



Traffic Safety Study

Final Report

MESA VERDE NATIONAL PARK

Far View / Weatherill
"Three-Way"
"Four-Way"

Traffic Safety Study

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Far View/Weatherill

"Three-way"

"Four-way"

Prepared by:

Lee Engineering

5031 S. Ulster St., Suite 205

Denver, Colorado 80237

303-773-3356

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INTRODUCTION

This study was undertaken to review three problem sites within Mesa Verde National Park, Colorado. A field visit to the park was conducted August 9 through August 12, 1995. During this time, the Park Service personnel were interviewed, problem sites were visited, and data collected. Preliminary recommendations were developed and presented in a technical memorandum to the Denver Service Center on September 15, 1995.

This final report describes the results of the preliminary analysis of the data collected at the site, the accident data, and the recommended solutions.

Three areas of concern (see Figure 1) were addressed in this study:

- The "Four Way," which is the intersection of Chapin Mesa Drive, and the loop road to the museum.
- The "Three Way," which is the intersection of the Ruins Road with the road to Cliff Palace.
- The Far View / Weatherill Mesa Road site, located about halfway into the park along Chapin Mesa Drive.

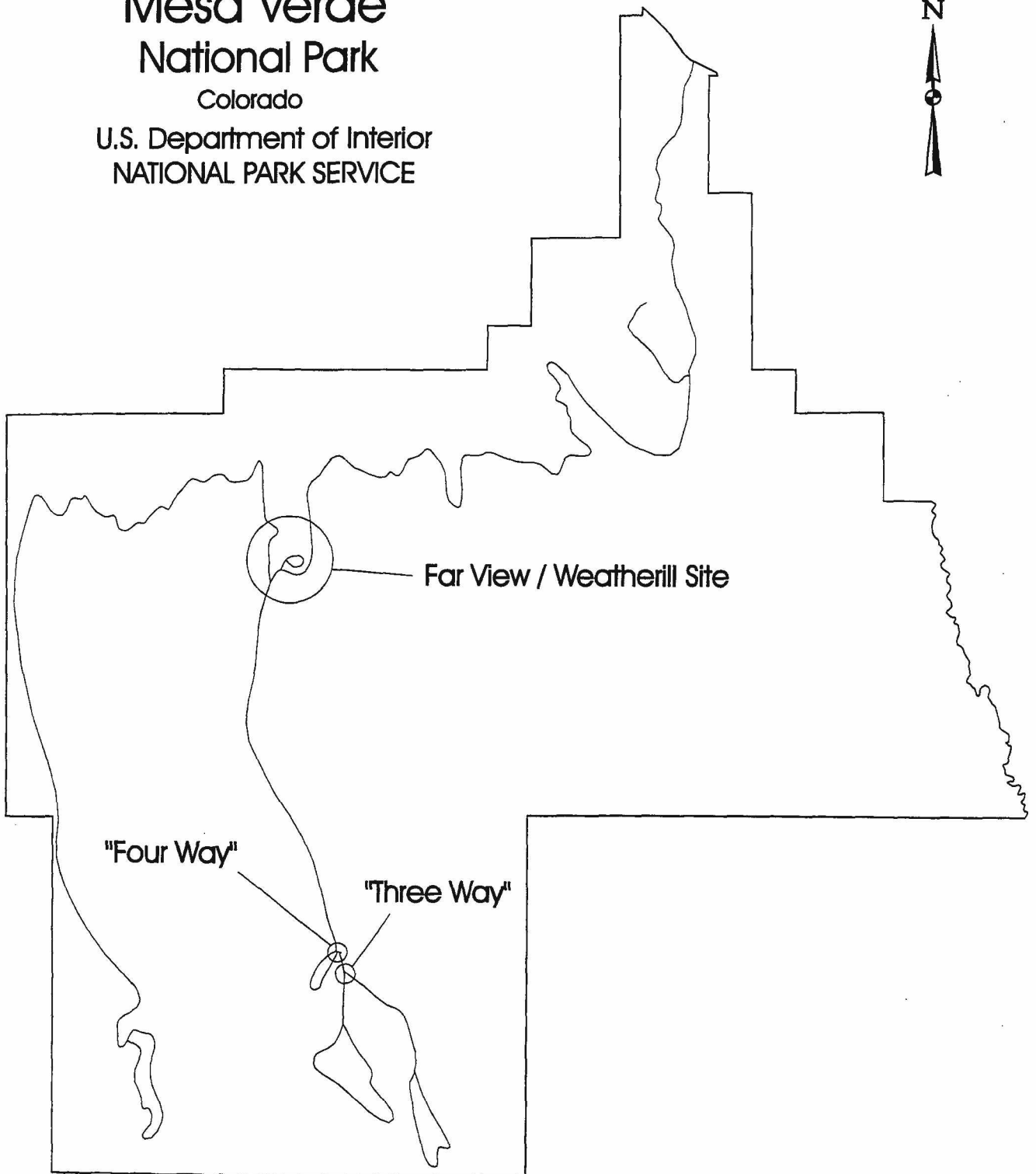
This report is comprised of three sections, one for each area of concern. Each section outlines the following:

- Discussions with the park service regarding the problems
- Field observations and data collection
- Accident analysis
- Potential solutions
- Recommended solution

Mesa Verde National Park

Colorado

U.S. Department of Interior
NATIONAL PARK SERVICE



FOUR WAY INTERSECTION

Problem Identification

This is the intersection between the Ruins Road and the road to the museum as shown in Figure 2. North of the intersection, Chapin Mesa Road is a two-lane, two-way park roadway. East of the intersection, Ruins Road is also a two-lane, two-way roadway. The south and west legs of the intersection are endpoints of a one-way roadway traveling clockwise through the park headquarters and the museum area. At the intersection, vehicles proceed southbound to the museum. The west approach is marked with a "Do Not Enter" sign. It is apparent from the intersection geometrics that the loop was one-way in the opposite direction at one point. There are traffic barrels in the now vacant southbound right turn lane blocking this movement.

Park Staff raised the concern that this intersection is operating poorly and is confusing to motorists. They confirmed that the museum loop roadway was operating in a counterclockwise direction at one time. However, in order to provide the visitor with the opportunity to pass the restaurant and the museum prior to encountering the majority of the parking areas, the direction of the one-way roadway was reversed. According to the Park Staff, the speed of traffic seems to be higher now with the clockwise circulation. They also advised that there is no significant accident problem at the intersection. Some delay does exist at the intersection where at peak times there may be a queue of 6 or 7 cars trying to get through the intersection. The Park Staff did not express strong feelings about whether the flow of the one-way road should be in a clockwise or counterclockwise direction. They also advised that motorists sometimes leave the parking areas and drive the wrong way on the one-way roadway.

Field Observation and Data Collection

A field visit was conducted at the intersection to collect data and watch the operations. The following visual items were noticed.

- 1) The stop line for the eastbound approach is located too far back from the intersection.
- 2) Southbound vehicles do not have any advanced warning that southbound right turns are prohibited.
- 3) There is only one "Do Not Enter" sign for the west leg of the intersection.

A turning movement count was also conducted at the intersection on Friday, August 11 from 11:15 am to 12:30 pm, the results of which are shown in Table 1.

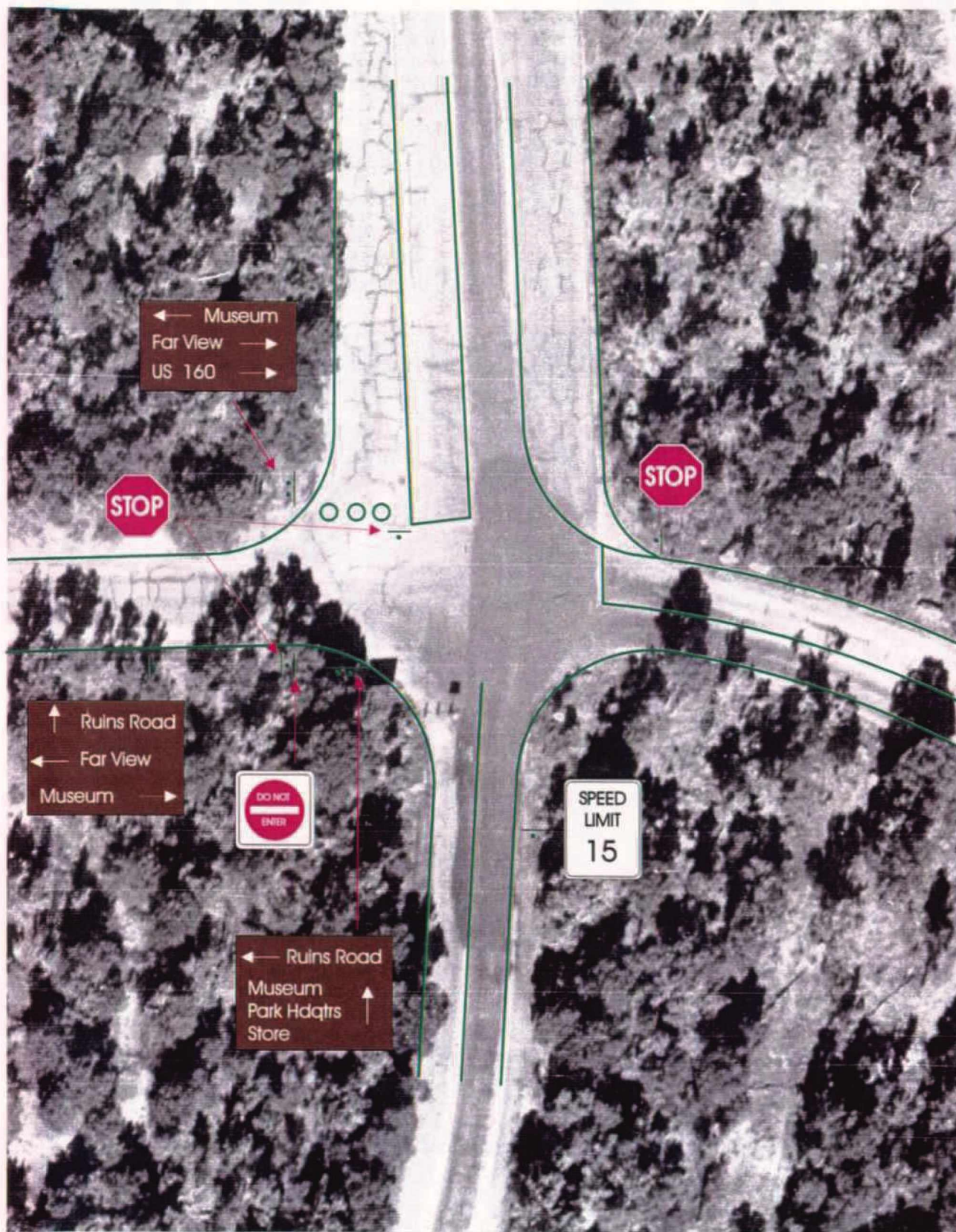


Table 1 - Four Way Intersection Count, Friday 08/11/95

Time End	PASSENGER CARS												HEAVY VEHICLES											
	NORTHBOUND			SOUTHBOUND			EASTBOUND			WESTBOUND			NORTHBOUND			SOUTHBOUND			EASTBOUND			WESTBOUND		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
11:30 AM	.	.	.	16	38	.	6	20	3	9	.	18	.	.	.	1	0	.	1	0	0	0	.	1
11:45 AM	.	.	.	20	29	.	10	22	1	17	.	24	.	.	.	3	2	.	0	1	1	0	.	1
12:00 PM	.	.	.	22	50	.	23	23	1	18	.	18	.	.	.	1	5	.	1	0	0	0	.	1
12:15 PM	.	.	.	13	30	.	9	31	2	18	.	19	.	.	.	1	2	.	0	0	1	1	.	0
12:30 PM	.	.	.	16	23	.	16	23	7	22	.	25	.	.	.	1	1	.	2	2	2	0	.	0
Peak Hour																								
11:30-12:30	0	0	0	71	132	0	58	99	11	75	0	86	0	0	0	6	10	0	3	3	4	1	0	2

Accident Analysis

A review of accidents was undertaken to determine if any patterns could be noted. The STARS accident database was provided for the years 1990 through 1994. A search of the database was conducted to locate any accidents that were tied into this intersection (node 201), and six accidents were located during this four-year period.

- Two of the accidents were located 300 to 475 feet south of the intersection, and were not intersection related.
- Two of the accidents were parking lot or parking related.
- One accident involved a vehicle traveling south at the intersection whose driver either fell asleep or fainted and struck a tree or shrub.
- One rear-end collision occurred at the intersection involving two westbound vehicles.

Given this four-year accident experience no definable accident pattern has emerged.

Possible Solutions

There were two solutions that were considered for this intersection. The first solution evaluated the changes that would be necessary if the flow were kept in the existing clockwise direction. This solution was considered, but rejected as it did not reduce conflict at the intersection. The second solution considered was to reverse the direction of traffic on the loop roadway. This is the recommended solution.

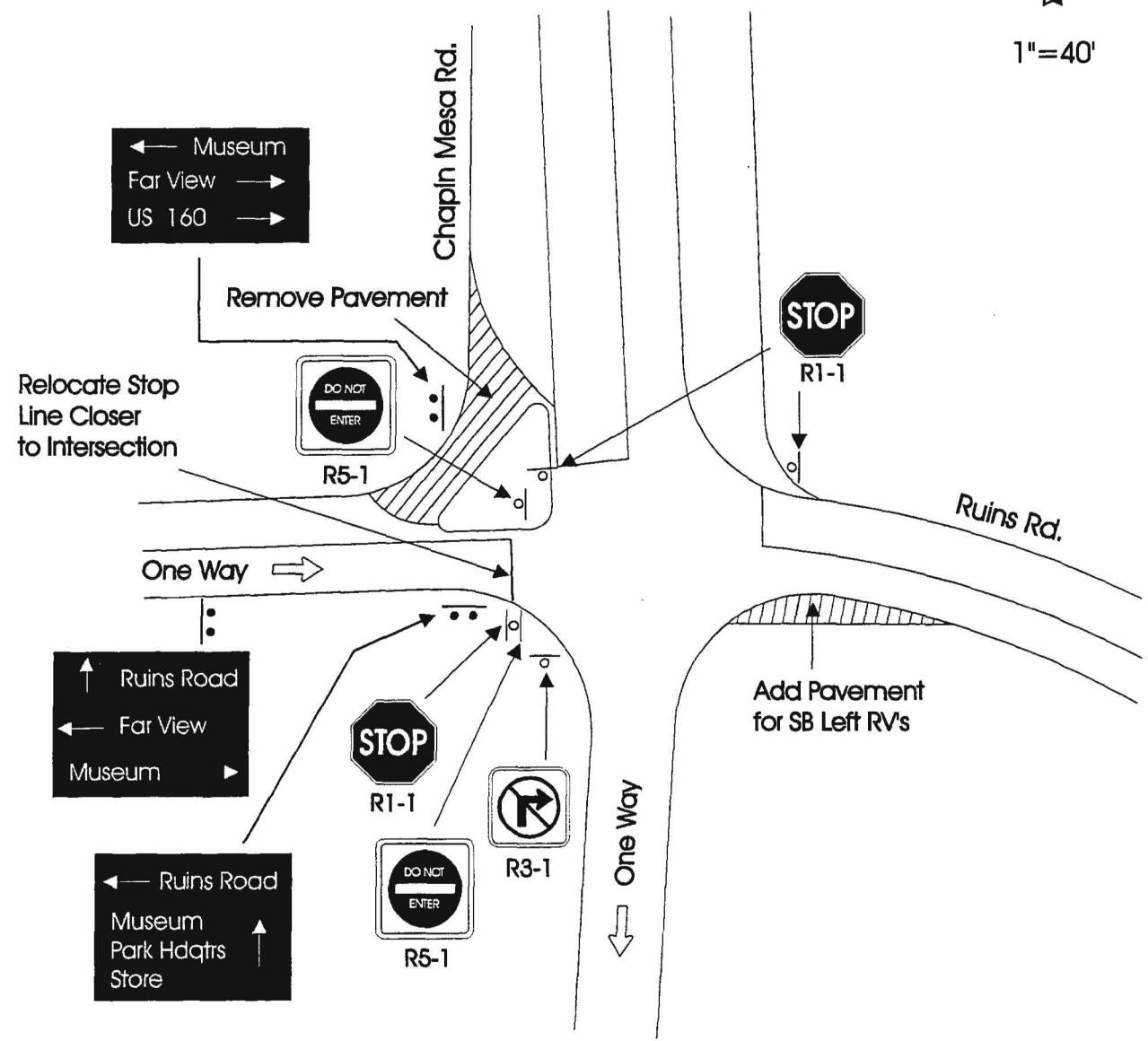
Keep flow in clockwise direction

This solution leaves the flow as it currently is, and improves the operation of the intersection. The approximate cost for this solution is \$10,000. Figure 3 shows the modifications that should be made to the intersection if it were to remain as a counterclockwise operation.

- 1) A southbound "No Right Turn" sign (R3-1) should be added to provide clear indication to southbound vehicles that a right turn movement is prohibited.



1"=40'



- 2) The westbound stop line should be relocated closer to the intersection. However, it should not be placed in such a manner that recreational vehicles cannot make their turning movements.
- 3) Another "Do Not Enter" sign (R5-1) should be added to the north side of the west approach. Westbound traffic may not see the existing R5-1 sign on the south side of the roadway until they are at the stop line.

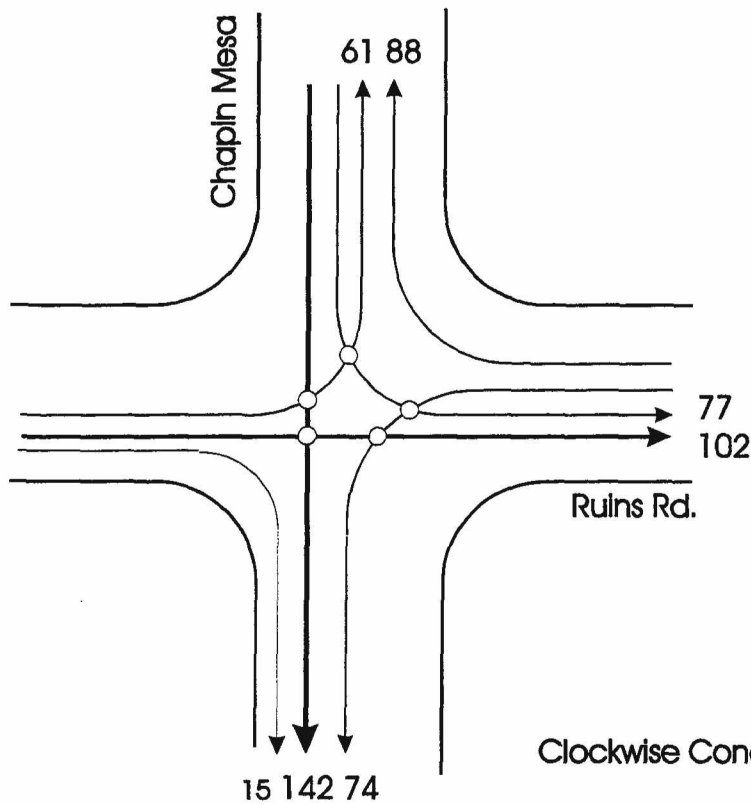
Figure 4 shows the sum of the products of the conflicting movements occurring under the current scenario and the conflicts that would occur if the roadway direction was reversed. The volumes in Figure 4 are the turning movements that were counted during the peak hour from Table 1. By reversing the one-way flow, the conflicts could be reduced from 41,089 to 14,909. This would be a reduction of 64% and, therefore, leaving the flow as it is in a clockwise direction is not the recommended solution.

Change flows to counterclockwise direction

Reversing the flow of the loop traffic to a counterclockwise direction is the recommended solution. By reversing the flow, congestion and confusion are reduced at the intersection. When the roadway operated in a counterclockwise direction previously, park staff provided guidance for parking when the lots were near capacity. This practice would need to resume.

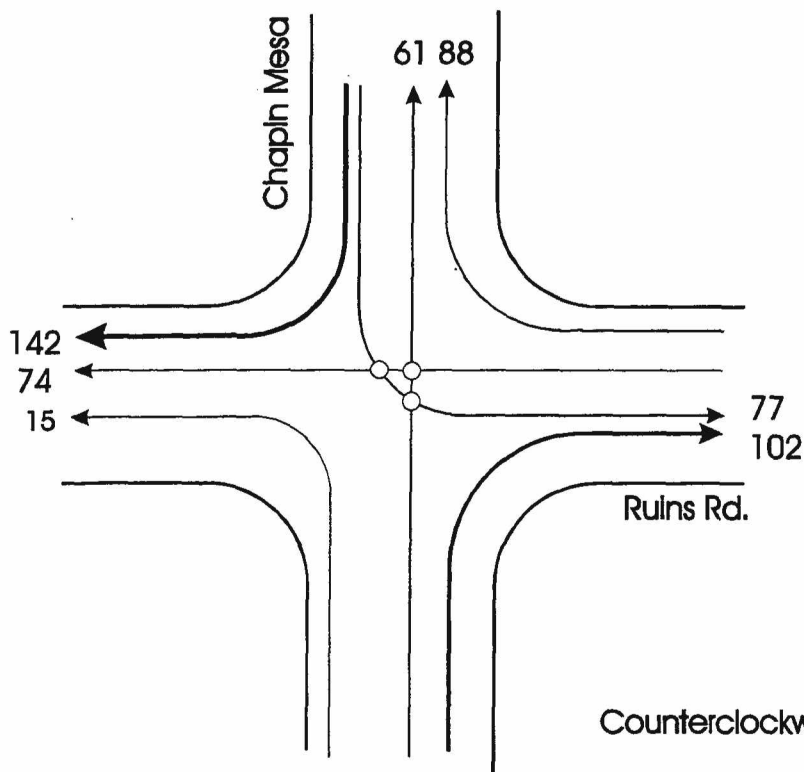
The three guide signs at the intersection, and the advanced guide sign north of the intersection for southbound traffic, need to be modified to reflect the new direction that vehicles must take to get to their destination. These modifications are shown in Figure 5. A new island should be constructed to channelize the southbound right turn movement.

Figure 5 shows the improvements that are recommended at Four Way. Figure 6 shows the signing and striping modifications to the loop roadway. The approximate cost for this solution is \$12,000.



Potential Conflicts

142 x 61	8662
102 x 142	14484
61 x 77	4697
74 x 77	5698
74 x 102	<u>7548</u>
	41,089



Potential Conflicts

74 x 61	4514
74 x 77	5698
77 x 61	<u>4697</u>
	14,909

Ruins Road
 Cliff Palace
 Balcony House
 Museum
 Spruce Tree House

Museum
 Far View
 US 160

Construct New Island



R1-2



R1-1



R3-2



R5-1

Ruins Road
 Museum
 Park Hdqtrs
 Store

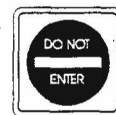
Ruins Road
 Far View
 Museum



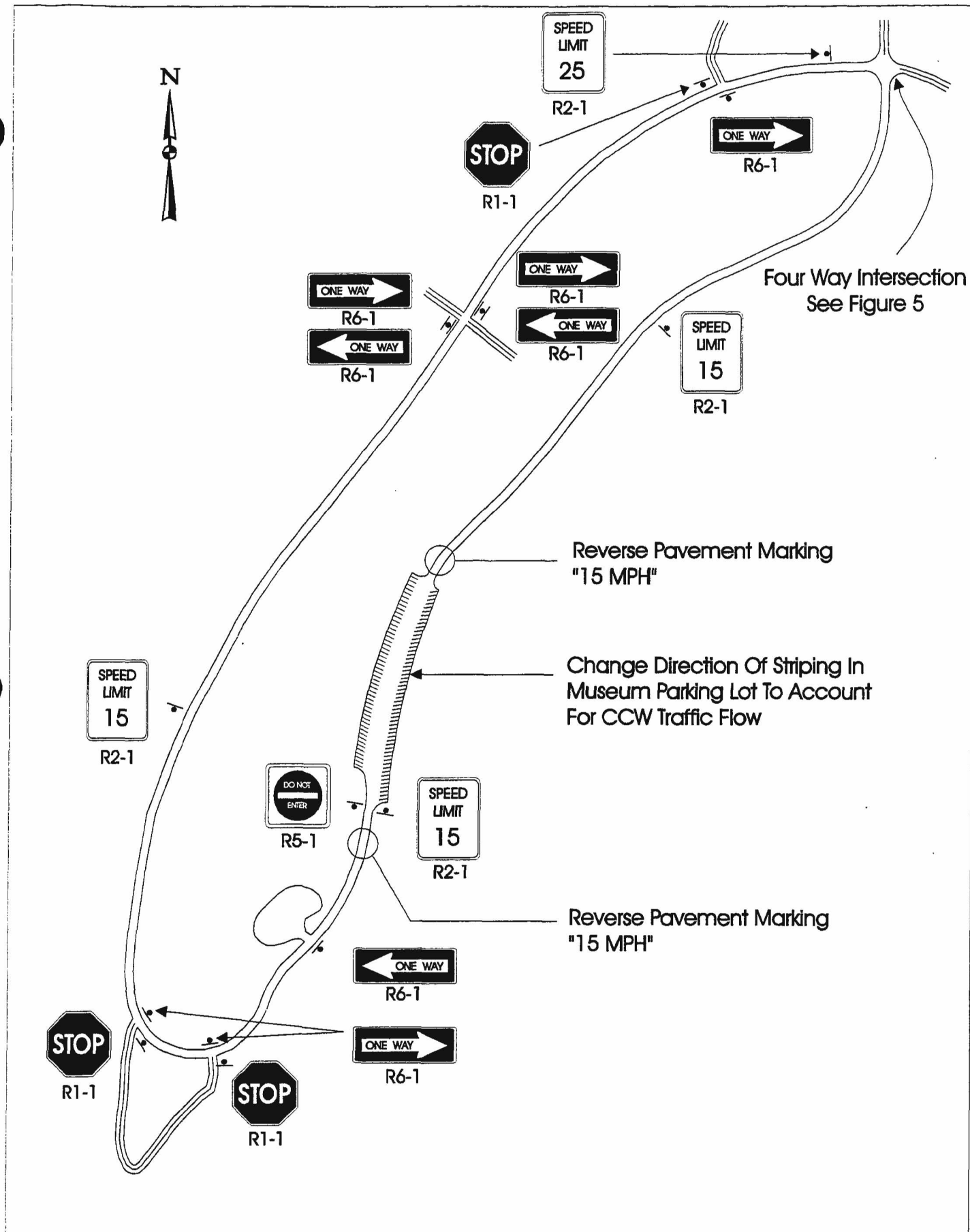
1"=40'



R1-1



R5-1



THREE WAY INTERSECTION

Problem Identification

This is the intersection of the Ruins Road with the road to Cliff Palace. The roadway is nearly a tee intersection with Ruins Road running north/south and Cliff Palace Loop Road being the stem of the tee to the east. However, the westbound right is a wye, and the northbound right is a wye, creating a large island in the middle of the intersection as shown in Figure 7. All three legs of the wye are two-way.

Discussions with the park staff revealed that this intersection causes confusion for visitors. For example, the angled stop signs are visible from two directions and, are confusing to some motorists. The two-way roads on each side of the island create many conflicting movements. The Park Staff felt that modifications to the alignment of the roadway may require an archaeological survey, although if all reconstruction occurred within the existing triangle, it may not be necessary. They will research this issue. The potential of a roundabout was discussed, and the park staff felt that this is not a good solution due to driver confusion. The right of way required for a roundabout encroaches on sensitive lands.

Data Collection

A field observation was conducted at this location. During the field observation the following items were noticed:

- 1) It was noticed that some drivers turn at the inappropriate, but legal location. For example, drivers proceeding southbound along Ruins Road who want to turn to Cliff Palace Road may easily do so at the north intersection. However, some are performing this movement at the south intersection. The angle at the south intersection is much greater.
- 2) The predominant movement was noticed to be to and from Cliff Palace. This was verified by traffic volumes which showed that the major movement is between the north and east approaches to the intersection.

Turning movement counts were conducted at this intersection on Friday, August 11 from 11:15 am to 12:30 pm, the results of which are given in Table 2.

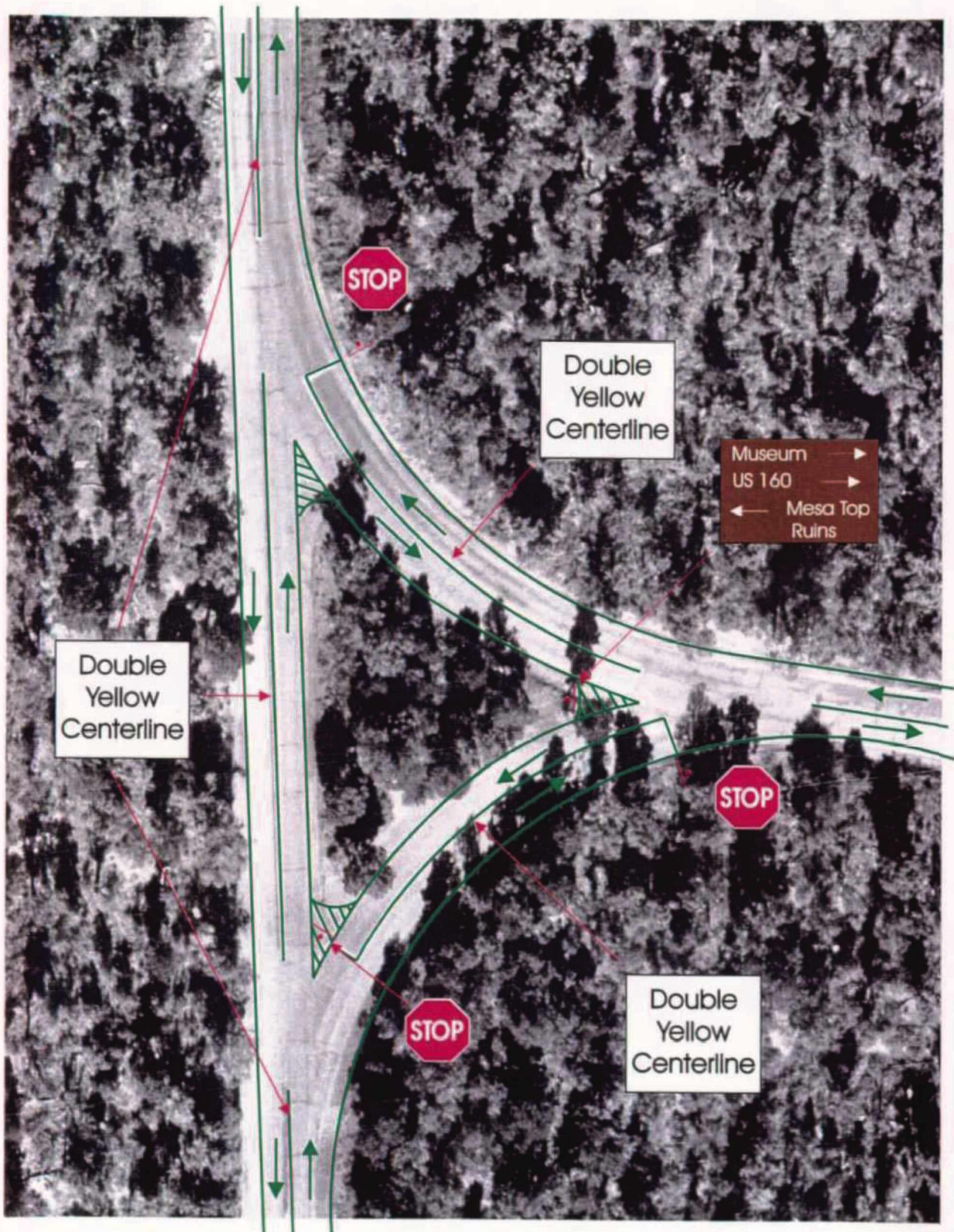


Table 2 - Three Way Intersection Count, Friday 08/11/95

Time End	PASSENGER CARS												HEAVY VEHICLES											
	NORTHBOUND			SOUTHBOUND			EASTBOUND			WESTBOUND			NORTHBOUND			SOUTHBOUND			EASTBOUND			WESTBOUND		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
11:30 AM	.	8	5	23	12	.	.	.	.	5	.	22	.	0	0	1	1	.	.	.	.	0	.	0
11:45 AM	.	10	6	30	11	.	.	.	.	9	.	26	.	1	0	2	1	.	.	.	.	0	.	0
12:00 PM	.	10	6	31	13	.	.	.	.	8	.	23	.	2	1	0	1	.	.	.	.	0	.	0
12:15 PM	.	17	3	24	16	.	.	.	.	4	.	27	.	0	0	0	0	.	.	.	.	0	.	0
12:30 PM	.	10	6	27	14	.	.	.	.	4	.	33	.	0	0	1	2	.	.	.	.	0	.	0
Peak Hour																								
11:30-12:30	0	47	21	112	54	0	0	0	0	25	0	109	0	3	1	3	4	0	0	0	0	0	0	0

Accident Analysis

The accidents at this location were also reviewed for patterns. The park link/node map showed that the northern portion of the wye of Cliff Palace Road intersects Ruins Road at node 205. Six accidents were identified as being associated with this node.

- Two accidents occurred outside of the boundaries of the intersection. One was one mile to the south, and the other was 350 feet to the north.
- Three accidents were due to improper backing.
- One accident was a rear-end collision.

The accident analysis supports the park staff concern that there is confusion at this intersection. Half of the accidents were due to improper backing. By changing the geometrics at the intersection, this problem will be reduced.

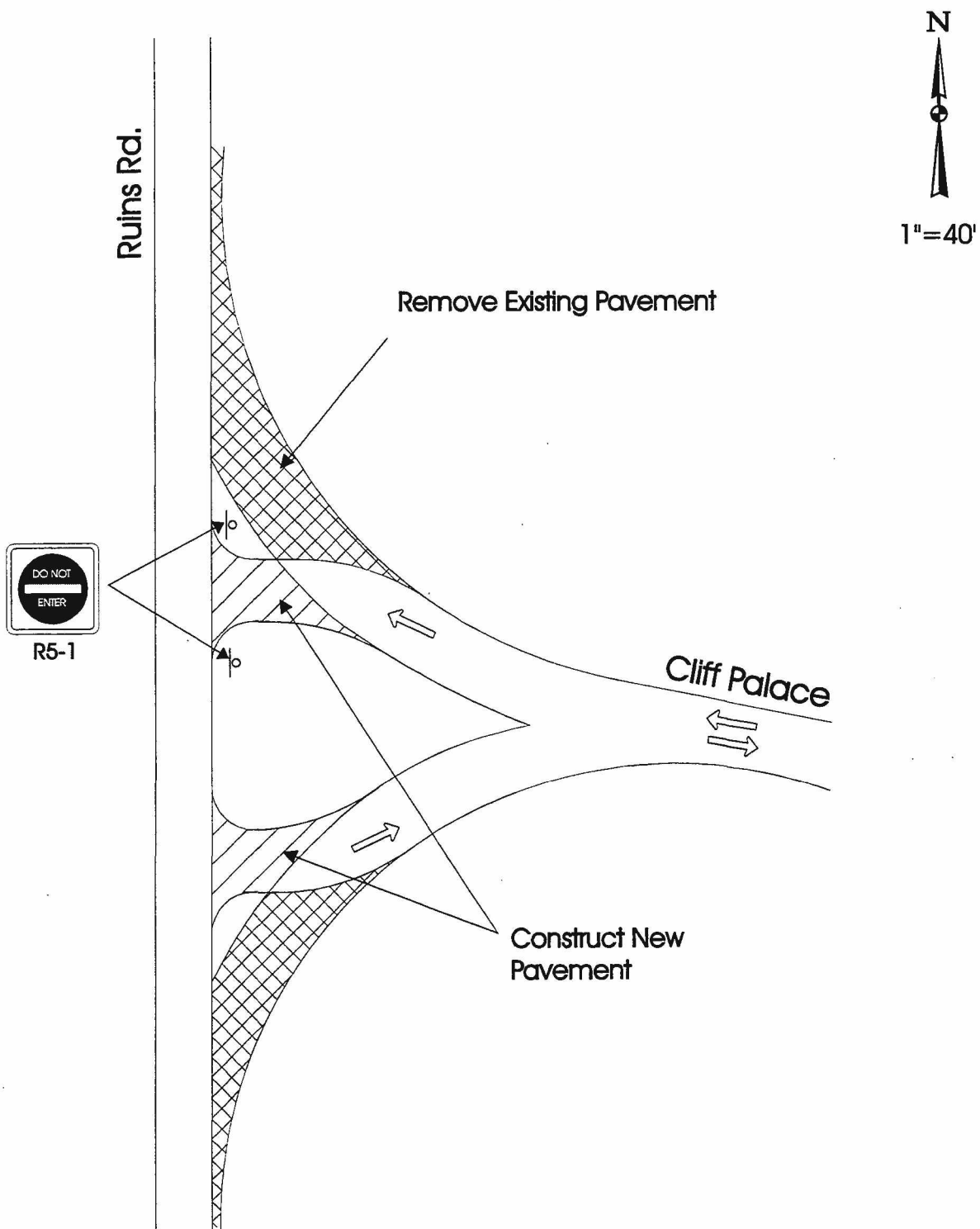
Solutions that were considered, but rejected

Several alternatives were considered to alleviate the confusion at the intersection. The following lists those solutions that were considered, but rejected.

Provide one-way roads on each side of island (Alternate A)

One solution that was considered, but rejected, was to reconfigure the roadways so that the westbound traffic would operate on a one-way road to the north of the existing island, and eastbound traffic would operate on a one-way road to the south of the existing island as shown in Figure 8. The advantage of this alignment is that very little modification needs to be made, and the island can be maintained. If the archaeological survey showed this to be a sensitive area, this type of configuration avoids major geometric changes to the median. The north and south points of the island need to be smoothed to allow these movements to take place. "Do Not Enter" signs would need to be placed at the north intersection. The approximate cost of this solution is \$12,000.

This solution still provides some degree of driver confusion since there would be two roadways at the entrance to Cliff Palace Road. Some people will still be confused in determining which roadway to take. Therefore, this alternate was rejected.



Create reverse tee intersection (Alternate B)

This solution was also investigated, but disregarded. Since the major traffic movements are to the north and east, this could be configured as the major movement. The roadway from the south could tee into this roadway as shown in Figure 9. The approximate cost of this solution is \$19,000. A measurement was taken to determine the approximate sight distance for traffic arriving from the north. The left sight distance was measured to be 290' from the potential northbound approach. The limiting factor for vehicles arriving from the left is 380' according to "A Policy on Geometric Design of Highways and Streets, AASHTO, 1990." Since the field measured distance is less than the safe distance, this configuration is not acceptable.

Recommended Solution

The recommended solution is to create a simple tee intersection. Ruins Road would be the top of the tee, and Cliff Palace Road would be the stem. The advantages of this configuration are that there is no sight distance problems for westbound traffic. However, substantial geometric changes need to occur. This will require paving through the island. This solution also provides the least amount of confusion for motorists, as drivers are familiar with tee intersections. The approximate cost of this solution is \$22,000.

The recommended geometric, signing and striping changes are shown in Figure 10.

Rulins Rd.

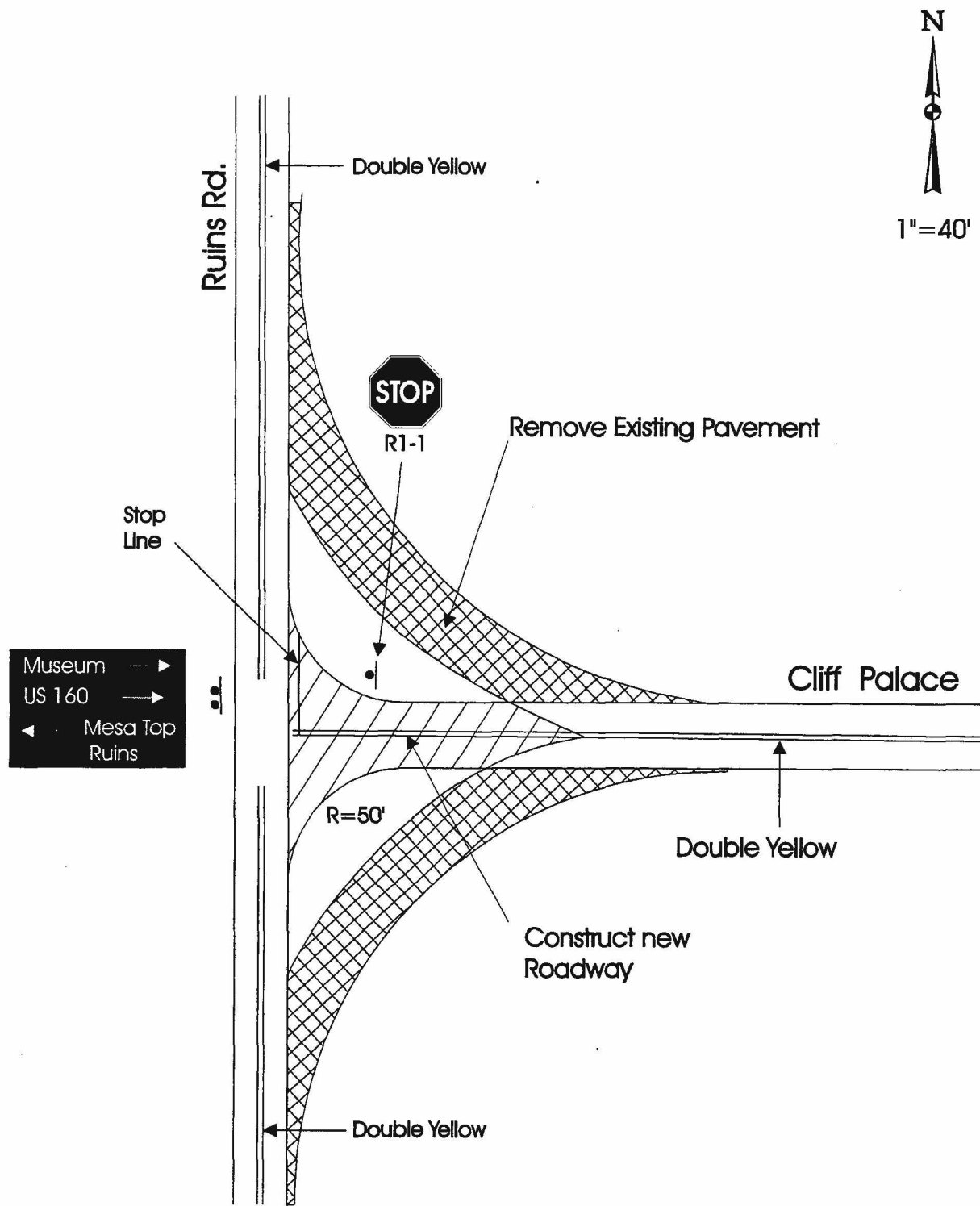


1"=40'

Construct New Pavement

Cliff Palace

Remove Existing Pavement



FAR VIEW / WEATHERILL AREA

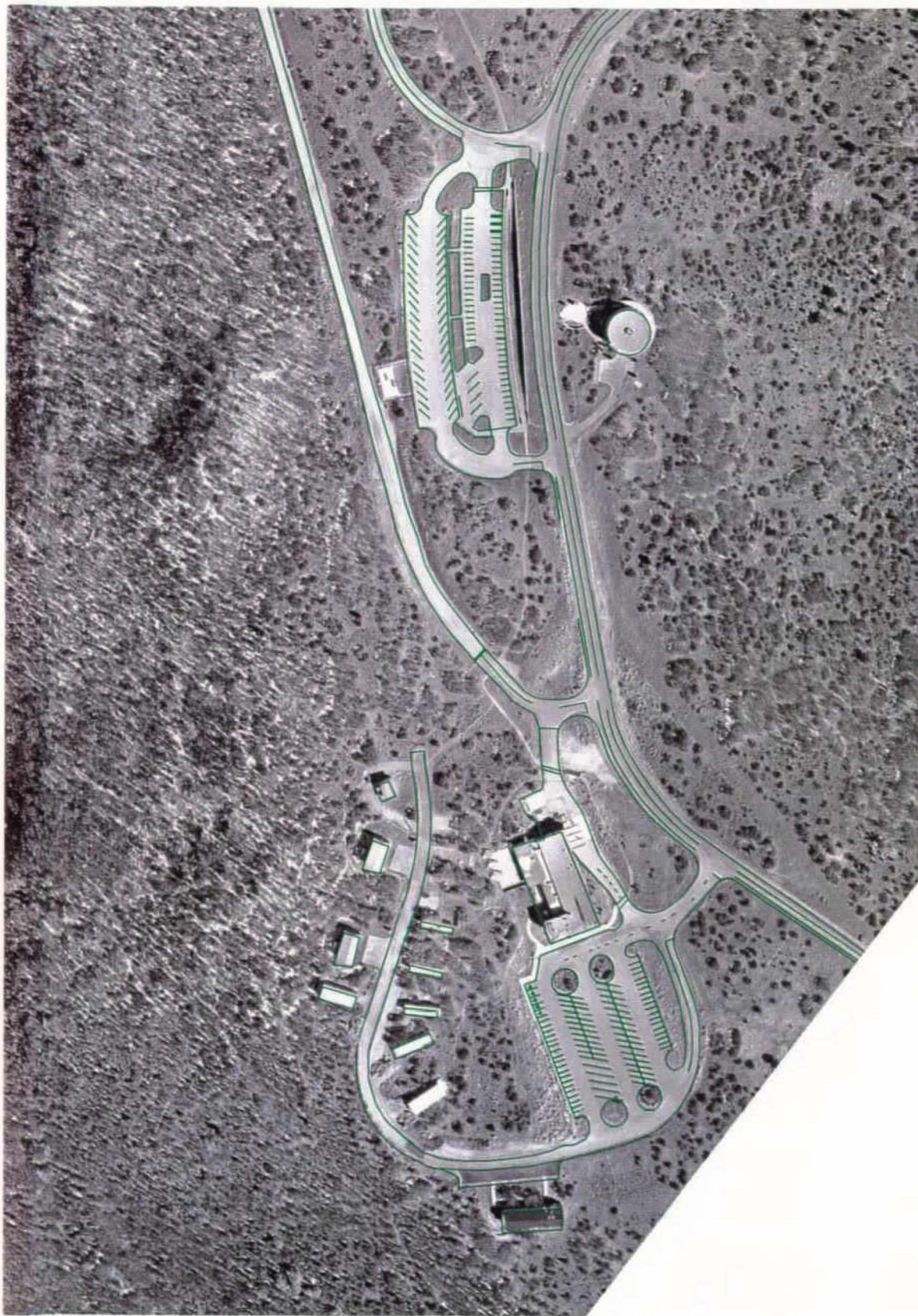
Problem Identification

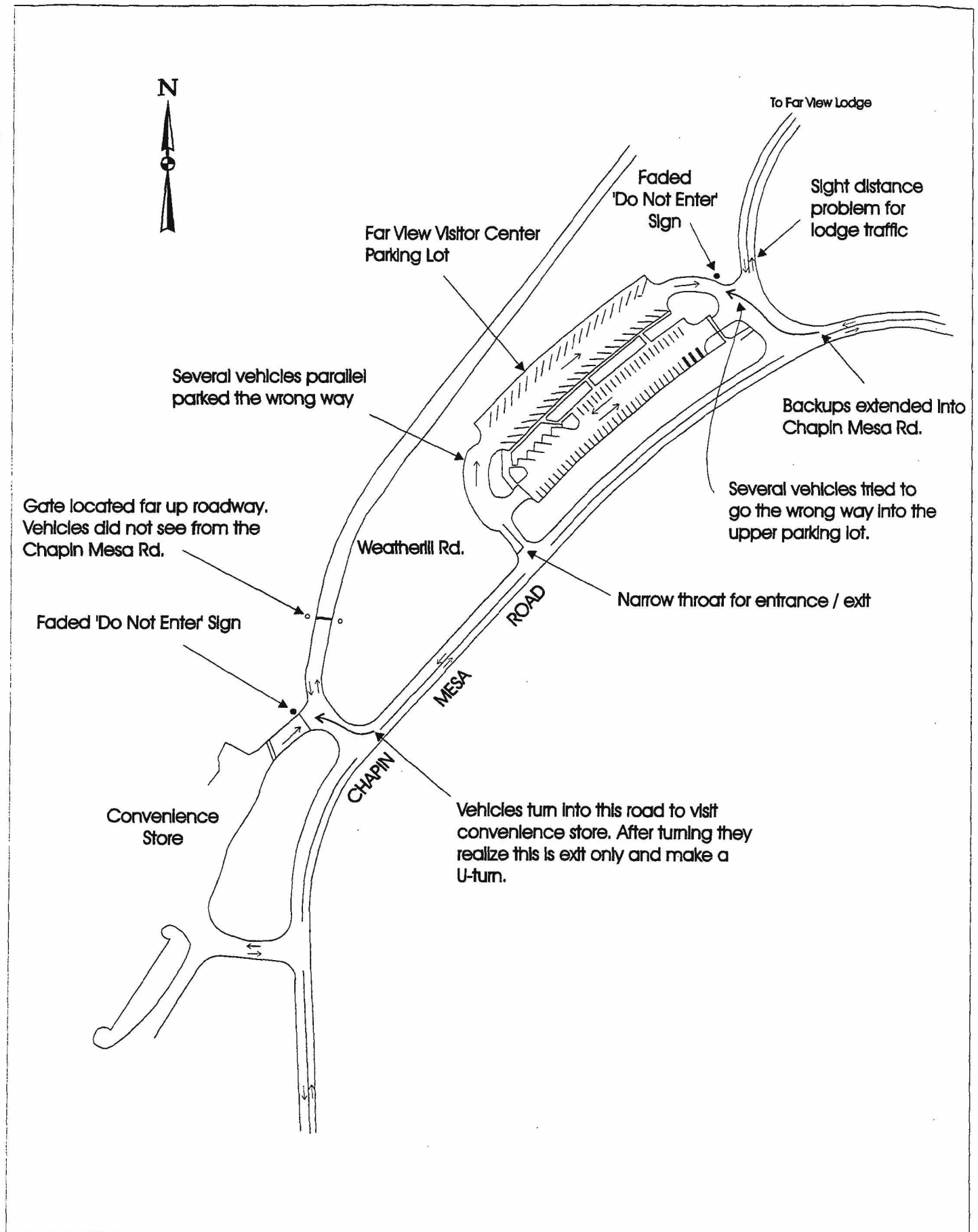
The Far View / Weatherill Area is located halfway into the park and consists of the visitor center, parking lot, lodge, and concession facilities as shown in Figure 11. The driveways into the Far View parking lot, the Far View Lodge and the convenience store provide considerable confusion. Drivers attempting to enter the Far View parking lot conflict with drivers exiting the lot and drivers to and from the lodge. The park staff indicated that visitors experience overall congestion and confusion in this area. Park staff have also noticed vehicles parking on the side of the roadway to drop off visitors. It was also noticed that motorists rarely use their turn signals. The park has implemented a ticketing system for visitors to Cliff Palace, and now many vehicles stop at the Far View Visitor Center to obtain a ticket.

Data Collection

Field observations were conducted in the area to determine points of conflict and confusion. The following observations were noticed during the field review (see Figure 12).

- 1) The north entrance road to Far View Visitor Center parking and the lodge has a sign for southbound traffic that says "Visitor Center Information." This sign is unclear since the parking lot is on the right and the visitor center is on the left.
- 2) There is a T-intersection warning sign for the north intersection. This sign may not be the best sign for this location. The sign does not appear to be in good shape.
- 3) There is a "Do Not Enter" sign at the north intersection which forbids traffic on the upper portion of the parking lot. This sign is extremely faded.
- 4) There is a crosswalk at the north intersection that does not extend fully across the roadway.
- 5) The sign "Lodge and Rooms" at the north intersection is not very visible.
- 6) General confusion was noted at the north intersection. Visitors could not distinguish the "Do Not Enter" sign until they had already partially pulled into the roadway to the upper parking lot. At times, visitors making a southbound right at the north intersection queued along Chapin Mesa Road causing through traffic to stop.
- 7) Drivers coming from the lodge and stopping at the stop sign just west of the upper parking lot cannot see drivers on Chapin Mesa Road.
- 8) There was a path worn into the ground at the south end of the parking lot showing that some pedestrians are not using the tunnel to the Visitor Center.
- 9) The south driveway to the Far View Visitor Center parking lot has a narrow throat.





- 10) Several non-RV vehicles were noted parking in the RV spaces.
- 11) The stop line at the south driveway is located too far back of the intersection and, at its present location, shrubbery impairs sight distance to the south.
- 12) Several visitors were observed turning into the Weatherill Road attempting to go to the service station. The signing at this location is unclear. The service station is accessed from the south. Those vehicles that attempt to use the north roadway must turn around in a very narrow roadway.
- 13) The gate at Weatherill Road is located a sufficient distance from Chapin Mesa Road so that it cannot be seen from Chapin Mesa Road. If the gate is closed, drivers may not know this until they turn onto Weatherill Road. At that point, they must make a U-turn in the roadway.

Accident Analysis

The park service link/node maps show this area to be comprised of three nodes. Node 146 is the intersection of the Lodge Road with Chapin Mesa Road. Node 148 is the intersection of Weatherill Road with Chapin Mesa Road and Node 149 is the intersection of the south entrance to the gas station with Chapin Mesa Road.

There were four accidents associated with Node 146, the entrance to the Far View Lodge and Far View Visitor's Center parking lot.

- Two of the accidents were related to parking lots. One was due to improper backing, and the other was a hit and run.
- Two accidents were automobiles hitting animals.

There were six accidents associated with Node 148, the intersection of Weatherill Road with Chapin Mesa Road.

- One accident occurred 1.5 miles north of the intersection and was not related to this area.
- One accident was a duplicate of the accident 1.5 miles north.
- Two accidents were due to improper backing.
- Two accidents were parking lot related.

There were seven accidents associated with node 149, the south entrance to the concession facilities.

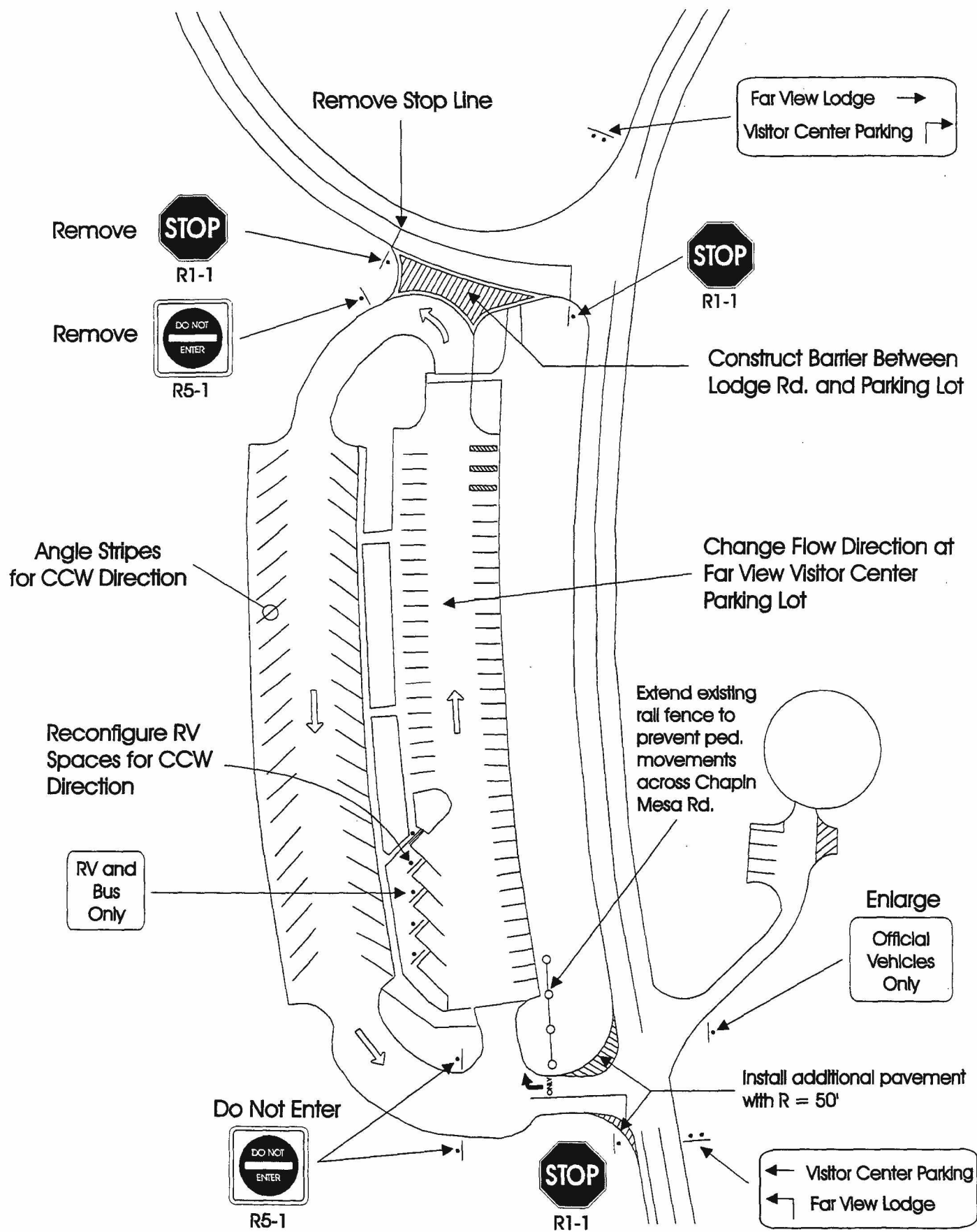
- Five accidents were associated with the parking lot.

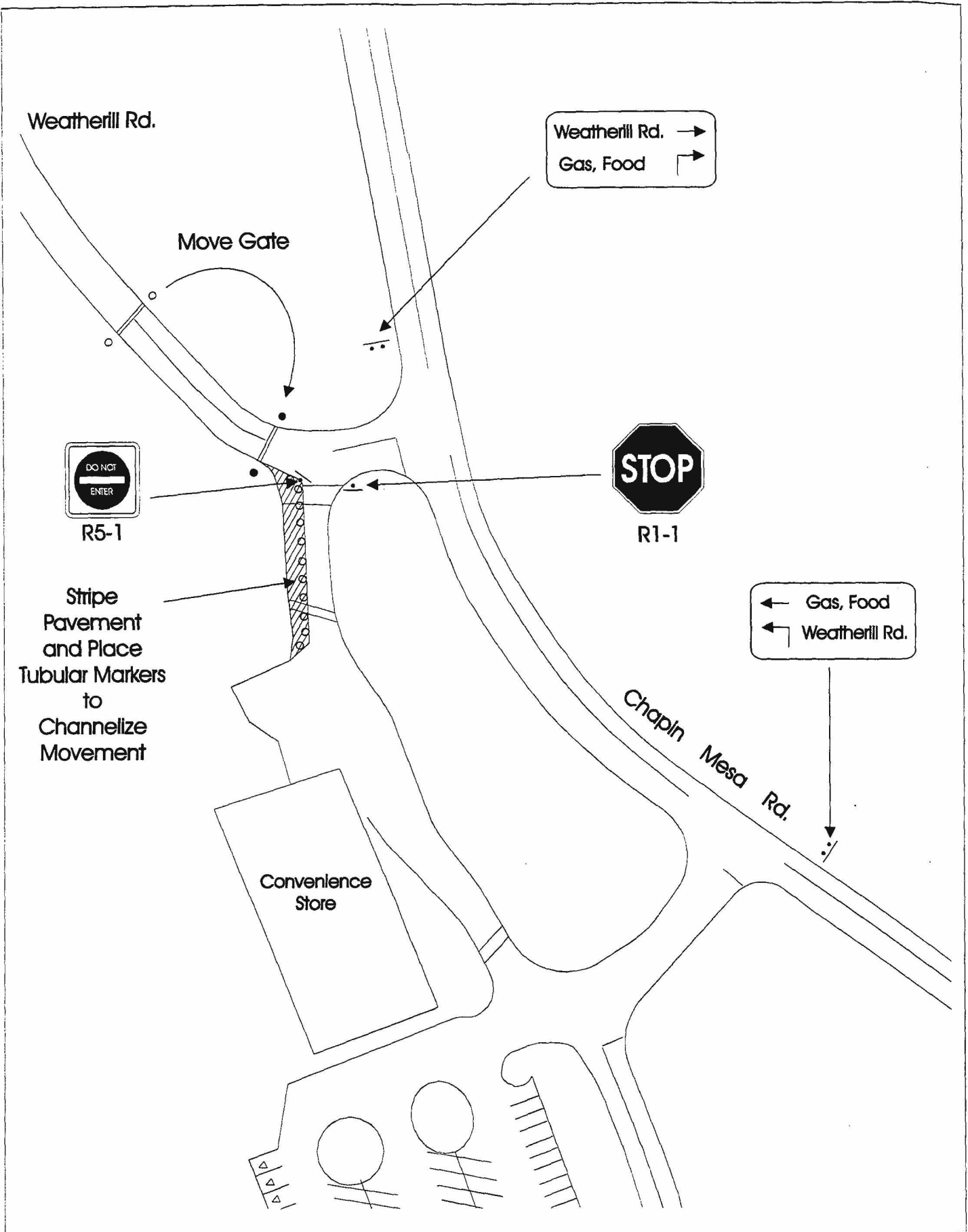
- One accident was .5 miles to the south. This accident was a sideswipe opposing vehicle accident, and was precipitated by an animal.
- One accident occurred at the gas station and was unrelated to this area.

Recommended Solutions

The recommended solutions are shown in Figures 13 and 14. The approximate cost for these improvements is \$30,000.

- 1) The north entrance should be reconfigured to only allow access to the Far View Lodge. A sign needs to be installed north of this intersection showing Far View Lodge as the immediate right, and the Visitor Center parking lot at the following right.
- 2) The parking lot access should be provided solely by the south entrance. This would be a two-way entrance, and should be widened. The direction of flow for the parking lot should be changed from clockwise to counterclockwise. This would reduce the number of conflicting movements at the south intersection. The angled RV parking would need to be reconfigured and signed.
- 3) The exit from the gas station to Weatherill should be channelized more so that it does not appear to be an entrance.
- 4) Another directional sign should be placed north of Weatherill Road showing directions to Weatherill Mesa Road and the concession facilities.



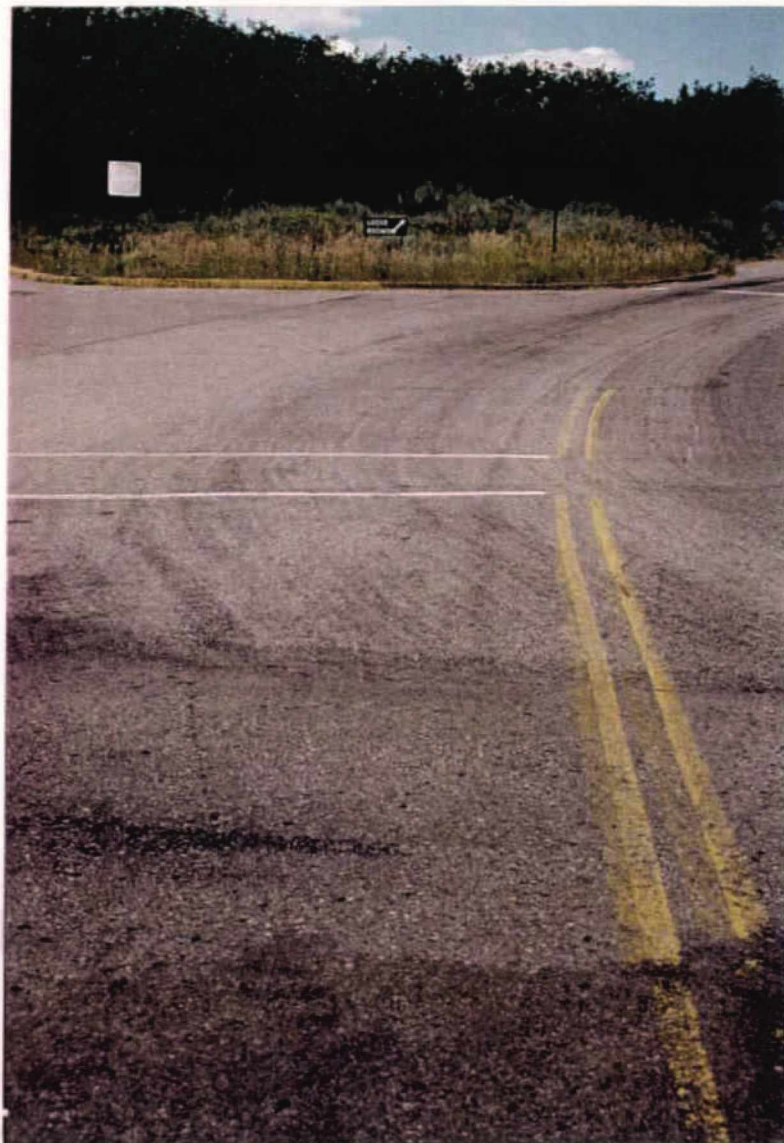




Photograph #1 - southbound at the entrance road at Mesa Verde approaching the Farview Visitor Center. The sign "Visitor Center Information" is on the right and perhaps should say next right or have a right arrow rather than just having the sign since the visitor center is on the left and the parking lot is on the right. There may be a better sign than the T-intersection warning sign that shows the variety of driveways or it may be that the sign is not necessary. If the sign is necessary, it should be replaced. It does not appear to be in very good shape and is probably not reflective.



Photograph #2 - shows the driveway entrance and the road that is also the lodge entrance. Again, the visitor center parking perhaps would be more clear if there were an arrow to the right.



Photograph #3 - is looking in a westerly direction at the lodge driveway. The "Do Not Enter" sign on the left is in extremely poor shape. The sign "lodge and rooms" perhaps could be made more clear. Note: the crosswalk in the foreground does not continue completely across the road.

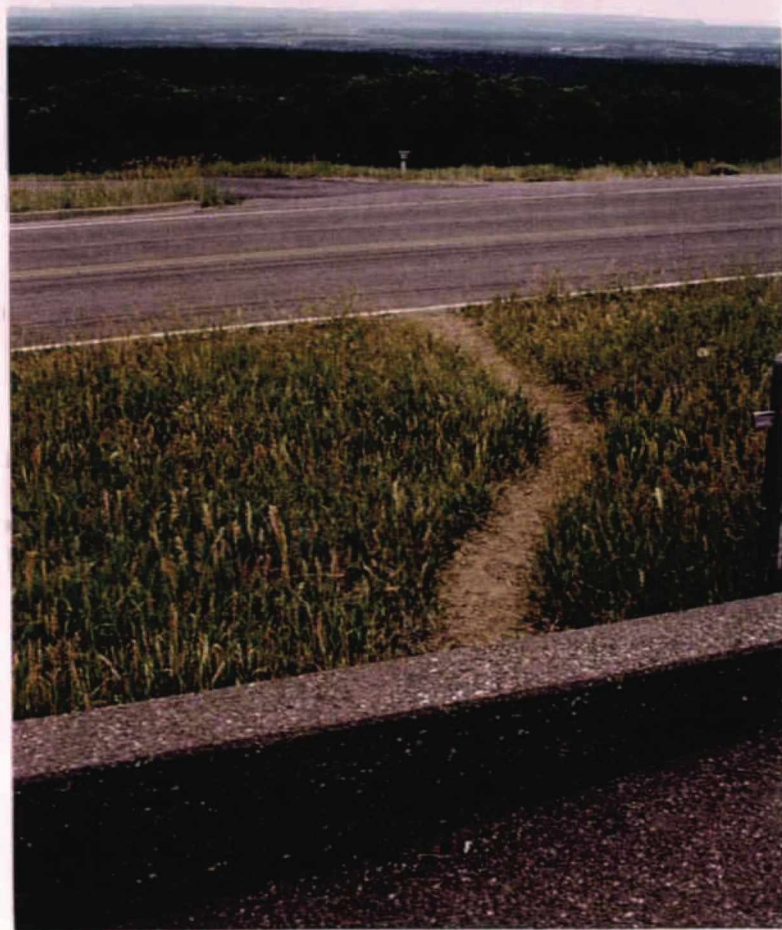


Photograph #4 - shows the similar condition.



Photograph #5 - shows the ramp to the tunnel which goes under the road to the visitor center which seems to work quite well. Where the lodge road and the parking lot come together there seems to be some confusion because of the different directions people are going. A lot of movements are happening right in that area which is shown in *Photograph #6*.

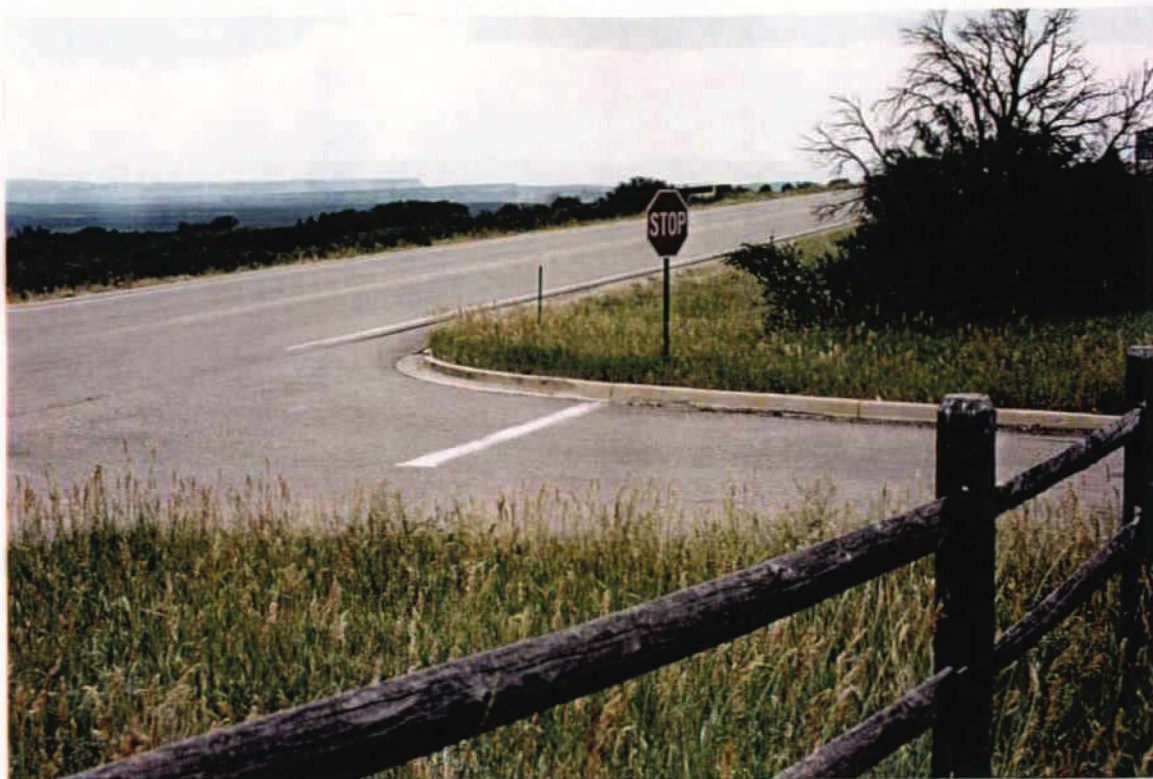




Photograph #7 and #8 - are at the south end of the parking lot at Farview showing the path that apparently some people, rather than taking the tunnel, are using to go across the road to the driveway for park service employees - very small parking lot down there. It may be that an additional taller barrier through there would help to discourage that.



Photograph #9 - is looking in a northwesterly direction at the parking lot. One idea, is to make the north driveway to the lodge only and the only entrance to the parking lot from the south. We would want to make the circulation of the parking lot in a counterclockwise direction which would be reversing the angle for the RV parking of the area shown in *Photograph #9*. Also, there should be signs that show that area of parking is reserved for oversized vehicles. Reversing the parking lot would mean changing the stripes on the west side of it. This will probably necessitate having a slurry seal of the entire lot and restripe the lot.



Photograph #10 - is the south driveway at the Farview Visitor Center parking lot. The stop line may need to be extended farther out. Most of the vehicles that were observed were pulling beyond that to be able to see back to the south. It appears this intersection throat should be widened, if this is the only location for entrance into the parking lot.



Photograph #11 - is looking in a southerly direction from the stop line. Shrubbery on the southwest corner of the driveway intersection should be trimmed to improve sight distance.



Photograph #12 - shows the curb for the exit from this driveway. It appears that right turning traffic out has broken the curb as evidenced by the black marks in the broken curb. Again, widening this throat and improving the radius would be desirable if this is the only entrance and exit.



Photograph #13 - is the "Do Not Enter" on the north side of the service station. We observed vehicles wanting to go to the gas station making a right turn from the main roadway and then realizing that they could not turn left into the gas station. We need to find out why the gas station driveway is one way.



Photograph #14 - shows the gate. You can see on the right where people turn around either when the gate is closed or perhaps when they have already made a right turn or have entered from the main road and then realize they can't turn into the gas station.



Photograph #15 - is looking south at the 4-way intersection. It also shows a van who made a mistake and is backing up.



Photograph #14 - shows the gate. You can see on the right where people turn around either when the gate is closed or perhaps when they have already made a right turn or have entered from the main road and then realize they can't turn into the gas station.



Photograph #15 - is looking south at the 4-way intersection. It also shows a van who made a mistake and is backing up.



Photograph #16 - is a closer view of that same approach looking south.



Photograph #17 - is looking east at the 4-way intersection.



Photograph #18 - is looking north at the 4-way intersection.



Photograph #19 - is looking west at the 4-way intersection.



Photograph #20 - is looking south toward the 3-way intersection.



Photograph #21 - is closer also looking south.



Photograph #22 - is closer also looking south.



Photograph #23 - is looking south from the north intersection.



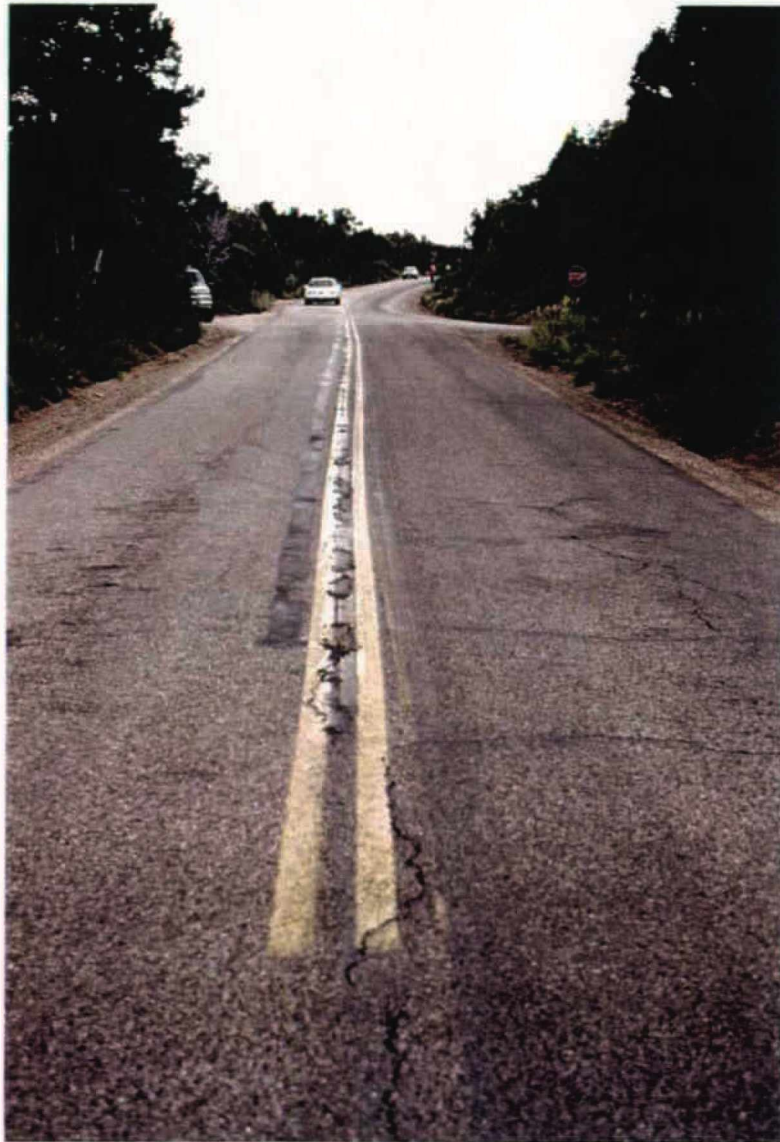
Photograph #24 - is looking southeasterly from the north intersection.



Photograph #25 - is looking south from the south intersection.



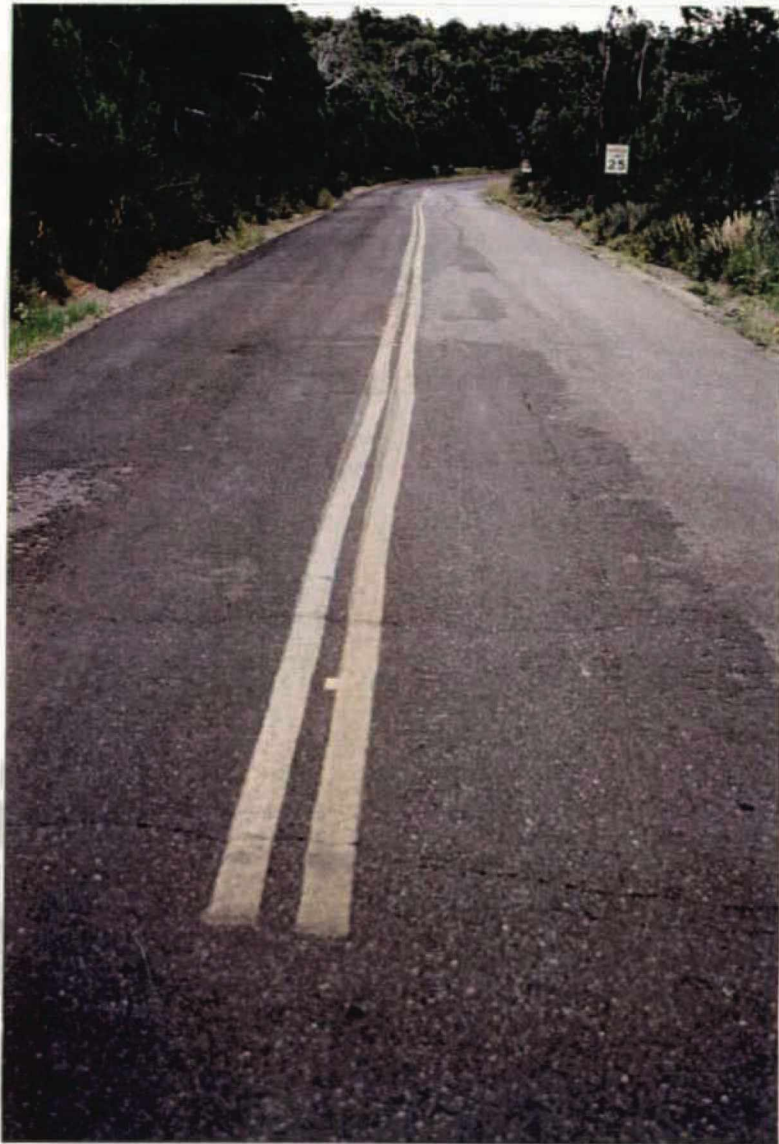
Photograph #26 - is looking northeasterly from the south intersection.



Photograph #27 - is looking north from the south intersection.



Photograph #28 - is looking easterly from the southeast leg of the three-way.



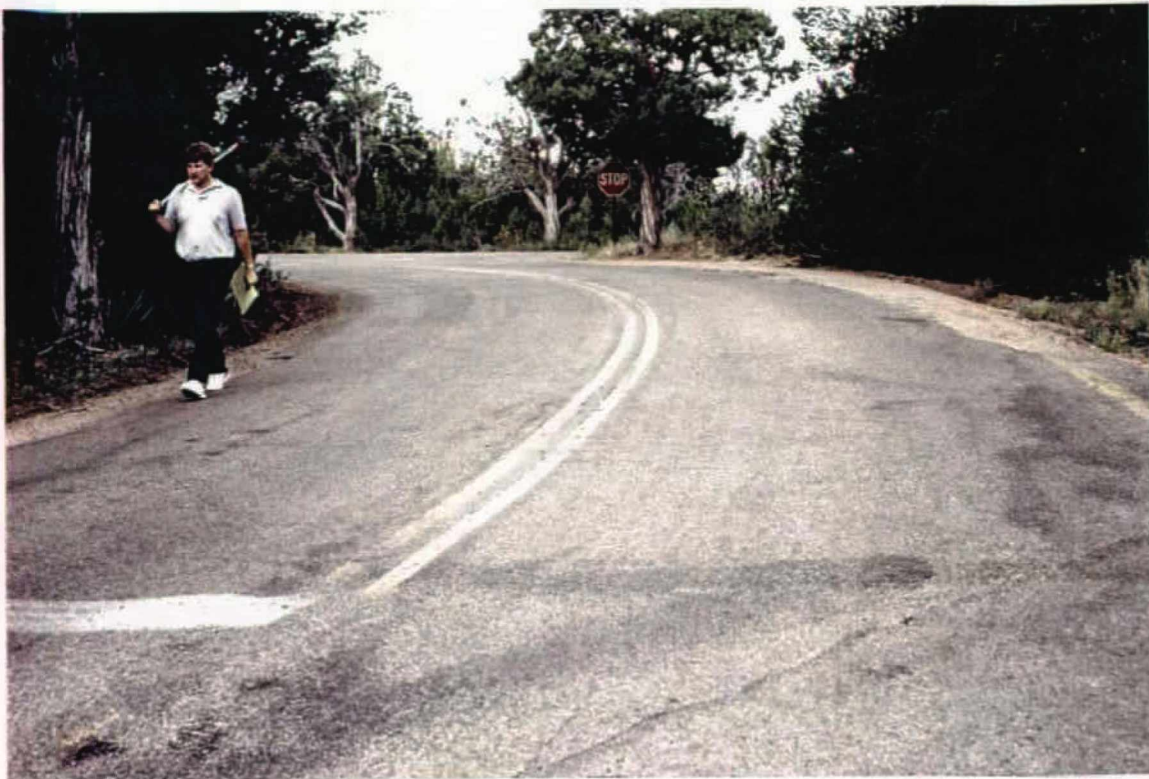
Photograph #29 - is looking easterly from the east intersection.



Photograph #30 - is looking west approaching the east intersection.



Photograph #31 - is looking northwest from the east intersection.



Photograph #32- is looking southwest from the east intersection.



Photograph #33 - is looking north approaching the three-way.



Photograph #34 - is looking north approaching the south intersection of the three-way.



Photograph #35 - is looking north from just south of the south intersection.



Photograph #36 - is looking easterly at the approximate route the roadway would come if we turned it into a T-intersection.

