BOSTON REGION METROPOLITAN PLANNING ORGANIZATION
Richard A. Davey, MassDOT Secretary and CEO and MPO Chairman
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MEMORANDUM

DATE **October 4, 2012**

TO **City of Quincy**

FROM **Chen-Yuan Wang, MPO Staff**
Mark Abbott, MPO Staff
Steven Andrews, MPO Staff

RE **Safety and Operations Analyses at Selected Boston Region MPO Intersections, FFY 2012: Southern Artery (Route 3A) at Sea Street/Coddington Street and at McGrath Highway/Field Street in Quincy**

Introduction

The two intersections are located in close proximity to each other, with highly correlated traffic flows, and therefore were examined together in this study. They are high-crash and congested locations, and both are on MassDOT's 2007–09 list of high-crash intersection locations.[1] In the three-year period, the intersection of Southern Artery at Sea Street/Coddington Street had 76 crashes (16 of them had caused personal injuries), and the intersection of Southern Artery at McGrath Highway/Field Street had 71 crashes (21 of them had caused personal injuries).

In addition to the high number of crashes, the two intersections were selected for their congested conditions during peak hours, the regional significance of Southern Artery, and their proximity to a major rapid transit station. Furthermore, the two intersections are expected to be impacted by a series of recently planned Quincy Center developments and transportation improvement projects.

This memorandum summarizes safety and operations analyses and proposes improvement strategies for the two intersections. It contains the following sections:

- Existing Conditions
- Issues and Concerns
- Crash Data Analysis
- Intersection Capacity Analysis
- Improvement Alternatives
- Future Conditions Analysis
- Improvement Recommendations

[1] MassDOT's 2007 Top Crash Locations Report, 2008 Top Crash Locations Report, and 2009 Top Crash Locations Report.

The memorandum also includes technical appendices that contain methods and data applied in the study and detailed reports of the intersection capacity analyses.

Existing Conditions

The two intersections are located about a quarter mile northeast of Quincy Center. They are only about 500 feet apart and are surrounded by commercial developments, except for the areas north of Sea Street and Coddington Street, where the Quincy High School playing field and a major cemetery are situated. All the roadways connected to the two intersections are under the City's jurisdiction. All of them function as an urban principal or minor arterial with regional significance, except Field Street, located at the second intersection (McGrath Highway/Field Street), which is a local street.

Southern Artery is the major street that connects the two intersections. It is an urban principal arterial about two miles in length running from Quincy Avenue near the Braintree border to slightly west of Furnace Brook Parkway. Its entire length is designated as state Route 3A, except for its westernmost section of about half a mile from Quincy Avenue to Washington Street (designated as Route 53). Route 3A serves the coastal communities south of Boston and runs parallel to Route 3, the only major freeway in the South Shore area. As Route 3 is usually very congested during peak traffic periods, especially in the vicinity of the Braintree Split (the interchange of Interstate 93 and Route 3), commuters frequently use the Southern Artery as one of their alternative routes for commuting between Boston and the South Shore communities.

Sea Street, an urban minor arterial, runs from its intersection with Coddington Street and Seat Street to Nut Island, serving the neighborhoods along Quincy Bay. About 2,000 feet east of the intersection, Sea Street intersects Quincy Shore Drive, a popular route connecting to Boston and points north via Neponset Bridge. For this reason, it carries a high volume of regional traffic in the section between the study intersection and Quincy Shore Drive.

Coddington Street is a short section of roadway, about half a mile long, running from The Southern Artery (at Sea Street) to Quincy Center and the MBTA (Massachusetts Bay Transportation Authority)'s Quincy Center Station. Although Coddington Street is categorized as an urban principal arterial, it carries much less traffic than Sea Street. Most of the traffic from Route 3A (Southern Artery) heading south to Quincy Center or to the MBTA station usually diverts to Washington Street before this intersection.

McGrath Highway (also known as Mayor Thomas J. McGrath Highway), running from the Southern Artery at Field Street to Washington Street near Quincy Center, is part of the recently constructed Quincy Center Concourse. The Concourse, located on Mayor Hannon Parkway, Revere Road, and McGrath Highway, is a four-lane urban boulevard running from Granite Street, through the southern part of Quincy Center, to Southern Artery. It was created to improve east-west travel across the city, to relieve congestion

at Quincy Center, and to promote economic development along the corridor and at Quincy Center. The significance of the Concourse is increasing because it is near a large-scale downtown redevelopment project that is currently being prepared for implementation by the City.[2]

The new downtown master plan envisions a mixed-use redevelopment for the area bounded by the MBTA station, Burgin Parkway, Mayor Hannon Parkway, Revere Road, Chestnut Street, Temple Street, and Washington Street. The plan includes the development of a major open space at the northern end of the redevelopment district, to be called Adams Green Park in order to celebrate the historic significance of the city.

The Adams Green project will transform the streets around Quincy Town Hall, City Hall, the Church of the Presidents (United First Parish Church), and the historic burial ground into a lively green civic common. It will close off the section of Hancock Street between Washington Street and Temple Street to vehicular traffic and integrate the section into the park to enhance pedestrian connections to the Quincy Center MBTA station. Thereby, it will also alter the traffic patterns in Quincy Center.

Figure 1 shows the locations of the two intersections, the adjacent roadways, the Concourse, and the proposed Quincy downtown redevelopment area. Based on the traffic forecasts of the proposed developments, the traffic flow from the Concourse, via Southern Artery between the two intersections, to Sea Street north of Southern Artery, or vice versa, is expected to increase gradually in the next 10 years.

Figure 2 shows the two intersections' existing layout and the adjacent developments and land uses. Both intersections are signalized. Their traffic signals are interconnected, but operate independently at present.

At the Sea Street/Coddington Street intersection, the Southern Artery northbound approach has four lanes: a shared left-turn/through lane, an exclusive through lane, and two channelized exclusive right-turn lanes. The channelized right-turn lanes have a storage length of about 200 feet and are signal-controlled. The Southern Artery southbound approach has two lanes: a shared left-turn/through lane and a shared through/right-turn lane. The Coddington Street eastbound approach has two lanes: one left-turn/through lane and one through/right-turn lane. The Sea Street westbound approach has three lanes: an exclusive left-turn lane, a shared left-turn/through lane, and a shared through/right-turn lane. However, due to the high proportion of left-turning traffic, the shared left-turn/through lane operates like an exclusive left-turn lane. The shared through/right-turn lane is short (about 225 feet in length) and directs its right-turning traffic to a channelized lane about 75 feet before the approach's stop line.

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[2] Adams Green Transportation Improvements Functional Design Report, Howard/Stein-Hudson Associates, Inc., April 2012.

No on-street parking is allowed on any of the approaches at the intersection. There are sidewalks on both sides of all approaches, and crosswalks across all of the approaches. The two right-turn channelized islands are used as pedestrian refuge areas between crosswalks. Pedestrian signal push buttons are located at all the corners of the intersection and at the two channelized islands facing the crosswalks. The intersection traffic signal provides an exclusive pedestrian signal phase of 24 seconds, when any of the buttons is activated. The pedestrian signal is not equipped with a countdown or accessible (audible) function.

Curb-cut ramps are installed at both ends of most of the crosswalks. However, there are no cub-cut ramps at the ends of the crosswalk between the two traffic islands on Sea Street, and there are no curb-cut ramps at the westbound traffic island for the crosswalks across the westbound right-turn lane and across Southern Artery. None of the ramps are equipped with tactile warning strips. Most of them are too narrow and some of them are too steep. These appear not to be in compliance with ADA (Americans with Disabilities Act) standards. Pedestrians using the crosswalks approaching the two traffic islands run the risk of walking into mast arm poles or pedestrian signal poles.

With multiple travel lanes on Southern Artery and Sea Street, the intersection is relatively wide. Traffic signal heads, pedestrian signals, and route/destination guide signs appear to have been added to the intersection over the years and lack consistency and integration. These many signs and indications within the intersection can be confusing for drivers. Figure 3 shows various route and destination signs and signal indications within the intersection of Southern Artery at Sea Street/Coddington Street.

There is a mast arm for each approach of the intersection. Generally, a traffic signal head should be placed over its intended travel lane and preferably be suspended from a mast arm. At this intersection, only the signal head of the leftmost lane is hung from the mast arm on each approach. The signal head for the lane next to the inside lane is mounted on the mast arm pole, which is too low, not over its lane, and difficult for drivers to see when they are approaching the intersection. Figure 4 shows two signals—one mounted on a mast arm and one on the mast arm pole—at the intersection of Southern Artery at Sea Street/Coddington Street. The mast arms were probably installed when the intersection had a layout smaller than the existing one, and the mast arms are probably not strong enough to hold more than one signal head.

At the McGrath Highway/Field Street intersection, the Southern Artery northbound approach has three lanes: an exclusive left-turn lane about 225 feet long, an exclusive through lane, and a shared through/right-turn lane. The Southern Artery southbound approach has three lanes: a shared left-turn/through lane, an exclusive through lane, and an exclusive channelized right-turn lane. The McGrath Highway eastbound approach has three lanes: an exclusive left-turn lane, a shared left-turn/through lane, and a channelized exclusive right-turn lane about 200 feet long. The Field Street westbound approach has only one lane, which is shared by all movements. In addition, a private road, Morrison Street, joins Southern Artery at the northeast corner of the

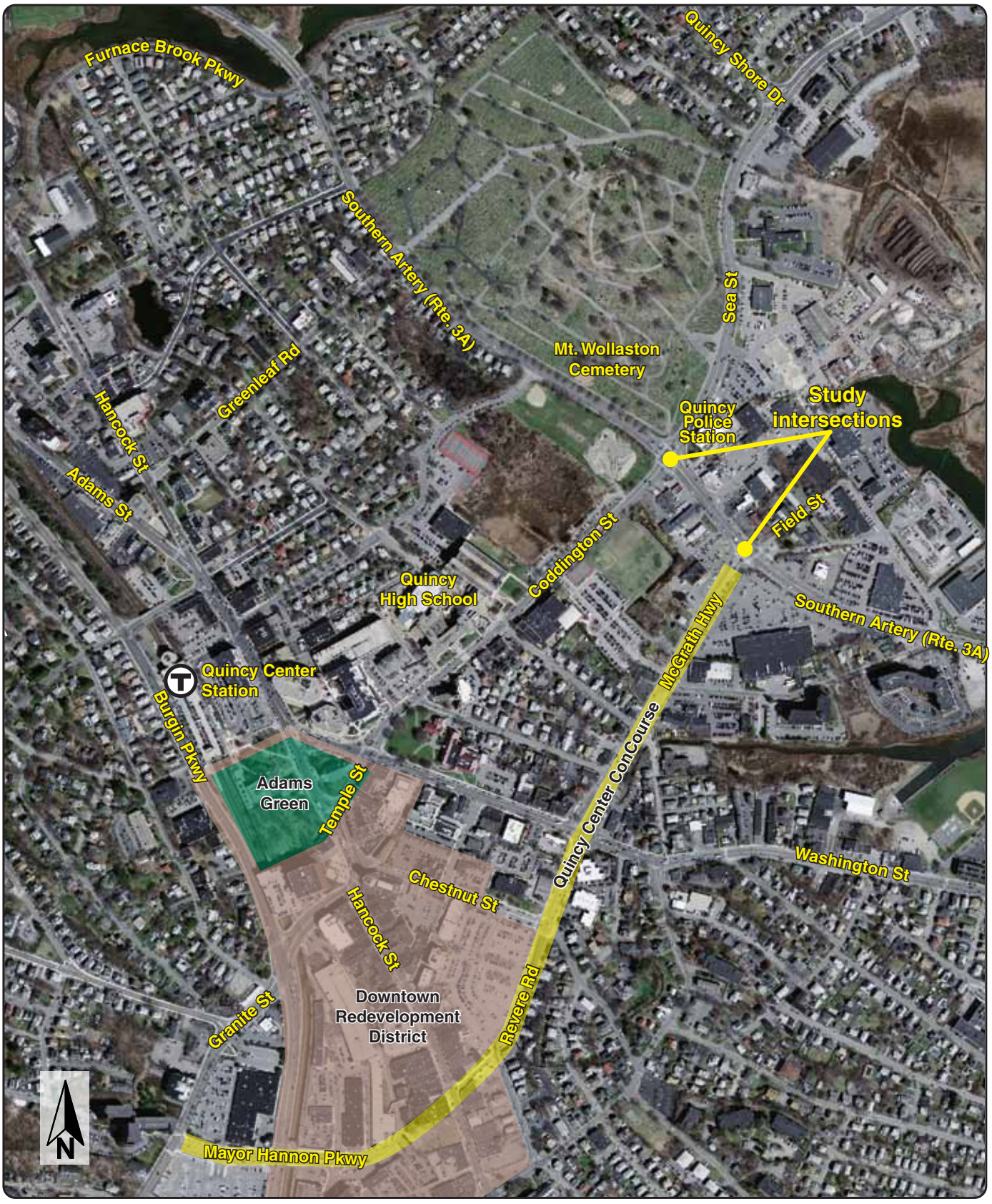

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FIGURE 1
Intersection Locations, Adjacent Roadways, and Quincy Center Developments

Safety and Operations Analyses at Selected Intersections

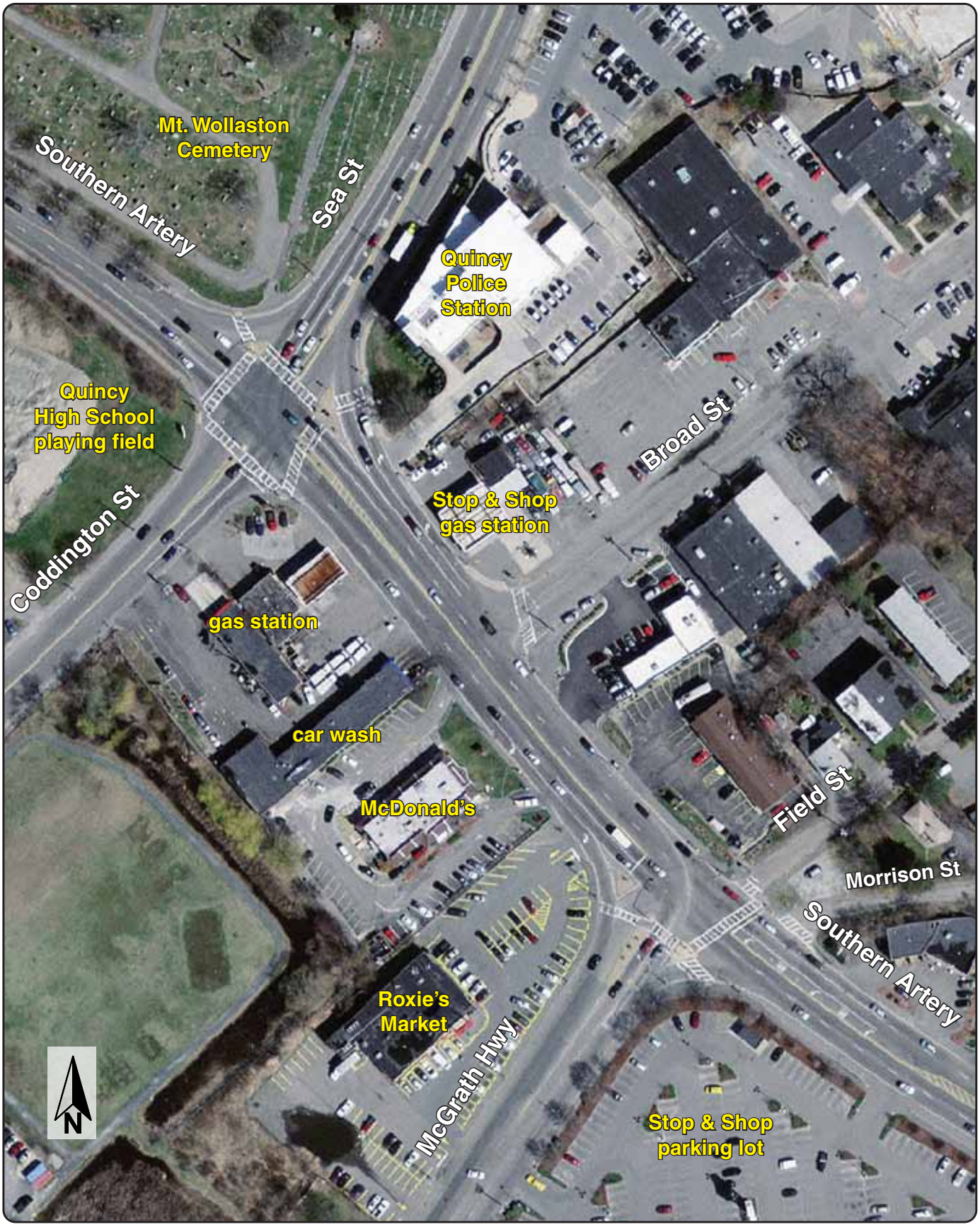

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FIGURE 2
Intersection Layout

Safety and Operations Analyses at Selected Intersections

intersection (see Figure 2). It carries very little traffic, and therefore does not usually affect the intersection's traffic operations during peak hours.

No on-street parking is allowed on any of the approaches at the intersection. There are sidewalks on both sides of all approaches except the Field Street approach, and crosswalks across all of the approaches except the Southern Artery southbound approach. The City reconstructed the crosswalks across McGrath Highway about a year ago. Curb-cut ramps with sufficient width are installed at both ends of all the crosswalks, including those at the two traffic islands. The ramps also are equipped with warning tactile strips.

Pedestrian crossings at this intersection are operated concurrently with traffic flows. The crossing on Southern Artery is concurrent with the McGrath Highway traffic phase, and the crossing on McGrath Highway is concurrent with the Southern Artery approach. The pedestrian signals for the crossing on Southern Artery are equipped with a countdown feature.

The surrounding areas are a mix of commercial developments, institutional land use, and open space. The commercial developments are located mainly on Southern Artery south of the intersection of Southern Artery at Sea Street/Coddington Street. There are many driveways on Southern Artery between the two intersections. Broad Street, located between the two intersections, is a local road that serves some commercial and office buildings. Although Southern Artery is striped with double yellow center lines, left turns from Broad Street are not clearly prohibited. Drivers do make the turns at times, but crash data collected for this study do not indicate that there are a high number of crashes at this location.

Pedestrian activity is at medium to high levels at the two intersections. Based on the peak-period counts that staff performed in April 2012, the two intersections carried about 25 to 45 pedestrians per hour during the two peak hours (one in the Am and one in the PM). The counts also indicated that there were about three to five bicycles at each of the two intersections during both the AM peak hour and during the PM peak hour. The percentage of heavy vehicles is moderate, at 1% to 2% of the total entry traffic at the two intersections, during peak hours.

Massachusetts Bay Transportation Authority bus Route 214 (Germantown – Quincy Center) and Route 216 (Houghs Neck – Quincy Center) runs on Sea Street and Coddington Street through the intersections: six outbound and six inbound trips during the AM peak hour and four inbound and four outbound trips during the PM peak hour. There are no bus stops immediately adjacent to either of the two intersections.

FIGURE 3
Various Route/Destination Signs and Signal Indications within the Intersection:
Southern Artery at Sea Street/Coddington Street

FIGURE 4
A Signal Head Mounted on a Mast Arm Pole:
Southern Artery at Sea Street/Coddington Street

Issues and Concerns

Based on field observations and the available crash and traffic data, the issues and concerns for the intersection can be summarized as:

- High number of crashes and high crash rate at the two intersections
- Traffic congestion at the two intersections during the peak hours, especially in the PM peak hour
- Extensive traffic queues and delays on Sea Street and on the Southern Artery southbound approach at the Coddington Street/Sea Street intersection in the PM peak hour
- Substandard crosswalks, some of which lack wheelchair curb-cuts, at the Coddington Street/Sea Street intersection
- Improper route/destination signs located in the middle of the Coddington Street/Sea Street intersection
- Unfitting signal indications at the Coddington Street/Sea Street intersection
- No bicycle travel accommodation at either intersection
- No accessible pedestrian signals at either intersection
- Dense commercial section between the two intersection, with multiple driveway entry and exit points

Crash Data Analysis

Based on MassDOT's Registry of Motor Vehicles Division crash data for 2005 to 2009, Table 1, a summary of MassDOT crash data for 2005 through 2009 for the intersection of Southern Artery at Sea Street/Coddington Street, shows that, on average, about 29 crashes occurred at the intersection of Southern Artery at Sea Street and Coddington Street each year. Slightly over 20% of the crashes resulted in personal injuries, and nearly 80% of the total crashes involved property damage only or unknown severity of injuries. None of the crashes caused a fatality. The crash types consist of about 35% rear-end collisions, 34% angle collisions, 19% sideswipe collisions, 5% single-vehicle collisions, and 2% head-on collisions. One crash involved a pedestrian, and one crash involved a bicyclist. About 35% of the total crashes occurred during peak periods. About 26% of the total crashes happened when the roadway pavement was wet or icy. Approximately 22% of the crashes occurred in dark conditions (dawn, dusk, and nighttime).

Crash rates are another effective metric for examining the relative safety of a particular location.[3] Based on the 2005 to 2009 crash data and the recently-collected traffic

[3] Crash rates are calculated based on crash frequency (crashes per year) and vehicle exposure (traffic volumes or miles traveled). Crash rates are expressed as "crashes

volume data, the calculated crash rate for this intersection is was 2.31 crashes per million entering vehicles (see Appendix A for the calculation). This crash rate is about three times the average rate for signalized intersections in MassDOT Highway Division District 6 (in which the intersections are located), reported by MassDOT to be 0.77 crashes per million entering vehicles.[4]

Staff also collected crash reports from the Quincy Police Department (QPD) for 42 reported crashes that occurred during the period April 2009 to April 2012. From the reports, staff constructed a collision diagram for the intersection (see Figure B-1, in Appendix B). The collision diagram shows that many rear-end crashes occurred on the Southern Artery northbound approach. More significant is that seven rear-end collisions occurred in the right-turn bay to Sea Street from Southern Artery in the three-year period. The right-turn bay is controlled by a stop light and right-turn-on-red is prohibited. A few drivers failed to stop at the red light, and ran into the vehicles that had done so. In addition, the signal indication for the right turns can be confusing. The right-turn movement is overlapped with the westbound left-turn movement. It shows a red ball and a green arrow simultaneously during the overlapped phase. Drivers who are not familiar with the operation can be confused and don't know if they should stop or should go. Hesitation at the approach could cause them to be rear ended.

Although most of the crashes on the northbound approach were related to the congested conditions on the multiple travel lanes, some were related to police vehicles exiting from the adjacent police station. An emergency exit driveway from the station is located near the northeast corner of the intersection about 30 feet from the northbound stop line. When a police vehicle exited and crossed four to six lanes of traffic in an emergency, vehicles on the approach near the intersection had little time and space to respond. This operation affects not only the northbound traffic, but also the southbound traffic. The rear-end collision involved two southbound vehicles on the approach related to a police car's heading to McGrath Highway from the driveway, and there was one crash on the approach related to a police vehicle turning into the driveway.

Another significant collision type was angle collisions between vehicles turning left from Southern Artery southbound with vehicles passing through the intersection heading northbound on Southern Artery. There were seven such crashes in the three-year

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per million entering vehicles" for intersection locations and as "crashes per million miles traveled" for roadway segments.

[4] The average crash rates calculated by the MassDOT Highway Division are based on a database that contains intersection crash rates submitted to MassDOT as part of the review process for an Environmental Impact Report or Functional Design Report. The most recent average crash rates, which are updated on a nearly annual basis, are based on all entries in the database, not just those entries made within the past year. The average crash rate for District 6 was calculated on July 7, 2011.

period. The left-turn movement is operated under a protected/permissive phase, as it shares a lane with the through movement. Such settings can be confusing to some left-turning drivers because they may think that they have the right-of-way when the green ball is on (even though the green left-turn arrow is off) and proceed without yielding to the opposite through traffic. However, a review of the crash reports indicated that most of the crashes were caused by aggressive driving by the left-turning drivers during congested traffic conditions. In contrast, there was only one crash that involved a vehicle turning left from the Southern Artery northbound approach with a vehicle heading south on Southern Artery, as there were many fewer left turns in the northbound approach than in the southbound approach.

Two crashes involved a bicyclist. Both were in part due to improper driving on the bicyclist's part. One occurred at the northbound right-turn bay. In this crash, the bicyclist started to ride his bicycle on the crosswalk across the right-turn bay when the light for the right turns was red. Soon the light turned green and a vehicle clipped the bicyclist. The other crash occurred on Southern Artery north of the intersection, when a bicyclist rode the wrong way on the northbound side heading south and a vehicle heading north hit the bicyclist with its mirror.

There were no crashes involving pedestrians in the police crash reports. However, the MassDOT crash data show that there was a crash in 2007 involving a pedestrian and a crash in 2005 involving a bicyclist.

Based on the MassDOT crash data, Table 2 shows that the intersection of Southern Artery at McGrath Highway/Field Street had an average of 20 crashes each year from 2005 to 2009. Most of the crashes (61%) involved property damage only. The crash types consisted of 36% rear-end collisions, 38% angle collisions, 10% sideswipe collisions, 10% single-vehicle collisions, 4% head-on collisions, and 2% unknown. About a quarter of the crashes occurred during a weekday peak period. About 20% of the crashes occurred on wet or icy pavement. Nearly 30% of the crashes occurred in dark conditions. There were six crashes involving a pedestrian and two crashes involving a bicyclist in the five-year period.

The calculated crash rate at the intersection was 1.47 crashes per million entering vehicles (see Appendix A for the calculation). It is lower than the intersection of Southern Artery at Sea Street/Coddington Street (2.31 crashes per million entering vehicles), but is higher than the average crash rate of District 6 signalized intersections (0.77 crashes per million entering vehicles).

The QPD provided 17 crash reports for this intersection for the three-year period between April 2009 and April 2012 for this study. Based on the reports, staff constructed a collision diagram for analysis (see Figure B-2, in Appendix B for the collision diagram). It should be noted that among the 17 reported crashes, 4 occurred at or near the Stop & Shop driveway on McGrath Highway rather than at the intersection.

In general, there are no prevailing collision patterns at this intersection. There were four crashes related to vehicles turning left from McGrath Highway onto Southern Artery. Two of them involved a left-turn vehicle from McGrath Highway colliding with a vehicle headed south on Southern Artery. Crash reports do not indicate that the crashes are related to signal timing (one crash was due to glare from sunlight and the other was in large part due to an aggressive maneuver). One involved a vehicle turning left from McGrath Highway colliding with a vehicle headed north on Southern Artery. Both operators claimed that they had a green light. The other crash involved a vehicle on the outside lane of McGrath Highway that turned left at too sharp an angle and hit a vehicle on the inside lane.

There were two crashes involving a vehicle turning left from Southern Artery onto McGrath Highway colliding with a vehicle heading south on Southern Artery. Crash reports indicate that both crashes relate to the turning vehicle's driver in choosing an unsafe traffic gap on Southern Artery. The Southern Artery northbound left turns are currently operated under a permissive operation. Since the approach has an exclusive lane for the left turns, it would be safer to operate the movement under a protected or a protected/permissive phase.

On Southern Artery, one crash occurred at the driveway of McDonald's and another one occurred just before the driveway of Roxie's Market. It is difficult for vehicles to get in and out of the driveways during peak hours, when right-turning traffic on the Southern Artery southbound approach is heavy.

There were no crashes involving pedestrians in the 2009–12 crash reports. The MassDOT 2005–09 crash data show that there were six crashes involving a pedestrian and two crashes involving a bicyclist in the five-year early period. As mentioned, the City reconstructed the pedestrian facilities and replaced mast arms and signal heads at this intersection about two years ago. It is possible that the replacement of traffic equipment has improved the safety of the users at this intersection, especially the pedestrians.

TABLE 1
Summary of MassDOT Crash Data 2005–09:
Southern Artery at Sea Street/Coddington Street, Quincy

Statistics Period		2005	2006	2007	2008	2009	5-Yr. Total	Annual Avg.
Total number of crashes		23	28	31	31	31	144	28.8
Severity	Property damage only	12	20	23	23	24	102	20.4
	Non-fatal injury	5	7	6	7	6	31	6.2
	Fatality	0	0	0	0	0	0	0.0
	Not reported/unknown	6	1	2	1	1	11	2.2
Collision type	Single vehicle	1	0	1	3	2	7	1.4
	Rear-end	10	7	9	8	16	50	10.0
	Angle	5	15	11	12	6	49	9.8
	Sideswipe, same direction	4	3	8	5	5	25	5.0
	Sideswipe, opposite direction	1	1	0	1	0	3	0.6
	Head-on	0	1	1	1	0	3	0.6
	Rear-to-rear	0	0	0	0	1	1	0.2
	Not reported/unknown	2	1	1	1	1	6	1.2
Involved pedestrian(s)		0	0	1	0	0	1	0.2
Involved cyclist(s)		1	0	0	0	0	1	0.2
Occurred during weekday peak periods		7	7	12	12	13	51	10.2
Wet or icy pavement conditions		6	7	9	9	7	38	7.6
Dark conditions (lit or unlit)		3	8	5	8	8	32	6.4

TABLE 2
Summary of MassDOT Crash Data 2005–09:
Southern Arterty at McGrath Highway/Field Street, Quincy

Statistics Period		2005	2006	2007	2008	2009	5-Yr. Total	Annual Avg.
Total number of crashes		24	22	15	21	18	100	20.0
Severity	Property damage only	15	12	8	16	10	61	12.2
	Non-fatal injury	5	9	5	5	8	32	6.4
	Fatality	0	0	0	0	0	0	0.0
	Not reported/unknown	4	1	2	0	0	7	1.4
Collision type	Single vehicle	1	1	2	3	3	10	2.0
	Rear-end	11	7	4	9	5	36	7.2
	Angle	11	11	3	6	7	38	7.6
	Sideswipe, same direction	1	0	2	1	2	6	1.2
	Sideswipe, opposite direction	0	1	1	1	1	4	0.8
	Head-on	0	1	2	1	0	4	0.8
	Not reported/unknown	0	1	1	0	0	2	0.4
Involved pedestrian(s)		0	1	2	1	2	6	1.2
Involved cyclist(s)		0	0	1	1	0	2	0.4
Occurred during weekday peak periods		7	7	4	3	5	26	5.2
Wet or icy pavement conditions		4	3	4	5	5	21	4.2
Dark conditions (lit or unlit)		6	7	3	4	7	27	5.4

Intersection Capacity Analysis

Staff collected turning- movement counts at the two intersections on two individual midweek days in April 2012. The data were recorded in 15-minute intervals during peak traffic periods in the morning, from 7:00 to 9:00, and in the evening, from 4:00 to 6:00. Meanwhile, 24-hour automatic traffic recorder (ATR) counts at locations near the two intersections for three consecutive midweek days were collected by the MassDOT Highway Division in the week beginning March 11, 2012 (see Appendix C for the ATR counts, summarized by hours of the day). Based on the 24-hour traffic counts, the turning- movement counts at the two intersections were adjusted and balanced.

Figure 5 shows the estimated vehicular turning-movement counts and the observed bicycle movements and pedestrian crossings in the AM peak hour (7:30–8:30) at the two intersections. In the AM peak hour, the intersection of Southern Artery at Sea Street/Coddington Street carried about 4,000 vehicles, five bicycles, and 25 pedestrians. The intersection of Southern Artery at McGrath Highway/Field Street carried about 3,120 vehicles, three bicycles, and 40 pedestrians.

Figure 6 shows the estimated vehicular turning-movement counts and the observed bicycles movements and pedestrian crossings in the PM peak hour (5:00–6:00) at the two intersections. In the AM peak hour, the intersection of Southern Artery at Sea Street/Coddington Street carried about 4,000 vehicles, three bicycles, and 45 pedestrians. The intersection of Southern Artery at McGrath Highway/Field Street carried about 3,350 vehicles, two bicycles, and 35 pedestrians.

Based on the turning-movement counts and the signal timings measured on the site, staff analyzed the intersection capacity by using an intersection capacity analysis program, Synchro.[5] Both intersections were modeled as actuated and uncoordinated signals. The first intersection has a cycle length of about 150 seconds in both peak periods; it consists of a lead/lag left-turn protected/permissive phase on the Southern Artery approaches, a split phase on the Sea Street/Coddington Street approach, and an on-call 24-second exclusive pedestrian phase. The second intersection has a cycle length of 100 seconds in the AM peak period and 90 seconds in the PM peak period; it consists of a permissive phase for all movements on Southern Artery and a split phase on McGrath Highway/Field Street. Pedestrian phases are operated concurrently with the Southern Artery approach or the McGrath Highway northbound approach.

The Synchro analyses indicate that the intersection of Southern Artery at Sea Street/Coddington Street operates at an acceptable level of service (LOS) D in the AM peak hour; it operates at a less desirable LOS E in the PM peak hour, with the

[5] Synchro Version 8 was used for these analyses. This software is developed and distributed by Trafficware Ltd. It can perform capacity analysis and traffic simulation (when combined with SimTraffic) for an individual intersection or a series of intersections.

southbound and westbound approaches enduring extensive delays. The intersection of Southern Artery at McGrath Highway/Field Street operates at LOS B during both peak hours. The AM and PM peak-hour analyses for the existing conditions are summarized in Table 3.

The analyses show that the estimated 95th-percentile queues on Southern Artery between the two intersections would not spill back into each other.[6] In general, the analyses are consistent with field observations for both peak hours. Detailed HCM (Highway Capacity Manual) signalized intersection capacity analysis reports for both intersections are included in Appendix D.

Improvement Alternatives

The two intersections are located in a built-up commercial area and each has a fairly large layout, especially the intersection at Sea Street/Coddington Street. Because the area is so built up, staff developed four improvement alternatives that do not involve major geometry modifications. They are analyzed below, progressing from simple to more involved options.

Alternative 1: Signal Timing Optimization

- Retain the existing geometry at both intersections
- Retain the existing signal phasing at the intersection of Southern Artery at Sea Street/Coddington Street
- Add a protected/permitted phase for the Southern Artery northbound left turns for the intersection of Southern Artery at McGrath Highway/Field Street
- Optimize the signal timings and phasing at both intersections

Alternative 2: Signal Coordination

- Retain the existing geometry at both intersections
- Use the same signal phasing as in Alternative 1
- Coordinate the signals for Southern Artery northbound in the AM peak hour and southbound in PM peak hour

[6] The 95th-percentile queue is defined to be the queue length (25 feet per vehicle) that has only a 5% probability of being exceeded during the analysis time period. It is a useful parameter for determining the appropriate length of turn pockets, but it is not typical of what an average driver would experience. It can be regarded as the potential maximum queue length under the input traffic conditions.

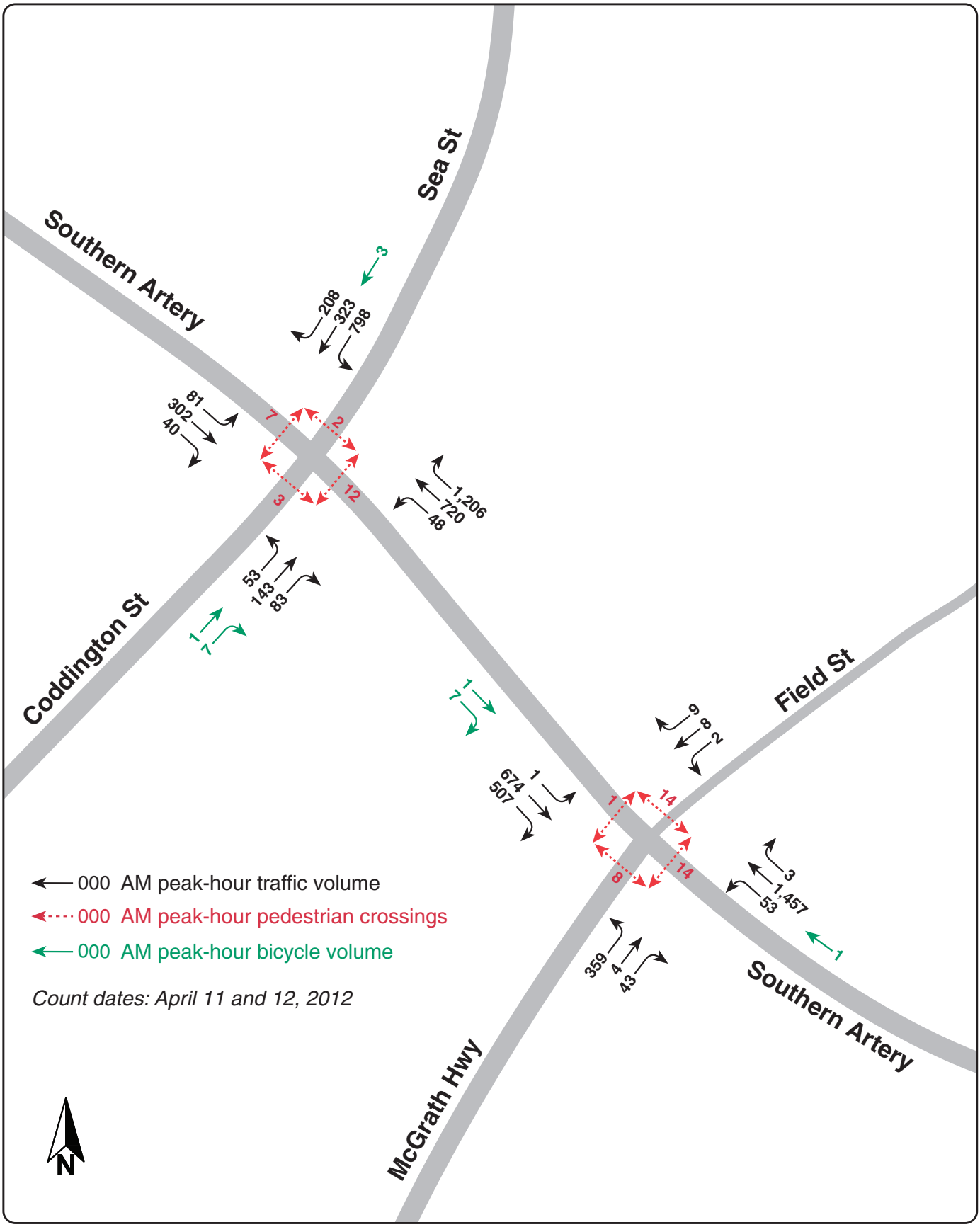

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FIGURE 5
Vehicle and Bicycle Counts and Pedestrian Crossings
2012 AM Peak Hour

Safety and Operations Analyses at Selected Intersections

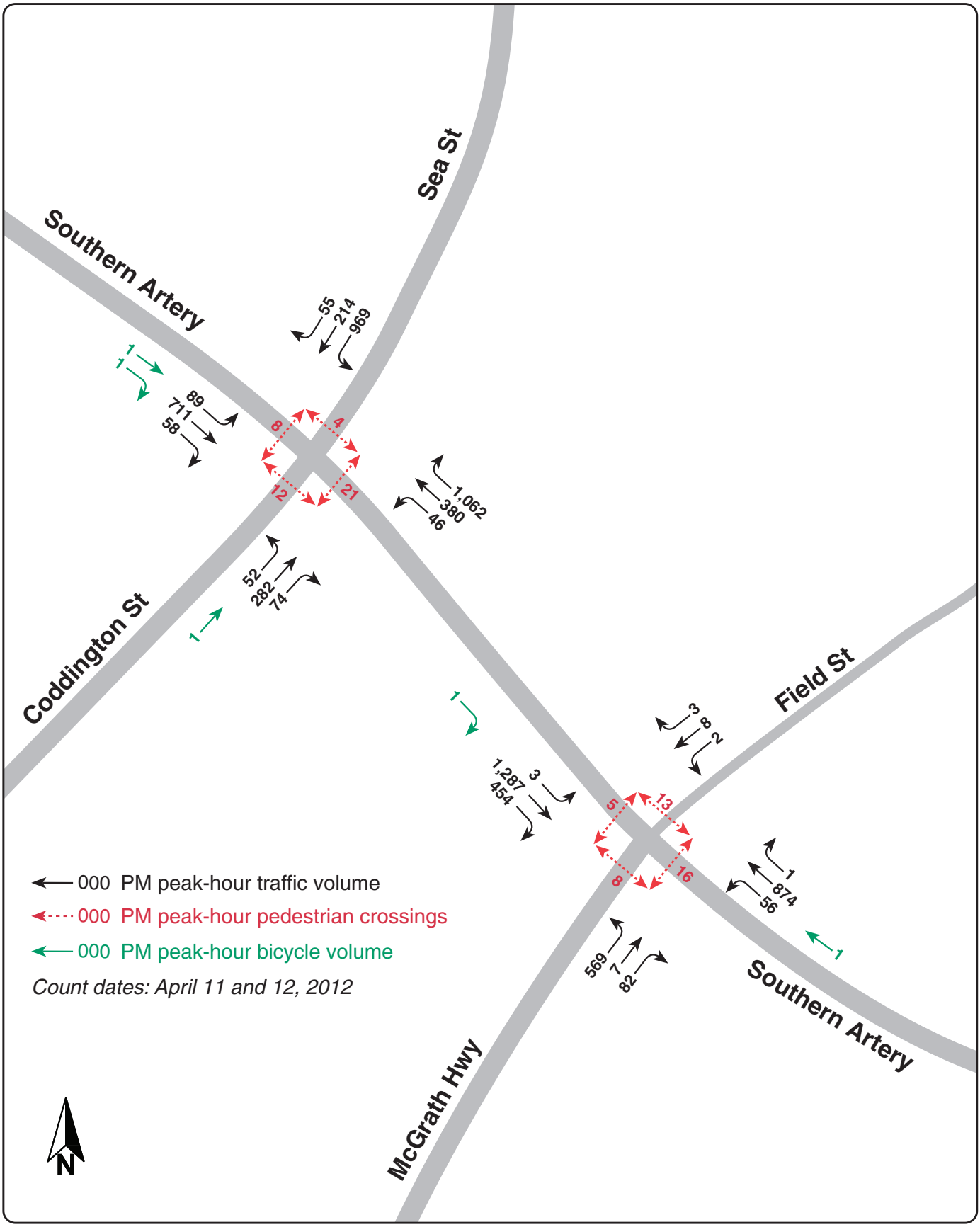

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FIGURE 6
Vehicle and Bicycle Counts and Pedestrian Crossings
2012 PM Peak Hour

Safety and Operations Analyses at Selected Intersections

TABLE 3
Intersection Analysis – 2012 Existing Conditions

Intersection/ Approach	Lane	AM Peak Hour			PM Peak Hour		
		LOS	Delay[1]	Q[3]	LOS	Delay[1]	Q[3]
Southern Artery at Sea St./Coddington St.							
Southern Artery – SB	LTR	C	33.8	255	F	87.1	#623
Southern Artery – NB	LT	D	37.3	#476	D	37.1	248
	R	B	14.4	294	B	16.9	232
Coddington St. – EB	LTR	D	53.8	178	E	61.2	#269
Sea St. – WB	L	E	77.9	#778	F	130.8	#856
	LTR	E	61.1	#658	D	51.7	#516
Overall		**D**	**41.0**	**-**	**E**	**59.1**	**-**
Southern Artery at McGrath Highway/Field							
Southern Artery – SB	LT	A	8.7	166	B	15.9	410
	R	A	8.5	45	A	9.8	59
Southern Artery – NB	L	A	7.5	38	B	16.1	#89
McGrath Highway – EB	L	C	27.6	191	C	30.7	#294
	LT	C	27.1	188	C	30.0	#289
	R	C	22.5	29	C	20.3	40
Field St – WB	LTR	C	34.7	29	D	38.3	24
	TR	B	14.3	482	B	11.0	224
Overall		**B**	**13.8**	**-**	**B**	**16.5**	**-**

[1] Delay in seconds per vehicle.
[2] V/C is the volume-to-capacity ratio.
[3] 95th percentile queue in feet.
95th percentile volume exceeds capacity, queue may be longer.

Alternative 3: Modifying Left-Turn Lanes on the Southern Artery Approaches at the Intersection of Southern Artery at Sea Street/Coddington Street

- Retain the existing geometry at the intersection of Southern Artery at McGrath Highway/Field Street.
- Use same signal phasing as in Alternative 1 at the intersection of Southern Artery at McGrath Highway/Field Street.
- Convert the shared left-turn/through lane on the Southern Artery northbound approach to a dedicated left-turn lane at the intersection of Southern Artery at Sea Street/Coddington Street.
- Add a dedicated left-turn lane to the Southern Artery southbound approach at the intersection of Southern Artery at Sea Street/Coddington Street. Provide the new left-turn lane with protected/permissive phasing.
- Optimize the signal timings.

Alternative 4: Adding a Left-Turn Lane on the Southern Artery Southbound Approach at the intersection of Southern Artery at Sea Street/Coddington Street

- Retain the existing geometry at the intersection of Southern Artery at McGrath Highway/Field Street
- Use same signal phasing as in Alternative 1 at the intersection of Southern Artery at McGrath Highway/Field Street
- Add a dedicate left-turn lane to the Southern Artery southbound approach at the intersection of Southern Artery at Sea Street/Coddington Street
- Provide the new left-turn lane with protected/permissive phasing
- Optimize the signal timings

In summary, Alternative 1 was developed to examine both signals to find out if they could be optimized under the existing intersection layout and signal sequencing. Alternative 2 was developed to assess whether signal coordination could improve the traffic operations at the two intersections. Alternative 3 was developed to reduce conflicts between left turns and opposite through traffic on Southern Artery. Alternative 4 was developed to improve both the safety and capacity of Southern Artery.

Due to the anticipated developments in the downtown area, the four improvement alternatives were also examined using projected future traffic conditions. The future year used in the analyses was 2022, a 10-year horizon commonly used for intersection operations analysis. Staff developed the projection based on historical traffic counts in

the area and information gathered from the functional design report of Adam Green Transportation Improvements.[7]

Figures 7 and 8 show the year 2022 projected vehicular turning movements, bicycle movements, and pedestrian crossings at the two intersections in the AM and PM peak hours, respectively. Overall, traffic at the intersection of Southern Artery at Sea Street/Coddington Street is projected to grow by 6.5% in the AM peak hour and 9.0% in the PM peak hour. Traffic at the intersection of Southern Artery at McGrath Highway/Filed Street is projected to grow by 9.0% in the AM peak hour and 11.5% in the PM peak hour. Traffic on McGrath Highway is expected to grow by 15.0% to 20.0% in the peak hours.

Future Conditions Analysis

A future no-build alternative was also analyzed, using the projected traffic conditions. It was developed to examine the impact of the traffic growth using the existing layout and signal timings as the baseline for evaluating the various proposed alternatives. Tables 4 and 5 summarize the intersection capacity analyses for the no-build scenario and the four alternatives using the projected 2022 traffic conditions for the AM peak hour. Tables 6 and 7 summarize the 2022 PM peak-hour analyses for the various alternatives. Detailed HCM signalized intersection capacity analysis reports for the 2022 no-build scenario and Alternatives 1 to 4 are included in Appendices E to I. The analysis results for the various alternatives are discussed below.

2022 No-Build Scenario

The 2022 analyses show that traffic operations in the AM peak hour at the intersection of Southern Artery at Sea Street/Coddington Street would remain at LOS D, with minor delay increases on all approaches except the Sea Street approach. That approach would deteriorate from LOS E to LOS F, with a noticeable delay increase. In the PM peak hour, traffic operations at the intersection would deteriorate from LOS E to LOS F, with noticeable delay increases on almost all of the approaches.

At the intersection of Southern Artery at McGrath Highway/Field Street, traffic operations in the AM peak hour would remain at LOS B, with minor delay increases on all of the approaches. Traffic operations in the PM peak hour would deteriorate from LOS B to LOS C, with noticeable delay increases on almost all of the approaches. Although this intersection has higher projected traffic growth than the other intersection, it would still operate at an acceptable LOS of C or better.

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[7] Howard/Stein-Hudson Associates Inc., Adams Green Transportation Improvements Functional Design Report, April 2012.

Alternative 1: Signal Timing Optimization

The analyses show that traffic operations in the peak hours at the intersection of Southern Artery at Sea Street/Coddington Street could be improved somewhat by signal timing optimization. Traffic operations in the PM peak hour would improve from LOS F to LOS E, with a reduction of overall delay by about 10 seconds per vehicle. Synchro optimization indicates that a slightly shorter cycle length, 145 seconds (which is less than the existing 150 seconds), including the exclusive on-call pedestrian phase with the current phasing sequence, would work for both the AM and PM peak hours.

At the intersection of Southern Artery at McGrath Highway/Field Street, traffic operations in both peak hours would maintain at the acceptable LOS of C or better, with either a minor delay increase or decrease on each approach. This alternative proposes to add a left-turn protected/permissive phase on the Southern Artery northbound approach that would reduce the conflicts between the left turns and their opposite through traffic on Southern Artery and would improve safety for drivers, pedestrians, and bicyclists at the intersection. The analyses show that the additional phase would not worsen the overall intersection traffic operations.

Alternative 2: Signal Coordination

Signal coordination between the two intersections is a possibility. However, it comes with high impacts to the LOS of the side streets. Sea Street, Coddington Street, and McGrath Highway traffic delays and queues increase as a result of the coordination.

Although the coordination is not favored in terms of the overall traffic operation, it could expedite traffic flow on certain approaches. In the AM peak hour, the coordination would allow most traffic from the Southern Artery northbound approach and the McGrath Highway westbound approach to travel freely through the intersections. In the PM peak hour, some traffic from the Southern Artery southbound approach and Sea Street could pass through the intersections without stopping. The Analyses indicate that a half signal cycle at the McGrath Highway intersection would operate efficiently for the coordination system in the AM peak hour.

One significant reason for keeping the two intersections interconnected and ready for coordination is to prevent queuing traffic spilling over to each other should spillback begin to occur. The City should regularly monitor the queuing conditions in the section and coordinated the two signals if necessary.

Alternative 3: Modifying Left-Turn Lanes on the Southern Artery Approaches at the Intersection of Southern Artery at Sea Street/Coddington Street

Converting the northbound left-turn/through shared lane to a dedicated left-turn lane and adding a southbound left-turn lane (by using the northbound inside departure lane) on Southern Artery would significantly improve traffic operations at the intersection in

the PM peak hour. However, it would cause serious deterioration of traffic operations at the intersection in the AM peak hour, when the northbound through traffic is heavy. Being reduced to one-lane capacity, the northbound through movement operations would deteriorate from LOS D to LOS to F, with delay increasing to more than four minutes per vehicle. Its traffic queue would likely spill back through the intersection of Southern Artery at /McGrath Highway/Field Street and would also block the right turns to Sea Street.

Alternative 4: Adding a Left-Turn Lane on the Southern Artery Southbound Approach at the Intersection of Southern Artery at Sea Street/Coddington Street

This alternative would maintain the same LOS (D) as Alternatives 1 and 2 in the AM peak hour, with similar delays at the approaches. However, it would significantly improve the PM peak hour traffic operations, to LOS E from LOS F (in the 2022 no-build scenario), with a reduction of about half a minute average delay per vehicle. Meanwhile, it would potentially reduce the conflicts between the southbound left turns and their opposite through traffic and improve traffic safety on Southern Artery.

The lane addition would likely require some land takings on the Southern Artery southbound approach. Based on the estimation of 95th-percentile queues in both peak hours, a storage length of 150 feet should be sufficient for the projected left turns. The MassDOT Roadway Inventory File indicates that the roadway currently has a surface width of 46 feet and a right-of-way width of 70 feet. It appears that it would be necessary to take an area about 10 feet wide and 200 feet long from the Quincy High School playing field to add a lane.

In summary, the above analyses indicate that Alternative 4 is the preferred option, as it would significantly improve the PM traffic operations at the intersection of Southern Artery at Sea Street/Coddington Street and improve traffic safety on the Southern Artery approaches. If the southbound left-turn lane cannot be added because of land taking issues, Alternative 1 or Alternative 2 could be implemented to partially accommodate future traffic growth. Alternative 3 is not recommended, as it would cause significant deterioration of traffic operations at both intersections in the AM peak period.

Improvement Recommendations

Staff performed a series of safety and operations analyses to identify geometry design and operational deficiencies at these two intersections. In general, the analyses found that the congestion and most of the crashes were caused by heavy peak-period traffic and significant commercial and commuting activities in the vicinity.

In addition, staff tested four improvement alternatives for the two intersections using the projected traffic conditions for the year 2022. Staff developed the projections based on

historical traffic counts in the area and the information related to the Quincy Center development and transportation improvement projects. The four alternatives are:

- Signal timing optimization
- Signal coordination
- Modifying left-turn lanes on the Southern Artery approaches at the intersection of Southern Artery at Sea Street/Coddington Street
- Adding a left-turn lane on the Southern Artery southbound approach at the intersection of Southern Artery at Sea Street/Coddington Street.

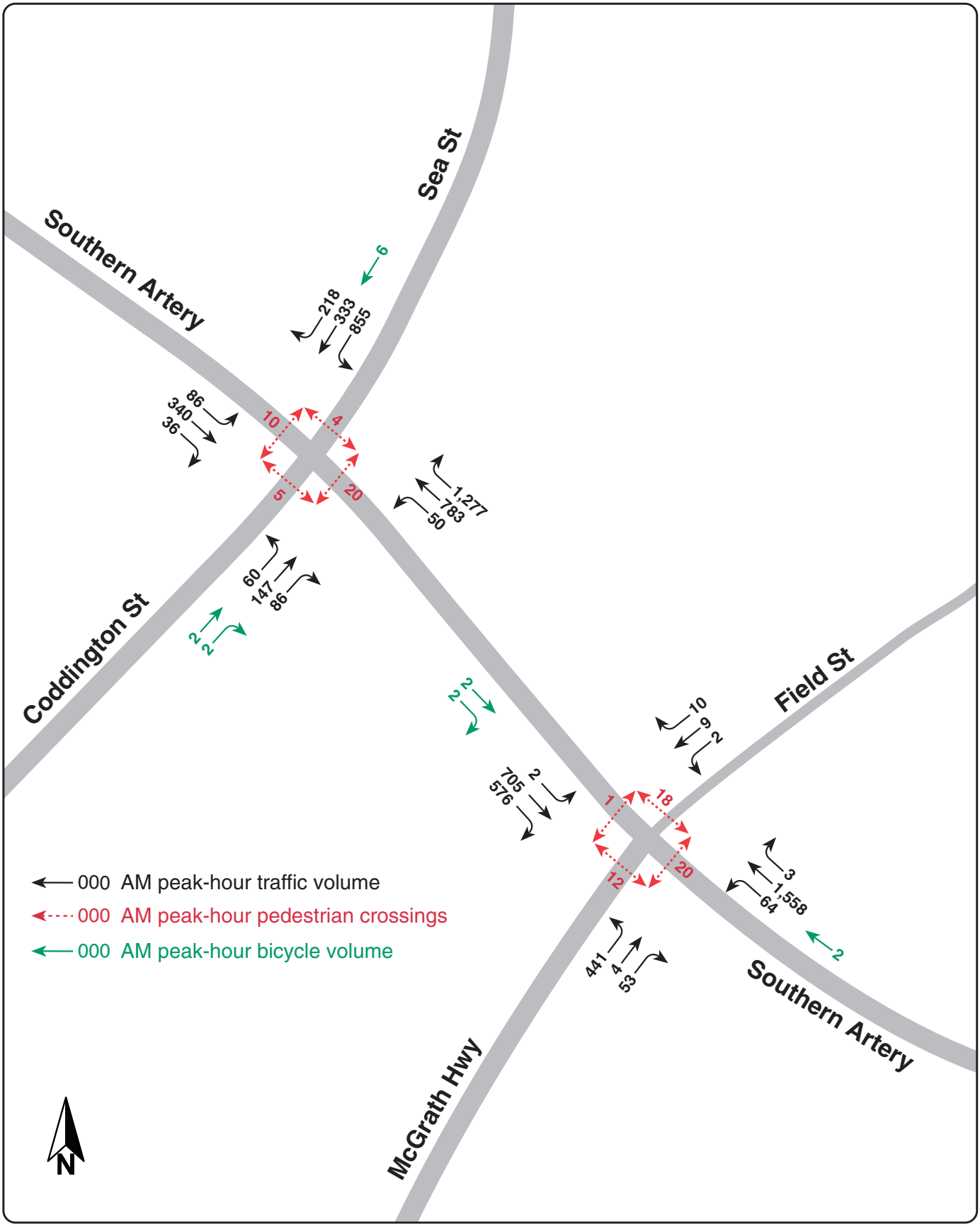

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FIGURE 7
Vehicle and Bicycle Volumes and Pedestrian Crossings
2022 AM Peak Hour

Safety and Operations Analyses at Selected Intersections

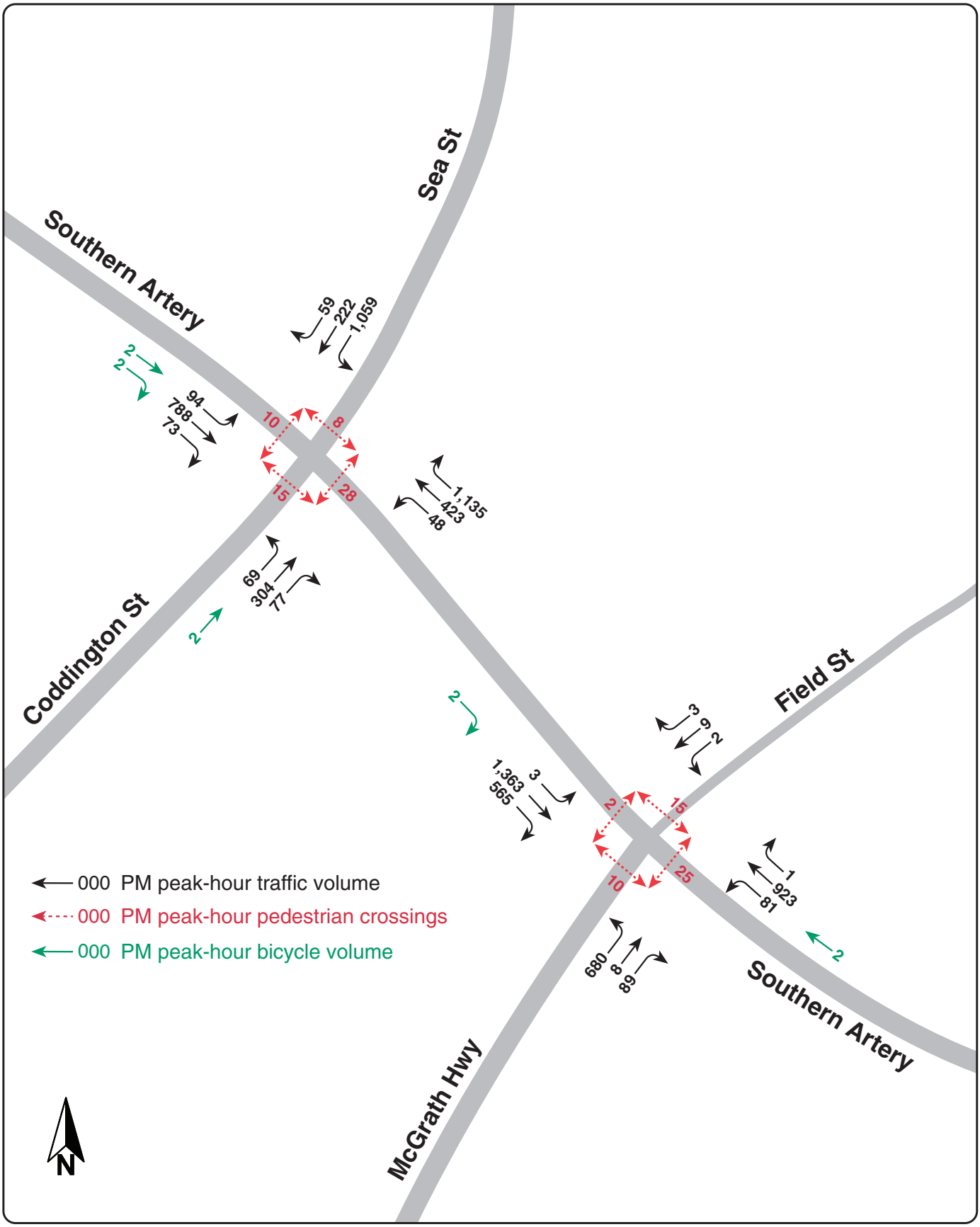

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FIGURE 8
Vehicle and Bicycle Volumes and Pedestrian Crossings
2022 PM Peak Hour

Safety and Operations Analyses at Selected Intersections

TABLE 4
Intersection Capacity Analysis – 2022 AM Peak Hour:
No-Build Scenario and Alternatives 1 and 2

Intersection/ Approach	Lane	2022 No-Build			2022 Alternative 1			2022 Alternative 2		
		LOS	Delay[1]	Q[3]	LOS	Delay[1]	Q[3]	LOS	Delay[1]	Q[3]
Southern Artery at Sea St./Coddington St.										
Southern Artery – SB	LTR	D	37.4	#313	D	45.8	#326	D	35.4	288
Southern Artery – NB	LT	D	42.1	#442	D	54.4	#570	C	33.4	#532
	R	B	16.0	331	B	14.7	302	A	9.6	139
Coddington St. – EB	LTR	E	55.2	187	E	65.0	#231	F	92.1	#241
Sea St. – WB	L	F	97.7	#831	E	62.2	#759	F	101.1	#792
	LTR	F	81.7	#718	D	51.3	#643	F	84.8	#671
Overall		**D**	**49.5**	**-**	**D**	**42.5**	**-**	**D**	**49.3**	**-**
Southern Artery at McGrath Highway/Field SSt.										
Southern Artery – SB	LT	A	9.4	176	A	9.1	170	B	15.8	115
	R	A	9.5	47	A	9.0	51	D	50.2	129
Southern Artery – NB	L	A	8.2	45	A	7.9	45	A	8.6	38
	TR	B	17.2	546	B	17.5	#577	C	20.1	#576
McGrath Highway – EB	L	C	31.4	230	C	32.1	186	C	31.2	158
	LT	C	31.8	234	C	32.8	189	C	31.7	161
	R	C	23.6	32	C	22.1	28	C	22.3	24
Field St – WB	LTR	D	37.8	31	C	33.5	27	C	33.4	24
Overall		**B**	**16.2**	**-**	**B**	**16.3**	**-**	**C**	**25.6**	**-**

[1] Delay in seconds per vehicle.
[2] V/C is the volume-to-capacity ratio.
[3] 95th percentile queues in feet.
95th percentile volume exceeds capacity, queue may be longer.

TABLE 5
Intersection Capacity Analysis – 2022 AM Peak Hour:
No-Build Scenario and Alternatives 3 and 4

Intersection/ Approach	Lane	2022 No-Build			2022 Alternative 3			2022 Alternative 4		
		LOS	Delay[1]	Q[3]	LOS	Delay[1]	Q[3]	LOS	Delay[1]	Q[3]
Southern Artery at Sea St./Coddington St.										
Southern Artery – SB	L	D	37.4	#313	F	88.9	#187	E	61.1	152
	TR				D	45.5	241	C	29.4	193
Southern Artery – NB	L	D	42.1	#442	C	24.5	64	E	62.0	606
	T				F	257.9	#1718			
	R	B	16.0	331	B	16.6	308	C	21.1	414
Coddington St. – EB	LTR	E	55.2	187	E	78.6	#254	E	77.6	#254
Sea St. – WB	L	F	97.7	#831	F	254.0	#968	F	86.5	#830
	LTR	F	81.7	#718	F	240.0	#851	E	71.0	#709
Overall		**D**	**49.5**	**-**	**F**	**151.4**	**-**	**D**	**52.6**	**-**
Southern Artery at McGrath Highway/Field SSt.										
Southern Artery – SB	LT	A	9.4	176						
	R	A	9.5	47						
Southern Artery – NB	L	A	8.2	45						
	TR	B	17.2	546						
McGrath Highway – EB	L	C	31.4	230	*Same as Alt. 1*			*Same as Alt. 1*		
	LT	C	31.8	234						
	R	C	23.6	32						
Field St – WB	LTR	D	37.8	31						
Overall		**B**	**16.2**	**-**						

[1] Delay in seconds per vehicle.
[2] V/C is the volume-to-capacity ratio.
[3] 95th percentile queues in feet.
95th percentile volume exceeds capacity, queue may be longer.

TABLE 6
Intersection Capacity Analysis – 2022 PM Peak Hour:
No-Build Scenario and Alternatives 1 and 2

Intersection/ Approach	Lane	2022 No-Build			2022 Alternative 1			2022 Alternative 2		
		LOS	Delay[1]	Q[3]	LOS	Delay[1]	Q[3]	LOS	Delay[1]	Q[3]
Southern Artery at Sea St./Coddington St.										
Southern Artery – SB	LTR	F	162.5	#738	F	110.0	#703	D	54.0	#654
Southern Artery – NB	LT	D	44.9	#309	D	37.7	275	C	27.6	233
	R	B	19.8	260	B	16.4	240	B	11.5	288
Coddington St. – EB	LTR	E	60.8	#317	F	107.3	#367	F	115.6	#394
Sea St. – WB	L	F	184.8	#954	F	174.0	#952	F	273.2	#1013
	LTR	E	66.5	#580	E	62.5	#575	F	118.3	#626
Overall		**F**	**86.8**	**-**	**E**	**76.4**	**-**	**F**	**85.1**	**-**
Southern Artery at McGrath Highway/Field SSt.										
Southern Artery – SB	LT	B	16.7	452	C	28.5	#570	B	18.6	#287
	R	B	11.0	89	B	15.0	151	B	18.2	102
Southern Artery – NB	L	E	65.1	#140	B	17.8	#42	C	22.0	#71
	TR	B	11.5	241	B	11.1	228	B	14.2	323
McGrath Highway – EB	L	D	49.3	#382	D	54.8	#405	E	73.7	#495
	LT	D	46.4	#372	D	51.5	#395	E	70.2	#481
	R	C	24.0	49	C	24.4	52	D	41.4	81
Field St – WB	LTR	D	46.4	25	D	46.3	25	E	70.0	34
Overall		**C**	**21.6**	**-**	**C**	**26.4**	**-**	**C**	**28.1**	**-**

[1] Delay in seconds per vehicle.
[2] V/C is the volume-to-capacity ratio.
[3] 95th percentile queues in feet.
95th percentile volume exceeds capacity, queue may be longer.

TABLE 7
Intersection Capacity Analysis – 2022 AM Peak Hour:
No-Build Scenario and Alternatives 3 and 4

Intersection/ Approach	Lane	2022 No-Build			2022 Alternative 3			2022 Alternative 4		
		LOS	Delay[1]	Q[3]	LOS	Delay[1]	Q[3]	LOS	Delay[1]	Q[3]
Southern Artery at Sea St./Coddington St.										
Southern Artery – SB	L	F	162.5	#738	F	105.4	#326	D	40.2	118
	TR				E	67.1		D	47.3	516
Southern Artery – NB	L	D	44.9	#309	D	43.6	#570	E	69.0	#368
	T				E	72.7				
	R	B	19.8	260	C	21.8	302	C	22.1	318
Coddington St. – EB	LTR	E	60.8	#317	F	144.1	#231	F	117.2	#388
Sea St. – WB	L	F	184.8	#954	F	107.5	#759	F	104.1	#928
	LTR	E	66.5	#580	D	47.1	#643	D	46.0	510
Overall		**F**	**86.8**	**-**	**E**	**65.5**	**-**	**E**	**56.8**	**-**
Southern Artery at McGrath Highway/Field St.										
Southern Artery – SB	LT	B	16.7	452	*Same as Alt. 1*			*Same as Alt. 1*		
	R	B	11.0	89						
Southern Artery – NB	L	E	65.1	#140						
	TR	B	11.5	241						
McGrath Highway – EB	L	D	49.3	#382						
	LT	D	46.4	#372						
	R	C	24.0	49						
Field St – WB	LTR	D	46.4	25						
Overall		**C**	**21.6**	**-**						

[1] Delay in seconds per vehicle.
[2] V/C is the volume-to-capacity ratio.
[3] 95th percentile queues in feet.
95th percentile volume exceeds capacity, queue may be longer.

Analysis of the alternatives indicates that Alternative 4 is the preferred option, as it would significantly improve the PM traffic operations at the intersection of Southern Artery at Sea Street/Coddington Street and improve safety for all users at the intersection. If a southbound left-turn lane cannot be added because of land taking issues, Alternative 1 or Alternative 2 could be implemented to partially accommodate future traffic growth. Alternative 3 is not recommended, as it would cause deterioration of traffic operations at both intersections in the AM peak period.

Also, for the short term, staff propose the following measures to improve operations and safety for all users at the two intersections and the adjacent roadways. They are mostly low-cost measures that could be implemented in a relatively short time:

- Retime traffic signals at the two intersections (Alternative 1). The retiming includes adding a protected/permissive phase for the Southern Artery northbound left turns at the intersection of Southern Artery at McGrath Highway/Field Street.[8]
- Continue monitoring traffic queues on Southern Artery between the two intersections. If the queues affect traffic operations at either of the intersections, signal coordination of the two intersections (Alternative 2) should be implemented.
- Remove the red ball indication and display only the right-turn arrow indication during the overlapping phase for the right turns at the intersection of Southern Artery at Sea Street/Coddington Street.
- Relocate all the route and destination guide signs from the middle of the intersection of Southern Artery at Sea Street/Coddington Street to appropriate roadside locations, about 100 to 200 feet before the intersection.
- Realign the crosswalks connected to the two traffic islands at the intersection of Southern Artery at Sea Street/Coddington Street so that they do not run into the poles[9] on the islands; and install ADA (Americans with Disabilities Act) compliant curb-cut ramps on traffic islands that have connecting crosswalks and that currently lack ramps.
- Install a “Turning Vehicles Yield to Pedestrians” regulatory sign (R10-15 (see Figure 9) about 50 feet before the crosswalk on the right-turn bays of the intersection of Southern Artery at McGrath Highway/Field Street.
- Ensure that pavement markings such as crosswalks, stop lines, yellow center lines, and white shoulder lines are well maintained and clearly visible to delineate the travel path of vehicles at the two intersections.

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[8] The addition would require replacing the existing signal head for the lane with a four- or five-section signal head, including a flashing yellow indication.

[9] Some poles on the traffic islands are for the route/destination guide signs. They should be removed when the signs are relocated.

FIGURE 9
"Turning Vehicles Yield to Pedestrians" Sign

* A fluorescent yellow-green background color may be used instead of yellow for this sign.

Source: Federal Highway Administration, *Manual on Uniform Traffic Control Devices,* 2009 Edition.

There are a number of driveways on Southern Artery between and near the two intersections. In order to reduce potential crashes on Southern Artery and enhance the continuity of pedestrian flow, a few access management measures should be considered by the City and the nearby businesses. These measures include:

- Clearly define a right-in-only entry and a right-out-only exit driveway for the gas station at the southwest corner of the intersection of Southern Artery at McGrath Highway/Field Street.
- Make the Maxie's Market driveway a right-in-only entry. It would prevent the dangerous left-turn exits from the driveway. The market also has a driveway on McGrath Highway, which could provide access to destinations in all directions.
- Close off the driveway for the commercial building at the southeast corner of the intersection of Southern Artery at Broad Street. All vehicles entering or exiting from the building can use Broad Street. Another option would be to narrow the driveway and make it a right-in-only entry, if the close-off is not favored.
- Relocate Morrison Street away from the functional area of the intersection of Southern Artery at McGrath Highway/Field Street. The area southeast of the intersection has a significant possibility of being redeveloped in the near future. At that time, Morrison Street should be relocated to at least 150 feet from the intersection.

For the long term, staff propose the following measures to further improve operations and safety at the two intersections and the adjacent roadways:

- Implement Alternative 4: adding a left-turn lane on the Southern Artery southbound approach at the intersection of Southern Artery at Sea Street/Coddington Street.

- Reconstruct the intersection of Southern Artery at Sea Street/Coddington Street. The reconstruction should include the following items.
    - Install new mast arms and signal heads on all approaches.
    - Reconstruct all of the crosswalk curb-cut ramps at the intersection to comply with ADA standards.
    - Install new accessible pedestrian signals with countdown features.
    - Incorporate a preemption function for the signal for police vehicles exiting from the police station.[10]
- Install an exclusive bicycle lane on both directions of Coddington Street and designate the outside lane of all of the approaches of the two intersections as a shared (with motor vehicles) bicycle lane. The bicycle lanes on Coddington Street should connect to the planned bicycle lanes in the new roadways surrounding the Adams Green Park.

The reconstruction of the intersection would be a much needed safety improvement for the intersection; even if the addition of the southbound left-turn lane is not feasible due to land taking issues, safety would be increased. At this preliminary planning stage, the reconstruction (without adding the lane) is estimated to be roughly $750,000 to $1,000,000.

CW/cw

[10] The preemption plan should include the installation of an emergency-vehicle exiting flashing beacon at the police station driveway with an “Emergency Signal Ahead” (W11-12P) supplemental plaque placed about 200 feet before the driveway. The preemption should be designed to clear the vehicles near the driveway and stop vehicles at all approaches.