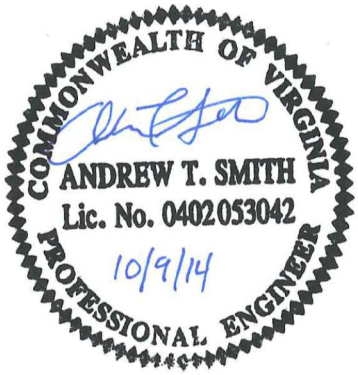
Kimley»Horn

# Memorandum




To: Gary Kilfeather
McDonald's USA, LLC

From: Andrew T. Smith, P.E. ATS
Edward Y. Papazian, P.E. EYP

Date: October 9th, 2014

Subject: Updated Purcellville McDonalds Queuing Analysis

## INTRODUCTION

This memorandum presents the results of an updated vehicle queuing study for the proposed modification of the McDonalds located along North Maple Avenue. This queuing study was prepared at the request of the Town of Purcellville staff and in accordance with their instructions on the elements to be included in the study. This memorandum also incorporates comments raised by Town staff to the July 14, 2014 vehicle queuing study.

The existing restaurant is located along the west side of North Maple Avenue just north of East Main Street. The existing restaurant contains 3,687 square feet of gross floor area and a single drive-thru lane with tandem ordering stations. The proposed modification will result in a 4,388 square foot restaurant with a double drive-thru lane at the ordering stations. These drive-thru lanes will be oriented side-by-side. This modification results in a 701 square foot increase. The proposed modification requires a special use permit (SUP).

There are instances in which vehicle queues at the drive-thru spill back onto Maple Avenue. The proposed modification of the restaurant will help alleviate the vehicle queuing. The restaurant footprint will be modified to result in a smoother traffic movement from North Maple Avenue to the drive-thru lanes. The restaurant will be modified from a single drive-thru lane to a double drive-thru lane oriented side-by-side at the ordering stations. The interior operation will be modified to provide for more efficient service to the drive-thru patrons.

This queuing study measures existing queuing at the drive-thru and forecasts future queuing based on improvements that will be part of the restaurant operations. This vehicle queuing study evaluates the following periods:

- Weekday AM commuter peak
- Weekday Mid-day peak
- Weekday PM commuter peak
- Saturday Mid-day peak

## EXISTING CONDITIONS

The McDonald's restaurant is located on Maple Avenue just north of Main Street in Purcellville. The main entrance to the McDonalds site is located on Maple Avenue to the east of the restaurant. There are additional entrances to the site from adjacent parking lots: to the south from the Wells Fargo Bank and to the west from the shopping center. Drive-thru users travel counterclockwise around the building to one of two ordering stations in tandem (one after another in line) located on the northwest corner of the building. When the drive-thru is under heavy use, both ordering stations are operated. At other times, only the downstream ordering station is used. After placing an order, the drivers continue around the building to the south side, where two windows are located. The first window on the south side of the building (cash window) is generally used for payment, and the downstream window (present window) is used for picking up the food order. Figure 1 shows the existing restaurant.

## DATA COLLECTION

Counts were collected for vehicles entering the drive-thru lane for each of the peak periods in order to determine the arrival rate for customers. The counts were taken on Wednesday, June 18th from 5:15-7:15 PM (weekday PM), and on Saturday, June 21st from 11:30 AM-1:30 PM (Saturday mid-day). Additional counts were taken on Thursday, October 2nd from 7:00-9:30 AM (weekday AM) and 11:30 AM-1:30 PM (weekday mid-day) to account for breakfast and lunch demand during the school year. Count data was taken in five minute intervals. The percentage of vehicles using drive-thru vs. parking was collected for a subset of the weekday AM vehicle count (from 8:00 AM to 9:30 AM) and for the weekday mid-day vehicle count.

Queue length (in units of vehicles), and processing times were recorded at approximate 5-minute intervals throughout the same peak periods. Overall processing time was defined as the time from when a driver stopped at the ordering station until the driver received their food at the pick-up window and began to drive away. It should be noted that queue length and processing time data was not collected from 7:00-7:15 PM during the weekday evening peak period data collection. Because this data is collected continually and averaged (as opposed to being recorded continuously like the vehicle count), it does not affect the analysis. The peak hour for this period was determined to be from 5:25 PM through 6:25 PM, so queue length and processing time data was still collected during the peak of drive-thru usage.

The data was analyzed, and is included in Table 1 below. The data collection sheets are included in the Appendix.

## GENERAL NOTES

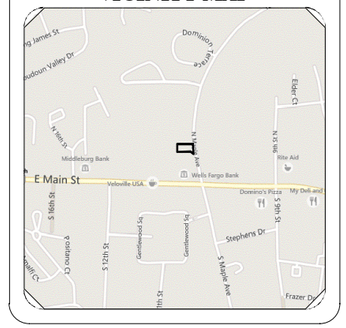
1. The bearing base for this survey originated from NAD 83
2. This property has an area of [insert area] square feet or [insert acres, 4 decimal places] acres of land.
3. This property is designated by Purcellville, as Tax Map # 35A2-3-6-5A.
4. There was no observable evidence of cemeteries found at the time of this survey.
5. The property has access via North Maple Avenue, which is a public right of way.
6. Interior roadways appear to be private, variable in width and unnamed, unless otherwise shown.
7. Elevations based on NAVD 1988

NAD 83
S.P.C. (4501 VA N)

## LEGEND OF SYMBOLS & ABBREVIATIONS

| | | |
|---|---|---|
| MONUMENT FOUND | POWERPOLE | SS SAN.SEWER LINE |
| MONUMENT SET | GUY WIRE | SEWER MANHOLE |
| P.K. NAIL FOUND | LIGHT POLE | CLEAN OUT |
| P.K. NAIL SET | STREET LIGHT POLE | STORM DRAIN MANHOLE |
| FND X MARK | ELEC. TRANSFORMER | STORM INLET |
| SET X MARK | AIR CONDITIONER | CURB INLET |
| R.R. SPIKE FOUND | E BURIED ELECTRIC | PAY PHONE |
| R.R. SPIKE SET | OH OVERHEAD UTILITIES | TELEPHONE BOX |
| BENCHMARK | ELEC. MANHOLE | TELEPHONE MANHOLE |
| CONC. R/W MARKER | ELECTRIC METER | X FENCE LINE |
| (R) RECORD DATA | W WATER LINE | T TELEPHONE LINE |
| (M) MEASURED DATA | WATER MANHOLE | UGT UNDERGROUND TELEPHONE MARKER |
| (C) CALCULATED DATA | WATER VALVE | UGC UNDERGROUND CABLE MARKER |
| (S) SURVEYED DATA | WATER METER | C CABLE TELEVISION |
| R.O.W. RIGHT OF WAY | HYDRANT | CABLE BOX |
| AKA ALSO KNOWN AS | GAS VALVE | TRAFFIC POLES |
| RCP REINFORCED CONC PIPE | GAS METER | TRAFFIC MANHOLE |
| CMP CORRUGATED METAL PIPE | UGG UNDERGROUND GAS MARKER | TRAFFIC SIGNAL BOX |
| DEP DEPRESSED | FLAG POLE | SIGN |
| MTL METAL | GAS MANHOLE | AGL ABOVE GROUND LEVEL |
| S.F. SQUARE FEET | G GAS LINE | L/S LANDSCAPING |
| FT. FEET | MW MONITORING WELL | TREE |
| P.O.B. POINT OF BEGINNING | MB MAIL BOX | EVERGREEN |
| P.O.C. POINT OF COMMENCEMENT | UNKNOWN MANHOLE | HANDICAP PARKING |
| CONC CONCRETE | SQUARE METAL LID | BOLLARD |
| BLD BUILDING | FUEL TANK LID | AIR COMPRESSOR |
| HT HEIGHT | PID PROPERTY ID | VACUUM |
| CH BRG CHORD BEARING | CH DIST CHORD DISTANCE | N/F NOW OR FORMERLY |

## VICINITY MAP




## LEGAL DESCRIPTION

## SCHEDULE B - TITLE EXCEPTION NOTES

## POTENTIAL ENCROACHMENT NOTES

None observed

## ZONING NOTES

Zoned: XX – [insert zoning district and definition]
Permitted Use Classification: [insert permitted use]
Observed Use(s): [insert use observed from outside observations]
Existing site conditions appear (from outside observations) to fall within permitted uses as listed above in the City of [insert]'s Zoning Regulations Section [insert number] Zoning Regulations are subject to change and interpretation, for further information contact: City [or County] of [insert] (phone: XXX-XXX-XXXX)
Contact's Name: [insert name]
(email: XXX@XXXXX)

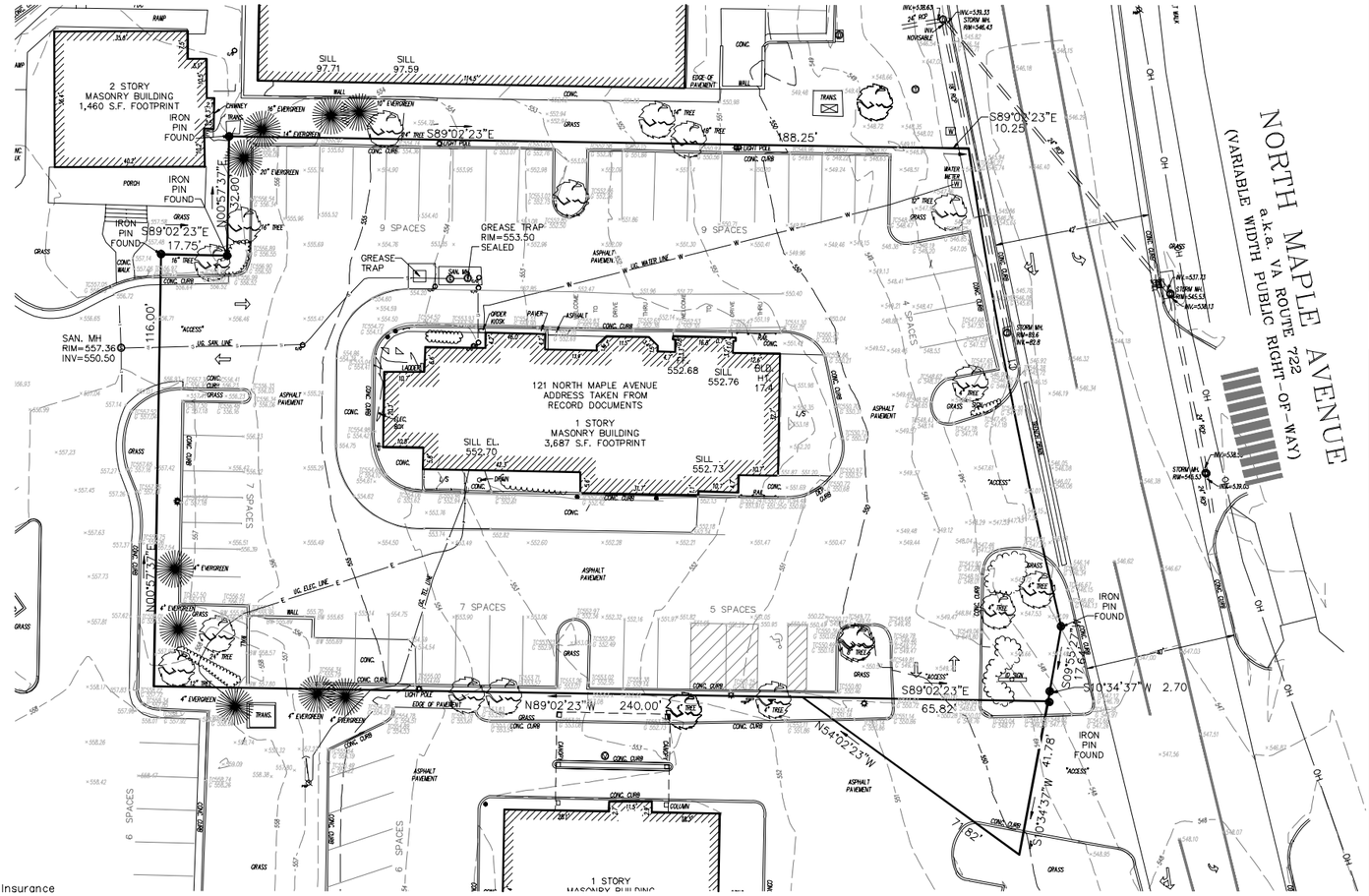
Site Restrictions:
1. Minimum building setbacks:
Front: XX' (min. provided: [insert tie distance] )
Side: XX' (min. provided: [insert tie distance] )
Rear: XX' (min. provided: [insert tie distance] )
2. Minimum lot size: [insert restriction] (min. provided: [insert lot size] )
3. Minimum lot frontage: [insert restriction] (min. provided: [insert measurement] )
4. Maximum building height: [insert restriction] (max. provided: [insert height] )
5. Maximum density: [Example: max. lot coverage and min. open space – if applicable]
6. Maximum floor area ratio:

Parking Tabulation:

– Regular parking space calculations are based on exterior footprint of building at ground level and are further calculated using the formula of: XX spaces per XX sq. ft. of floor space.

– Handicap spaces are calculated based on ADA requirements (Total spaces: 1–25, Required ADA spaces = 1)

Total regular spaces required: XX – provided: XX
Total handicap spaces required: XX – provided: XX
Total combined spaces required: XX – provided: XX




## FLOOD ZONE NOTE

By graphic plotting only, this property is in Zone X (UNSHADED) of the Flood Insurance Rate Map, Community Panel No. 51107C0089 D, which bears an effective date of July 5, 2001 and IS NOT in a Special Flood Hazard Area. By telephone call to the National Flood Insurance Program (800-638-6620) we have learned this community DOES NOT currently participate in the program. No field surveying was performed to determine this zone and an elevation certificate may be needed to verify this determination or apply for a variance from the Federal Emergency Management Agency.

| Curve Table | | | | | |
|---|---|---|---|---|---|
| Curve # | Radius | Length | Ch. Brg. | Ch. Dist. | Delta |
| C1 | 1457.00 | 130.76 | S10°55'52"E | 130.72 | 05°08'32" |

Survey Prepared By:


**FIRST ORDER, LLC**
1700 SULLIVAN TRAIL, SUITE 13
EASTON, PA 18040
Phone: 610-438-5840 Fax: 610-438-0004


| | |
|---|---|
| Surveyor's Drawing No.: | 3299.dwg |
| Surveyor's Site Ref: | 3299 |
| Checked by: JWS | Drawn by: REP |

0 20' 40'
GRAPHIC SCALE: 1" = 20'

## ALTA/ACSM LAND TITLE SURVEY

Mcdonalds
121 N. Maple
Purcellville, VA

Surveyor's Certification

To: [to be provided by client] and MKAssociates, Inc.

This is to certify that this map or plat and the survey on which it is based were made in accordance with the 2011 Minimum Standard Detail Requirements for ALTA/ACSM Land Title Surveys, jointly established and adopted by ALTA and NSPS and includes Items 1, 2, 3, 4, 5, 6(b), 7(a), 7(b)(1), 7(c), 8, 9, 10, 11(b), 13, 14, 16, 17, 18 of Table A thereof.

The field work was completed on June 3, 2014

Date of Plat or Map: June 6, 2014.

PRELIMINARY

Surveyor's Signature

Professional Land Surveyor: Jack W. Shoemaker
Registration Number: 0403 002186
In the State of: Virginia

[Insert Surveyor's Signature/Seal]

| | | | |
|---|---|---|---|
| PROJECT NAME: | MCDONALDS | MKA PROJECT No.: | 6061-14-3088 |
| ADDRESS: | 121 N. MAPLE | CITY: Purcellville | STATE: VA |


MKA
A National Land Services Group

**For Inquiries Concerning This Survey Contact MKA**
**National Coordinators of Land Survey Services**
6593 Commerce Court – Warrenton, Virginia 20187
Phone: (540) 428-3550 Fax: (540) 428-3560
Email: comments@mkassociates.com
www.mkassociates.com

| Table 1: Drive-thru Data Collection | | | | |
|---|---|---|---|---|
| | **Weekday AM** | **Weekday Mid-day** | **Weekday PM** | **Saturday Mid-day** |
| Peak Hour | 7:45A-8:45A | 11:50A-12:50P | 5:25P-6:25P | 11:35A-12:35P |
| Peak Hour Arrival Rate (veh/hr) | 123 | 105 | 69 | 90 |
| Drive-thru Percentage | 76% | 69% | - | - |
| Peak Hour Average Processing Time (min:sec/veh) | 2:05 | 2:43 | 2:01 | 2:33 |
| Peak Hour Average Present Window Queue Length (veh) | 3.83 | 4.42 | 2.50 | 3.67 |
| Peak Hour Average Ordering Station Queue Length (veh) | 5.25 | 3.83 | 1.58 | 2.67 |
| Maximum Observed Present Window Queue Length (veh) | 7 | 7 | 6 | 7 |
| Maximum Observed Ordering Station Queue Length (veh) | 8 | 8 | 6 | 7 |
| Maximum Total Number of Cars in Both Queues During One Observation | 14 | 15 | 10 | 12 |

## OBSERVATIONS AND DISCUSSION OF RESULTS

The heaviest use of the drive-thru was during the weekday AM and mid-day peaks. For all of the collected time periods with the exception of the weekday AM peak, a greater arrival rate corresponded with a longer processing time. There was enough space for approximately seven cars to stack at the present window before reaching the ordering station. The queue at the present window rarely reached as far back as the ordering station (once or twice per peak period). Regardless of whether the two queues interacted, the queue length at the ordering station was always measured from the same location. The ordering station queue determined whether cars were backed up onto Maple Avenue. Depending on the size of cars in the queue, circulation around the restaurant began to be affected when 7 to 8 cars were in the ordering station queue. With this number of vehicles, the drive aisle around the restaurant could be blocked and cars were observed waiting on Maple Avenue or in the cut-through to the Wells Fargo Bank lot. This occurred several times during the heaviest use

portions of the weekday AM, weekday mid-day, and Saturday mid-day peak periods, but was not observed during the weekday PM peak period.

## EXISTING OPERATIONS

The ordering station queue is the driving factor that determines whether or not vehicles will be backed up into Maple Avenue. The queue for the present window is metered by patrons making their orders. As a result, the queuing analysis was performed only at the ordering station queue. The analysis was performed assuming the queue at the ordering stations follows a single-channel queuing model with Poisson arrivals and exponential service-times (M/M/1 model). This is a simplification of the queuing type that occurs in practice, and it allows the queue length to be forecast without running a simulation.

The average queue length and arrival rate were used to calculate the existing service rate of the ordering stations. This was accomplished using the following equation, applicable for M/M/1 queues:

$$Average\ number\ of\ vehicles\ in\ the\ system\ = \frac{\lambda}{\mu - \lambda}$$

where λ is the arrival rate and μ is the service rate.

The equation was rearranged to solve for μ. In this equation, the average number of vehicles in the system refers to the number of vehicles in the queue and in service. The “queue length” recorded as a part of the data collection includes vehicles being served and vehicles in the queue, and is therefore equivalent to the number of vehicles in the system.

Analysis was performed to calculate how often the existing queue will reach a length that will block circulation or reach Maple Avenue. This was accomplished using the following equation, applicable for M/M/1 queues:

$$Probability\ of\ more\ than\ k\ units\ in\ the\ system\ = \left(\frac{\lambda}{\mu}\right)^{k+1}$$

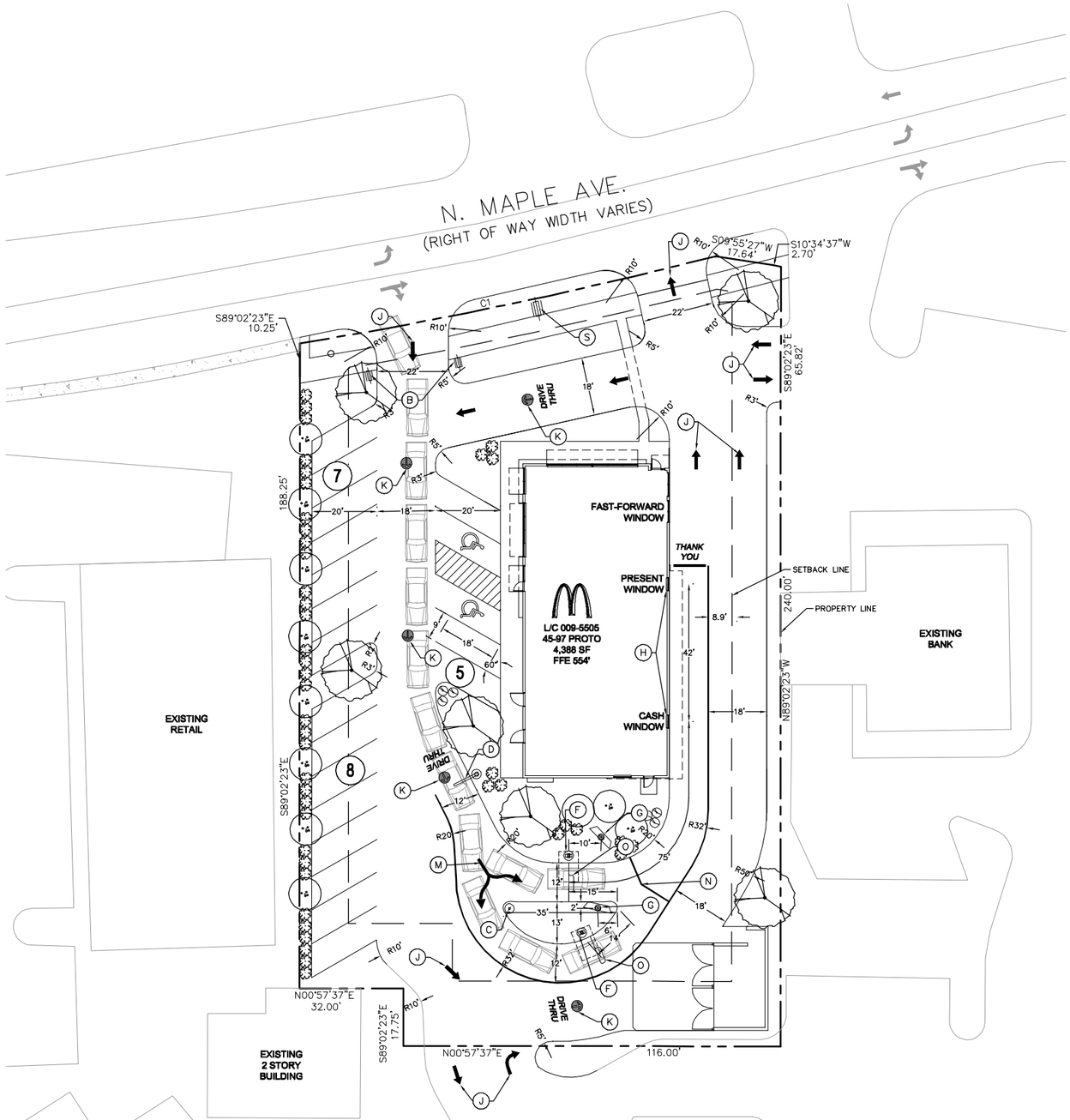
The results of the analysis are included in Table 2 below.

| Table 2: Existing Service Rates and Queue Lengths | | | | |
|---|---|---|---|---|
| | **Weekday AM** | **Weekday Mid-day** | **Weekday PM** | **Saturday Mid-day** |
| Peak Hour Arrival Rate, λ (veh/hr) | 123 | 105 | 69 | 90 |
| Peak Hour Average Queue Length (number of vehicles in service and queue) | 5.25 | 3.83 | 1.58 | 2.67 |
| Calculated Service Rate, μ (veh/hr) | 146.43 | 132.42 | 112.67 | 123.71 |
| Service Time (sec/veh) | 24.59 | 27.19 | 31.95 | 29.10 |
| Probability of more than 7 vehicles in the system (when vehicle queue blocks circulation) | 24.79% | 15.63% | 1.98% | 7.85% |
| Probability of more than 8 vehicles in the system (when vehicle queue extends into Maple Avenue) | 20.82% | 12.39% | 1.21% | 5.71% |

## PROPOSED CONDITIONS

The proposed McDonald's site includes several enhancements, both internally and in site layout, that will improve the efficiency of drive-thru operations. The building footprint will be shifted south and all parking will be located to the north of the building. The drive aisle will be one-way counterclockwise around the entire building. Instead of two ordering stations located in tandem, the drive-thru is split into two lines near the two side-by-side ordering stations. This will serve two purposes: the new layout increases the stacking length upstream of the ordering stations (up to approximately 14 vehicles before reaching Maple Avenue), and the layout also ensures that both ordering stations are being utilized at all possible times. In the current tandem layout, it is possible for a vehicle ordering at the upstream ordering station to block the downstream ordering station. The new layout will not reduce the time it takes a patron to put in his or her order, but because ordering station utilization increases, it does reduce the average service time for both ordering stations *combined*, which results in and increased service rate (i.e., μ). This will reduce time a vehicle will wait in the queue.

The proposed layout also features a "fast-forward window." This window allows a patron who has ordered a specialty item that will take longer to prepare to move forward from the pickup window so that they do not block the other patrons from picking up their orders which may be completed more quickly. Internally, a larger kitchen and improved headsets will enhance operations and overall processing time. The conceptual proposed site layout is shown in Figure 2.




GRAPHIC SCALE IN FEET
0 10 20 40

## SITE DATA

| | | |
|---|---|---|
| LOCATION: | PURCELLVILLE, VA | |
| ADDRESS: | 121 N. MAPLE AVENUE | |
| ZONING: | MIXED COMMERCIAL | |
| LAND USE: | RESTAURANT | |
| SITE AREA: | 33,540 SF | 0.77 AC |
| SEATING CAPACITY: | 87 | |
| LOT COVERAGE: | 33,540 SF | 100% |
| BUILDING AREA: | 4,388 SF | 13.1% |
| IMPERVIOUS AREA: | 22,364 SF | 66.7% |
| PERVIOUS AREA: | 6,788 SF | 20.2% |

## PARKING SUMMARY

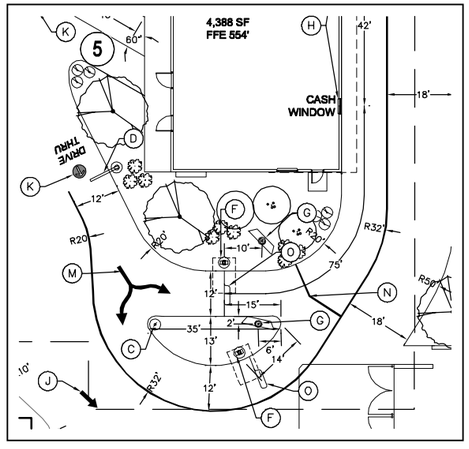
REQUIRED PARKING RATIO: N/A. McDONALD'S TO PROVIDE LETTER TO SUPPORT PROVIDED PARKING COUNT

| | EXISTING | PROVIDED |
|---|---|---|
| STANDARD | 36 | 18 |
| ACCESSIBLE PER ADA | 2 | 2 |
| TOTAL PARKING | 38 | 20 |

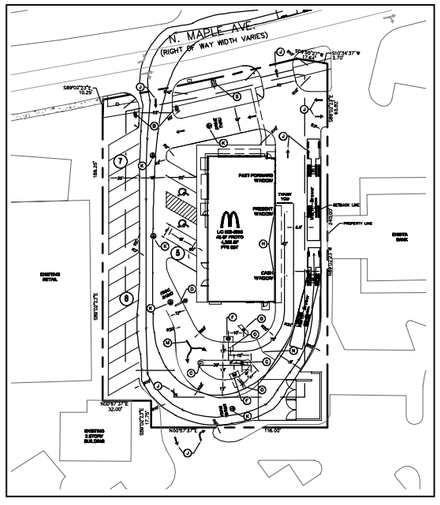
SITE LEGEND

A. HIGHWAY OR ROAD SIGN (AS ALLOWED) WITH READER BOARD (OPTIONAL) - MONUMENT SIGN ALTERNATIVE
B. DIRECTIONAL SIGN
C. "ANY TIME-ANY LANE" BOLLARD SIGN
D. GATEWAY (SINGLE OR DOUBLE ARM)
E. PRE-SELL BOARD (OPTIONAL)
F. DRIVE-THRU CANOPY WITH BUILT IN COD
G. MENU BOARD
H. NEXTGEN WINDOW POSITION SIGNS
I. DRIVE-THRU PULL FORWARD/PARK SIGNS
J. DIRECTIONAL ARROW
K. McDONALDS GOLD STANDARD TRAFFIC ARROW (PMS 123 YELLOW)
L. 6" STRIPE (PMS 123 YELLOW)
M. DOUBLE HEADED ARROW (PMS 123 YELLOW)
N. MERGE POINT
O. LOOP DETECTOR
P. FLAG POLE
Q. PULL FORWARD SPACE
R. RESERVED DRIVE-THRU SIGN
S. PROPOSED SIGN

| Curve Table | | | | | |
|---|---|---|---|---|---|
| Curve # | Radius | Length | Ch. Brg. | Ch. Dist. | Delta |
| C1 | 1457.00 | 130.76 | S10°55'52"E | 130.72 | 05°08'32" |




DRIVE THRU DETAIL
SCALE: 1"=20'




TRUCK ROUTE ACCESS DETAIL
SCALE: 1" = 50'

NOTE: THIS CONCEPTUAL SITE PLAN IS BASED ON LIMITED AVAILABLE INFORMATION WHICH MAY INCLUDE AERIAL PHOTOGRAPHY, GIS DATA, AND TAX MAP INFORMATION. IT IS INTENDED AS PRELIMINARY, FOR THE PURPOSE OF UNDERSTANDING A POTENTIAL SITE CONFIGURATION. LOCAL LAND DEVELOPMENT CODE COMPLIANCE, ACCESS POINTS, SPECIFIC TENANT REQUIREMENTS, ETC. HAVE NOT BEEN REVIEWED OR CONFIRMED WITH LOCAL JURISDICTIONAL AGENCIES DURING THE PREPARATION OF THIS CONCEPTUAL SITE PLAN. THIS PLANS WAS PREPARED WITHOUT THE BENEFIT OF A RECENT TITLE COMMITMENT OR SURVEY.

| No. | REVISIONS | DATE | BY |
|---|---|---|---|

Kimley»Horn
© 2014 KIMLEY-HORN AND ASSOCIATES, INC.
11400 COMMERCE PARK DRIVE, SUITE 400, RESTON, VA 20191
PHONE: 703-674-1300 FAX: 703-674-1350
WWW.KIMLEY-HORN.COM

DESIGN ENGINEER:
VIRGINIA REGISTRATION NUMBER:

SCALE: AS NOTED
DESIGNED BY: SM
DRAWN BY: SM
CHECKED BY: JK
DATE:

# SITE AND LANDSCAPE PLAN

PURCELLVILLE REBUILD
009-5505
TOWN OF PURCELLVILLE VIRGINIA

DATE
6/26/2014
PROJECT NO.
110368002
SHEET NUMBER
CSP-1

## FUTURE OPERATIONAL FORECASTING

The proposed 701 square foot expansion of the McDonalds will result in the following increases in trip generation based on trip generation rates contained in the ITE Trip Generation Manual, 9th Edition for Land Use Code 934 (fast-food restaurant with drive-through window).

| | IN | OUT | TWO-WAY |
|---|---|---|---|
| Weekday | | | |
| AM Peak Hour | 16 | 16 | 32 |
| AM Peak Hour of Generation | 19 | 19 | 38 |
| PM Peak Hour | 12 | 11 | 23 |
| Saturday | | | |
| Peak Hour of Generation | 21 | 20 | 41 |

The AM Peak Hour of Generation was chosen to represent trip generation during the weekday midday because it results in more trips than the PM Peak Hour of Generation and is more conservative. It was assumed that 80% of the increased trip generation would use the drive-thru, as this is the expected drive-thru percentage for the proposed restaurant according to data from McDonald's.

Additionally, it is assumed that the proposed drive-thru will be a more attractive option than the existing drive-thru and the drive-thru percentage will increase. This increase in attraction is captured by increasing the existing arrival rate by a factor of 80% divided by the existing drive-thru percentage for that period. Drive-thru percentage was not collected for the PM and Saturday periods, and while it's possible that the drive-thru percentages for those periods are lower than mid-day since the customers may have more time to eat within the restaurant, it is likely that the increase in drive-thru percentage would not be drastic enough to reach 80%. For simplification, it is assumed that the PM and Saturday periods have the same drive-thru percentage as the mid-day. The drive-thru trips generated by the additional square footage were added to the factored peak hour arrival rate to create a forecast peak hour arrival rate.

Based on data from McDonald's that compares processing rate for different drive-thru configurations, it is expected that conversion from a tandem ordering station to a side by side configuration, with no change to the efficiency or capacity of the staff within the restaurant, will increase the processing rate by approximately 19%. The service rate at the ordering windows is increased by 19% for the purposes of this study.

Analysis was performed to calculate how often the ordering station queue will extend for a length that will reach Maple Avenue (more than 14 vehicles). This was accomplished using the same equation as used in the existing conditions analysis.

The results of the analysis are included in Table 3.

| Table 3: Forecast Arrival Rates, Service Rates, and Queue Lengths | | | | |
|---|---|---|---|---|
| | **Weekday AM** | **Weekday Mid-day** | **Weekday PM** | **Saturday Mid-day** |
| Additional Peak Hour Trips Generated (entering site) | 16 | 19 | 12 | 21 |
| 80% of Additional Peak Hour Generation | 13 | 15 | 10 | 17 |
| Existing Drive-thru Percentage | 76% | 69% | 69%* | 69%* |
| Forecast Drive-thru Percentage | 80% | 80% | 80% | 80% |
| Factored Arrival Rate (accounting for drive-thru % increase) | 129.47 | 121.74 | 80.00 | 104.35 |
| Forecast Total Peak Hour Arrival Rate (factored arrival rate plus additional trips generated), λ (veh/hr) | 142.47 | 136.74 | 90.00 | 121.35 |
| Forecast Peak Hour Service Rate (Calculated Service Rate with 19% increase), μ (veh/hr) | 174.25 | 157.58 | 134.08 | 147.21 |
| Calculated Peak Hour Average Queue Length (number of vehicles in service and queue) | 4.48 | 6.56 | 2.04 | 4.69 |
| Difference between Existing and Forecast Average Queue Lengths (veh)** | -0.77 | 2.73 | 0.46 | 2.02 |
| Probability of more than 14 vehicles in the system (when vehicle queue extends into Maple Avenue) | 4.88% | 11.91% | 0.25% | 5.51% |
| Difference between Existing and Forecast Probability of Vehicle Queues Extending into Maple Avenue** | -15.94% | -0.48% | -0.96% | -0.20% |

* - Assumed value, based on Weekday Mid-day Drive-thru percentage.
** - See Table 2 for existing queue lengths and probabilities.

The analysis shows that the average queue lengths grow by between 2 and 3 vehicles in the weekday and Saturday mid-day peak periods, grow a negligible amount in the PM peak period, and decrease by almost a vehicle for the AM peak period. The weekday AM peak hour average queue length is reduced because the existing drive-thru percentage is already very high and the improved service rate has a greater effect on the queue length than the increased drive-thru demand. The largest change in average queue length is during the weekday mid-day peak hour, which increases

from 3.83 vehicles to 6.56 vehicles, 2.73 vehicles difference. Due to the upgraded site layout, however, the drive-thru can accommodate the larger average queue length without affecting circulation. With the proposed site layout, the number of vehicles that can queue before reaching Maple Avenue increases from 8 to 14.

The most significant benefit that will result from the proposed modifications is indicated by the reduction in the probability that the vehicle queues will extend to Maple Avenue during the weekday AM peak hour, which contained the longest average observed queues, and the highest probability of vehicles reaching Maple Avenue. During the AM peak hour, the forecast probability of a queue reaching Maple Avenue is 4.88% compared to 20.82% under existing conditions. The probability of the queues reaching Maple Avenue is also reduced a relatively small amount during each of the other study peak hours.

This analysis is conservative in that it does not take into account any increase in internal capacity level that will be achievable with the upgrades internal to the proposed restaurant.

## CONCLUSIONS

The analyses show that with the proposed improvements, the upgrades to the McDonald's will result in significant reductions in the probability that vehicle queues will reach Maple Avenue in the AM peak period, and will not increase the probability that queues will reach Maple Avenue in the mid-day, PM , and Saturday peak periods. The shifting of the store footprint and the modification of the drive-thru ordering operation will provide for additional capacity within the site.

Weekday AM Peak Period Arrival Count

Start Date: 10/2/2014
Start Time: 7:00:00 AM

| Start Time | Count | Error | Corrected Count | Hourly |
|---|---|---|---|---|
| 07:00 AM | 10 | 0 | 10 | 103 |
| 07:05 AM | 8 | 1 | 7 | 100 |
| 07:10 AM | 5 | 0 | 5 | 104 |
| 07:15 AM | 5 | 0 | 5 | 108 |
| 07:20 AM | 10 | 1 | 9 | 111 |
| 07:25 AM | 9 | 0 | 9 | 116 |
| 07:30 AM | 7 | 0 | 7 | 115 |
| 07:35 AM | 15 | 1 | 14 | 118 |
| 07:40 AM | 11 | 3 | 8 | 120 |
| 07:45 AM | 8 | 1 | 7 | 123 |
| 07:50 AM | 13 | 4 | 9 | 122 |
| 07:55 AM | 18 | 5 | 13 | 121 |
| 08:00 AM | 12 | 5 | 7 | 119 |
| 08:05 AM | 15 | 4 | 11 | 120 |
| 08:10 AM | 13 | 4 | 9 | 117 |
| 08:15 AM | 14 | 6 | 8 | 116 |
| 08:20 AM | 15 | 1 | 14 | 115 |
| 08:25 AM | 13 | 5 | 8 | 110 |
| 08:30 AM | 12 | 2 | 10 | 110 |
| 08:35 AM | 16 | 0 | 16 | |
| 08:40 AM | 13 | 2 | 11 | |
| 08:45 AM | 10 | 4 | 6 | |
| 08:50 AM | 12 | 4 | 8 | |
| 08:55 AM | 12 | 1 | 11 | |
| 09:00 AM | 12 | 4 | 8 | |
| 09:05 AM | 9 | 1 | 8 | |
| 09:10 AM | 13 | 5 | 8 | |
| 09:15 AM | 8 | 1 | 7 | |
| 09:20 AM | 12 | 3 | 9 | |
| 09:25 AM | 10 | 2 | 8 | |

Before 8:00 AM, "Error" is a vehicle that appeared at first to join the drive-thru queue but did not actually become a part of the queue. After 8:00 AM, the "Error" represents a count of vehicles entering to park.

| | per min | per hr |
|---|---|---|
| Average Arrival Rate (veh/min) | 1.8 | 108 |
| Peak Hour Arrival Rate (veh/min) | 2.05 | 123 |
| Peak 5-min Arrival Rate (veh/min) | 3.2 | 192 |

| | |
|---|---|
| Drive Thru Percentage | 76% |
| Sit Down Percentage | 24% |
| (between 8:00 and 9:30) | |

Weekday Mid-day Peak Period Arrival Count

Start Date: 10/2/2014
Start Time: 11:30:00 AM

| Start Time | Total Count | Parking Count | Drive-Thru Count | Hourly |
|---|---|---|---|---|
| 11:30 AM | 10 | 0 | 10 | 102 |
| 11:35 AM | 11 | 3 | 8 | 98 |
| 11:40 AM | 9 | 4 | 5 | 101 |
| 11:45 AM | 10 | 2 | 8 | 105 |
| 11:50 AM | 12 | 7 | 5 | 105 |
| 11:55 AM | 18 | 6 | 12 | 104 |
| 12:00 PM | 9 | 3 | 6 | 100 |
| 12:05 PM | 16 | 5 | 11 | 101 |
| 12:10 PM | 13 | 5 | 8 | 97 |
| 12:15 PM | 15 | 4 | 11 | 98 |
| 12:20 PM | 9 | 2 | 7 | 94 |
| 12:25 PM | 16 | 5 | 11 | 96 |
| 12:30 PM | 10 | 4 | 6 | 90 |
| 12:35 PM | 18 | 7 | 11 | |
| 12:40 PM | 14 | 5 | 9 | |
| 12:45 PM | 10 | 2 | 8 | |
| 12:50 PM | 7 | 3 | 4 | |
| 12:55 PM | 9 | 1 | 8 | |
| 01:00 PM | 10 | 3 | 7 | |
| 01:05 PM | 7 | 0 | 7 | |
| 01:10 PM | 13 | 4 | 9 | |
| 01:15 PM | 9 | 2 | 7 | |
| 01:20 PM | 13 | 4 | 9 | |
| 01:25 PM | 12 | 7 | 5 | |

| | per min | per hr |
|---|---|---|
| Average Arrival Rate (veh/min) | 1.6 | 96 |
| Peak Hour Arrival Rate (veh/min) | 1.75 | 105 |
| Peak 5-min Arrival Rate (veh/min) | 2.4 | 144 |

| | |
|---|---|
| Drive Thru Percentage | 69% |
| Sit Down Percentage | 31% |
| (between 11:30 AM and 1:00 PM) | |

**Weekday PM Peak Period Arrival Count**

("Error" is a vehicle that appeared at first to join the drive-thru queue but did not actually become a part of the queue)

Start Date: 6/18/2014

Start Time: 5:15:00 PM

| Start Time | Count | Error | Corrected Count | Hourly |
|---|---|---|---|---|
| 05:15 PM | 2 | 2 | 0 | 57 |
| 05:20 PM | 4 | 0 | 4 | 65 |
| 05:25 PM | 9 | 0 | 9 | 69 |
| 05:30 PM | 7 | 0 | 7 | 64 |
| 05:35 PM | 8 | 1 | 7 | 60 |
| 05:40 PM | 2 | 0 | 2 | 61 |
| 05:45 PM | 4 | 0 | 4 | 65 |
| 05:50 PM | 4 | 0 | 4 | 66 |
| 05:55 PM | 7 | 0 | 7 | 65 |
| 06:00 PM | 6 | 0 | 6 | 62 |
| 06:05 PM | 2 | 0 | 2 | 62 |
| 06:10 PM | 6 | 1 | 5 | 65 |
| 06:15 PM | 8 | 0 | 8 | 63 |
| 06:20 PM | 8 | 0 | 8 | |
| 06:25 PM | 4 | 0 | 4 | |
| 06:30 PM | 3 | 0 | 3 | |
| 06:35 PM | 8 | 0 | 8 | |
| 06:40 PM | 6 | 0 | 6 | |
| 06:45 PM | 5 | 0 | 5 | |
| 06:50 PM | 3 | 0 | 3 | |
| 06:55 PM | 4 | 0 | 4 | |
| 07:00 PM | 6 | 0 | 6 | |
| 07:05 PM | 5 | 0 | 5 | |
| 07:10 PM | 3 | 0 | 3 | |

| | per min | per hr |
|---|---|---|
| Average Arrival Rate (veh/min) | 1 | 60 |
| Peak Hour Arrival Rate (veh/min) | 1.15 | 69 |
| Peak 5-min Arrival Rate (veh/min) | 1.8 | 108 |

**Saturday Mid-day Peak Period Arrival Count**

("Error" is a vehicle that appeared at first to join the drive-thru queue but did not actually become a part of the queue)

Start Date: 6/21/2014

Start Time: 11:30:00 AM

| Start Time | Count | Error | Corrected Count | Hourly |
|---|---|---|---|---|
| 11:30 AM | 8 | 0 | 8 | 90 |
| 11:35 AM | 10 | 0 | 10 | 90 |
| 11:40 AM | 5 | 1 | 4 | 80 |
| 11:45 AM | 8 | 0 | 8 | 81 |
| 11:50 AM | 10 | 0 | 10 | 82 |
| 11:55 AM | 7 | 0 | 7 | 78 |
| 12:00 PM | 8 | 0 | 8 | 81 |
| 12:05 PM | 7 | 0 | 7 | 83 |
| 12:10 PM | 8 | 0 | 8 | 82 |
| 12:15 PM | 6 | 0 | 6 | 83 |
| 12:20 PM | 4 | 0 | 4 | 84 |
| 12:25 PM | 10 | 0 | 10 | 84 |
| 12:30 PM | 8 | 0 | 8 | 78 |
| 12:35 PM | 2 | 2 | 0 | |
| 12:40 PM | 5 | 0 | 5 | |
| 12:45 PM | 9 | 0 | 9 | |
| 12:50 PM | 7 | 1 | 6 | |
| 12:55 PM | 10 | 0 | 10 | |
| 01:00 PM | 10 | 0 | 10 | |
| 01:05 PM | 6 | 0 | 6 | |
| 01:10 PM | 9 | 0 | 9 | |
| 01:15 PM | 7 | 0 | 7 | |
| 01:20 PM | 4 | 0 | 4 | |
| 01:25 PM | 4 | 0 | 4 | |

| | per min | per hr |
|---|---|---|
| Average Arrival Rate (veh/min) | 1.4 | 84 |
| Peak Hour Arrival Rate (veh/min) | 1.5 | 90 |
| Peak 5-min Arrival Rate (veh/min) | 2 | 120 |

Weekday AM Peak Period Process Time and Queuing Obvserations — Purcellville McDonalds — 10/2/2014

| | Processing Time (sec) | | | | Queue @ Time (# of cars) | | |
|---|---|---|---|---|---|---|---|
| | 1st Observation | | 2nd Observation (if time allows) | | | | |
| | Time at Order | | Time at Order | | Present | Ordering | |
| Start Time | Station | Total Time to Exit | Station | Total Time to Exit | Window | Station | Total |
| 7:00 | 30 | 150 | | | 3 | 5 | 8 |
| 7:05 | 23 | 233 | | | 5 | 1 | 6 |
| 7:10 | 20 | 170 | | | 5 | 4 | 9 |
| 7:15 | 15 | 70 | 13 | 111 | 0 | 1 | 1 |
| 7:20 | 25 | 87 | 19 | 75 | 3 | 5 | 8 |
| 7:25 | 15 | 147 | 29 | 107 | 4 | 1 | 5 |
| 7:30 | 115 | 156 | | | 4 | 4 | 8 |
| 7:35 | 28 | 121 | | | 4 | 6 | 10 |
| 7:40 | 20 | 129 | | | 7 | 7 | 14 |
| 7:45 | 17 | 151 | | | 5 | 1 | 6 |
| 7:50 | 22 | 104 | 15 | 147 | 3 | 5 | 8 |
| 7:55 | 46 | 87 | 26 | 77 | 2 | 5 | 7 |
| 8:00 | 51 | 107 | | | 2 | 6 | 8 |
| 8:05 | 12 | 144 | | | 4 | 6 | 10 |
| 8:10 | 20 | 139 | 22 | 136 | 4 | 6 | 10 |
| 8:15 | 29 | 169 | | | 3 | 8 | 11 |
| 8:20 | 22 | 138 | 26 | 88 | 4 | 5 | 9 |
| 8:25 | 33 | 117 | 23 | 124 | 6 | 6 | 12 |
| 8:30 | 17 | 123 | 20 | 79 | 5 | 3 | 8 |
| 8:35 | 17 | 134 | | | 3 | 5 | 8 |
| 8:40 | 21 | 189 | | | 5 | 7 | 12 |
| 8:45 | 25 | 112 | | | 4 | 7 | 11 |
| 8:50 | 31 | 184 | | | 6 | 5 | 11 |
| 8:55 | 18 | 181 | | | 4 | 7 | 11 |
| 9:00 | 28 | 182 | | | 6 | 8 | 14 |
| 9:05 | 40 | 100 | | | 2 | 6 | 8 |
| 9:10 | 37 | 240 | | | 6 | 3 | 9 |
| 9:15 | 43 | 131 | | | 5 | 6 | 11 |
| 9:20 | 24 | 98 | 52 | 89 | 0 | 4 | 4 |
| 9:25 | 19 | 112 | | | 4 | 3 | 7 |

| | | | | |
|---|---|---|---|---|
| Average Processing Time | 131 | Seconds | 02:11 | Min:Sec |
| Average Pickup Window Queue | 3.93 | | | |
| Average Order Window Queue | 4.87 | | | |
| Average Cars in both Queues | 8.8 | | | |
| Peak Hour Avg Processing Time | 125 | Seconds | 02:05 | Min:Sec |
| Peak Hour Avg Service Time | 25.58 | | | |
| Peak Hour Avg Pickup Window Queue | 3.83 | | | |
| Peak Hour Avg Order Window Queue | 5.25 | | | |
| Peak Hour Avg Cars in both Queues | 9.08 | | | |
| Max Pickup Window Queue | 7 | | | |
| Max Order Window Queue | 8 | | | |
| Max Cars in both Queues | 14 | | | |

Weekday Midday Peak Period Process Time and Queuing Obvserations — Purcellville McDonalds — 10/2/2014

| | Processing Time (sec) | | | | Queue @ Time (# of cars) | | |
|---|---|---|---|---|---|---|---|
| | 1st Observation | | 2nd Observation (if time allows) | | | | |
| Start Time | Time at Order Station | Total Time to Exit | Time at Order Station | Total Time to Exit | Present Window | Ordering Station | Total |
| 11:30 | 25 | 72 | 19 | 138 | 0 | 4 | 4 |
| 11:35 | 39 | 116 | | | 4 | 4 | 8 |
| 11:40 | 14 | 45 | | | 3 | 0 | 3 |
| 11:45 | 13 | 72 | | | 2 | 2 | 4 |
| 11:50 | 13 | 78 | 26 | 70 | 0 | 0 | 0 |
| 11:55 | 18 | 134 | | | 4 | 5 | 9 |
| 12:00 | 33 | 102 | | | 3 | 0 | 3 |
| 12:05 | 22 | 181 | | | 2 | 2 | 4 |
| 12:10 | 19 | 142 | | | 4 | 4 | 8 |
| 12:15 | 23 | 150 | | | 6 | 3 | 9 |
| 12:20 | 25 | 177 | | | 5 | 3 | 8 |
| 12:25 | 40 | 260 | | | 4 | 6 | 10 |
| 12:30 | 21 | 206 | | | 7 | 8 | 15 |
| 12:35 | 38 | 302 | | | 6 | 3 | 9 |
| 12:40 | 18 | 164 | | | 6 | 4 | 10 |
| 12:45 | 38 | 152 | | | 6 | 8 | 14 |
| 12:50 | 27 | 175 | | | 4 | 5 | 9 |
| 12:55 | 27 | 155 | | | 5 | 4 | 9 |
| 13:00 | 19 | 141 | | | 3 | 0 | 3 |
| 13:05 | 43 | 119 | | | 5 | 3 | 8 |
| 13:10 | 29 | 122 | | | 4 | 1 | 5 |
| 13:15 | 17 | 92 | | | 1 | 2 | 3 |
| 13:20 | 34 | 102 | | | 5 | 0 | 5 |
| 13:25 | 29 | 118 | | | 1 | 0 | 1 |

| | | | | |
|---|---|---|---|---|
| Average Processing Time | 138 | Seconds | 02:18 | Min:Sec |
| Average Pickup Window Queue | 3.75 | | | |
| Average Order Window Queue | 2.96 | | | |
| Average Cars in both Queues | 6.71 | | | |
| Peak Hour Avg Processing Time | 163 | Seconds | 02:43 | Min:Sec |
| Peak Hour Avg Service Time | 25.67 | | | |
| Peak Hour Avg Pickup Window Queue | 4.42 | | | |
| Peak Hour Avg Order Window Queue | 3.83 | | | |
| Peak Hour Avg Cars in both Queues | 8.25 | | | |
| Max Pickup Window Queue | 7 | | | |
| Max Order Window Queue | 8 | | | |
| Max Cars in both Queues | 15 | | | |

Weekday PM Peak Period Process Time and Queuing Obvserations

| | 6/18/2014 | Purcellville Mcdonalds | | |
|---|---|---|---|---|
| | Processing Time (sec) | Queue @ Time (# of cars) | | |
| Start Time | | Present Window | Ordering Station | Total |
| 17:15 | 85 | 0 | 0 | 0 |
| 17:20 | 138 | 2 | 3 | 5 |
| 17:25 | 207 | 3 | 4 | 7 |
| 17:30 | 175 | 6 | 1 | 7 |
| 17:35 | 95 | 3 | 2 | 5 |
| 17:40 | 80 | 0 | 0 | 0 |
| 17:45 | 90 | 0 | 0 | 0 |
| 17:50 | 118 | 1 | 0 | 1 |
| 17:55 | 102 | 2 | 1 | 3 |
| 18:00 | 94 | 5 | 0 | 5 |
| 18:05 | 135 | 2 | 1 | 3 |
| 18:10 | 139 | 0 | 1 | 1 |
| 18:15 | 112 | 4 | 3 | 7 |
| 18:20 | 110 | 4 | 6 | 10 |
| 18:25 | 147 | 4 | 1 | 5 |
| 18:30 | 122 | 2 | 2 | 4 |
| 18:35 | 126 | 4 | 2 | 6 |
| 18:40 | 241 | 6 | 1 | 7 |
| 18:45 | 170 | 4 | 0 | 4 |
| 18:50 | 128 | 1 | 1 | 2 |
| 18:55 | 214 | 1 | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| Average Processing Time | 135 | Seconds | 02:15 | Min:Sec |
| Average Processing Rate | 27 | | | |
| Average Pickup Window Queue | 2.57 | | | |
| Average Order Window Queue | 1.52 | | | |
| Average Cars in both Queues | 4.1 | | | |
| Peak Hour Avg Processing Time | 121 | Seconds | 02:01 | Min:Sec |
| Peak Hour Avg Processing Rate | 30 | | | |
| Peak Hour Avg Pickup Window Queue | 2.5 | | | |
| Peak Hour Avg Order Window Queue | 1.58 | | | |
| Peak Hour Avg Cars in both Queues | 4.08 | | | |
| Max Pickup Window Queue | 6 | | | |
| Max Order Window Queue | 6 | | | |
| Max Cars in both Queues | 10 | | | |

Saturday Mid-day Peak Period Process Time and Queuing Obvserations

| | 6/21/2014 | Purcellville Mcdonalds | | |
|---|---|---|---|---|
| | Processing Time (sec) | Queue @ Time (# of cars) | | |
| Start Time | | Present Window | Ordering Station | Total |
| 11:30 | 140 | 4 | 1 | 5 |
| 11:35 | 125 | 3 | 3 | 6 |
| 11:40 | 98 | 0 | 1 | 1 |
| 11:45 | 115 | 2 | 3 | 5 |
| 11:50 | 123 | 4 | 4 | 8 |
| 11:55 | 145 | 4 | 3 | 7 |
| 12:00 | 200 | 6 | 3 | 9 |
| 12:05 | 143 | 5 | 1 | 6 |
| 12:10 | 195 | 5 | 0 | 5 |
| 12:15 | 110 | 3 | 1 | 4 |
| 12:20 | 144 | 0 | 3 | 3 |
| 12:25 | 165 | 5 | 5 | 10 |
| 12:30 | 278 | 7 | 5 | 12 |
| 12:35 | 155 | 2 | 1 | 3 |
| 12:40 | 103 | 3 | 1 | 4 |
| 12:45 | 122 | 3 | 2 | 5 |
| 12:50 | 175 | 2 | 5 | 7 |
| 12:55 | 135 | 3 | 4 | 7 |
| 13:00 | 137 | 3 | 6 | 9 |
| 13:05 | 153 | 5 | 7 | 12 |
| 13:10 | 247 | 7 | 5 | 12 |
| 13:15 | 134 | 6 | 3 | 9 |
| 13:20 | 164 | 2 | 2 | 4 |
| 13:25 | 96 | 2 | 3 | 5 |

| | | | | |
|---|---|---|---|---|
| Average Processing Time | 150 | Seconds | 02:30 | Min:Sec |
| Average Processing Rate | 24 | | | |
| Average Pickup Window Queue | 3.58 | | | |
| Average Order Window Queue | 3 | | | |
| Average Cars in both Queues | 6.58 | | | |
| Peak Hour Avg Processing Time | 153 | Seconds | 02:33 | Min:Sec |
| Peak Hour Avg Processing Rate | 23 | | | |
| Peak Hour Avg Pickup Window Queue | 3.67 | | | |
| Peak Hour Avg Order Window Queue | 2.67 | | | |
| Peak Hour Avg Cars in both Queues | 6.33 | | | |
| Max Pickup Window Queue | 7 | | | |
| Max Order Window Queue | 7 | | | |
| Max Cars in both Queues | 12 | | | |