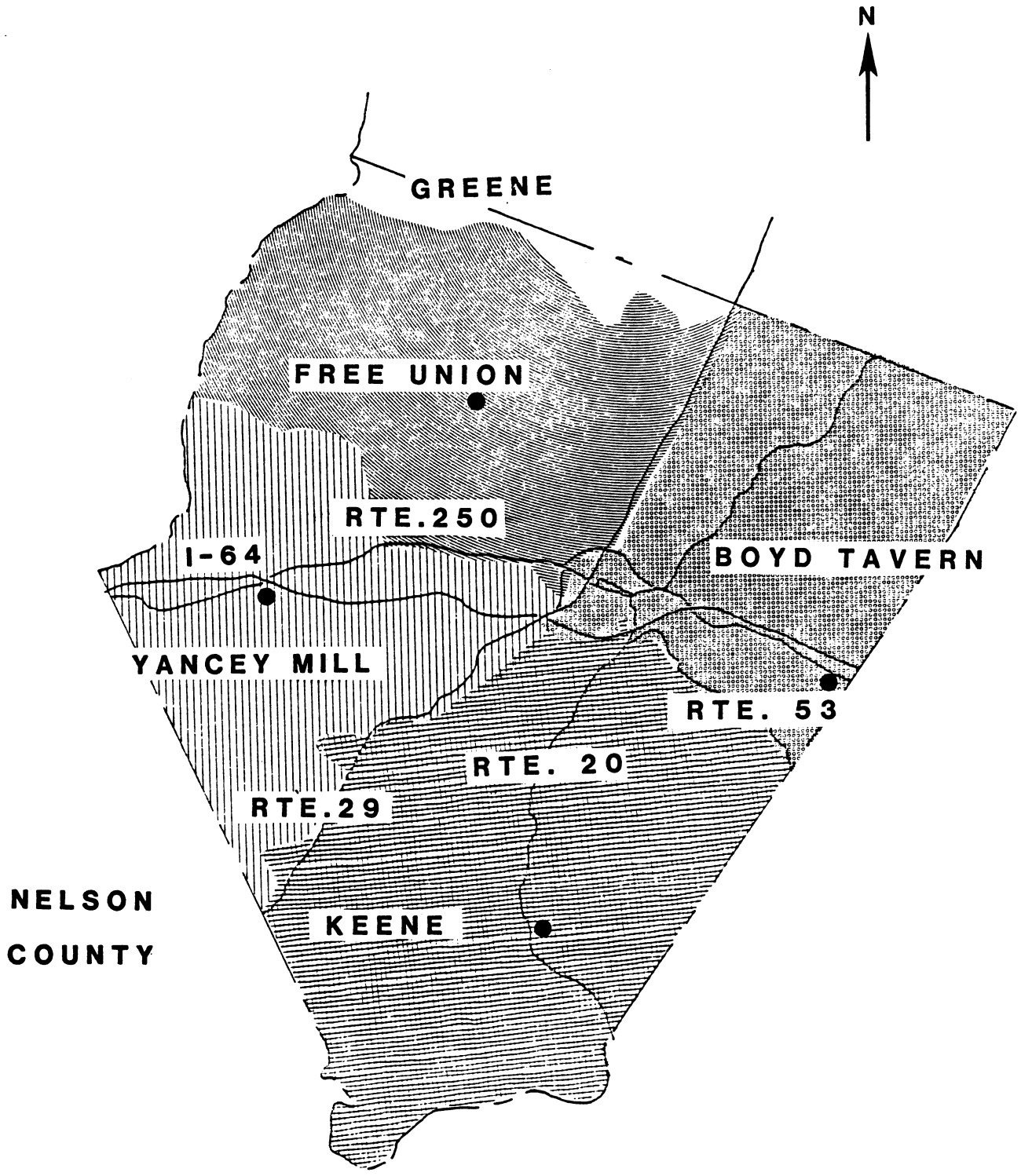

Figure 7. Boundaries of existing area headquarters.

be used to assist in establishing these area headquarters boundaries once the maximum travel time desired by the Department is established. The critical question is: Is 30 minutes a reasonable and practical travel time?

PROPOSED WORK

In this study, a methodology was developed and pilot checked in the Charlottesville Residency. Department personnel and the author deem the methodology to be a viable and worthwhile tool. However, several questions need to be answered to make the methodology a practical and implementable procedure. First, will the methodology give similar results if all intersections are not inputted into the computer (sensitivity analysis)? How sensitive is the travel speed used in the computer program? What is the average travel speed for each class of road?

Second, what is a reasonable maximum travel time for a headquarters crew? Many approaches to finding an answer to this question have been offered, but regardless of the approach taken, the maximum travel time established by the Department is a critical question to the implementation of this methodology.

Therefore, it is proposed in the next study to determine the maximum travel time the Department should establish, the sensitivity of the methodology to the number of intersections inputted, and a common value for the speed of the vehicle, and to verify the methodology in typical Coastal, Piedmont, and Valley counties. In addition, the cost-benefit ratio of relocating or closing a headquarters to the reduction or increase in travel time should be determined.

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