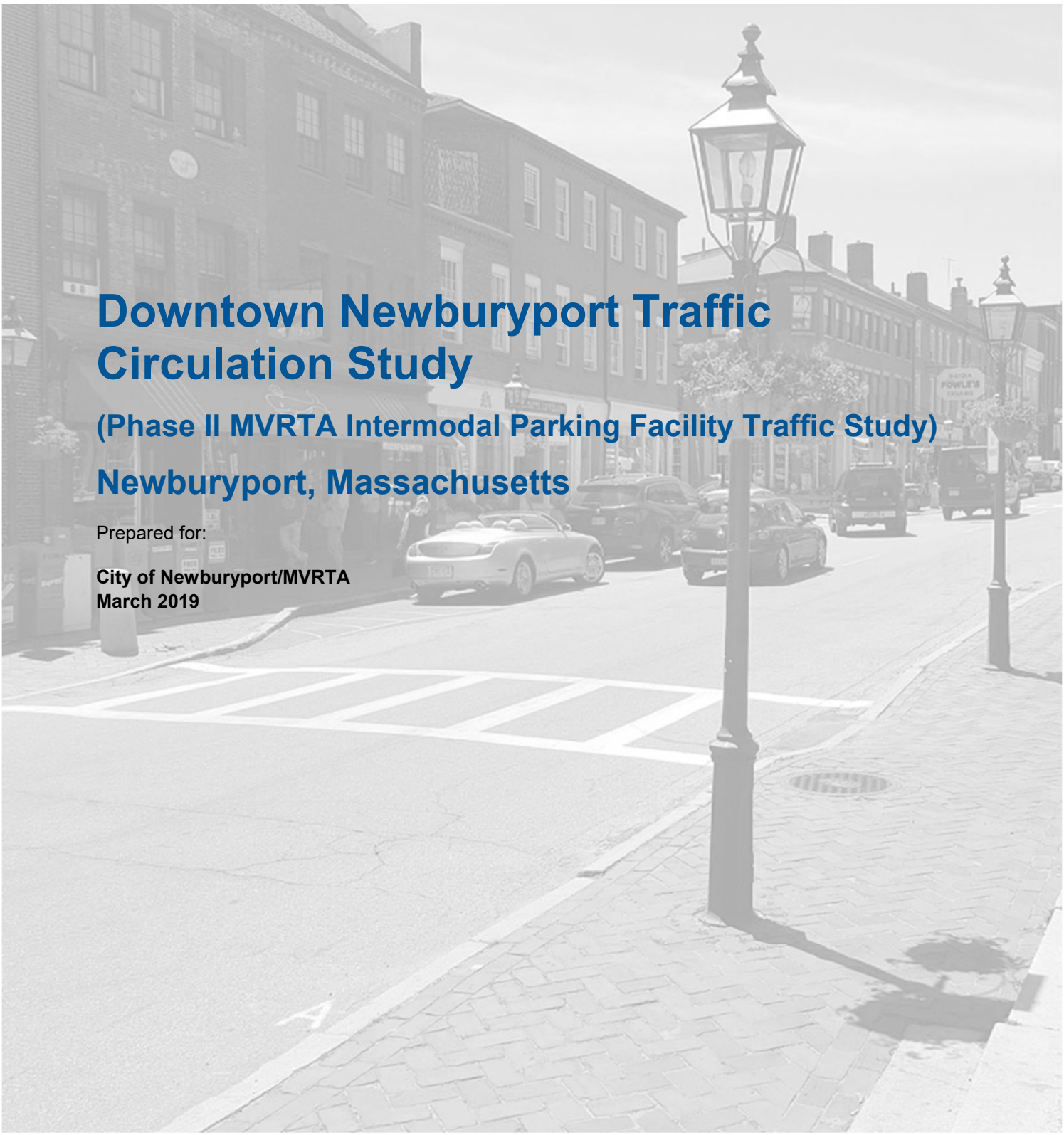

Downtown Newburyport Traffic Circulation Study

(Phase II MVRTA Intermodal Parking Facility Traffic Study)

Newburyport, Massachusetts

Prepared for:

City of Newburyport/MVRTA
March 2019

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

As part of the City of Newburyport's long-term goal of enhancing transportation accommodations, the City is working to create a local transportation hub and improve traffic circulation in the downtown area. In the first phase of achieving this goal (Phase I), the City collaborated with the Merrimack Valley Regional Transit Authority (MVRTA) to construct a new Intermodal Parking Facility (IPF) to be located east of Route 1 at the Merrimac Street/Titcomb Street intersection. The IPF would provide approximately 207 parking spaces (approximately 167 parking spaces relocated from the waterfront parking lots to the new IPF as well as an additional 40 new parking spaces at the garage). In November 2016, Tetra Tech completed a Phase I traffic study which included an evaluation of potential traffic impacts of the proposed IPF facility and concluded that it would not have a significant impact to traffic operations in downtown Newburyport assuming implementation of minor improvements to the Merrimac Street intersections with Titcomb Street and Pleasant Street. The Newburyport Planning Board approved the IPF in December 2016.

Subsequent to the approval of the IPF, the City requested that Tetra Tech conduct a separate (Phase II) traffic study that includes a broader review of the existing downtown area circulation patterns and identifies potential modifications aimed at reducing vehicular traffic and improving pedestrian accommodations in the vicinity of Market Square (Merrimac Street at State Street). Specifically, the Phase II study evaluates the traffic impacts associated with converting Green Street from one-way northbound traffic flow to two-way operation between High Street and Merrimac Street.

The Phase II study expands upon the Phase I traffic study and includes a detailed evaluation of traffic operations at 21 intersections in or near downtown Newburyport for the existing (2017) and future year (2027) weekday morning, weekday afternoon, and Saturday midday peak hour traffic conditions. Independent of the IPF, a ten percent increase in overall peak period vehicular traffic is projected for Market Square by 2027. This increase is attributed to several developments proposed in the downtown area as well as growth in general background traffic. The Phase II study determined that approximately 30 percent of traffic which proceeds east on Merrimac Street and then south on State Street could be diverted onto Green Street if Green Street is converted to two-way flow.

The Phase II study concludes that the existing 42 to 44 foot pavement width on Green Street can accommodate two-way vehicular flow with minimal changes to the existing curb lines. However, roadway and traffic control improvements would be required at several area intersections, including modifications to the existing Green Street traffic signals at High Street and Pleasant Street as well as traffic control and geometric improvements at the Merrimac Street/Green Street/NRA Driveway intersection. Several traffic signal control alternatives as well as implementation of a single-lane roundabout were considered at the Merrimac Street/Green Street/NRA Driveway intersection. Capacity analyses indicate that the roundabout option would provide significantly better operations resulting in shorter vehicle delays and queues compared to the signalized options. A more detailed functional design study would be required to refine the preliminary design options and associated construction costs.

Existing safety and/or capacity constraints at the Merrimac Street/Route 1 ramp intersections and the Water Street intersections with Fair Street and Federal Street indicated the need for intersection enhancements independent of the Green Street conversion to two-way flow. Traffic signal implementation at the Merrimac Street/Route 1 ramp intersections would improve operations for the off-ramps but would significantly increase vehicle queues on Merrimac Street. Therefore, along with installing traffic signals, auxiliary through lanes on Merrimac Street are recommended to reduce the anticipated vehicle queues. Safety improvements, focused on improved sight lines, are recommended for the Water Street/Federal Street and Water Street/Fair Street intersections.

Depending on the feasibility and costs associated with the conversion of Green Street to two-way traffic flow, the City may also want to consider evaluating alternative circulation and/or geometric improvements to reduce traffic flow and enhance traffic and pedestrian safety in Market Square. For example, construction of a roundabout at State Street and Merrimac Street would also likely reduce vehicle queues on Merrimac Street and allow pedestrians to cross Merrimac Street in shorter segments as pedestrian refuge areas would be provided in the roundabout splitter islands. Evaluation of the conversion of State Street to two-way traffic flow as an alternative to converting Green Street to two-way flow is recommended as it would also reduce traffic through the square and may prove to be a less costly alternative.

1.0 INTRODUCTION

As part of the City of Newburyport's long-term goal of enhancing transportation accommodations, the City aims to create a local transportation hub and improve traffic circulation in the downtown area. In the first phase of achieving this goal (Phase I), the City collaborated with the Merrimack Valley Regional Transit Authority (MVRTA) to construct a new Intermodal Parking Facility (IPF) to be located east of Route 1 at the Merrimac Street/Titcomb Street intersection. In November 2016, Tetra Tech completed a Phase I traffic study which included an evaluation of potential traffic impacts of the proposed IPF facility. The study concluded that the IPF would not have a significant impact on traffic operations in downtown Newburyport, assuming implementation of minor improvements to the Merrimac Street intersections with Titcomb Street and Pleasant Street. The Newburyport Planning Board approved the IPF in December 2016.

Subsequent to the approval of the IPF, Tetra Tech was retained by the City to conduct a separate traffic study, known as Phase II. This Phase II study expands upon the Phase I traffic study and includes an evaluation of traffic operations at 21 intersections in or near downtown during the weekday morning, weekday afternoon and Saturday midday peak hours under existing (2017) and future year (2027) traffic conditions. Specifically, this study evaluates the traffic impacts associated with converting Green Street from one-way (northbound) vehicular traffic flow to two-way operation (northbound and southbound) between High Street and Merrimac Street, as well as some other roadway improvements within localized parts of the study area. Conceptual design plans were developed for roadway modifications needed to accommodate the potential traffic pattern change along Green Street as well as the other locations outside of the Green Street corridor. This report documents our findings.

1.1 STUDY PROCESS

This Phase II study was completed in four major steps. First, existing conditions were established for the downtown area based on field visits, review of safety data, and collection of traffic data. Future conditions are then defined assuming no changes to the roadway network. Next, the modification of Green Street from one-way northbound to two-way traffic flow was evaluated and circulation patterns and operations were addressed. Finally, potential roadway modifications unrelated to the Green Street directionality change were examined.

1.2 STUDY AREA

The study area for this downtown circulation study expands upon the Phase I study area. The new Phase II study area was developed in consultation with representatives from the City of Newburyport and the Merrimack Valley Planning Commission and accounts for input received at public hearings conducted for the MVRTA Intermodal Parking Facility. As illustrated in Figure 1, the study focuses on the following intersections:

1. Merrimac Street/Route 1 SB Ramp/Winter Street
2. Merrimac Street/Route 1 NB Ramp/Summer Street
3. Merrimac Street/Market Street/Tournament Wharf
4. Merrimac Street/McKay's Wharf
5. Merrimac Street/Titcomb Street
6. Merrimac Street/IPF Site Driveway (Proposed)

7. Titcomb Street/IPF Site Driveway (Proposed)
8. Merrimac Street/Brown's Wharf
9. Merrimac Street/Green Street/Newburyport Redevelopment Authority (NRA) Driveway
10. Merrimac Street/Water Street/State Street
11. Water Street/Fair Street
12. Water Street/Federal Street
13. Pleasant Street/Titcomb Street
14. Pleasant Street/Green Street
15. Pleasant Street/State Street
16. Titcomb Street/Court Street/Washington Street
17. Green Street/Washington Street/Harris Street
18. High Street/Market Street
19. High Street/Court Street
20. High Street/Green Street
21. High Street/State Street

2.0 EXISTING CONDITIONS

The existing conditions assessment consists of an inventory of the roadway and intersection geometries and traffic control devices, collection of new peak period traffic volumes, and field observation of the existing traffic operations. An evaluation of intersection safety was also conducted as part of this analysis.

2.1 ROADWAY GEOMETRY AND LAND USE CONDITIONS

The following section provides a brief description of the key roadways in the downtown area, including Green Street, State Street, Merrimac Street, Titcomb Street, Pleasant Street and High Street.

Green Street. Green Street is classified by the Massachusetts Department of Transportation (MassDOT) as an urban minor arterial roadway under local (City) jurisdiction. It provides access to downtown Newburyport from High Street. Green Street is one-way northbound and generally provides two travel lanes and on-street parking along both sides of its 0.26 mile length. It is 42 to 44 feet wide (curb to curb) except near Brown Square and Merrimac Street, where curb bump-outs narrow the cross-section. Approximately 75 parking spaces are located along Green Street, most restricted to two hours. Sidewalks are provided on both sides of the roadway and crosswalks at all major intersections. Pedestrian-activated traffic signals are located at three intersections along Green Street: High Street, Pleasant Street and Merrimac Street. No bicycle accommodations or posted speed limits are provided on Green Street. Land uses along Green Street include Newburyport City Hall, Newburyport Police Department, retail and public parking north of Pleasant Street and a funeral home, church, school (K through 8) and residential uses south of Pleasant Street.

State Street. State Street is classified as an urban minor arterial roadway under City jurisdiction and is one-way southbound, serving as a major egress route from downtown to High Street. State Street generally provides two travel lanes and on-street parking on both sides of the roadway within its 42 feet. On-street parking is generally provided on both sides of State Street except at Market Square and at the signalized intersection of State Street with High Street where the full width of the street is required to provide turn lanes. Approximately 75 marked parking spaces are located along State Street. Parking is generally limited to two hours north of Temple Street and unrestricted south of Temple Street.

Pedestrians are served via brick sidewalks on both sides of the roadway and crosswalks at most intersecting roadways. Curb bump-outs shorten pedestrian crossings in the vicinity of Liberty Street, Middle Street and Pleasant Street. Pedestrian-activated traffic signals are located at Merrimac Street and Pleasant Street. No bicycle accommodations or posted speed limits are provided on State Street. Land uses along State Street are a mix of retail, commercial, restaurants, residential, restaurants, and the Newburyport Public Library.

Merrimac Street/Water Street. Merrimac Street is a two-lane roadway that runs northwest/southeast through downtown Newburyport, extending from the Spofford Street roundabout to State Street. East of State Street, Merrimac Street continues as Water Street. In the study area, Merrimac Street and Water Street are classified as urban minor arterial roadways and are under City jurisdiction. Sidewalks are located on both sides of the roadway. Water Street has a posted speed limit of 30 miles per hour. Outside of the study area, Merrimac Street has a posted speed limit of 30 miles per hour. Access management on Merrimac Street between Route 1 and Green Street is poor with numerous driveways and curb cuts. Ten driveways/wharf curb-cuts, serving commercial properties, are located along this 800-foot long, 38-foot wide segment of road. Land uses along Merrimac Street/Water Street within the study area are primarily retail and commercial uses, with some residential.

Titcomb Street. The 250-foot-long segment of Titcomb Street between Merrimac Street and Pleasant Street is approximately 34-feet wide accommodating two-way traffic and on-street parking on both sides of the street. Titcomb Street is a local roadway under City jurisdiction. Titcomb Street, from Pleasant Street to Washington Street, is designated as one-way southbound. Sidewalks are generally provided along both sides of the street. There are no posted speed limits along Titcomb Street. Land uses along Titcomb Street include the proposed IPF, church, hotel, commercial and residential.

Pleasant Street. Pleasant Street provides one-way westbound travel between State Street and Summer Street. It is a local road under City jurisdiction. The segment of Pleasant Street between State Street and Green Street has a width of approximately 30 feet accommodating on-street parking on both sides of the roadway and a single westbound travel lane. Along this busy commercial area, one loading zone is provided on the north side of the street, just west of State Street. Pleasant Street widens west of Green Street to approximately 39 feet accommodating two westbound travel lanes but narrows past Titcomb Street to approximately 26 feet. Pleasant Street provides approximately 90 parking spaces along its length. Parking is generally restricted to two hours. Crosswalks are located at most intersections along Pleasant Street. There are no bicycle accommodations.

High Street. High Street is classified as an urban principal arterial and is under City jurisdiction. Located approximately 1,400 feet south of Merrimac Street, High Street has a northwest/southeast orientation, roughly paralleling Merrimac Street. High Street generally provides a single travel lane in each direction

with edge lines separating the travel lanes from the parking lanes or shoulders. The parking lanes and shoulders have varying widths. Shared-lane markings (sharrows) are provided in both travel directions indicating that bicyclists should travel in the travel lanes and not in the shoulder areas. Between Market Street and State Street, crosswalks are provided at most major intersections and brick sidewalks are located along the north side of the street. A posted speed limit was not observed in the vicinity of the study area.

2.2 INTERSECTION GEOMETRY AND TRAFFIC CONTROL

This section describes the existing lane geometry and traffic control at the key study area intersections. The geometry for all other locations is shown on the capacity analysis worksheets included in the appendix.

Merrimac Street/Route 1 SB Ramp/Winter Street. Merrimac Street forms a compact diamond interchange with Route 1 approximately 90 feet east of the Clipper City Rail Trail Bridge. The Route 1 southbound off-ramp intersects Merrimac Street opposite Winter Street to form an unsignalized, four-way intersection. The Route 1 southbound off-ramp approach operates under Stop control. Merrimac Street operates under free-flow conditions. The Route 1 southbound on-ramp is located on Winter Street approximately 250 feet south of Merrimac Street.

Lane use pavement markings are not provided on the approaches to the intersection. For purposes of this report, lane use assignments are based on observations of traffic operations. The Route 1 southbound off-ramp is 23 feet wide and operates with a left-turn lane and a shared through/right lane. Winter Street is 45 feet wide and accommodates two travel lanes and a parking lane. The Merrimac Street westbound approach, located under the Route 1 overpass, functions as a left-turn lane and a through lane. The Merrimac Street eastbound approach consists of one shared through/right lane. On-street parking is provided on the south side of the Merrimac Street eastbound approach. Pavement markings for pedestrian crosswalks are provided across the Route 1 southbound off-ramp and Winter Street approaches. The surrounding land uses are primarily residential and commercial in nature. Winter Street provides access to commercial and residential land uses located along its west side.

Merrimac Street/Summer Street/Route 1 NB Ramp. The intersection of Merrimac Street, the Route 1 northbound on-ramp and Summer Street form the easterly side of the diamond interchange that connects Merrimac Street and Route 1. This is an unsignalized, four-way intersection. The Summer Street approach operates under Stop control and traffic movements along Merrimac Street operate freely. The Route 1 northbound off-ramp intersects Summer Street approximately 200 feet south of Merrimac Street.

The Route 1 drawbridge over the Merrimac River is located north of Merrimac Street and is operated by the Coast Guard. The bridge is opened on the hour and half hour from Memorial Day through Labor Day between 6:00 a.m. and 10:00 p.m. It was observed that when the drawbridge is open, the queues on the Route 1 northbound on-ramp extend onto Merrimac Street and effectively create gridlock conditions through the interchange.

Summer Street widens as it approaches Merrimac Street and provides an exclusive left-turn lane, a through lane and an exclusive right-turn lane. The exclusive right-turn lane is separated from the through lane via a short median island. The left-turn and through lanes are 12 feet wide and the right-turn lane is 22 feet wide. The Route 1 northbound on-ramp consists of a single receiving lane. The Merrimac Street westbound approach consists of one shared through/right lane. The Merrimac Street eastbound approach was observed to operate with a left-turn lane and a through lane. Crosswalks are provided across the Route 1 on-ramp, Summer Street approaches, and the Merrimac Street westbound approach. The surrounding land uses are primarily commercial. The Route 1 northbound off-ramp is functionally classified as an urban collector, is under MassDOT jurisdiction and provides access to residential land uses along its east side. Overall, the wide approaches and lack of pavement markings defining lane usage result in inefficiencies and confusion by motorists through the Route 1/Merrimac Street interchange.

Merrimac Street/McKay's Wharf/IPF Existing Site Driveway. McKay's Wharf and the existing driveway currently providing access to the IPF site intersect Merrimac Street to form an unsignalized intersection approximately 200 feet west of Titcomb Street. The 47-foot wide existing site driveway and McKay's Wharf are offset by approximately 20 feet. An exit only driveway serving Horton's Yard, a retail/residential building, intersects Merrimac Street adjacent to McKay's Wharf. McKay's Wharf and the IPF site driveway are the minor approaches and yield to traffic on Merrimac Street. All approaches to the intersection consist of one shared travel lane and one receiving lane. Stop signs are not posted on the minor approaches. Sidewalks exist on both sides of Merrimac Street. Adjacent to the IPF site, sidewalks are in poor condition. The surrounding land uses are retail, residential and commercial.

Merrimac Street/Titcomb Street. Titcomb Street intersects Merrimac Street to form a three-way unsignalized intersection. Stop signs are not posted at the intersection; however, the northbound Titcomb street approach was observed to operate as under Stop control. All approaches to the intersection have a single travel lane. On-street parking in the vicinity of the intersection is provided on both sides of Merrimac Street and Titcomb Street. Crosswalks are located across the Titcomb Street northbound and Merrimac Street eastbound approaches. The surrounding land uses are primarily residential, retail, and commercial.

Merrimac Street/Green Street/NRA Driveway. Green Street and a driveway to the Newburyport Redevelopment Authority (NRA) municipal parking lot intersect Merrimac Street to form an offset four-way intersection. Brown's Wharf functions as an access way to/from the waterfront area and intersects the north side of Merrimac Street approximately 100 feet west of the NRA driveway.

Green Street is one-way northbound and provides exclusive left- and right-turn lanes on its approach to Merrimac Street. Both Merrimac Street approaches provide a single travel lane. On-street parking is located on both sides of Merrimac Street west of Green Street and on the north side of Merrimac Street east of the NRA Driveway. Brick sidewalks are located on both sides of Green Street. A granite stairway connects the sidewalk to the Green Street municipal parking lot. Curb bump-outs are provided at both Green Street corners. Crosswalks are located across Green Street, the NRA driveway and on Merrimac Street between Green Street and the NRA driveway. The surrounding land uses are primarily residential, retail, and commercial.

An audible, pedestrian-actuated traffic signal is located at the intersection for the crosswalk across Merrimac Street. In the absence of a pedestrian call, a flashing red light faces the Green Street and NRA Driveway approaches and a flashing yellow indication faces the Merrimac Street approaches. When a

pedestrian call is made, the intersection goes to a steady RED signal indication on all approaches to provide exclusive right of way to pedestrians. Upon actuation, pedestrians receive a six second "WALK" symbol plus 12 seconds of flashing "DON'T WALK" time plus three seconds of all red time. Under normal operations, only the Green Street approach operates under Stop control.

Merrimac Street/Water Street/State Street. Merrimac Street and Water Street meet State Street to form a three-way intersection more commonly known as Market Square. State Street operates one-way southbound (away from the intersection). The Merrimac Street eastbound approach consists of a through lane and a 350-foot channelized right-turn lane. Water Street westbound consists of a 90-foot left-turn lane (marked with a Stop bar) and a single through lane.

Pedestrians are served by a crosswalk on the east leg of the intersection. A pedestrian-actuated traffic signal is located at the crosswalk. The signal heads facing Merrimac Street (eastbound) show a flashing yellow indication. The signal heads facing the Water Street (westbound) left-turn lane show a flashing red left arrow indication and the signal head facing the Water Street through lane shows a solid green indication. Upon actuation, pedestrians are served by a seven second "WALK" indication plus an additional 12 seconds of flashing "DON'T WALK" time. Although a flashing red arrow signal indication faces the Water Street left-turn lane, motorists were observed yielding to oncoming Merrimac Street through traffic and generally did not come to a complete stop.

A second crosswalk, under pedestrian-actuation traffic signal control, is located approximately 225 feet west of the Water Street crosswalk. Although the crosswalk is on the west leg of the Market Square intersection crossing the intersection's eastbound through and right-turn lanes, it is designed as a midblock crosswalk with traffic signal heads facing both the eastbound and westbound approaches. A steady green indication is shown to both approaches unless a pedestrian call is placed. Upon actuation, pedestrians are served by a six second "WALK" indication plus an additional 12 seconds of flashing "DON'T WALK" time.

Water Street/Fair Street. Fair Street intersects the south side of Water Street. A private driveway, serving two properties, forms the fourth leg of the unsignalized intersection. All approaches to the intersection have a single travel lane. No crosswalks were observed at this location at the time of a site visit.

Stop signs are not posted at the intersection, however, the Fair Street and driveway approaches were observed to operate under Stop control. On-street parking is allowed on both sides of Water Street. Although only 16-feet wide, the Water Street eastbound approach to Fair Street accommodates both a parking lane and a travel lane. On-street parking along the south side of Water Street, east of Fair Street, restricts sight lines for vehicles exiting from Fair Street. The sight line restriction is exacerbated by the curving alignment through the intersection. On-street parking along the west side of Fair Street is restricted for use by visitors to the Newburyport Salvation Army between 8:00 a.m. and 6:00 p.m. on weekdays.

Water Street/Federal Street. Federal Street meets Water Street to form an unsignalized, three-legged intersection. The intersection has an unusual geometry with the easterly corner of the intersection set back approximately 15 feet from the Water Street travel way. As a result of this geometry, the Federal Street Stop bar and crosswalk are also set back from Water Street. Although a Stop sign is not posted on Federal Street, it was observed to operate under Stop control. Motorists exiting from Federal Street onto Water Street were observed stopping north of the Stop line and crosswalk in order to see oncoming vehicles on Water Street. Federal Street and Water Street (east of Federal Street) are on the Newburyport Waste Water

Treatment Facility Truck Route. East of Federal Street, on-street parking is permitted on the south side of Water Street. However, vehicles were observed parked on the north side of Water Street. On-street parking is permitted on both sides of Federal Street.

Pleasant Street/Titcomb Street. Pleasant Street and Titcomb Street form a four-way unsignalized intersection. Pleasant Street is one-way through the intersection in the westbound direction. South of Pleasant Street, Titcomb Street becomes one-way southbound (away from the intersection). A Stop sign is located on the westbound Pleasant Street approach. One-way signs are not provided on the east leg of Pleasant Street. On-street parking is permitted on both sides of Pleasant Street and Titcomb Street.

The Pleasant Street westbound approach to Titcomb Street is sufficiently wide to allow right-turning traffic to pass vehicles waiting to turn left or travel straight to continue on Pleasant Street. West of Titcomb Street, and adjacent to the IPF project site, Pleasant Street narrows to accommodate a single through lane. The Titcomb Street southbound approach provides one shared through/right lane. Surrounding land uses include the IPF project site, the Central Congregational Church and a residential building.

Pleasant Street/Green Street. East of Titcomb Street and south of Merrimac Street, Pleasant Street intersects Green Street to form an unsignalized, four-way intersection. The Green Street northbound approach consists of a shared left/through lane and a through lane. Pleasant Street is designated as one-way westbound providing a single travel lane. On-street parking is generally permitted on both sides of Green Street and Pleasant Street. Crosswalks are provided across all approaches. Surrounding land use includes residential, retail, and municipal uses.

A pedestrian-actuated traffic signal is located at the intersection. In the absence of a pedestrian call, a flashing red indication faces the Pleasant Street westbound approach and a flashing yellow indication faces the Green Street northbound approach. When a pedestrian call is made, the intersection goes to a steady red signal indication on all approaches to provide exclusive right-of-way to pedestrians. Upon pedestrian push-button actuation, all vehicles at the intersection have a steady red indication while the crosswalks operate with six seconds of “WALK” time, eight seconds of flashing “DON’T WALK” time and six seconds of all red time.

Green Street/Washington Street/Harris Street. Green Street is intersected by Harris Street from the east and Washington Street from the west to form an offset, unsignalized intersection. Green Street is designated as one-way northbound and Harris Street operates as one-way eastbound (away from the intersection). A Stop sign is provided on the Washington Street approach, while all other approaches are uncontrolled. The Green Street approach to the intersection consists of a shared left/through lane and a shared through/right lane. Washington Street consists of a single eastbound left-turn lane. On-street public parking is available on both sides of Green Street, both sides of Harris Street and the north side of Washington Street. Pedestrians are served by crosswalks on all approaches to the intersection.

High Street/Green Street. Green Street intersects High Street from the north. As Green Street is one-way northbound (away from the intersection) only turns from High Street onto Green Street are accommodated. High Street eastbound consists of a 100-foot left-turn lane and a through lane. Similarly, High Street westbound consists of a through lane and a 100-foot right-turn lane. On-street parking is only available on Green Street at this intersection.

A pedestrian-actuated traffic signal is located at the intersection. Although crosswalks are located on the north and east legs of the intersection, pedestrian signal heads are located on the west leg of the intersection. Green signal indications face both High Street approaches unless a pedestrian call is placed.

Upon actuation, pedestrians receive eight seconds of "WALK" time plus ten seconds of flashing "DON'T WALK" time.

2.3 EXISTING TRAFFIC VOLUMES

In order to fully understand existing conditions, traffic volume data were collected. Vehicles, pedestrians and bicycles were counted at the study area intersections over a two-year period, generally in the late spring and early fall as summarized in Table 1. The counts were conducted during the typical weekday morning commuter peak period (7:00 a.m. to 9:00 a.m.), weekday afternoon commuter peak period (4:00 p.m. to 6:00 p.m.) and Saturday midday peak traffic period (11:00 a.m. to 2:00 p.m.). The traffic count data is provided in Appendix A.

Annual Growth Adjustment. To adjust the 2015 and 2016 count data to 2017 levels, traffic data obtained by the Merrimack Valley Planning Commission (MVPC) was reviewed and the historical 2010 count data contained in the *Intermodal Parking Facility Site Evaluation & Alternative Analysis Report* (Tetra Tech, June 25, 2010) was compared to the recent count data obtained for this study.

Traffic data obtained between 2004 and 2016 by the MVPC on State Street, Merrimac Street and High Street indicate changes in traffic levels from zero percent to -3 percent per year. Based on this information, an annual growth rate of 0.5 percent per year was applied to the 2015 and 2016 peak hour traffic volume data to reflect 2017 conditions.

Additionally, trips generated by The Poynt restaurant at 31 Water Street were added to the study area intersections which were counted in September 2015, just before the restaurant opened. The annual growth factor data is provided in Appendix A.

Seasonal Adjustments. MassDOT traffic volume data obtained in 2013 from permanent count station #5128 located on the Newburyport Turnpike (Route 1), south of Hanover Street in the town of Newbury, indicates that traffic volumes obtained in May, June, July and September are generally higher than average annual volumes. April traffic volumes are approximately one percent lower than average annual volumes. Therefore, a one percent seasonal factor was applied to the counts obtained in April. The data used to establish the seasonal adjustment factor is provided in Appendix A.

Figures 2, 3 and 4 depict the existing weekday morning, weekday afternoon and Saturday midday peak hour traffic volumes, respectively. Bi-directional (two-way) peak hour traffic volumes are approximately 300 vehicles per hour on Green Street, 400 to 500 vehicles per hour on State Street and 1,000 to 1,300 vehicles per hour on Merrimac Street, between Green Street and Market Square.

During periods of peak vehicular traffic in Market Square, approximately 300 vehicles turn right from Merrimac Street onto State Street, conflicting with approximately 30 to 150 pedestrians. Approximately 700 pedestrians crossed Merrimac Street (450 in the westerly crosswalk and 250 in the easterly crosswalk) during periods of peak pedestrian traffic in Market Square.

Table 1 Count Program Summary

Intersection	Count
Merrimac Street/Route 1 SB Ramp/Winter Street	June 2016
Merrimac Street/Route 1 NB Ramp/Summer Street	June 2016
Merrimac Street/Market Street/Tournament Wharf	September 2015
Merrimac Street/McKay's Wharf	September 2015
Merrimac Street/Titcomb Street	September 2015
Merrimac Street/IPF Site Driveway	September 2015
Merrimac Street/Brown's Wharf	AM/PM: April 2016, SAT: September 2015
Merrimac Street/Green Street/NRA Driveway	AM/PM: April 2016, SAT: September 2015
Merrimac Street/State Street/Water Street	May 2017
Water Street/Fair Street	July 2017
Water Street/Federal Street	July 2017
Pleasant Street/Titcomb Street	September 2015
Pleasant Street/Green Street	September 2015
Pleasant Street/State Street	May 2017
Titcomb Street/Court Street/Washington Street	May 2017
Green Street/Washington Street/Harris Street	June 2017
High Street/Market Street	May 2017
High Street/Court Street	May 2017
High Street/Green Street	May 2017
High Street/State Street	May 2017

2.4 EXISTING TRAFFIC OPERATIONS

The following section describes the quality of traffic flow at the study area intersections. Level of service (LOS) is a term used to describe the quality of the traffic flow on a roadway facility. It is an aggregate measure of travel delay, travel speed, congestion, driver discomfort, convenience, and safety based on a comparison of roadway system capacity to roadway system travel demand. Operating levels of service are reported on a scale of A to F, with A representing the best operating conditions and F representing the worst. Depending upon the type of facility being analyzed, level of service A represents free-flow or uncongested conditions with little or no delay to motorists, while level of service F represents long delays with traffic demands sometimes exceeding roadway capacity.

Intersection operating levels of service are calculated following the methodologies defined in the 2000 *Highway Capacity Manual. The 2010 Highway Capacity Manual* does not support intersections with exclusive pedestrian phasing, which are present at some of the study intersections. Intersections with a pedestrian-actuated traffic signal and no approach under Stop sign control were analyzed assuming traffic signal control with a permissive left-turn phase and exclusive pedestrian phase. These locations included High Street/Green Street, State Street/Merrimac Street and State Street/Pleasant Street. At the Merrimac Street/Green Street/NRA Driveway intersection and Green Street/Pleasant Street intersection, the minor street approaches are under Stop control. Therefore, these intersections were analyzed as unsignalized to provide a conservative analysis. The capacity analysis worksheets and detailed summary tables are provided in Appendix B.

The capacity analysis indicates that the study area intersections generally operate at LOS D or better during the weekday morning, weekday afternoon and Saturday midday peak hours with a few notable exceptions. The Green Street approach to Merrimac Street operates at LOS E/F during the weekday afternoon and Saturday midday peak hour. Long vehicle queues form on Green Street during the afternoon peak hour. However, when the pedestrian phase is in effect and all approaches to the intersection receive a red signal indication, long queues form on both Merrimac Street and Green Street. At the unsignalized Route 1 ramp approaches to Merrimac Street, long queues form during peak hours that occasionally extend onto Route 1 southbound. Based on this analysis, additional capacity is currently needed at the Merrimac Street/Green Street and Merrimac Street/Route 1 ramp intersections.

2.5 TRAFFIC SAFETY

Safety analyses were performed at the study area intersections. A review of the 2012 to 2014 MassDOT Top Crash Locations data indicates that none of the study area intersections were identified as a Top 200 Intersection Cluster or a Highway Safety Improvement Program (HSIP) Cluster. In order to provide a more detailed evaluation, crash data was obtained from the MassDOT crash database for the study area intersections for the three most recent years available (2012, 2013 and 2014). The crash data, including the crash rate calculations, are provided in Appendix C and summarized in Table 2.

The crash rate, which represents the number of crashes at the intersection per million entering vehicles, provides an indication of how the intersection compares with other similar intersections (signalized and unsignalized) within the region or the state. MassDOT calculates the average crash rate for intersections on a statewide basis and for each of its six engineering districts. Newburyport is located within MassDOT District 4. All of the study intersections have crash rates that were lower than the average rates for District 4 and the State; with the exception of Merrimac Street at the Route 1 SB Ramp (Winter Street) which has a crash rate slightly higher than the District 4 average rate, but below the statewide average rate.

A pedestrian crash (MassDOT crash #3349297) occurred on December 7, 2012 at 4:40 p.m. at the unsignalized intersection of Merrimac Street/McKay's Wharf. According to the police crash report, the vehicle that hit the pedestrian was traveling westbound on Merrimac Street, approaching Tournament Wharf, while the pedestrian was attempting to cross Merrimac Street. The crash report states that the contributing factor that led to this collision was driver inattention. It was also reported that, at the time of the collision, it was dark, raining and the roadway was lighted. According to the crash report, the collision resulted in a non-fatal/non-incapacitating injury.

At most study area locations, one to three crashes were reported during the three-year period evaluated. At the Merrimac Street/Market Street, Merrimac Street/Route 1 northbound ramps, Merrimac Street/Route 1 southbound ramps and High Street/State Street intersections six to eleven crashes were reported at each

location. Of the eleven crashes reported at Merrimac Street/Route 1 Southbound Ramp/Winter Street (the highest crash location), 73 percent were either rear-end or angle type, with 18 percent of crashes resulting in personal injuries. The crashes occurred in clear weather and during daylight hours (between 9:00 AM and 6:00 PM).

A Road Safety Audit (RSA) was conducted at the Merrimac Street/Route 1 interchange by the Merrimack Valley Metropolitan Planning Organization in November 2012. Safety deficiencies at the interchange noted in the RSA include:

- Heavy traffic flows on Merrimac Street make turning from the ramps onto Merrimac Street difficult.
- Excessive delays on the ramps leads to a lack of courtesy and hard acceleration through the intersection.
- The sight line from the Stop line on the northbound ramp is restricted by the Route 1 bridge piers.
- The Stop line on the southbound ramp is set 14 feet back from the crosswalk which results in poor sight lines and longer travel distances when crossing onto Winter Street or turning onto Merrimac Street.
- A lack of pavement markings results in driver confusion.

The RSA concluded with recommendations to improve safety including short-term/low cost improvements such as installing pavement markings, installing left-turn lanes on Merrimac Street under the overpass and striping separate turn lanes on the southbound ramp. More long-term/higher cost improvements were recommended including full signalization of both ramps and narrowing the northbound off-ramp to two-lanes. The RSA included a full traffic signal warrant analysis of both ramp intersections with Merrimac Street. Traffic signals were found to be warranted at both locations and would also address capacity deficiencies described in the previous section.

In August 2014, MassDOT initiated a project to improve the interchange, including full traffic signalization and improved pedestrian and bicycle accommodations. However, the project is currently not funded and there is no established timeframe for the design or implementation of these improvements.

Table 2 Crash Data Summary

	Merrimac St./ Rte. 1 SB	Merrimac St./ Rte. 1 NB	Merrimac St./ Market St./ Tournament Wharf	Merrimac St./ McKay's Wharf/ Site Dr.	Merrimac St./ Titcomb St.	Merrimac St./ Green St./ Brown Wharf/ NRA Dr.	Merrimac St./ Water St./ State St.	Water St./ Fair St.	Water St./ Federal St.	Pleasant St./ State St.	Pleasant St./ Titcomb St.	Pleasant St./ Green St.	Titcomb St./ Court St./ Washington St.	Green St./ Wash. St./ Harris St.	High St./ Market St.	High St./ Court St.	High St./ Green St.	High St./ State St.
2012	4	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	3
2013	6	4	3	0	2	2	0	0	0	0	0	0	0	1	1	0	2	1
2014	1	1	3	1	1	1	1	3	1	1	1	3	0	0	0	0	0	3
Total	**11**	**6**	**7**	**2**	**3**	**3**	**1**	**3**	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**0**	**2**	**7**
Angle	5	2	4	1	1	2	0	1	0	0	0	0	1	1	0	0	0	4
Rear-end	3	1	2	0	1	1	0	1	0	0	0	0	0	0	1	0	1	2
Head-on	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Sideswipe	1	1	0	0	1	0	0	1	1	1	1	3	0	0	0	0	0	1
Single Vehicle	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Unknown	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**11**	**6**	**7**	**2**	**3**	**3**	**1**	**3**	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**0**	**2**	**7**
Property	9	3	4	0	2	3	0	2	1	1	1	3	1	0	0	0	2	6
Injury	1	2	2	2	1	0	1	0	0	0	0	0	0	1	1	0	0	0
Fatality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Total	**11**	**6**	**7**	**2**	**3**	**3**	**1**	**3**	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**0**	**2**	**7**
Pedestrians	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Bicyclists	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vehicles Only	11	6	7	1	3	3	0	3	1	1	1	3	1	1	1	0	0	7
Total	**11**	**6**	**7**	**2**	**3**	**3**	**1**	**3**	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**0**	**2**	**7**
Clear	11	3	6	1	3	3	0	1	1	1	1	3	1	1	0	0	2	3
Cloudy	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Rain	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	2
Snow	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Sleet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fog	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**11**	**6**	**7**	**2**	**3**	**3**	**1**	**3**	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**0**	**2**	**7**
7:00 am to 9:00 am	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9:00 am to 4:00 pm	7	4	4	1	3	1	0	1	1	1	1	2	1	1	1	0	2	5
4:00 pm to 6:00 pm	4	1	2	1	0	1	1	1	0	0	0	1	0	0	0	0	0	2
6:00 pm to 7:00 am	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total	**11**	**6**	**7**	**2**	**3**	**3**	**1**	**3**	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**0**	**2**	**7**
Crash Rates																		
Statewide Rate	0.58	0.58	0.58	0.58	0.58	0.58	0.77	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.77	0.77
District 4 Rate	0.56	0.56	0.56	0.56	0.56	0.56	0.73	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.73	0.73
Intersection Rate	**0.57**	**0.27**	**0.39**	**0.12**	**0.18**	**0.17**	**0.06**	**0.28**	**0.10**	**0.16**	**0.35**	**0.55**	**0.29**	**0.22**	**0.06**	**0.00**	**0.12**	**0.39**

3.0 2027 FUTURE CONDITIONS

The first step in developing circulation and design options for downtown was to estimate future traffic volumes. Consistent with current state requirements for roadway improvement projects, existing peak hour traffic volumes in the study area were projected to a future year of 2027 to represent a ten-year planning horizon. Growth in traffic over the next ten years will result from several proposed projects in the area and a general background growth rate. The 2027 Future condition assumes no changes to the directionality of roadways in the downtown area.

3.1 2027 FUTURE TRAFFIC VOLUMES

Projections of future traffic in the study area are based on two components. The first considers site-specific projects in the area that are presently in the permitting stage or have completed permitting but are not yet fully occupied. The second considers an overall background traffic growth rate that is applied to address anticipated future changes in traffic patterns that cannot be directly related to specific developments but may be influenced by other factors such as regional demographic changes or development outside of the traffic study area.

3.1.1 Development Projects

Discussions were held with City of Newburyport planning staff to identify proposed development projects in the study area. The City anticipates increases to traffic volumes in the downtown area as a result of several new developments, including the proposed Central Waterfront Park and Ale House projects, as well as changes to traffic flows from relocating a portion of its downtown parking supply from the waterfront lots to the proposed IPF. Several other projects were identified and are listed in Table 3. Table 3 includes the size, location and current status of each project. For projects where a traffic study was not prepared, trip generation calculations were developed for purposes of this analysis and are provided in Appendix D.

The four most significant projects proposed for the downtown area are the Waterfront Park Expansion, the IPF, the Ale House Restaurant and the Waterfront West mixed-use development. These projects, along with any associated traffic mitigation, are described below.

Central Waterfront Park Expansion. This project entails expansion of the existing Newburyport Redevelopment Authority (NRA) Waterfront Park and reconfiguration of the westerly and easterly parking areas located along the Merrimack River. Based on the November 2016 *Framework Plan for the Central Waterfront Park Expansion*, it is estimated that approximately 200 parking spaces would be removed and replaced with park land. Assuming Alternative 1, as presented in the Framework Plan, the westerly parking lot would be reduced by 63 spaces from 163 spaces to 100 spaces and the easterly parking lot would be reduced by 137 spaces from 221 spaces to 84 spaces. Approximately 167 of the 200 eliminated waterfront parking spaces would be replaced in the proposed IPF.

MVRTA Intermodal Parking Facility. The MVRTA, in conjunction with the City of Newburyport, has proposed a new intermodal parking facility at the intersection of Merrimac Street and Titcomb Street. Access to the garage will be provided by full-access driveways on Titcomb Street and Merrimac Street. The impacts of the IPF on intersections located in the vicinity of the facility were fully evaluated in the Phase I traffic study. At the time that study was conducted, the garage was designed with 212 parking spaces. The number of parking spaces in the garage has since been reduced from 212 spaces to 207 spaces. Therefore, the trip generation estimates for the IPF were updated as part of this Phase II study.

Table 3 Proposed Developments

Name	Location	Type	Size	Status	Include in Study?
MVRTA Intermodal Parking Facility	Merrimac Street at Titcomb Street	Parking	207 parking space garage	Approved	Yes
Central Waterfront Park Expansion	Merrimac Street (Waterfront Trust Lot, NRA West Lot and NRA East Lot)	Park Expansion	200 waterfront parking spaces will be removed to accommodate park expansion	In planning	Yes
Ale House Restaurant	40 Merrimac Street	Restaurant	13,812 s.f.	Under Construction	Yes
Waterfront West	Merrimac Street at Route 1	Mixed-Use	200 condominiums 100 room hotel 20,000 s.f. retail/restaurant	In planning	Yes
92R Merrimac Street	92R Merrimac Street	Residential	26 condominiums	In planning	Yes
Brown School Reuse	40 Milk Street	Residential	29 condominiums	In planning	Yes
1 Boston Way	1 Boston Way	Residential	76 apartments/live work units	In planning	Yes
Hillside Living, LLC	4 Hillside Ave. and Cottage Ct.	Residential	58 apartments	In planning	Yes
Evergreen Commons	18 Boyd Drive	Residential	38 to 44 lot subdivision	In planning	No*
Port Health Care	4-6 Hale Street	Nursing Home	123 beds	Under construction	No*
2 Parker Street Residential	2 Parker Street	Residential	23 units	In planning	No*

* Accounted for in background growth factor

As currently envisioned by the MVRTA and the City of Newburyport, the parking spaces within the proposed Intermodal Parking Facility will be utilized as follows:

Transit-related	40 spaces
Replacement parking for Central Waterfront Park Expansion	167 spaces
Total	207 spaces

The trip rates associated with each type of parking space (transit and replacement) remain the same as presented in the Phase I study. Applying those rates to the new proposed number of parking spaces assumed for each use yields the trip generation for the proposed IPF. The trip generation expected at the project site is summarized in Table 4. The trips noted in Table 4 are slightly lower (one to three fewer trips during each of the peak hours) than the numbers presented in the Phase I study.

Table 4 IPF Trips at Site Driveways

Description	AM Peak Hour			PM Peak Hour			SAT Peak Hour		
	In	Out	Total	In	Out	Total	In	Out	Total
Project Trips at Site Driveways									
New Trips - 40 Parking Spaces for Transit Use	22	6	28	6	18	24	12	13	25
Redistributed Trips - 167 Replacement Spaces	33	15	48	52	55	107	52	55	107
Total	**55**	**21**	**76**	**58**	**74**	**132**	**64**	**68**	**132**
Existing Trips at Site Driveway	-14	-4	-18	-12	-2	-14	-2	-10	-12
Net Increase at Site Driveways	**41**	**17**	**58**	**46**	**72**	**118**	**62**	**58**	**120**

The distribution of project-related trips through the study intersections was based on an understanding of the existing one-way travel patterns in downtown and analysis of existing peak hour traffic volumes at the key gateways to the downtown area. The distribution of IPF trips presented in the Phase I study was expanded, and adjusted slightly, based on new traffic data obtained as part of this Phase II study, including intersections along Merrimac Street, east of Green Street and along High Street from Market Street to State Street. The regional distribution shown in Table 5 was used to distribute new IPF trips, remove existing site trips and redistribute existing trips from the NRA parking lots to the IPF.

Table 5 IPF Trip Distribution

Approach	
Merrimac Street West	25%
Route 1 South	5%
Route 1 North	15%
High Street West	20%
State Street South - via Green/State	5%
High Street East - via Green/State	5%
Fair Street	2%
Federal Street	4%
Merrimac Street East	19%
Total	100%

Improvements to pedestrian and transit accommodations along Titcomb Street, Merrimac Street and Pleasant Street are proposed by the MVRTA as mitigation for the IPF. The improvements include new crosswalks, handicap ramps and curb bump-outs. The curb bump-outs improve pedestrian visibility by motorists and reduce crossing distances. All sidewalks along the perimeter of the IPF site will be reconstructed as well as a short segment of sidewalk along the north side of Merrimac Street opposite Titcomb Street. A new 100 foot bus turnout will be located adjacent to the proposed garage on Merrimac Street. The sidewalk adjacent to the turnout is designed to include fully accessible landing areas for passengers alighting from buses.

A conceptual plan of these improvements was presented in the Phase I study. Subsequent to the completion of the Phase I study, minor comments on the plan were received from City staff and the plan was revised. The updated concept plan for the Merrimac Street/Titcomb Street and Titcomb Street/Pleasant Street intersections is presented on Figure 5.

The proposed improvements and new curb cuts for the site driveways results in the removal of approximately 24 on-street parking spaces including eight spaces along the south side of Merrimac Street to accommodate the site driveway and bus turnout, four spaces on the north side of Merrimac to accommodate the curb bump-outs, four spaces along the east side of Titcomb Street and eight spaces along the west side of Titcomb Street.

The Merrimac Street Ale House. This 13,812 s.f. restaurant will be located on the north side of Merrimac Street, opposite Green Street. Trips associated with this restaurant will likely be shared with other uses in the downtown area. Ale House guests are expected to utilize both existing on-street and off-street parking facilities located along Merrimac Street and Green Street. However, for purposes of this study, it was conservatively assumed that all trips generated by the restaurant would enter and exit via the existing NRA Driveway adjacent to the site. This assumption accounts for vehicles that will likely enter the NRA and Waterfront Trust parking lots, find the parking areas full and exit to find parking elsewhere in the downtown area.

Waterfront West. The Waterfront West site is located on the north side of Merrimac Street, across from the proposed IPF site. As currently envisioned, the project includes 140 condominiums, a 100 room hotel and 20,000 s.f. of retail/restaurant space. The proposed uses and size may change in the future. It is assumed that parking would be accommodated on-site. This project is active and is in its permitting phase with the City of Newburyport. Trips associated with this project were obtained from the project's traffic study.

3.1.2 General Background Growth

Based on traffic data obtained by the Merrimack Valley Planning Commission and discussion with the City of Newburyport Planning Department, a general background traffic growth rate of 0.5 percent per year was used. The 2027 future peak hour volumes include the 2017 peak hour volumes increased by 0.5 percent per year for 10 years (5.1 percent in total) plus trips generated by the eight proposed projects summarized above. The resulting 2027 weekday morning, afternoon and Saturday peak hour volumes with the current circulation are shown respectively on Figures 6, 7 and 8.

3.2 2027 INTERSECTION OPERATIONS – CURRENT CIRCULATION

The peak hour intersection capacity analyses and summary tables are presented in Appendix B. With 10 years of traffic growth and additional trips generated by numerous development projects in the study area, average vehicle delays at the study area intersections are expected to increase, and in some locations, levels of service will degrade. Notably, the left turn from Green Street onto Merrimac Street will degrade significantly in the future as a result of development projects in the downtown area. Additional capacity will be needed at the Merrimac Street/Green Street intersection to accommodate the anticipated growth in downtown traffic.

By 2027, vehicle trips through Market Square are expected to increase by approximately 90 vehicles during the morning peak hour, 140 vehicles during the afternoon peak hour and 170 vehicles during the midday peak hour. This additional traffic will increase potential conflicts between pedestrians and vehicles.

4.0 TRAFFIC CIRCULATION ALTERNATIVES: 2-WAY GREEN STREET

In an effort to mitigate the anticipated increases in traffic through Market Square as documented above, providing two-way traffic flow on Green Street has been evaluated. Also under consideration is implementing two-way traffic flow on Pleasant Street in order to facilitate access to Green Street from the proposed IPF. This section of the report identifies changes to future traffic flows which would occur if two-way traffic flow were provided on Green Street and introduces conceptual level designs for the Green Street corridor.

4.1 TWO-WAY GREEN STREET TRAFFIC VOLUMES

Changing the circulation on Green Street from one-way to two-way necessitates some reassignment of traffic volumes. The 2027 future volumes shown in Figures 6, 7 and 8 were reassigned through the study area to account for the change in circulation. The reassignment was based on three basic assumptions:

1. Motorists with origins west of Green Street who currently utilize Winter Street, Market Street or Titcomb Street/Court Street to travel south towards High Street and who are destined for westbound travel along High Street, would not change their travel patterns if a southbound lane were provided on Green Street.
2. A portion of motorists with origins west of Green Street who currently utilize State Street to travel south towards High Street and who are destined to points east of State Street or south of High Street (via Pond Street or State Street), would divert from State Street onto Green Street.
3. A portion of motorists with origins east of State Street who currently utilize State Street to travel west along High Street, would divert onto Green Street.

Over 25 changes in traffic patterns through downtown and along High Street were identified which could occur if Green Street were to become a two-way roadway facility. Each of these potential changes to traffic patterns are illustrated in Appendix E; the most significant of these are depicted in Figure 9. The red lines depict the existing travel patterns and the green lines depicts the future travel patterns.

Figures 10, 11 and 12 provide a summary of the estimated changes to the future peak hour traffic volumes in downtown Newburyport at the study area intersections if Green Street were to accommodate two-way traffic flow. It is estimated that 90 to 130 vehicles turning right from Merrimac Street onto State Street would be diverted onto Green Street. This represents a 30 to 37 percent decrease to the future right-turn volume through Market Square. A minor reduction in the Water Street left-turn volume onto State Street would also occur with a corresponding increase in the Water Street westbound through volume (10 to 20 vehicles during each peak hour).

Based on these projected decreases in Market Square peak hour traffic, it is concluded that converting Green Street to two-way operation would significantly reduce vehicle traffic through Market Square.

The 2027 peak hour traffic volumes shown in Figures 6, 7 and 8 were combined with the traffic diversions presented in Figures 10, 11 and 12 to estimate the 2027 weekday morning, weekday afternoon and Saturday midday peak hour traffic volumes with two-way travel on Green Street. The 2027 peak hour traffic volumes with two-way Green Street are presented in Figures 13, 14 and 15. These future two-way peak hour traffic volumes are used to identify the appropriate modifications that would be needed at key study area intersections to accommodate the conversion of Green Street to two-way operation between High Street and Merrimac Street.

4.2 CONCEPTUAL ROADWAY DESIGN WITH TWO-WAY GREEN STREET

A conceptual design to accommodate a two-way Green Street corridor was developed. Green Street generally has a 42 to 44 foot pavement width which is sufficient to accommodate two-way travel, and either on-street parking or dedicated bicycle lanes, but not both. To retain as many on-street parking spaces along Green Street as possible, shared vehicle/bicycle lanes are proposed. The northbound and southbound travel lanes are designed to be 14 feet wide, the minimum acceptable width for a shared vehicle/bicycle lane. On each side of the road, an eight foot parking lane is proposed. In some areas where the curb-to-curb width is only 42 feet, the on-street parking lanes would be reduced to seven feet. Figures 16A, 16B and 16C depict the conceptual design for the Green Street corridor from High Street to Merrimac Street.

North of Pleasant Street, 14 on-street parking spaces (ten along the west side and four along the east side) of Green Street and curb bump-outs at Merrimac Street would need to be removed to provide a sufficient roadway for separate left- and right-turn lanes in the northbound direction and a single southbound travel lane. Design elements associated with two-way travel on Green Street at the corridor's major intersections are presented below.

4.2.1 High Street/Green Street

Improvements to the intersection at High Street would be required to accommodate two-way travel on Green Street. As shown on Figure 16A, these include:

- Install a Stop sign facing the Green Street approach.
- Install traffic signal heads facing the Green Street approach. These signal heads would provide a flashing red ball facing Green Street unless a pedestrian call is placed in which case a solid yellow indication and then a steady red indication would be shown.
- Update existing traffic signal equipment.

During the weekday and Saturday peak hours, it is estimated that fewer than 200 vehicles would approach High Street from Green Street. Therefore, it is recommended that the intersection remain unsignalized with the pedestrian-actuated traffic signal, but should be monitored to determine if full traffic signal control is warranted.

4.2.2 Washington Street/Harris Street/Green Street

At the Washington Street/Harris Street/Green Street intersection, the new left-turn movement from Green Street onto Harris Street and the new right-turn movement from Washington Street onto Green Street would increase vehicle traffic at the existing Green Street crosswalk located between Washington and Harris Streets. Therefore, it is recommended that this crosswalk be removed and crosswalks be provided at the intersection north of Washington Street and south of Harris Street. This is shown on Figure 16A.

On Green Street, near Washington Street, the City noted that double parking occurs during funerals held at the Immaculate Conception Parish. Double parking would no longer be feasible with one lane provided in each travel direction on Green Street.

4.2.3 Pleasant Street/Green Street

Improvements to the Pleasant Street intersection would be required to accommodate two-way travel on Green Street. As shown on Figure 16B, these include:

- Install traffic signal heads facing the Green Street southbound approach. These signal heads would flash a yellow ball to Green Street unless a pedestrian call is placed in which case a solid yellow and then steady red indication would be shown.
- Update existing traffic signal equipment.

4.2.4 Merrimac Street/Green Street/NRA Driveway

The improvements at the Merrimac Street/Green Street/NRA Driveway intersection include modifications to accommodate new turning movements, including left and right turns from Merrimac Street onto Green Street. The design shown on Figure 16C retains the existing Stop-sign control for both Green Street and the NRA Driveway, and the pedestrian-actuated traffic signal. The improvements proposed at this intersection include:

- Install a 45-foot-long left-turn lane on the Merrimac Street westbound approach.
- Install traffic signal heads facing the proposed Merrimac Street westbound left-turn lane.
- Update existing traffic signal equipment.

4.3 TWO-WAY GREEN STREET OVERVIEW

The two-way Green Street corridor concept as presented above was analyzed with respect to safety, traffic operations and cost and is summarized as follows.

Safety

- Approximately 90 to 130 fewer peak hour vehicles would turn right from Merrimac Street onto State Street, reducing potential vehicle/pedestrian conflicts through Market Square.
- There would be an increased potential for angle and head-on collisions along Green Street.

Design & Construction Costs

- The conceptual level construction cost estimate for implementing a two-way Green Street corridor as shown on Figures 16A, 16B and 16C is $1,210,000. This cost includes new signs, pavement markings, some sidewalk construction, updates to existing traffic signal equipment at four locations and no pavement milling and overlay.
- It can be assumed that preparation of design documents would be approximately 10 to 15 percent of the construction cost.

Intersection Operations

- Long vehicle queues (350 to 400 feet) may occur on the Green Street approach to Merrimac Street during peak hours if Green Street remains under Stop control. These queues could extend past the Green Street parking lot driveway and Pleasant Street. However, these queues are not significantly different from the queues that would form if Green Street were to remain one-way.
- The left turn onto Green Street from Pleasant Street westbound would operate with minor delays.

- Approximately 40 fewer peak hour vehicles would travel through the High Street/State Street intersection resulting in slightly better operations.
- Reduced traffic levels along State Street may reduce congestion from Market Square to High Street.
- Minor reductions in southbound traffic on Titcomb Street and Court Street would improve intersection operations along the Titcomb Street/Court Street corridor.

4.4 MERRIMAC ST/GREEN ST/NRA DRIVEWAY ALTERNATIVES

As discussed above, with the pedestrian-actuated traffic signal at the Merrimac Street/Green Street intersection retained and Green Street and the NRA Driveway under Stop-sign control, long queues and poor operations would be expected by 2027 for the weekday afternoon and Saturday midday peak hours. Therefore, several alternative designs were considered for the Merrimac Street/Green Street/NRA Driveway intersection with the objectives of reducing vehicle queues on Green Street and improving operations through the intersection. In total, five concepts were developed.

Capacity analyses for each alternative were conducted and summarized in the tables contained in Appendix B. Each conceptual design alternative is presented below, along with a brief summary of expected peak hour operations, vehicle queues and conceptual level construction cost estimates.

4.4.1 Alternative 1 – Stop Control on Green St and NRA Driveway

Alternative 1, presented on Figure 16C is discussed above in Section 4.2.4. In summary, long vehicle queues would be expected on Green Street if the intersection were to remain under Stop control with a pedestrian-actuated traffic signal. The conceptual level construction cost estimate for implementing a two-way Green Street corridor as shown on Figures 16A, 16B and 16C is $1,210,000.

4.4.2 Alternative 2A – Full Traffic Signal Control

This alternative, shown on Figure 17, retains the geometry of Alternative 1, but includes the replacement of the existing pedestrian-actuated traffic signal with a fully-actuated traffic signal. The traffic signal would operate with concurrent pedestrian signal phases. As the Green Street and NRA Driveway approaches remain offset, separate traffic signal phases would be required for both minor street approaches which results in inefficient intersection operation. However, during the afternoon peak hour, the vehicle queues on Green Street would be reduced (from 400 feet to 150 feet) as compared to Alternative 1, but vehicle queues on Merrimac Street eastbound could extend as far as 750 feet.

The additional cost to construct Alternative 2A (as compared to Alternative 1) is approximately $100,000, resulting in a total construction cost estimate for the Green Street corridor of $1,310,000.

4.4.3 Alternative 2B – Partial Traffic Signal Control – Green St Only

Alternative 2B, shown on Figure 18, removes the NRA Driveway from traffic signal control. The Merrimac Street/Green Street intersection is controlled by a traffic signal with the NRA Driveway under Stop control. As expected, vehicle queues on both Merrimac Street and Green Street would be reduced with this more efficient traffic signal operation. However, vehicles exiting from the NRA driveway would be under Stop control and would be expected to operate with poor levels of service and long queues. Merrimac Street eastbound queues would extend approximately 600 feet under this alternative.

The cost to construct Alternative 2B is approximately $100,000 less than Alternative 1, resulting in a total construction cost estimate for the Green Street corridor cost of $1,110,000.

4.4.4 Alternative 3 – Realigned Intersection with Full Traffic Signal Control

The next alternative, shown on Figure 19, considers shifting Green Street to the east to form a realigned four-way, fully-signalized intersection. With the alignment shown on Figure 19, a simple two-phase traffic signal could operate the intersection. However, this alternative does not provide any measurable improvement to the vehicle queues on Merrimac Street as compared to Alternative 2B.

Alternative 3 would require major modifications to the northwest quadrant of the Green Street parking lot, would require the loss of two parking spaces within the lot and would have significant impacts to the landscaping along the east side of Green Street. However, by shifting Green Street east, some additional landscaping could be provided along the west side of the street as shown on Figure 19. Because of the difference in elevation between Green Street and the Green Street parking lot, the realignment of Green Street would require a retaining wall, approximately 100 feet long and two to six feet tall.

The additional cost associated with Alternative 3 (as compared to Alternative 1) is approximately $400,000, resulting in a total construction cost estimate for the Green Street corridor of $1,610,000.

4.4.5 Alternative 4 – Roundabout Intersection

Installing a traffic signal at the Merrimac Street/Green Street/NRA Driveway, with any of the geometries presented above, would reduce delays for vehicles on the Green Street and NRA Driveway approaches, but would result in long queues on Merrimac Street. Therefore, a roundabout option was considered and is presented in Figure 20.

Alternative 4 replaces the intersection with a modern roundabout by utilizing City of Newburyport property located at the southeast quadrant of the intersection and the Green Street parking lot. The roundabout is designed with a 32-foot inner radius and an 18-foot travel way to accommodate truck traffic at the intersection. All approaches to the roundabout are designed with a single entry lane and a crosswalk. Because of the difference in elevation between Green Street and the Green Street parking lot, the roundabout would require constructing a retaining wall approximately 200 feet long and two to six feet tall. Implementing the roundabout option would result in a loss of approximately 11 parking spaces, including six spaces in the Green Street parking lot and five on-street spaces. During the future peak hours, the roundabout is expected to operate with good levels of service with vehicle queue lengths of approximately 250 feet or less on each approach.

The roundabout would allow pedestrians to cross one travel lane at a time as pedestrian refuge is provided in the roundabout splitter islands. Additionally, speeds on Merrimac Street would be reduced by the roundabout also facilitating pedestrian crossings. However, for pedestrians walking in the Merrimac Street sidewalks, the travel path would be less direct than under the Stop or signal-controlled alternatives. For example, pedestrians traveling within the southerly Merrimac Street sidewalk from the new parking garage to Market Square, crossing Green Street would require turning south onto Green Street, walking approximately 40 feet to reach the Green Street crosswalk, crossing Green Street and then proceeding around the outer diameter of roundabout.

The additional cost associated with Alternative 4 (as compared to Alternative 1) is approximately $1,000,000, resulting in a total construction cost estimate for the Green Street corridor of $2,210,000.

Table 6 summarizes the construction cost estimates for the various design alternatives evaluated for the Merrimac Street/Green Street/NRA Driveway intersection.

Table 6 Preliminary Construction Cost Estimate Summary

	Alternative 1[1]	Alternative 2A[2]	Alternative 2B[3]	Alternative 3[4]	Alternative 4[5]
Green Street (High St. to Green Street Parking Lot Dr.)	$710,000	$710,000	$710,000	$710,000	$710,000
Merrimac Street/Green Street/NRA Driveway Intersection	$500,000	$600,000	$400,000	$900,000	$1,500,000
Total	**$1,210,000**	**$1,310,000**	**$1,110,000**	**$1,610,000**	**$2,210,000**

[1] Includes stop sign control with pedestrian actuated traffic signals.

[2] Includes installation of fully actuated traffic signal at NRA driveway & Green Street.

[3] Includes installation of fully actuated traffic signal at Green Street only. NRA driveway remains under Stop control.

[4] Includes realignment of Green Street, retaining wall, reconstruction of parking lot, and fully actuated traffic signal for Green Street & NRA driveway.

[5] Includes a roundabout, retaining wall, and reconstruction of the Green Street lot.

5.0 PLEASANT STREET CIRCULATION ALTERNATIVES

In addition to the potential conversion of Green Street to provide two-way traffic operations, the City of Newburyport Planning Board has requested a review of other possible downtown circulation modifications to reduce traffic increases on adjacent neighborhood streets. One key roadway segment identified during the initial public hearings that could potentially be impacted by increased traffic from the IPF is the one block segment of Pleasant Street, between Market Street and Titcomb Street. Residents on this portion of Pleasant Street had expressed concerns that vehicles exiting the IPF garage via Titcomb Street would turn right onto Pleasant Street. To minimize these potential impacts, the following options have been reviewed. Options include converting Pleasant Street from one-way to two-way circulation, reversing the direction of portions of Pleasant Street, and imposing turn restrictions.

5.1 TWO-WAY PLEASANT STREET

One alternative to reduce exiting traffic from the IPF on Pleasant Street west of Titcomb Street would be to convert a portion of Pleasant Street from its current designation as one-way westbound from State Street to Summer Street to two-way traffic flow from Green Street to Titcomb Street. Under this alternative, a small portion of the trips associated with the IPF would utilize Green Street to travel south and out of the downtown area. As the Titcomb Street/Court Street and Market Street corridors are generally predicted to operate with little or no delay in the future, there is little incentive for motorists exiting the garage to use the Green Street corridor to access High Street. During the weekday and Saturday peak hours, it is estimated that less than 10 vehicles from the IPF garage would travel east on Pleasant Street and then south on Green Street.

This modification would result in a loss of parking near City Hall. In the vicinity of City Hall, Pleasant Street is approximately 30 feet wide curb to curb. To provide minimum 11-foot travel lanes in each direction, on-

street parking could only be accommodated on one side of the street. This would result in the loss of four parking spaces directly adjacent to City Hall.

Alternatively, this section of Pleasant Street could be widened by eight feet to accommodate a travel lane and a parking lane on both sides of the street. This widening would result in a narrower sidewalk in front of City Hall. West of City Hall, Pleasant Street widens to 39 feet and could accommodate an 11.5-foot travel lane and an eight-foot parking lane in both travel directions.

Allowing two-way travel on Pleasant Street may also require additional removal of the existing curb bump-out at the northwest corner of the Green Street/Pleasant Street intersection in order to maintain the four parking spaces in front of City Hall. New heads for the pedestrian signal would need to be provided for the Pleasant Street eastbound approach.

In consideration of the minor reduction in IPF trips on Pleasant Street, increased construction costs, and impacts to the on-street parking near City Hall and Brown Square, it is not recommended that Pleasant Street be modified to accommodate two-way travel.

5.2 ONE-WAY PLEASANT STREET EASTBOUND

Additional options which reverse traffic flow on portions of Pleasant Street from one-way westbound to one-way eastbound were also evaluated. Some of these options were also suggested by the City to allow access to Green Street southbound for motorists exiting from the proposed IPF and preventing traffic from exiting the IPF and traveling on Pleasant Street between Titcomb Street and Market Street.

5.2.1 One-Way Eastbound (From Summer Street to Green Street)

Designating Pleasant Street as one-way eastbound from Summer Street to Green Street would prevent vehicles from exiting the IPF and traveling along the section of Pleasant Street from Market Street to Titcomb Street. However, reversing the direction of Pleasant Street to one-way eastbound could introduce substantially more traffic on the segment of Pleasant Street between Market Street and Titcomb Street than under the existing one-way westbound flow, as drivers traveling north on Route 1 or Market Street may choose to use this section of Pleasant Street as a way to access the IPF and the rest of the downtown area without traveling up to the more congested Merrimac Street corridor. In consideration of the potential traffic increases on Pleasant Street between Market Street, this alternative is not recommended.

5.2.2 One-Way Eastbound (From Titcomb Street to Green Street)

A variation of the Pleasant Street one-way eastbound option is to designate the direction as one-way eastbound on only the portion of Pleasant Street between Titcomb Street to Green Street. This would still allow traffic exiting the IPF to travel to Green Street (less than 10 trips during the peak hours), but without the larger impacts of shifting some of the downtown entering traffic on the segment from Market Street to Titcomb Street since the western portion of the roadway would remain designated as one-way westbound. This designation would make travel along Pleasant Street more difficult for that segment since the remainder of the roadway would remain one-way westbound. Vehicles traveling west on Pleasant Street, including those destined for the IPF, east of Green Street would have to turn left or right onto Green Street and then use Merrimac Street or Washington Street to continue to the west to their destination.

Reversing the direction of Pleasant Street from westbound to eastbound for this segment would require few geometric changes. It is likely that all curb lines could remain as they are under existing conditions, but signage and pavement markings would need to be modified to accommodate the new traffic flow.

In consideration of the impacts to vehicular circulation including additional traffic on the congested Merrimac Street corridor and the minor reduction of IPF trips on Pleasant Street, it is not recommended that Pleasant Street be designated as one-way eastbound from Titcomb Street to Green Street.

5.2.3 One-Way Eastbound (From Market Street to Titcomb Street)

A second variation to the Pleasant Street one-way eastbound option is to reverse the direction to eastbound only on the portion of Pleasant Street from Market Street to Titcomb Street. This would prevent trips exiting the IPF from using this segment of Pleasant Street but would allow IPF entering trips to use the segment. This designation would make travel along Pleasant Street more difficult for that segment since the remainder of the roadway would remain one-way westbound. Vehicles traveling west on Pleasant Street heading to a destination on that block or west to Market Street or Summer Street would need to turn right onto Titcomb Street, left onto Merrimac Street, and left onto Market Street to get to their destinations. This would put additional strain on the already congested Merrimac Street corridor but would provide some relief for Pleasant Street from Market Street to Titcomb Street.

Reversing the direction of Pleasant Street from westbound to eastbound for this segment would not likely require any geometric changes. It is likely that all curb lines could remain as they are under existing conditions, but signage and pavement markings would need to be modified to accommodate the new traffic flow.

Further study of the designation of Pleasant Street as one-way eastbound from Market Street to Titcomb Street is recommended after the opening of the IPF. If the trips along this segment of Pleasant Street increase more than projected and the City desires to reduce impacts of the IPF on this segment of roadway, the change in direction from one-way westbound to one-way eastbound could be a viable option.

5.3 TITCOMB STREET TURN RESTRICTION AT PLEASANT STREET

A third option to limit the amount of IPF traffic using Pleasant Street from Titcomb Street to Market Street involves implementing a turn restriction from Titcomb Street southbound. That would prohibit vehicles from turning right from Titcomb Street onto Pleasant Street. This would permit these vehicles to continue straight through to Titcomb Street southbound only, as Pleasant Street would remain one-way westbound. No geometric changes would be needed to implement this restriction, but signage and enforcement would be needed. This turn restriction could reduce trips from the IPF by up to ten vehicles during peak hours and likely shift them to Washington Street by way of Titcomb Street southbound. Residents and visitors to this segment of Pleasant Street would only be able to access their homes and businesses from Pleasant Street westbound. In consideration of the relatively minor reduction in IPF trips on Pleasant Street, minimal construction costs, and impacts to circulation, further study of this option is recommended, if the post-build monitoring study shows impacts to this segment of Pleasant Street greater than those projected in this report.

While three of these options presented above are not recommended, the other two potential changes will be best informed by data collected in 2019 after the IPF is opened and actual travel patterns are observed. Further study after collection of 2019 data is recommended to confirm the actual travel patterns of IPF users and trip impacts on the adjacent intersections. If impacts to portions of Pleasant Street are higher than those projected in this report, the turn restriction or reversal of direction on Pleasant Street between Market Street and Titcomb Street are viable options that could be explored to mitigate the impacts of the IPF.

6.0 OTHER IMPROVEMENTS

Independent of the improvements needed to accommodate two-way traffic flow on Green Street, safety and capacity improvements to study area intersections outside of the Green Street corridor have been identified. These include improvements at the intersections of Merrimac Street at Route 1, Fair Street and Federal Street.

6.1 MERRIMAC STREET/ROUTE 1 RAMPS

The Road Safety Audit (RSA) conducted in 2012 at the Route 1/Merrimac Street interchange recommended that traffic signal control be installed at both ramp intersections with Merrimac Street. A traffic signal warrant analysis presented in the RSA indicates that installation of traffic signals is warranted at both locations. MassDOT has initiated a preliminary review of potential improvements at this location which includes installation of traffic signals at both ramps, along with improved bicycle and pedestrian accommodations. However, the MassDOT project is in the early design phase and has not yet been assigned to a design consultant.

The proponent of the Waterfront West development has also identified potential traffic mitigation measures at this location which would include signalization of the Route 1 ramp intersections to offset traffic impacts associated with the proposed development. The proponent agreed to fund the final design of the future roadway improvements at the Route 1 ramps and Merrimac Street and to assist the City in seeking construction funding for these improvements. The conceptual design of the proposed traffic signals at the Route 1 ramps was presented in the Waterfront West traffic study and is shown on Figure 21 in this report. The design includes minor widening on Merrimac Street under the Route 1 overpass to formalize left-turn lanes and bicycle accommodations. However, no additional lanes are proposed on Merrimac Street.

With the geometry shown in Figure 21, the level of service for the Route 1 ramp approaches improves and the vehicle queues on the ramps are reduced. However, vehicles traveling along Merrimac Street eastbound and westbound are likely to experience significant increases in delay and vehicle queues during the weekday commuter peak hours. The intersection analysis summary tables provided in Appendix B indicate that with signal control, the queues on the ramps would decrease during future peak hours by at least 100 feet as compared to the ramps under Stop control. Conversely, Merrimac Street, under signal control could see vehicle queues during peak hours of 700 feet to 1,000 feet in the eastbound direction and 500 feet to 1,100 feet in the westbound direction. The capacity analysis indicates that each ramp intersection would operate at acceptable levels. However, due to the proximity of these intersections (spaced approximately 130 feet apart), the traffic simulations show that the interaction between these closely spaced intersections will result in significantly longer queues than predicted in the capacity analysis.

Tetra Tech has identified a potential alternative roadway improvement to address queuing at the two Route 1 ramp intersections. With two-lane approaches, the queue lengths on Merrimac Street can be reduced to 250 to 300 feet. This alternative improvement would require roadway widening beyond the limits of the existing right-of-way in order to provide two general purpose lanes in each direction as shown on Figure 22. While it appears that the additional roadway widening needed to enhance traffic flow along Merrimac Street could be accommodated by land controlled by the proponent of the Waterfront West project, this would require modification of the currently proposed building setback along the project site frontage on Merrimac Street. We, therefore, recommend that the City work with the Waterfront West project proponent during the final site plan review to establish the appropriate future building setback along Merrimac Street

to ensure the constructability of the appropriate roadway improvements at Merrimac Street and the Route 1 ramps.

As traffic levels through these intersections are affected by seasonal fluctuation in tourism in Newburyport, frequent special events held in downtown and opening of the Route 1 drawbridge, it is recommended that an adaptive signal control system be considered. With a network of detectors placed throughout the interchange, approaching traffic can be monitored and the signal timing constantly adjusted to reflect current conditions to provide optimum operations.

It is also suggested that variable-message signs be installed on both Merrimac Street approaches to the Route 1 northbound on-ramp. These signs would be hard-wired or connected via a wireless network to the drawbridge control facility and would inform motorists that the draw-bridge will be opening or is in an open position. This will allow motorists to make an informed decision whether to turn onto the on-ramp or seek an alternate route to areas north of Newburyport.

6.2 WATER STREET/FAIR STREET

Fair Street approaches Water Street along the inside of a horizontal curve which, along with on-street parking, reduces sight lines; specifically, sight lines looking east from Fair Street. It is recommended that three existing on-street parking spaces be removed along the south side of Water Street, east of Fair Street to improve sight lines. A crosswalk on Fair Street is also recommended. This improvement is shown on Figure 23.

6.3 WATER STREET/FEDERAL STREET

The easterly corner of the Water Street/Federal Street intersection is set back approximately 15 feet from the Water Street travel way. This setback causes the Federal Street stop bar and crosswalk to be set back from Water Street which results in poor visibility of pedestrians by motorists turning onto Federal Street. Also, pedestrians traveling in the Water Street sidewalk are unlikely to use the crosswalk to travel across Federal Street.

It is recommended that the easterly corner of the intersection be reconstructed as shown on Figure 24 to provide a curb bump-out. With the curb bump-out, the crosswalk and stop line can be shifted closer to Water Street, increasing the visibility of pedestrians by motorists turning onto Federal Street. As seen in Figure 24, the curb bump-out is designed to accommodate trucks as Federal Street is on the route for the Newburyport waste water facility. The bump-out would result in the loss of approximately three parking spaces on Water Street.

7.0 CONCLUSION

Providing two-way traffic flow on Green Street would reduce vehicular traffic through Market Square with an estimated reduction of approximately 90 to 130 vehicles during peak hours. However, long vehicle queues on the Green Street approach to Merrimac Street could potentially be exacerbated by allowing turning movements from Merrimac Street and the NRA Driveway onto Green Street. Several alternatives were developed to improve operations at the Merrimac Street/Green Street/NRA Driveway intersection if Green Street is converted to two-way operation. The alternatives include full traffic signal control, combined traffic signal control/Stop control, realignment of Green Street to create a more traditional four-way intersection and reconfiguration of the intersection into a modern roundabout. Each of these alternatives

have operational or constructability issues. The alternative that provides both acceptable levels of service as well as minimal vehicle queues is the roundabout option. However, the roundabout would require construction of a 200-foot long retaining wall at a significant cost.

Improvements to the Merrimac Street/Water Street intersections with the Route 1 ramps, Fair Street, and Federal Street could be implemented with or without the Green Street circulation change from one-way to two-way flow. These improvements would improve safety and/or operations at the intersections and should be kept in mind as future projects are planned. Potential changes to reduce IPF traffic along portions of Pleasant Street could also be explored, if the traffic monitoring program reveals any impacts that vary greatly from the projections made in this report.

Depending on the feasibility and costs associated with the conversion of Green Street to two-way traffic flow, the City may also want to consider evaluating alternative circulation and/or geometric improvements to reduce traffic flow and enhance traffic and pedestrian safety in Market Square. For example, construction of a roundabout at State Street and Merrimac Street would also likely reduce vehicle queues on Merrimac Street and allow pedestrians to cross Merrimac Street in shorter segments as pedestrian refuge areas would be provided in the roundabout splitter islands. Additionally, with the available right-of-way and more level topography present within Market Square, a roundabout could potentially be installed at this location at a lower cost than at Green Street. Evaluation of the conversion of State Street to two-way traffic flow as an alternative to converting Green Street to two-way flow is recommended as it would also reduce traffic through the square and may prove to be a less costly alternative.

P:\32030\143-32030-15001\DOCS\REPORTS\PHASE II REPORT\PHASE II CIRCULATION STUDY-REV.DOCX