NBAF
Traffic Impact Study

Manhattan, KS | 2009
Project No. SP0908
HWS Project No. 57-39-1009

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October 1, 2009

Dale Houdeshell
Director of Public Works
City of Manhattan
1101 Poyntz Avenue
Manhattan, KS 66502

Dear Mr. Houdeshell,

HWS Consulting Group is pleased to present you with the National Bio and Agro-Defense Facility (NBAF) Traffic Impact Study you requested. The attached report provides analysis of the impact this facility will have on the transportation system of the City of Manhattan and the improvements we recommend to mitigate this impact.

The City's transportation system was analyzed for existing conditions, existing plus NBAF conditions, and 2030 conditions. Trip generation projections, volume and capacity analysis, and geometric improvements are all included in the report. Should you have any questions or comments regarding this traffic impact study please do not hesitate to contact me. I can be contacted at the HWS Manhattan Office at (785) 539-2202.

Sincerely,

Kurt Rotering, IE

Mike McKenna, PE, PTOE
Traffic & Transportation Planning Manager

TABLE OF CONTENTS

1.0 PURPOSE AND STUDY OBJECTIVE

The purpose of this study is to assess the impact of the proposed National Bio and Agro-Defense Facility (NBAF) on the surrounding transportation system in the City of Manhattan, Kansas. The proposed site for the NBAF is at the southeast quadrant of the intersection of Kimball Avenue and Denison Avenue. The general location of the NBAF relative to the surrounding streets is shown on page 4. This study includes a discussion of existing conditions, the expected impact of the NBAF on the street system and the future 2030 conditions. The study includes trip generation projections, volume/capacity analyses, and recommendation of improvements to the transportation system to mitigate the potential impact of the proposed facility.

2.0 PROPOSED DEVELOPMENT PLAN

The NBAF will be approximately 520,000 square feet and is proposed to sit on 45 acres. 250-350 employees will be working at the facility during the normal 8:00 a.m. to 5:00 p.m. workday. The proposed site plan for the NBAF can be seen on page 5.

3.0 STUDY AREA

To study the impacts of the NBAF on the surrounding street system, multiple intersections were identified for study during the A.M. and P.M. peak hours. The intersections studied are:

1) Kimball Ave. & Hwy. K-113 (West On/Off Ramps)
2) Kimball Ave. & Hwy. K-113 (East On/Off Ramps)
3) Kimball Ave. & College Ave.
4) Kimball Ave. & Denison Ave.
5) Kimball Ave. & Manhattan Ave.
6) Kimball Ave. & Meadowlark Rd.
7) Kimball Ave. & Tuttle Creek Blvd./Hwy. US-24
8) Denison Ave. & Marlatt Ave.
9) Denison Ave. & Kerr Dr.
10) Denison Ave. & Jardine Dr.
11) Manhattan Ave. & Blue Hills Ln.
12) Manhattan Ave. & Research Park Dr./Keen Dr.
13) Manhattan Ave. & Claflin Rd./Pioneer Dr.
14) Marlatt Ave. & College Ave.
15) Marlatt Ave. & Tuttle Creek Blvd./Hwy. US-24

3.1 TRAFFIC COUNTS

The proposed facility creates a new intersection along Denison Avenue. This intersection was added to the model in both the Existing Plus NBAF and Future 2030 Conditions.

A.M. and P.M. peak hour and 24-hour counts were taken at all of the study intersections by the City of Manhattan staff within the last year and a half. Counts were taken using tube counters, permanent cameras on the signals, and by field observation.

3.2 SURROUNDING AREA

The land surrounding the proposed site of the NBAF is mostly owned by Kansas State University. The University's Recreation Complex and playfields are across Denison Avenue to the west and Pat Roberts Hall is directly to the south. The National Institute for Strategic Technology Acquisition and Commercialization (NISTAC) is to the east and a City of Manhattan fire station is across Kimball Avenue to the north.

Kansas State University's football, basketball, and baseball stadiums are located along the south side of Kimball Avenue between College Avenue and Denison Avenue. These facilities cause huge traffic events numerous times throughout the year. These events were not taken into account as they are not the normal conditions, but still should be noted because of the high volume of traffic that occurs.

3.3 STREET NETWORK

Kimball Avenue is a 4-lane arterial for the City of Manhattan with a 40 mph speed limit from College Avenue to US-24, and 30 mph speed limit from College Avenue to K-113. Denison Avenue is a Collector with a 30 mph urban 3-lane cross-section south of Kimball and a rural 35 mph 2-lane section north of Kimball Avenue that turns to 50 mph about halfway to Marlatt Avenue. College Avenue is a 30 mph 4-lane collector south of Kimball Avenue and a half-mile north of Kimball Avenue where it turns into a 40 mph 2-lane rural street. Marlatt Avenue runs east-west with a 50 mph speed limit and has a 2-lane rural section. Manhattan Avenue is a 2-lane 35 mph rural street from Claflin Road to Kimball Avenue, and a 3-lane urban section south of Claflin Road. Jardine Drive, Kerr Drive, Meadowlark Road, Blue Hills Lane, Research Park Drive, and Keen Street are all two lane local roads with 30 mph speed limits. Claflin Road is also a 2-lane local street but has a speed limit of 20 mph west of Manhattan Avenue and 30 mph east of Manhattan Avenue.

K-113/Seth Child Road is a 4-lane arterial with a 45 mph speed limit. The intersection of Seth Child and Kimball Avenue is a diamond interchange with Wreath Avenue providing access to the southbound on-ramp.

[File Location: H:\Projects\37391000 - Manhattan NBAF Traffic Impact Study\Dwgs\1 Location Map.dwg] [Plot Date: 10/5/2009 8:17:53 AM] [Last Saved: 6/29/2009 4:59:19 PM] [Plotted]

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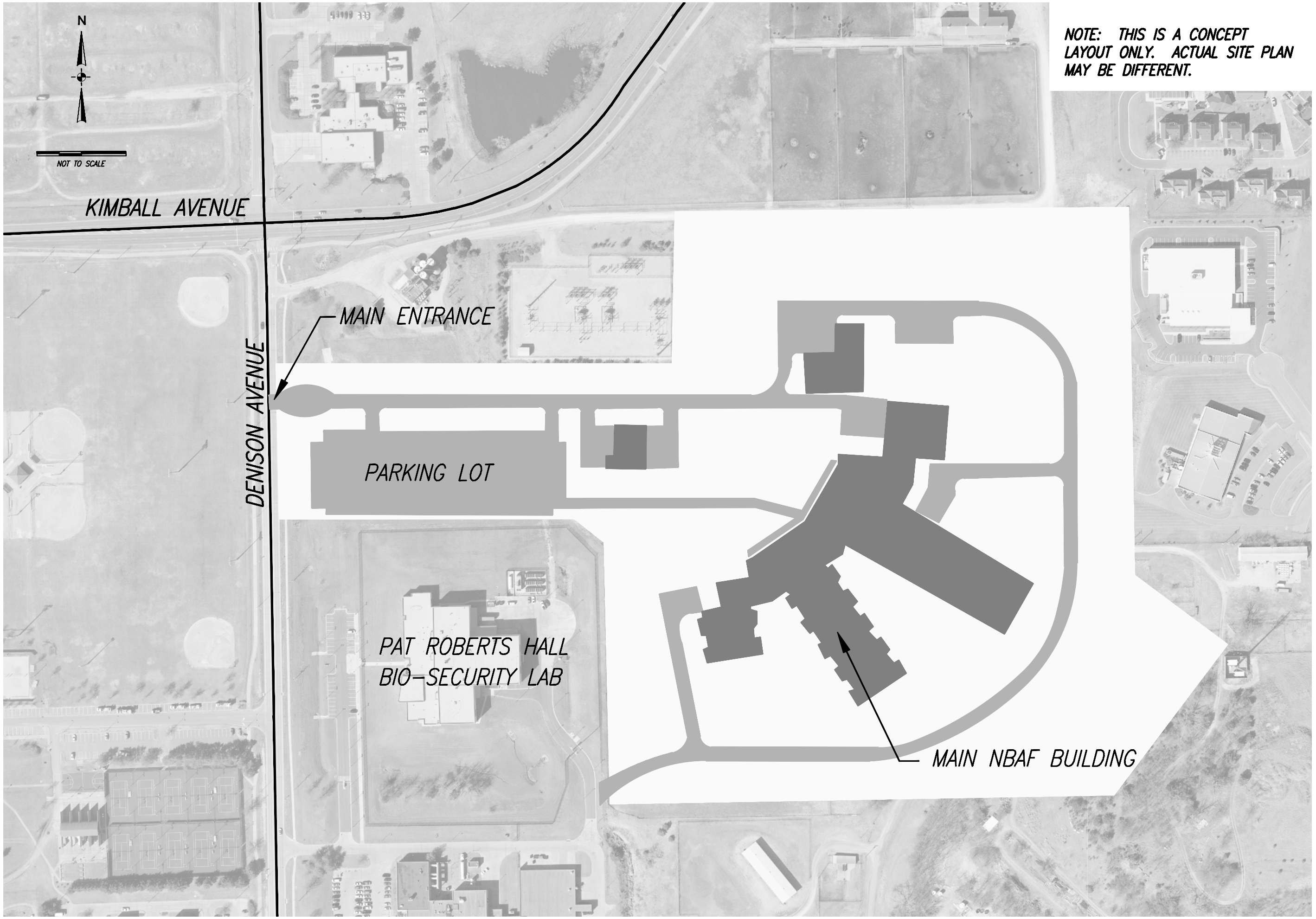
NBAF TRAFFIC IMPACT STUDY

MANHATTAN, KANSAS

FIGURE 1

SITE LOCATION

NO.	REVISIONS	DATE
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-



NOTE: THIS IS A CONCEPT LAYOUT ONLY. ACTUAL SITE PLAN MAY BE DIFFERENT.

NO.	REVISIONS	DATE
-	-	-

FIGURE 2
SITE PLAN

NBAF TRAFFIC IMPACT STUDY
MANHATTAN, KANSAS

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4.0 ANALYSIS

The analysis of the NBAF's impact includes estimates of vehicle trip generation, distribution of these trips onto the street network, and analysis of the network's operations during peak hour. Each of these analysis techniques and their results are described below. The study focused on typical weekday A.M. and P.M. peak hour operations during the school year.

4.1 TRIP GENERATION

The vehicle trips generated by the proposed facility were estimated using the Institute of Transportation Engineers' Trip Generation, 7th Edition. The estimated peak hour volumes to be generated by the NBAF for 3 different ITE intensity classifications are shown in Table 1. To be conservative the average of the three was increased by 10%.

TABLE 1

TRIP GENERATION

LAND USE	INTENSITY	ITE CODE	DAILY	A.M. PEAK HOUR TOTAL	A.M. PEAK HOUR IN	A.M. PEAK HOUR OUT	P.M. PEAK HOUR TOTAL	P.M. PEAK HOUR IN	P.M. PEAK HOUR OUT
National Bio and Agro Defense Facility (NBAF)									
Light Industrial	350 employees*	110	1,063	188	164	24	192	56	136
	520,000 square feet	110	3,782	553	498	55	613	86	527
	45 acres	110	2,163	287	244	43	328	98	230
	*Adjusted Average***		*2,570*	*377*	*332*	*45*	*415*	*88*	*327*

*NBAF is projected to have between 250 and 350 employees

**Adjusted Average = Average x 1.1

4.2 TRIP DISTRIBUTION

The estimated new peak hour trips generated by the proposed facility were distributed onto the street system based on the trip distributions summarized below. Table 2 illustrates the general distributions used in this study which were derived based on existing travel patterns, existing land uses, and projected land uses in the City. Trip distribution through the Kimball Avenue and Denison Avenue intersection was based mainly on existing travel patterns. Figure A-2, Existing A.M. Peak Hour Traffic Volumes, shows that about 50% of the traffic going through the south leg is either coming from or going to the east, 20% to the north, and 30% to the west.

TABLE 2 TRIP DISTRIBUTION	
DIRECTION TO/FROM	**NBAF**
Denison Avenue Access	
North on Denison Avenue	75%
South on Denison Avenue	25%
TOTAL	100%
Through Kimball Intersection	
North on Denison Avenue	20%
West on Kimball Avenue	30%
East on Kimball Avenue	50%
TOTAL	100%

5.0 TRAFFIC OPERATION ASSESSMENT

An assessment of traffic operations was made for three separate scenarios. These scenarios allowed for comparison of the before and after impacts of the proposed development in the study area. The scenarios studied included:

- Existing Conditions
- Existing plus NBAF Conditions
- Future Year 2030 Conditions

The study intersections were evaluated based on the methodologies outlined in the Highway Capacity Manual, 2000 Edition, published by the Transportation Research Board. The operating conditions at an intersection are graded by the "Level of Service." Level of service (LOS) describes the quality of traffic operating conditions and is rated from "A" to "F". LOS A represents the most desirable condition with free-flow movement of traffic with minimal delays. LOS F generally indicates severely congested conditions with excessive delays to motorists. Intermediate grades of B, C, D, and E reflect incremental increases in the average delay per stopped vehicle. Delay is measured in seconds per vehicle. Table 3 shows the upper limit of delay associated with each level of service for signalized and unsignalized intersections. It is important to note that safety is not included in the measures that establish service levels.

TABLE 3 INTERSECTION LEVEL OF SERVICE DELAY THRESHOLDS		
LEVEL OF SERVICE (LOS)	**SIGNALIZED**	**UNSIGNALIZED**
A	< 10 Seconds	< 10 Seconds
B	< 20 Seconds	< 15 Seconds
C	< 35 Seconds	< 25 Seconds
D	< 55 Seconds	< 35 Seconds
E	< 80 Seconds	< 50 Seconds
F	≥ 80 Seconds	≥ 50 Seconds

Each community has a certain LOS that is deemed acceptable. The City of Manhattan tries to obtain a LOS D for all movements at unsignalized intersections. A LOS E or F may be acceptable at locations where low to moderate traffic volumes exist and a traffic signal is not warranted or is not desirable for other reasons. For signalized intersections the LOS relates to all vehicles using the intersection. The City of Manhattan uses a LOS D as the minimum desirable standard for each movement at signalized intersections. LOS for intersections was calculated and all intersections were evaluated using Synchro 7, a traffic signal software package based on Highway Capacity Manual methods.

5.1 EXISTING CONDITIONS

A summary for the intersection analysis of existing A.M. and P.M. peak hour conditions is shown in Table 4. Existing lane configurations, traffic volumes, and traffic controls for the study intersections are shown in Appendix A, Figures A-3, A-4, and A-5.

TABLE 4
INTERSECTION LEVEL OF SERVICE - EXISTING CONDITIONS

Intersection	A.M. Peak Hour		P.M. Peak Hour	
Approach / Movement	LOS	Delay	LOS	Delay
1 Kimball Ave. & Hwy. K-113 (West On/Off Ramps)				
Westbound Left-turn	B	3.7	B	2.9
Northbound	E	42.4	F	140.1
Southbound	D	27.9	F	91.0
2 Kimball Ave. & Hwy. K-113 (East On/Off Ramps)				
Eastbound Left-turn	A	1.1	B	10.0
Northbound	D	27.7	F	67.3
3 Kimball Ave. & College Ave.				
Signalized (All Movements)	B	17.7	B	18.0
4 Kimball Ave. & Denison Ave.				
Signalized (All Movements)	C	22.0	C	21.9
5 Kimball Ave. & Manhattan Ave.				
Signalized (All Movements)	A	9.5	B	14.4
6 Kimball Ave. & Meadowlark Rd.				
Eastbound Left-turn	B	9.2	B	10.1
Southbound	C	17.3	C	22.4
7 Kimball Ave. & Tuttle Creek Blvd./Hwy. US-24				
Signalized (All Movements)	C	22.3	D	42.8
8 Denison Ave. & Marlatt Ave.				
Westbound	A	3.8	A	4.8
Northbound	B	14.1	C	16.6
9 Denison Ave. & Kerr Dr.				
Eastbound	C	18.4	C	19.0
Westbound	A	0.0	B	10.5
Northbound Left-turn	A	0.2	A	0.5
Southbound Left-turn	A	0.2	A	0.0
10 Denison Ave. & Jardine Dr.				
Signalized (All Movements)	B	18.1	B	19.0
11 Manhattan Ave. & Blue Hills Ln.				
Eastbound	C	19.6	C	20.2
Westbound	A	9.8	D	28.1
Northbound Left-turn	A	0.0	A	0.0
Southbound Left-turn	A	0.0	A	0.0
12 Manhattan Ave. & Research Park Dr.				
Eastbound	C	16.9	E	41.5
Westbound	C	16.9	D	26.5
Northbound Left-turn	A	0.5	A	0.3
Southbound Left-turn	A	0.1	A	0.2
13 Manhattan Ave. & Claflin Rd.				
Signalized (All Movements)	B	16.3	C	22.3
14 Marlatt Ave. & College Ave.				
Eastbound Left-turn	A	0.3	A	0.2
Westbound Left-turn	A	1.8	A	1.1
Northbound	B	12.2	B	11.8
Southbound	B	14.2	B	12.5
15 Marlatt Ave. & Tuttle Creek Blvd./Hwy. US-24				
Eastbound	F	239.6	E	44.2
Westbound	F	206.6	D	25.4
Northbound Left-turn	B	1.8	A	1.6
Southbound Left-turn	B	3.0	A	0.1

The analysis results of the existing traffic conditions indicate that most of the intersections or movements are better than the City's desirable Level of Service. The Marlatt Avenue and Tuttle Creek Boulevard intersection is currently being upgraded to a signalized intersection which brings its LOS to an acceptable level and is reflected in the Existing Plus NBAF Conditions as it will be constructed once the NBAF is open.

The K-113 on/off ramps both fail in the minor left turn movement. Both of these locations are known by the City as problem locations and have been looked at for improvements. Signals and roundabouts have both been suggested for these locations. In order to compare the impact the NBAF has on these intersections, the geometry was not changed during analysis for Existing plus NBAF Conditions. Suggested recommendations are in section 5.3. The only other movement that failed is the eastbound movement from Research Park Drive onto Manhattan Avenue. This location does not warrant a signal at this time.

5.2 EXISTING PLUS NBAF CONDITIONS

Intersection analysis was then conducted to determine the impact on existing conditions with the addition of the proposed NBAF. The results for the intersection analyses of existing plus NBAF development A.M. and P.M. peak hours have been summarized in Table 5.

The proposed NBAF site plan adds a new intersection on Denison about 500 feet south of Kimball. The median will need to be restriped to add a southbound left turn lane. A northbound exclusive right turn lane will also need to be added to minimize delay for through northbound traffic.

TABLE 5
INTERSECTION LEVEL OF SERVICE - EXISTING PLUS NBAF CONDITIONS

Intersection	A.M. Peak Hour		P.M. Peak Hour	
Approach / Movement	LOS	Delay	LOS	Delay
1 Kimball Ave. & Hwy. K-113 (West On/Off Ramps)				
Westbound Left-turn	B	11.2	B	10.9
Northbound	E	48.1	F	175.9
Southbound	E	40.4	F	110.5
2 Kimball Ave. & Hwy. K-113 (East On/Off Ramps)				
Eastbound Left-turn	A	9.1	B	10.2
Northbound	D	30.2	F	73.1
3 Kimball Ave. & College Ave.				
Signalized (All Movements)	B	18.5	B	18.0
4 Kimball Ave. & Denison Ave.				
Signalized (All Movements)	C	22.3	C	26.3
5 Kimball Ave. & Manhattan Ave.				
Signalized (All Movements)	A	9.5	B	15.3
6 Kimball Ave. & Meadowlark Rd.				
Eastbound Left-turn	A	9.3	B	10.0
Southbound	C	17.5	C	22.3
7 Kimball Ave. & Tuttle Creek Blvd./Hwy. US-24				
Signalized (All Movements)	C	23.2	D	52.3
8 Denison Ave. & Marlatt Ave.				
Westbound	A	4.4	A	5.0
Northbound	C	20.1	C	19.4
9 Denison Ave. & Kerr Dr.				
Eastbound	C	21.6	C	22.3
Westbound	A	0.0	B	10.6
Northbound Left-turn	A	8.5	A	0.5
Southbound Left-turn	A	8.3	A	0.0
10 Denison Ave. & Jardine Dr.				
Signalized (All Movements)	B	18.7	C	23.5
11 Manhattan Ave. & Blue Hills Ln.				
Eastbound	C	20.0	C	21.1
Westbound	B	10.0	D	29.4
Northbound Left-turn	A	0.0	A	0.0
Southbound Left-turn	A	0.0	A	9.6
12 Manhattan Ave. & Research Park Dr.				
Eastbound	C	17.4	E	45.3
Westbound	C	17.6	D	27.8
Northbound Left-turn	A	0.4	A	0.3
Southbound Left-turn	A	0.1	A	0.2
13 Manhattan Ave. & Claflin Rd.				
Signalized (All Movements)	B	16.4	C	22.7
14 Marlatt Ave. & College Ave.				
Eastbound Left-turn	A	0.2	A	0.2
Westbound Left-turn	A	1.9	A	1.0
Northbound	B	12.6	B	12.6
Southbound	B	14.9	B	13.0
15 Marlatt Ave. & Tuttle Creek Blvd./Hwy. US-24				
Signalized (All Movements)	A	8.4	B	11.2
16 Denison Ave. & NBAF Access Rd.				
Westbound	D	26.2	D	31.9
Southbound Left-turn	B	10.2	A	9.0

A couple of intersections' LOS decreased but no more additional movements or intersections dropped below the City of Manhattan's acceptable LOS therefore no intersection improvements are recommended beyond K-113 on-off ramps already under consideration by the City.

5.3 FUTURE 2030 CONDITIONS

To try to prepare the transportation network for future expansion and growth of the City and surrounding area, the estimated traffic volume growth for the next 20 years were added to current traffic volumes to predict future 2030 conditions. Future volumes were estimated by using a 2.0% growth per year compounded annually. This growth takes into account the normal growth seen in the Manhattan area and the growth predicted to follow NBAF and other related industries and businesses.

Table 6 shows the impact this growth will have on the existing street network. As can be seen in the table, almost all of the intersections and movements fail with existing geometric and traffic control conditions. Multiple infrastructure upgrades are necessary to keep the network at an acceptable Level of Service.

TABLE 6
INTERSECTION LEVEL OF SERVICE - 2030 CONDITIONS

Intersection / *Approach / Movement*	A.M. Peak Hour LOS	A.M. Peak Hour Delay	P.M. Peak Hour LOS	P.M. Peak Hour Delay
1 Kimball Ave. & Hwy. K-113 (West On/Off Ramps)				
Westbound Left-turn	C	20.0	C	18.8
Northbound	F	>9999	F	>9999
Southbound	F	>9999	F	>9999
2 Kimball Ave. & Hwy. K-113 (East On/Off Ramps)				
Eastbound Left-turn	B	10.7	B	14.0
Northbound	F	701.9	F	>9999
3 Kimball Ave. & College Ave.				
Signalized (All Movements)	D	41.5	C	25.8
4 Kimball Ave. & Denison Ave.				
Signalized (All Movements)	E	74.9	F	94.2
5 Kimball Ave. & Manhattan Ave.				
Signalized (All Movements)	B	12.4	C	24.2
6 Kimball Ave. & Meadowlark Rd.				
Eastbound Left-turn	B	10.7	B	12.7
Southbound	D	33.4	F	65.1
7 Kimball Ave. & Tuttle Creek Blvd./Hwy. US-24				
Signalized (All Movements)	D	38.2	F	155.6
8 Denison Ave. & Marlatt Ave.				
Westbound	A	5.4	A	5.7
Northbound	F	205.1	F	112.9
9 Denison Ave. & Kerr Dr.				
Eastbound	F	69.4	F	88.1
Westbound	A	0.0	B	12.3
Northbound Left-turn	A	9.4	A	9.4
Southbound Left-turn	A	9.2	A	0.0
10 Denison Ave. & Jardine Dr.				
Signalized (All Movements)	C	26.1	C	26.1
11 Manhattan Ave. & Blue Hills Ln.				
Eastbound	D	31.2	F	53.9
Westbound	B	11.2	F	73.5
Northbound Left-turn	A	0.0	B	11.6
Southbound Left-turn	A	0.0	A	0.0
12 Manhattan Ave. & Research Park Dr.				
Eastbound	D	30.3	F	587.6
Westbound	E	39.2	F	108.4
Northbound Left-turn	A	0.7	A	0.7
Southbound Left-turn	A	0.1	A	0.3
13 Manhattan Ave. & Claflin Rd.				
Signalized (All Movements)	D	44.7	F	130.8
14 Marlatt Ave. & College Ave.				
Eastbound Left-turn	A	0.2	A	0.2
Westbound Left-turn	A	2.2	A	1.1
Northbound	C	16.7	C	17.4
Southbound	C	21.8	C	17.9
15 Marlatt Ave. & Tuttle Creek Blvd./Hwy. US-24				
Signalized (All Movements)	C	28.5	B	13.9
16 Denison Ave. & NBAF Access Rd.				
Westbound	F	107.4	F	2566.1
Southbound Left-turn	B	12.1	B	10.6

5.3 FUTURE 2030 IMPROVEMENTS

To bring the existing conditions to an acceptable level of service for future traffic volumes, multiple improvements to the traffic network are necessary. Table 7 shows the level of service and delay in seconds of the intersections if the recommended improvements are implemented. The following improvements were identified in order to meet acceptable levels of service at the following streets and intersections:

Kimball Avenue

No major road improvements are recommended along Kimball Avenue. There is a multi-use trail along the south side of Kimball Avenue from College Avenue to Manhattan Avenue The 5′ sidewalk from Manhattan Avenue to US-24 could be widened to 10′ as well to accommodate bicycles. Between K-113 and College Avenue there are 5′ sidewalks on both sides of the road but no bike lanes. On street bike lanes here would be optimal since the sidewalk is residential and bikes along here would be dangerous because of driveways and pedestrians.

There is room along Kimball Avenue for bus stops if the City of Manhattan chooses to pursue transit. There is one existing bus stop, for a daycare, west of College Avenue and there is room along both sides of Kimball Avenue just west of K-113 and between College Avenue and Denison Avenue for bus stops to be constructed. Intersection improvements along Kimball Avenue are as follows:

<u>Kimball Ave. & Hwy. K-113 (West On/Off Ramps)</u>

- Install a traffic signal due to the high volume of left turn movements from the north and south.
- To minimize delay from the off ramp of K-113, it is recommended that separate left and right turn lanes be constructed making a three lane section on the off ramp.

<u>Kimball Ave. & Hwy. K-113 (East On/Off Ramps)</u>

- Install a traffic signal due to high volumes and delays from off ramp.
- Restripe the off-ramp from K-113 to create exclusive left and right turn lanes.

NOTE: Roundabouts were considered for the on/off ramp intersections of K-113 because of large left turn movements. Because of the volume of traffic on Kimball, a 2-lane roundabout was most likely needed. This is still an option, but further analysis is needed to see if the large pedestrian movement from the nearby park mixed with the 2-lane roundabout would work.

Kimball Ave. & Denison Ave.

- Dual northbound left turn lanes and an exclusive northbound right-turn lane should be constructed to minimize delay for vehicles and to allow for more storage without impeding the NBAF Access intersection.
- It is recommended that an exclusive southbound right turn lane also be installed to minimize delay.
- This signal will also need to be retimed for the new geometry and increased volumes.

Kimball Ave. & Tuttle Creek Blvd./Hwy. US-24

- Construct dual eastbound left turn lanes
- Construct a eastbound right-turn slip lane, this will be a free movement that will merge into US-24.
- This signal will also need to be retimed to accommodate the increased volume of traffic efficiently.

Denison Avenue

The existing 3-lane cross-section of Denison Avenue is sufficient for 2030 traffic volumes. There is a multi-use trail along most of the west side and part of the east side from Jardine Dr. to Kimball Avenue that can be used by bicycles. Depending how development and the University grow, the three lane section may need to be extended north to Marlatt Avenue. If this situation occurs, extending the multi-use trail along the west side of the street is recommended. Intersection Improvements along Denison Avenue are as follows:

Denison Ave. & Marlatt Ave.

- Construct a single-lane roundabout. This intersection is a great location for a roundabout because of the large left turn movements from both the northbound and westbound legs which cause delay at a signalized or stop-controlled intersection. Additionally, the traffic volumes for each leg of the intersection are relatively even.

Denison Ave. & NBAF Access Rd.

- Install traffic signal. A traffic signal is warranted based on Warrant 3, Peak hour Volume. This warrant can be used because of the high volume of vehicles projected to be entering and leaving the NBAF during peak hours. The challenge with putting a signal here is it would be only 400 feet to the signal at Kimball Avenue, but the delay on the westbound left turn is very large, so it is recommended to have one installed.

- Coordinate signal with Kimball Avenue and Denison Avenue signal to reduce delay.
- It is also recommended to move the entrance into the NBAF farther south, switching locations with the parking lot, to increase the distance between the two signals. This would increase the distance from 400 feet to 600 feet.

Denison Ave. & Kerr Dr.

- To minimize delays add an exclusive eastbound left-turn lane. This movement still has a failing P.M. Peak Hour LOS, but the volume of vehicles doesn't warrant a signal.
- A westbound left turn lane may be added as well in order to line up the east-west through movement.

Manhattan Avenue

Upgrade Manhattan Ave to a 3-lane urban section with a two way left turn lane. This will allow for more development along Manhattan without causing excess delay to through traffic. Bike lanes will not be needed as there is a multi-use trail running along the west side of the road from Claflin to Kimball. Intersection Improvements along Manhattan Avenue are as follows:

Manhattan Ave. & Blue Hills Ln.

- Although these movements are failing due to the high volume of traffic on Manhattan Avenue, no improvements are recommended. A turning lane would not improve the LOS, and the volume of traffic on Blue Hills Lane falls below the threshold needed to warrant a traffic signal.

Manhattan Ave. & Research Park Dr.

- Construct an eastbound left turn lane.

Manhattan Ave. & Claflin Rd.

- Construct northbound right turn lane.
- Construct westbound right turn lane.
- Retime signal to accommodate the extra lanes and traffic volume.

TABLE 7

INTERSECTION LEVEL OF SERVICE - 2030 CONDITIONS WITH IMPROVEMENTS

Intersection	A.M. Peak Hour		P.M. Peak Hour	
Approach / Movement	**LOS**	**Delay**	**LOS**	**Delay**
1 Kimball Ave. & Hwy. K-113 (West On/Off Ramps)				
Signalized (All Movements)	B	13.3	B	17.6
2 Kimball Ave. & Hwy. K-113 (East On/Off Ramps)				
Signalized (All Movements)	B	13.3	B	17.6
3 Kimball Ave. & College Ave.				
Signalized (All Movements)	D	41.5	C	25.8
4 Kimball Ave. & Denison Ave.				
Signalized (All Movements)	C	33.8	C	30.7
5 Kimball Ave. & Manhattan Ave.				
Signalized (All Movements)	B	12.4	C	24.2
6 Kimball Ave. & Meadowlark Rd.				
Eastbound Left-turn	B	10.7	B	12.7
Southbound	D	33.4	F	65.1
7 Kimball Ave. & Tuttle Creek Blvd./Hwy. US-24				
Signalized (All Movements)	C	27.3	C	32.6
8 Denison Ave. & Marlatt Ave.				
Single Lane Roundabout	-	-	-	-
9 Denison Ave. & Kerr Dr.				
Eastbound	F	62.8	C	18.7
Westbound	A	0.0	B	12.2
Northbound Left-turn	A	9.4	A	9.4
Southbound Left-turn	A	9.2	A	0.0
10 Denison Ave. & Jardine Dr.				
Signalized (All Movements)	C	26.1	C	26.1
11 Manhattan Ave. & Blue Hills Ln.				
Eastbound	C	24.0	C	19.1
Westbound	B	11.2	F	73.5
Northbound Left-turn	A	0.0	A	0.0
Southbound Left-turn	A	0.0	A	0.0
12 Manhattan Ave. & Research Park Dr.				
Eastbound	C	17.7	D	31.8
Westbound	C	16.7	C	24.2
Northbound Left-turn	B	10.2	A	0.1
Southbound Left-turn	A	8.2	B	0.1
13 Manhattan Ave. & Claflin Rd.				
Signalized (All Movements)	C	31.0	D	49.2
14 Marlatt Ave. & College Ave.				
Eastbound Left-turn	A	0.2	A	0.2
Westbound Left-turn	A	2.2	A	1.1
Northbound	C	16.7	C	17.4
Southbound	C	21.8	C	17.9
15 Marlatt Ave. & Tuttle Creek Blvd./Hwy. US-24				
Signalized (All Movements)	C	28.5	B	13.9
16 Denison Ave. & NBAF Access Rd.				
Signalized (All Movements)	A	4.4	B	16.8

6.0 SUMMARY

This study documents the impact of the proposed NBAF to be located in the southeast quadrant of the Kimball Avenue and Denison Avenue in Manhattan, Kansas. This study included operational analyses for the intersections adjacent to and surrounding the proposed development during typical weekday A.M. and P.M. peak hours during the school year. Brief descriptions of the results for each study scenario have been provided below.

6.1 EXISTING CONDITIONS

This scenario considered only the existing traffic volumes at the study intersections. The analysis indicates that operations at a few of the movements at some of the study intersections are below desirable levels of service (LOS) in this scenario.

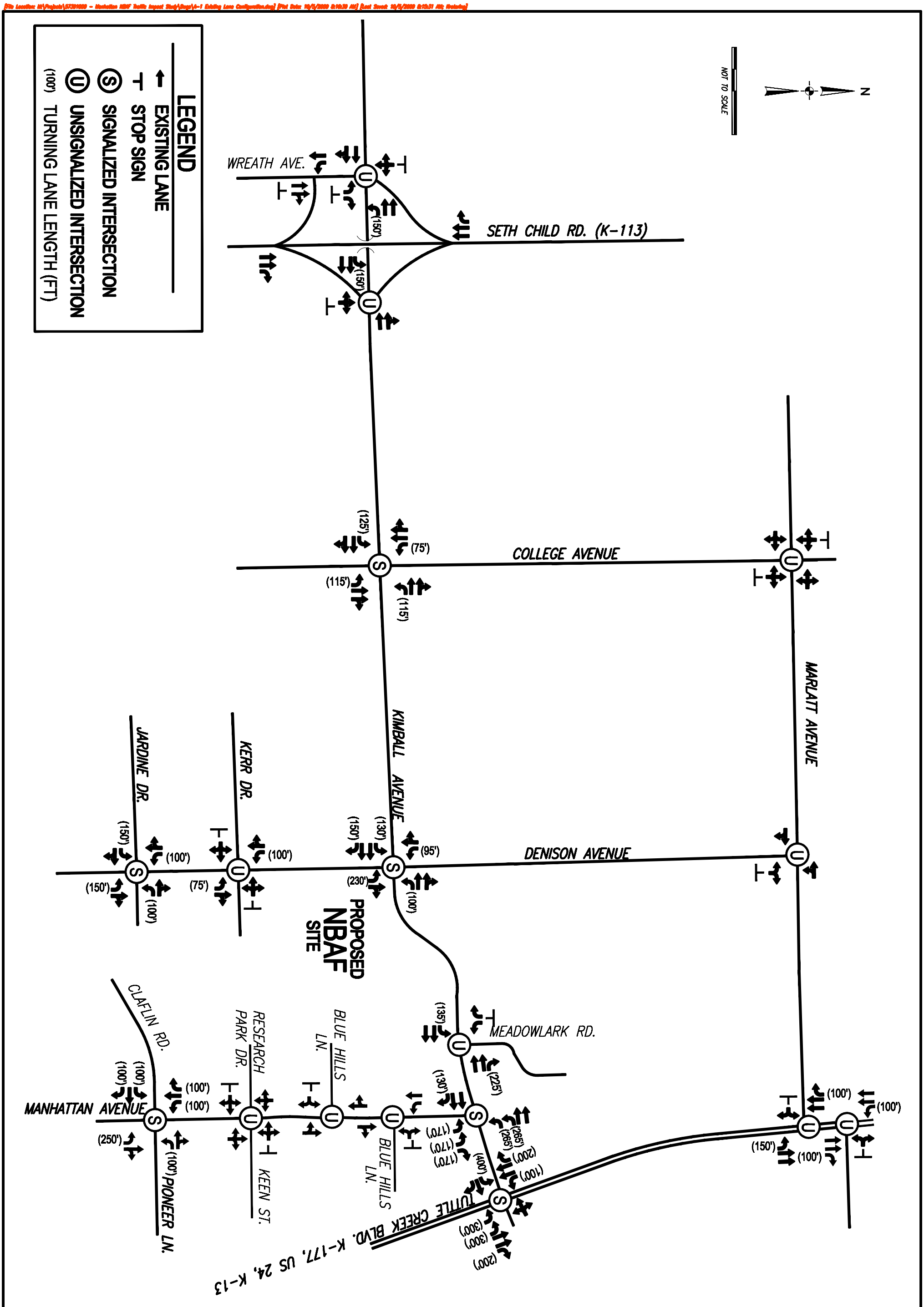
6.2 EXISTING PLUS NBAF CONDITIONS

The NBAF has minimal impact to the existing roadway network. The limited addition is an entrance on Denison Avenue. The additional volume of traffic added to the network does not require any street or intersection improvements.

6.3 FUTURE 2030 CONDITIONS

The City of Manhattan is projected to grow at a faster rate over the next 20 years than the last because of the NBAF and associated business, industries, and jobs that will follow it. This increased growth will challenge the existing traffic system requiring multiple street and intersection upgrades. In addition, bus routes, bike paths, and sidewalks can all help to reduce the vehicle growth the system. To promote these alternate forms of transportation, upgrades to their system will also need to take place including bus stops, multi-use paths, and bike lanes.

APPENDIX A - FIGURES



HWS MANHATTAN OFFICE 3226 Kimball Ave. Manhattan, KS 66503 (785) 539-2202 www.hws.com	NBAF TRAFFIC IMPACT STUDY MANHATTAN, KANSAS	FIGURE A-1 EXISTING LANE CONFIGURATIONS

NO.	REVISIONS	DATE
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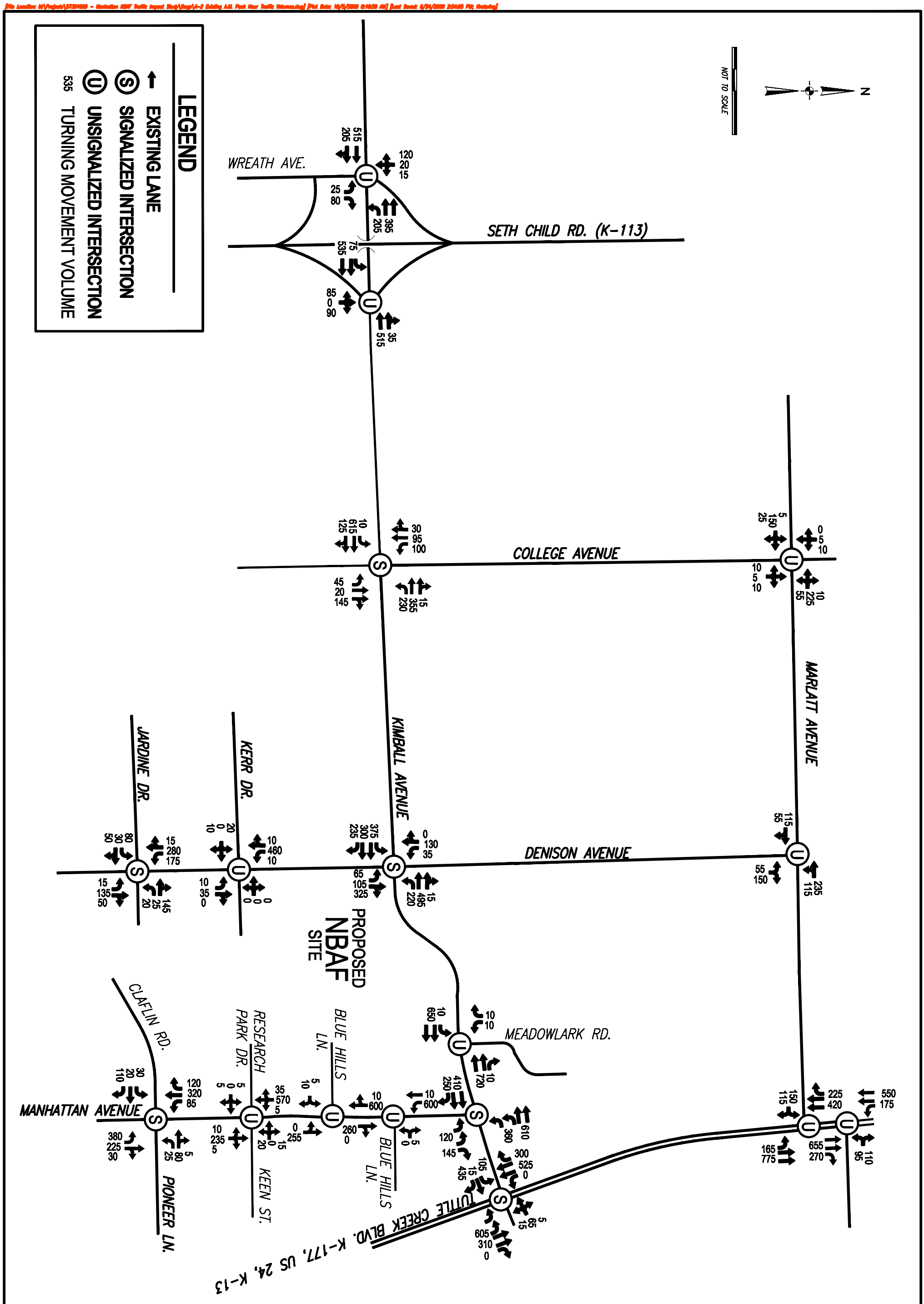

HWS MANHATTAN OFFICE 3226 Kimball Ave. Manhattan, KS 66503 (785) 539-2202 www.hws.com	NBAF TRAFFIC IMPACT STUDY MANHATTAN, KANSAS	FIGURE A-2 EXISTING A.M. PEAK HOUR TRAFFIC VOLUMES

NO.	REVISIONS	DATE
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-

LEGEND

- ↑ EXISTING LANE
- (S) SIGNALIZED INTERSECTION
- (U) UNSIGNALIZED INTERSECTION
- 535 TURNING MOVEMENT VOLUME

NOT TO SCALE

N

WREATH AVE.

SETH CHILD RD. (K-113)

COLLEGE AVENUE

MARLATT AVENUE

KIMBALL AVENUE

DENISON AVENUE

JARDINE DR.

KERR DR.

PROPOSED NBAF SITE

MEADOWLARK RD.

CLAFLIN RD.

RESEARCH PARK DR.

BLUE HILLS LN.

BLUE HILLS LN.

KEEN ST.

PIONEER LN.

MANHATTAN AVENUE

TUTTLE CREEK BLVD. K-177, US 24, K-13

MANHATTAN OFFICE 3226 Kimball Ave. Manhattan, KS 66503 (785) 539-2202 www.hws.com	**NBAF TRAFFIC IMPACT STUDY** **MANHATTAN, KANSAS**	**FIGURE A-3** **EXISTING P.M. PEAK HOUR TRAFFIC VOLUMES**

NO.	REVISIONS	DATE
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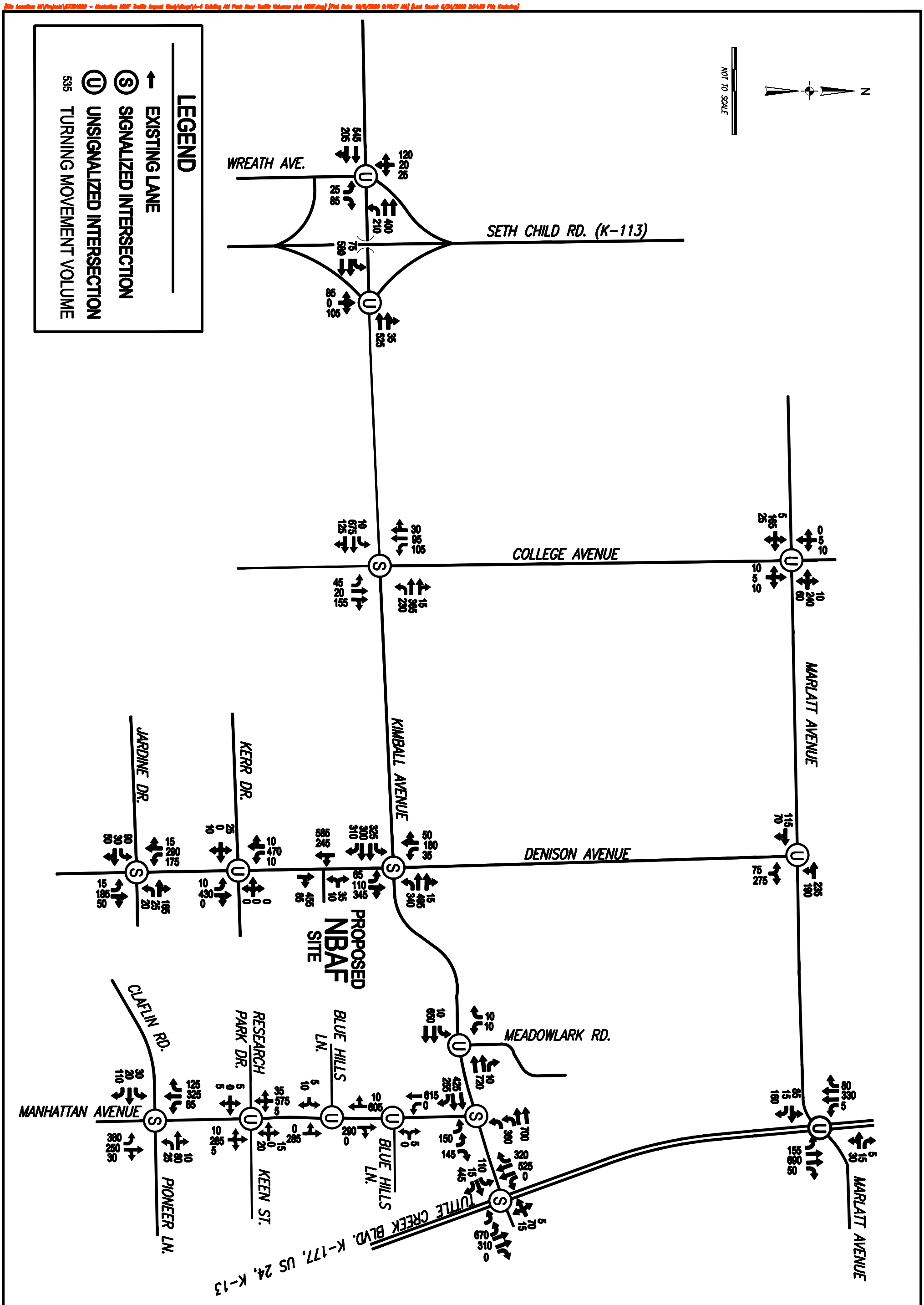
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-

NOT TO SCALE

N

LEGEND

- EXISTING LANE
- (S) SIGNALIZED INTERSECTION
- (U) UNSIGNALIZED INTERSECTION
- 535 TURNING MOVEMENT VOLUME



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NO.	REVISIONS	DATE
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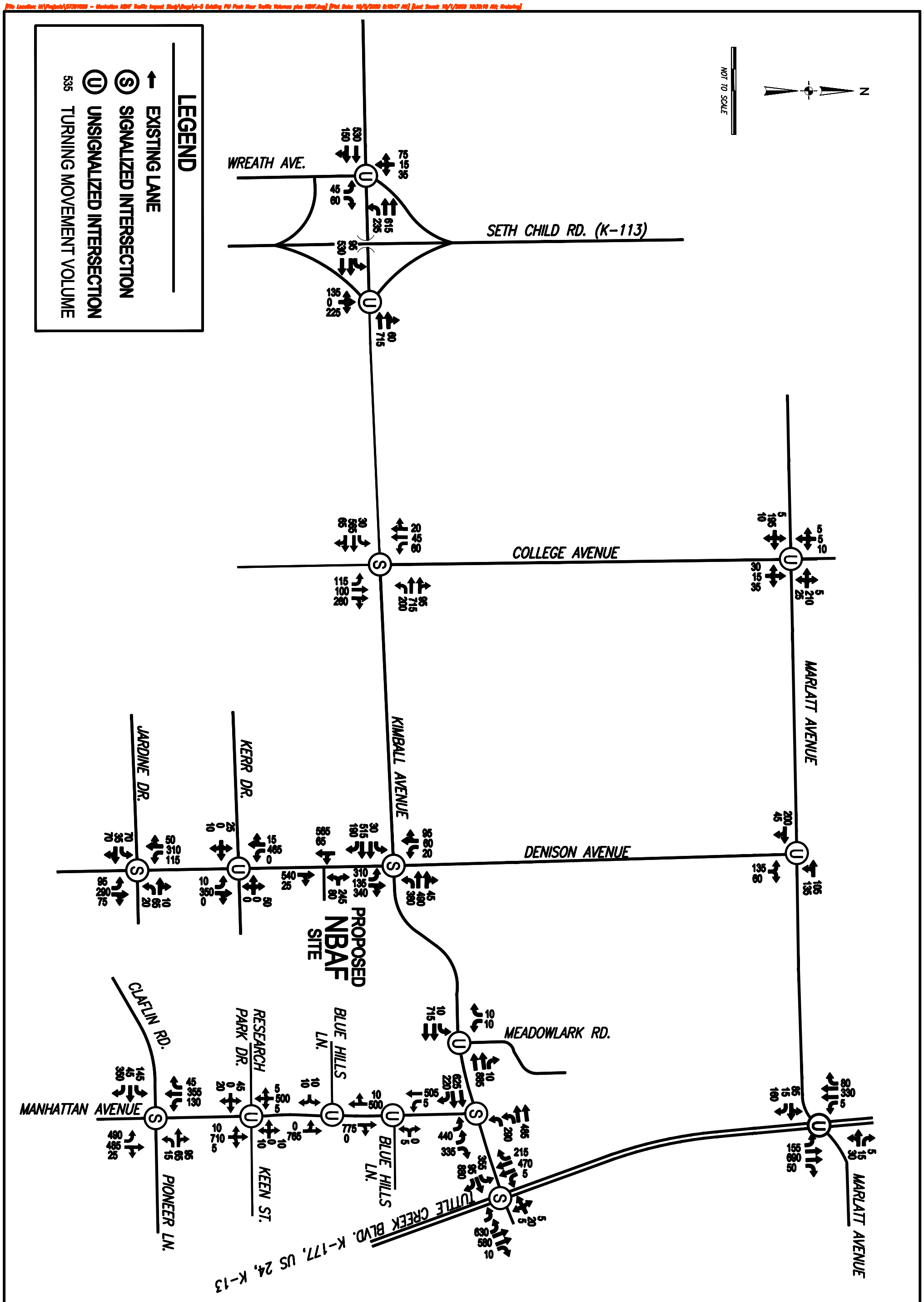

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NO.	REVISIONS	DATE
-	-	-
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-	-	-
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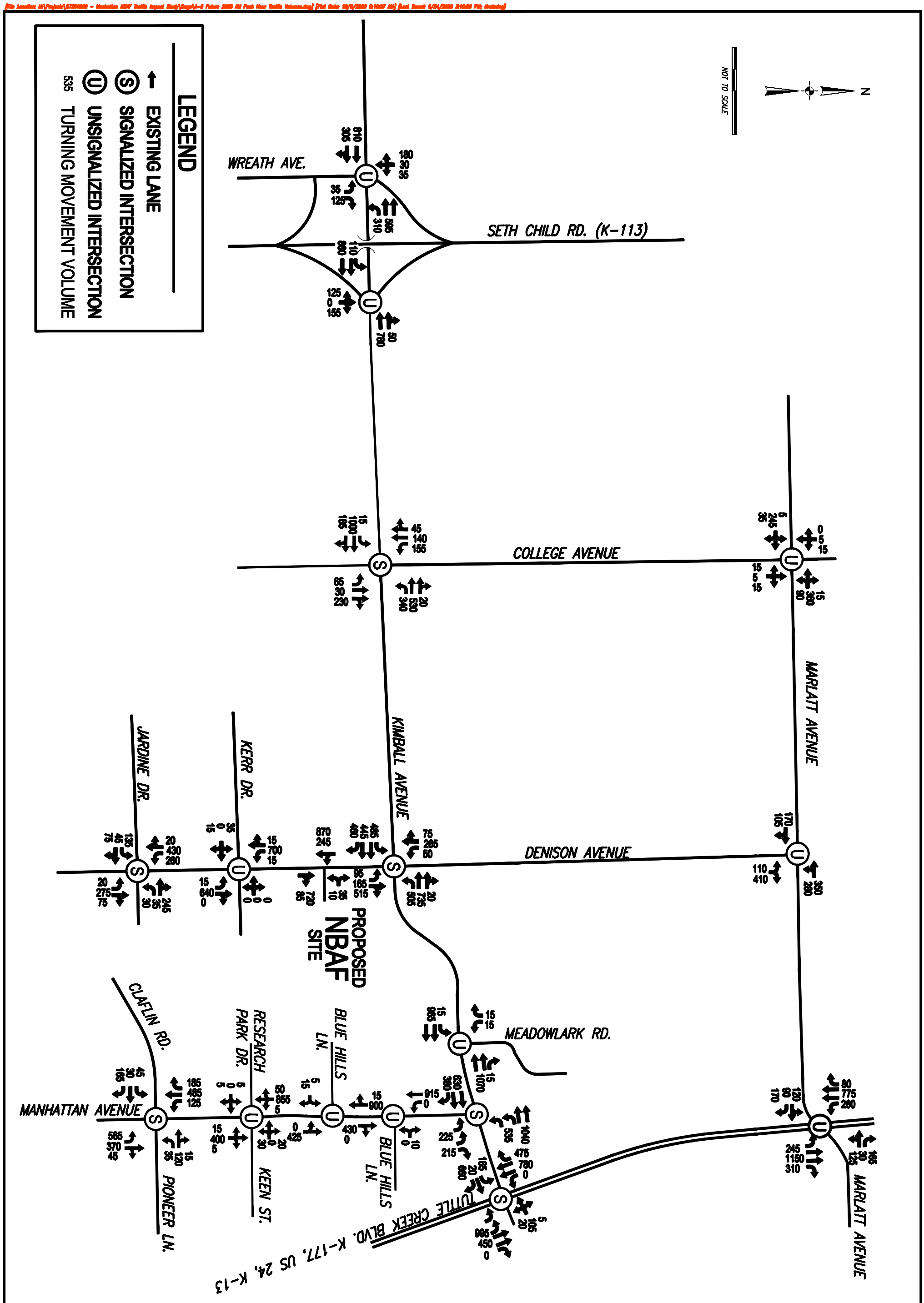
-	-	-

[File Location: H:\Projects\3739100 - Manhattan NBAF Traffic Impact Study\Dwgs\A-6 Future 2030 AM Peak Hour Traffic Volumes.dwg] [Plot Date: 10/5/2009 8:19:07 AM] [Last Saved: 9/24/2009 3:16:59 PM; thielenkg]



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NO.	REVISIONS	DATE
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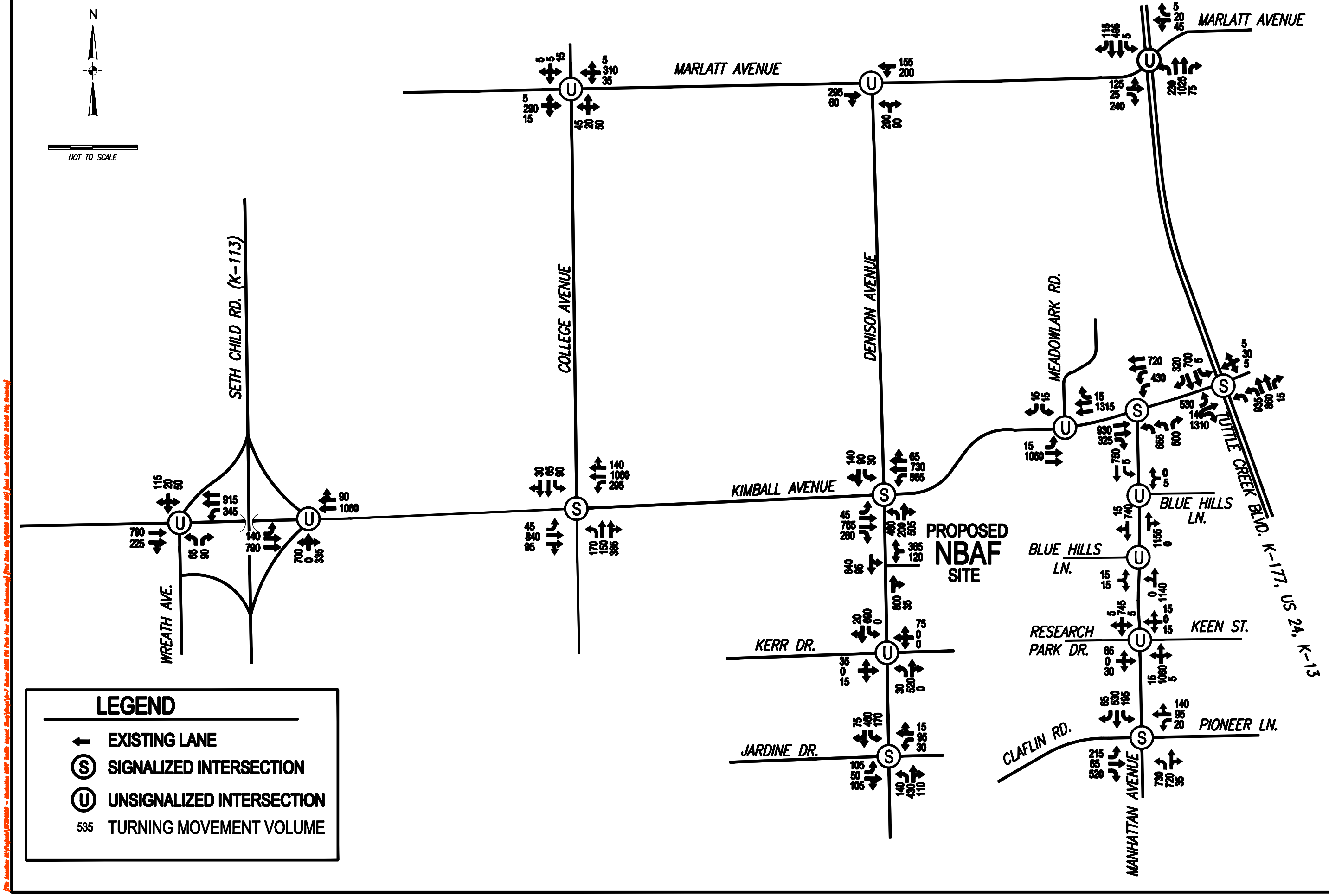

LEGEND

- ← EXISTING LANE
- (S) SIGNALIZED INTERSECTION
- (U) UNSIGNALIZED INTERSECTION
- 535 TURNING MOVEMENT VOLUME

NO.	REVISIONS	DATE
-	-	-

FIGURE A-7

FUTURE YEAR 2030
P.M. PEAK HOUR
TRAFFIC VOLUMES

NBAF TRAFFIC IMPACT STUDY

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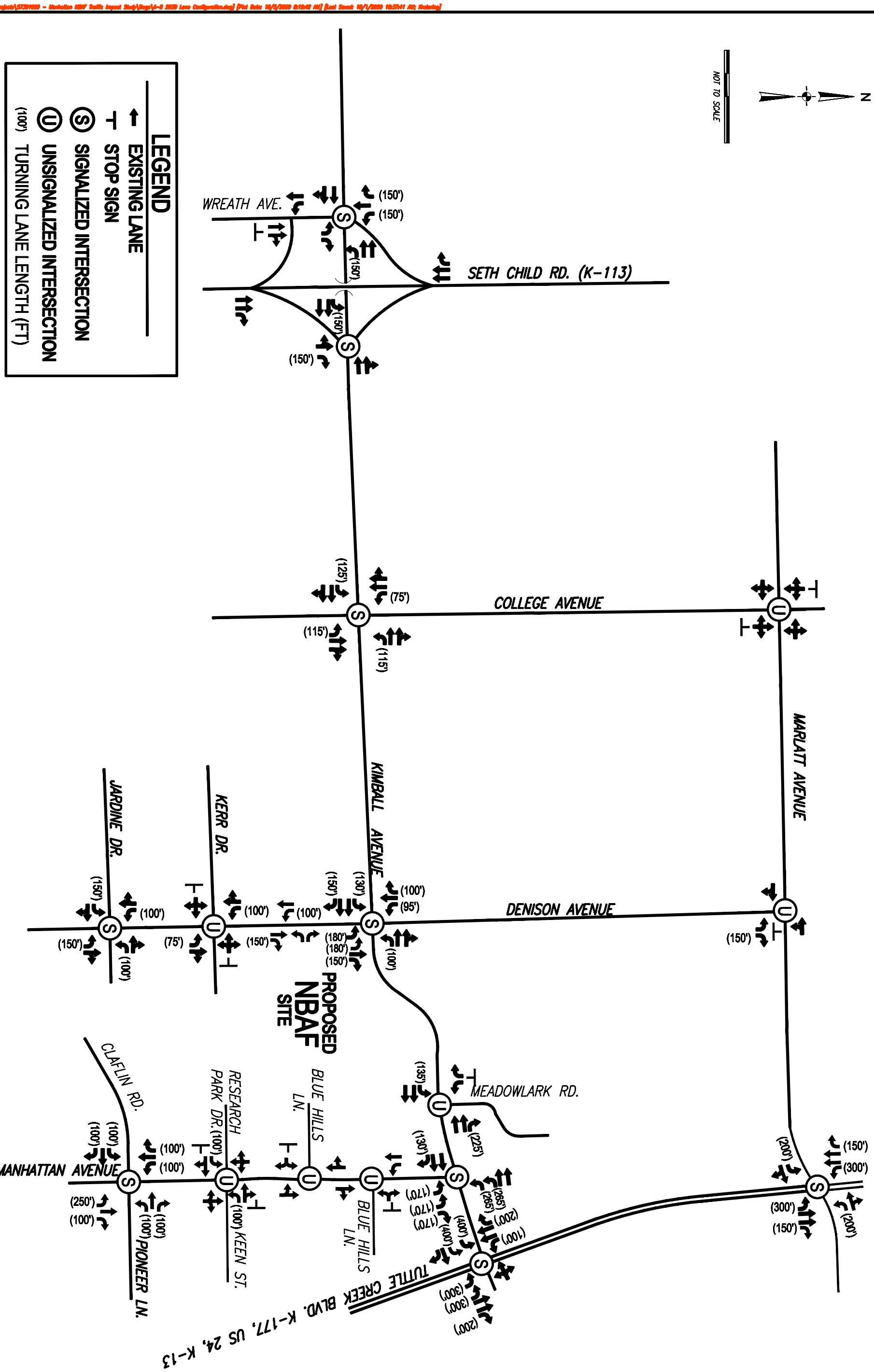

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NBAF TRAFFIC IMPACT STUDY

MANHATTAN, KANSAS

FIGURE A-8

FUTURE 2030 LANE CONFIGURATIONS

NO.	REVISIONS	DATE
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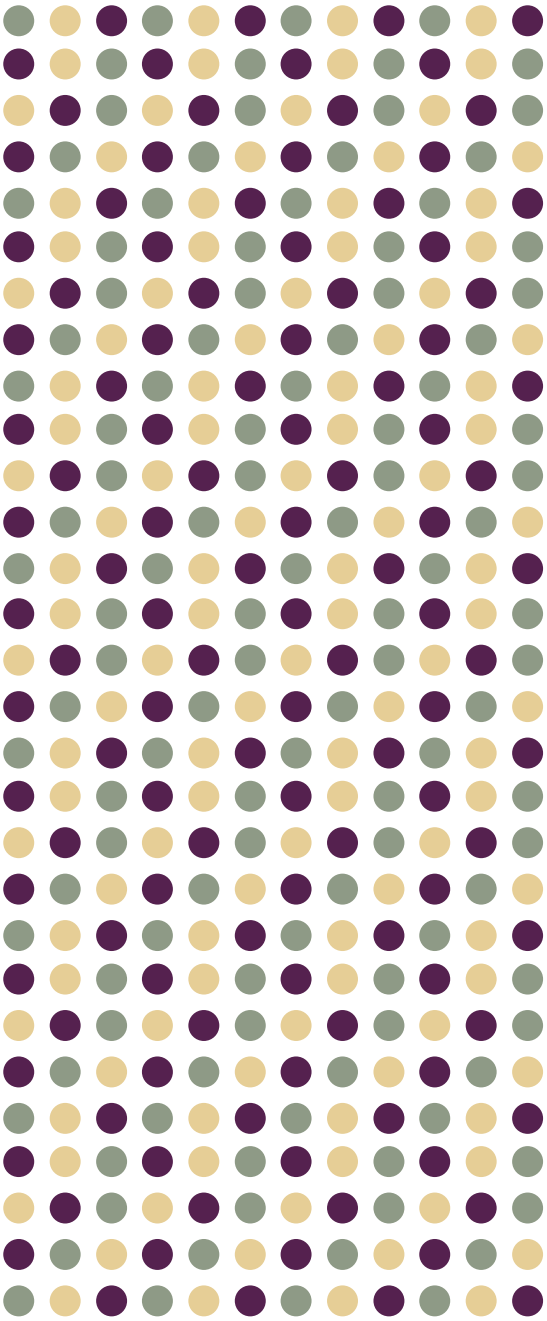

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