

Transit Systems Analysis Applied to Port Authority of Allegheny County Service

Overview

This paper describes an analysis of transit services of Port Authority of Allegheny County (PAAC) utilizing a transportation system- or network-based analysis tool. The information used by this tool incorporates demographic information and traditional transit data, and will include data based on observed operational results.

Ongoing enhancements of the systems approach will utilize additional information from census, analysis of the overall transportation network including other transportation modes, and information from PAAC including “real-time” transit data.

Introduction

Carnegie Mellon University’s Traffic21, along with the Institute for Complex Engineered Systems (ICES), recently undertook a systems analysis for route and service planning for Allegheny County’s transit system.

The work involved analyzing the transit system from a transportation systems or network perspective, which considers regional and local travel patterns as well as comparison of how well transit serves these travel patterns in comparison with the automobile mode.

From this perspective, transit’s role in serving transportation needs is assessed by analyzing ridership, travel time, population and population density, consideration of overall travel patterns, and quantity and quality of transit service.

The geographic unit of analysis presented in this paper is municipality. There are 130 municipalities in Allegheny County including City of Pittsburgh. The City is too large a unit to be able to evaluate transit service in detail, so the analysis focuses on the 129 County municipalities outside of Pittsburgh. Subsequent analysis can address transit service within Pittsburgh at the neighborhood/ward level, with particular focus on Downtown Pittsburgh and Oakland as appropriate.

This project uses the term “district” as a general term referring to geographic unit. In the specific analyses described herein, the municipalities plus Downtown and Oakland were considered analysis districts.

The following parameters are covered in the scope of the transportation network analysis (a subset of this information is covered in this paper):

Overall travel patterns – number of overall person trips to/from each district. This includes the overall number of trips to/from each district, as well as breaking down to/from two specific locations: Downtown Pittsburgh and Oakland

Transit travel patterns – number of transit person trips to/from each district. This includes the overall number of transit trips to/from each district, as well as breaking down to/from two specific locations: Downtown Pittsburgh and

Oakland. In addition to transit person trips, there must be transit service provided to/from a given district (or the vicinity of the district) in order that there be transit person trips to/from the district. Therefore, the number of transit vehicle trips (bus and rail vehicle trips) serving a district is an important parameter

Automobile travel patterns – number of automobile person trips to/from each district. This includes the overall number of automobile person trips to/from each district, as well as breaking down to/from two specific locations: Downtown Pittsburgh and Oakland

Population – number of residents of each district from the 2010 Census. In addition, when divided by the area of a district in square miles, provides the population density expressed in residents per square mile

Workers – number of workers in each district from the 2010 Census

Quality of transit service – includes a range of parameters such as travel time, on-time performance/reliability, number of bus+rail vehicle trips per day, service to particular locations such as Downtown, Oakland, neighborhood business districts, office centers, shopping centers, etc. In addition, the quality of transit service expressed as travel time, will be compared with the automobile mode.

The initial basis for expressing transit service quality, contained in this paper, is identifying the routes and the number of bus and rail vehicle trips serving an area. The following section provides introductory data regarding transit routes serving the municipalities in Allegheny County.

Transit Routes Serving Municipalities

The following table lists the transit routes that serve 129 municipalities in Allegheny County. City of Pittsburgh is not included because it is served by many routes and is too large at 55 square miles; it will be subject to a more detailed analysis in the future (on the neighborhood/ward level)

Table 1: Transit Routes and Number of Weekday Bus, Rail Trips by Municipality in Allegheny County

<u>Municipality</u>	<u>Routes Serving</u>	<u>Daily bus+ rail trips</u>
Aleppo Township		0
Aspinwall	1, 71B, 91	301
Avalon	14, 16, 19L	226
Baldwin	51, Y1, Y45, Y46, Y49	337
Baldwin Township	BLLB, BLSV	227
Bell Acres		0
Bellevue	13, 14, 16, 19L	298
Ben Avon	14, 19L	100
Ben Avon Heights		0
Bethel Park	36, BLLB, BLSV, RED, Y45	424
Blawnox	1	47
Brackenridge	P10	18
Braddock	59A, 61A, 61B	240
Braddock Hills	59A, 68, P68	77
Bradford Woods		0

Brentwood	51, 51L, Y1, Y46, Y49	338
Bridgeville	31, 41, G31	166
Carnegie	31, G2, G31	348
Castle Shannon	BLLB, BLSV, RED	369
Chalfant	59	38
Cheswick	1, P10	65
Churchill	67, P12, P16, P67	136
Clairton	55, Y46	97
Collier Township	31, 38, G31	204
Coraopolis	21	62
Crafton	28X, 29, G2, G31	318
Crescent Township		0
Dormont	36, 41, RED	260
Dravosburg	56, 59	96
Duquesne	52L, 59, 61C, P7	187
East Deer Township	1, P10	65
East McKeesport	P76	24
East Pittsburgh	56, 68, P68, 69, P69, P76	166
Edgewood	61A, 61B, 71, P7, P71	267
Edgeworth	14	79
Elizabeth	Y46	62
Elizabeth Township		0
Emsworth	14, 19L	100
Etna	1, 2, P13	111
Fawn Township		0
Findlay Township	29, 28X	112
Forest Hills	59, 68, P68, 69, P69, P76	152
Forward Township		0
Fox Chapel	91	120
Franklin Park		0
Frazer Township		0
Glassport	55	35
Glen Osborne	14	79
Glenfield	14	79
Green Tree	31, 38	180
Hampton Township	2, P13	64
Harmar Township	1, 78, P16, P78	123
Harrison Township	P10	18
Haysville	14	79
Heidelberg	31, G31	90
Homestead	52L, 53, 53L, 57, 59, 61C, 61D, 64	455
Indiana Township		0
Ingram	26, 27, 28X, 29, G2, G31	452
Jefferson Hills	55, Y1, Y46	116
Kennedy Township	20, 22, 24	148
Kilbuck Township		0
Leet Township	14	79
Leetsdale	14	79
Liberty		0
Lincoln		0
Marshall Township		0
McCandless	2, 12, O5, O12, P13	154
McDonald		0
McKees Rocks	20, 21, 22, 24	210
McKeesport	55, 56, 59, 60, 61C, P7	292
Millvale	1, 2	101
Monroeville	67, 68, 69, P67, P68, P69, 77, P12	258
Moon Township	21, G3	89
Mount Oliver	44, 48, 51, 51L, 54	381
Mt. Lebanon	36, 38, 41, RED	374
Munhall	52L, 53, 53L, 59, 61C	209
Neville Township	21	62
North Braddock	59, 61A, 61B, P68	260
North Fayette Township	29	36
North Versailles Township	55, 59, P76	97
O'Hara Township	1, 71B, 91, P10	319
Oakdale		0

Oakmont	78, P16, P78	76
Ohio Township		0
Penn Hills	77, 78, P16, P17, P78	150
Pennsbury Village		0
Pine Township		0
Pitcairn	69, P69	51
Pleasant Hills	51, 55, Y46, Y47	242
Plum	77, P12, P16	126
Port Vue		0
Rankin	59, 61B, 71, P7	185
Reserve Township	4	58
Richland Township		0
Robinson Township	24, 28X, 29	172
Ross Township	12, 13, 17, O5, O12	204
Rossllyn Farms		0
Scott Township	31, 38, 41, G31	280
Sewickley	14, 21	141
Sewickley Heights		0
Sewickley Hills		0
Shaler Township	2, P13	64
Sharpsburg	1, 91	167
South Fayette Township		0
South Park Township	BLLB, Y45	103
South Versailles Township		0
Springdale	1, P10	65
Springdale Township	P10	18
Stowe Township	21, 22, 24	168
Swissvale	59, 61A, 61B, 71, P1, P3, P7, P71	664
Tarentum	1, P10	65
Thornburg	29	36
Trafford	69, P69	51
Turtle Creek	68, 69, P68, P69	90
Upper St. Clair	36, 41	118
Verona	78, P78	48
Versailles	60, P76	52
Wall		0
West Deer Township		0
West Elizabeth		0
West Homestead		0
West Mifflin	51, 52L, 53, 53L, 55, 56, 59, 61C, P7, Y47, Y49	524
West View	8, 13	208
Whitaker	52L, 59, 61C	158
White Oak	P76	24
Whitehall	Y1, Y45, Y46, Y47, Y49	187
Wilkins Township	67, P67	70
Wilkinsburg	61A, 67, 68, 69, 71C, 71D, 78, 79, 86, P1, P2, P3, P12, P16, P68, P69, P71, P76, P78	1221
Wilmerding	69, P69	51

Of the 129 municipalities, 31 do not have transit routes serving them. Wilkinsburg has the most routes serving, with 19. Other areas served by a large number of routes are West Mifflin with 11 and Homestead, Monroeville and Swissvale with 8 routes serving.

In the next section, additional data for the municipalities is introduced, including population and population density, followed by an analysis relating population density with the amount of transit service in the municipalities.

Comparing Transit Service and Population Density

The following table shows for each municipality the 2010 population, area in square miles, and population density, along with daily bus+rail vehicle trips that were included in the previous table.

The municipalities are listed in increasing order by population density (low density areas at the top of the table, high density toward the bottom).

Table 2: Municipalities Ranked by Increasing Population Density

Municipality	2010 Population	Area (Sq.Mi.)	Population Density	Daily bus, rail trips
Sewickley Heights	810	7.3	111	0
Frazer Township	1,157	9.4	123	0
Findlay Township	5,060	32.6	155	112
Forward Township	3,376	19.9	170	0
Fawn Township	2,376	12.9	184	0
Glenfield	205	1.0	205	79
Lincoln	1,072	5.0	214	0
Haysville	70	0.3	233	79
Sewickley Hills	639	2.5	256	0
Bell Acres	1,388	5.2	267	0
Kilbuck Township	697	2.6	268	0
S. Versailles Township	351	1.0	351	0
West Deer Township	11,771	29.0	406	0
Aleppo Township	1,916	4.7	408	0
Indiana Township	7,253	17.7	410	0
Marshall Township	6,915	15.6	443	0
Harmar Township	2,921	6.4	456	123
Neville Township	1,084	2.2	493	62
Collier Township	7,080	14.2	499	204
North Fayette Township	13,934	25.1	555	36
East Deer Township	1,500	2.6	577	65
Elizabeth Township	13,271	23.0	577	0
Jefferson Hills	10,619	16.6	640	116
Springdale Township	1,636	2.4	682	18
Pine Township	11,497	16.8	684	0
South Fayette Township	14,416	21.0	688	0
Ohio Township	4,757	6.9	689	0
Fox Chapel	5,388	7.8	691	120
Roslyn Farms	427	0.6	712	0
Richland Township	11,100	14.6	760	0
Robinson Township	13,354	14.9	896	172
Glen Osborne	547	0.6	912	79
Plum	27,126	29.0	935	126
Edgeworth	1,680	1.7	988	79
Franklin Park	13,470	13.6	990	0
Moon Township	24,185	24.1	1,004	89
Leet Township	1,634	1.6	1,021	79
Leetsdale	1,218	1.1	1,107	79
Thornburg	455	0.4	1,138	36
Hampton Township	18,363	16.0	1,148	64
Crescent Township	2,640	2.3	1,148	0
O'Hara Township	8,407	7.3	1,152	319
Bradford Woods	1,171	1.0	1,171	0
White Oak	7,862	6.7	1,173	24
N. Versailles Township	10,229	8.3	1,232	97
Harrison Township	10,461	7.7	1,359	18
Churchill	3,011	2.2	1,369	136
Kennedy Township	7,672	5.5	1,395	148
West Mifflin	20,313	14.4	1,411	524
McKeesport	19,731	13.9	1,419	292
Monroeville	28,386	19.8	1,434	258
Wall	580	0.4	1,450	0
South Park Township	13,416	9.2	1,458	103
Dravosburg	1,792	1.1	1,629	96

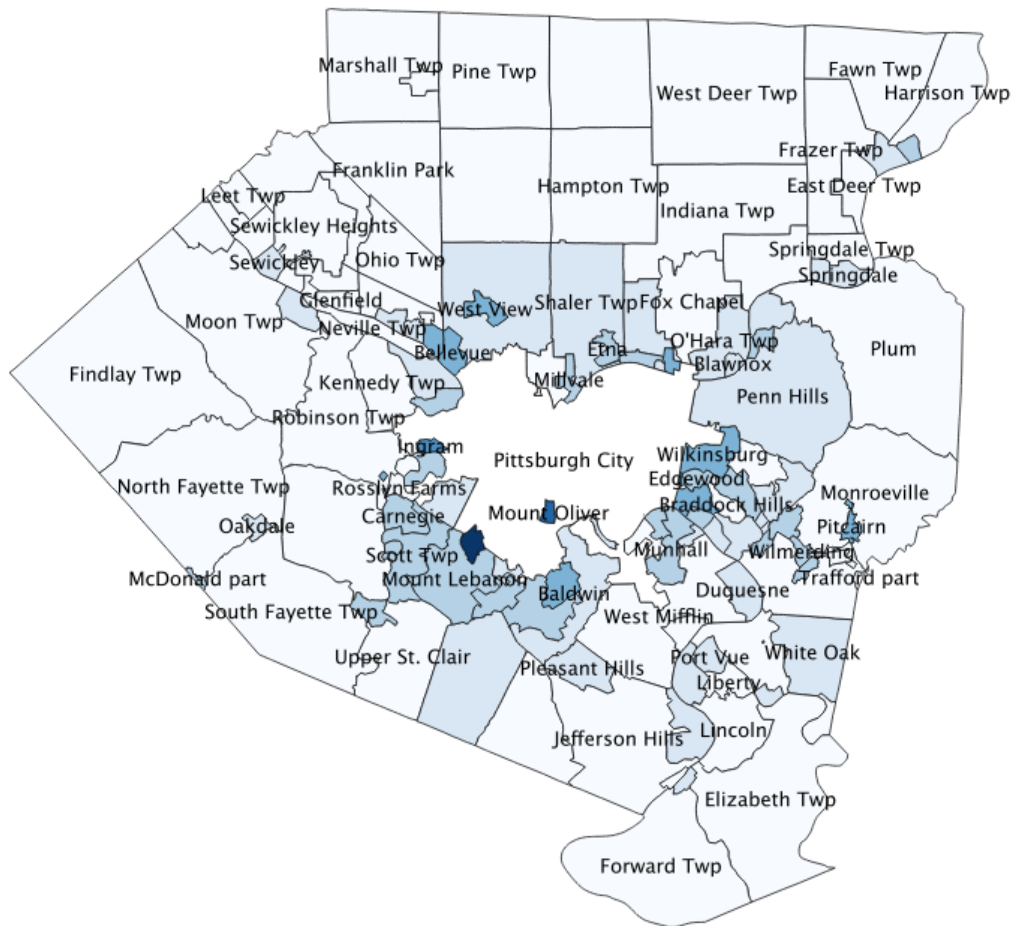
Reserve Township	3,333	2.0	1,667	58
Liberty	2,551	1.5	1,701	0
McCandless	28,457	16.6	1,714	154
West Elizabeth	518	0.3	1,727	0
Ben Avon Heights	371	0.2	1,855	0
Braddock Hills	1,880	1.0	1,880	77
West Homestead	1,929	1.0	1,929	0
Upper St. Clair	19,229	9.8	1,962	118
Green Tree	4,432	2.1	2,110	180
Ross Township	31,105	14.4	2,160	204
Penn Hills	42,329	19.3	2,193	150
Clairton	6,796	3.0	2,265	97
Trafford	3,174	1.4	2,267	51
Glassport	4,483	1.9	2,359	35
Wilkins Township	6,357	2.6	2,445	70
Shaler Township	28,757	11.2	2,568	64
Bethel Park	32,313	11.7	2,762	424
Stowe Township	6,362	2.3	2,766	168
Duquesne	5,565	2.0	2,783	187
Cheswick	1,746	0.6	2,910	65
Oakdale	1,459	0.5	2,918	0
Versailles	1,515	0.5	3,030	52
North Braddock	4,857	1.6	3,036	260
Pleasant Hills	8,268	2.7	3,062	242
Springdale	3,405	1.1	3,095	65
Tarentum	4,530	1.4	3,236	65
Baldwin	19,767	5.9	3,350	337
Port Vue	3,798	1.1	3,453	0
Sewickley	3,827	1.1	3,479	141
Emsworth	2,449	0.7	3,499	100
Oakmont	6,303	1.8	3,502	76
Ben Avon	1,781	0.5	3,562	100
Blawnox	1,432	0.4	3,580	47
Braddock	2,159	0.6	3,598	240
Elizabeth	1,493	0.4	3,733	62
Whitaker	1,271	0.34	3,738	158
Coraopolis	5,677	1.5	3,785	62
Baldwin Township	1,992	0.5	3,984	227
Chalfant	800	0.2	4,000	38
Forest Hills	6,518	1.6	4,074	152
Verona	2,474	0.6	4,123	48
Heidelberg	1,244	0.3	4,147	90
Whitehall	13,944	3.3	4,225	187
Rankin	2,122	0.5	4,244	185
Scott Township	17,024	4.0	4,256	280
McDonald	2,149	0.5	4,298	0
Etna	3,451	0.8	4,314	111
East Pittsburgh	1,822	0.4	4,555	166
Bridgeville	5,148	1.1	4,680	166
Munhall	11,406	2.4	4,753	209
Carnegie	7,972	1.6	4,983	348
Edgewood	3,118	0.6	5,197	267
Castle Shannon	8,316	1.6	5,198	369
Homestead	3,165	0.6	5,275	455
East McKeesport	2,126	0.4	5,315	24
Millvale	3,744	0.7	5,349	101
Turtle Creek	5,349	1.0	5,349	90
Crafton	5,951	1.1	5,410	318
Brackenridge	3,260	0.6	5,433	18
Mt. Lebanon	33,137	6.1	5,468	374
Wilmerding	2,190	0.4	5,475	51
McKees Rocks	6,104	1.1	5,549	210
Sharpsburg	3,446	0.6	5,743	167
Brentwood	9,643	1.5	6,429	338
Pennsbury Village	661	0.1	6,610	0
Avalon	4,705	0.7	6,721	226
West View	6,771	1.0	6,771	208

Swissvale	8,983	1.3	6,910	664
Wilkinsburg	15,930	2.3	6,926	1221
Aspinwall	2,801	0.4	7,003	301
Pitcairn	3,689	0.5	7,378	51
Bellevue	8,370	1.1	7,609	298
Ingram	3,330	0.4	8,325	452
Mount Oliver	3,403	0.3	11,343	381
Dormont	8,593	0.7	12,276	260

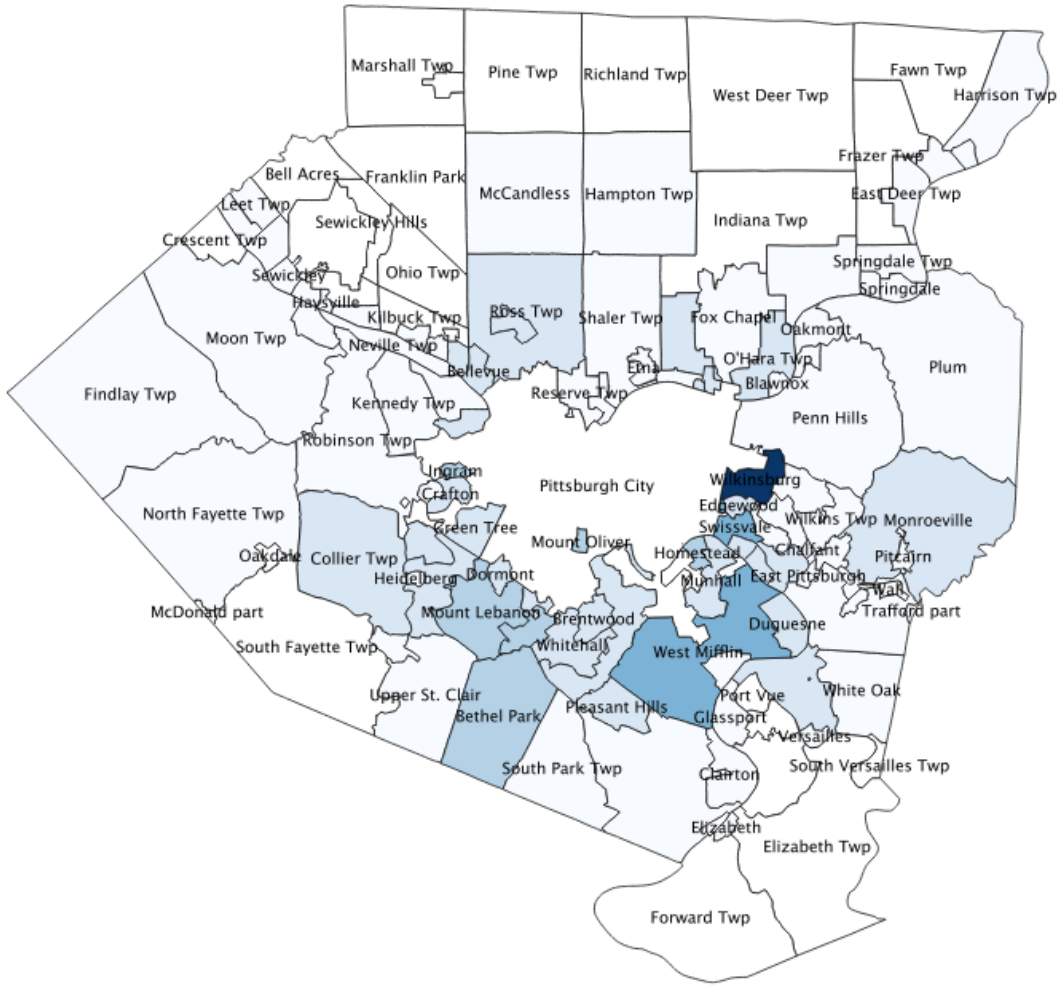
Not only does population density increase from top to bottom of the table, there is also a trend for number of bus+rail vehicle trips to increase as the table is reviewed from top to bottom.

Maps Displaying Population Density and Bus+Rail Trips for Municipalities

The basic “correlation” between population density and number of daily bus+rail trips is shown in the following maps:



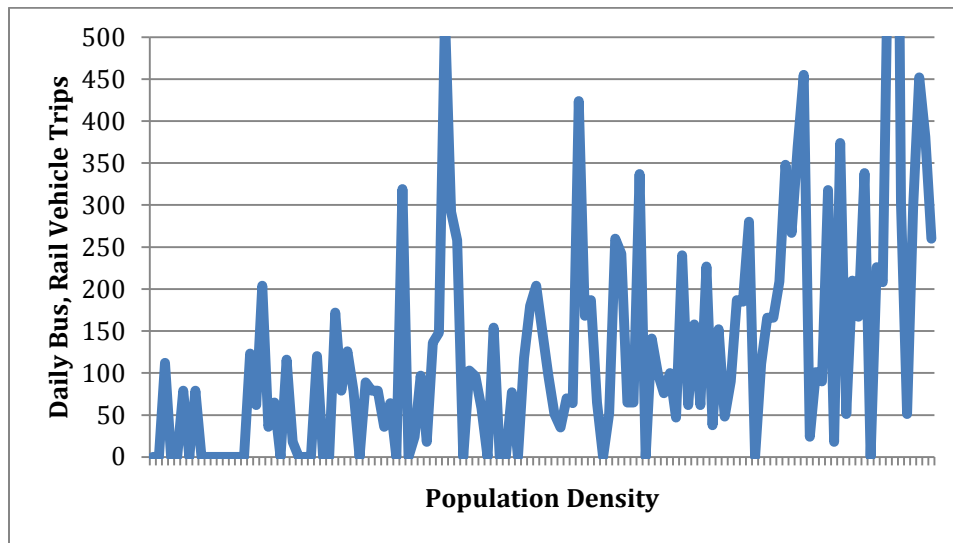
Map of Population Density by Municipality



Map of Number of Daily Bus+Rail Trips by Municipality

Correlation Analysis of Population Density and Bus+Rail Trips for Municipalities

The following chart portrays the number of daily bus/rail vehicle trips for the 129 municipalities. The data for the municipalities is portrayed from left to right in increasing order of population density.



There is significant variation in number of bus/rail trips, with an increasing trend from left to right. In other words, as population density goes up, number of bus/rail trips increases.

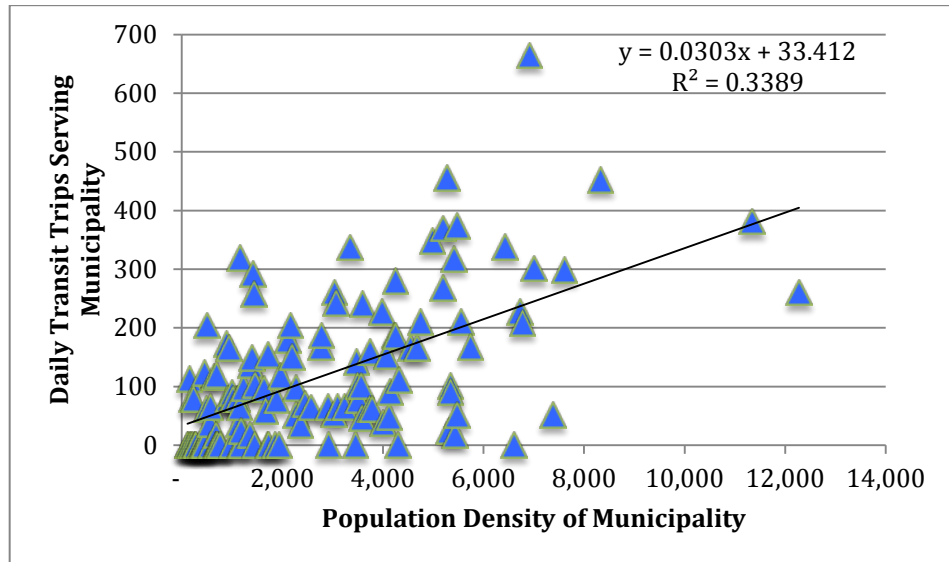
What this shows is that as population increases, more bus/rail service is provided. Overall, this makes sense because it is Port Authority’s “job” to provide transit service to those who need it, and certainly population centers are logical foci of transit service. In addition, the variability of the data makes sense because there might be a high-density area next to less-populated areas, and in providing transit service for the populated area the route may have to pass through less-populated areas. As such, the low-population areas are benefiting from proximity to population centers.

It is observed that at least three data points stand out from the data of Table 2 and the above figure. For example, there are two “spikes” towards the middle of the figure, in which the data points (representing bus+rail vehicle trips) stand much higher than the nearby data points on the chart. The two municipalities represented by these two points are Bethel Park and West Mifflin. A major reason why these two municipalities have “too many” transit vehicle trips serving them is because of the bus garage located in West Mifflin and the rail depot at the edge of Bethel Park. There are many vehicles going to or from the two facilities that cause the spikes in number of trips on the chart.

Similarly, as observed from Table 2, Wilkinsburg has twice as many trips as the next closest municipality. This is a result of the very many buses that utilize the East Busway, many of which get off the busway at Wilkinsburg to access local streets and subsequently to access the Parkway East.

A scatter plot was prepared showing daily bus+rail vehicle trips serving municipality vs. population density. The scatter plot does not include data from Bethel Park, West Mifflin and Wilkinsburg in order to eliminate the data skewed by the factors cited above. The regression equation is shown on the chart that contains the scatter plot. Although the R-squared of 33.9% is less than what is typically considered acceptable, the result is

probably useful in this case because of the systemic issue of low-density areas in proximity to high density areas being “over served.”



Areas With “Too Little” and “Too Much” Transit Service

In the next step of the analysis, the equation was used to estimate each municipality’s “expected” number of transit trips per day as a function of population density.

The following table shows for each municipality 2010 population, population density, daily bus/rail trips serving, the calculated “quota” of trips by use of the regression equation, and the number of excess trips or deficiency of trips calculated by subtracting the quota of trips from the actual number of bus/rail trips.

Table 3: Application of Equation to Determine Excess or Insufficiency of Transit Trips by Municipality

Municipality	2010 Population	Area (Sq.Mi.)	Population Density	Daily bus, rail trips	Trips Quota, by Equation	Too (few), many trips
Sewickley Heights	810	7.3	111	0	41	(41)
Frazer Township	1,157	9.4	123	0	41	(41)
Findlay Township	5,060	32.6	155	112	42	70
Forward Township	3,376	19.9	170	0	43	(43)
Fawn Township	2,376	12.9	184	0	43	(43)
Glenfield	205	1.0	205	79	44	35
Lincoln	1,072	5.0	214	0	44	(44)
Haysville	70	0.3	233	79	45	34
Sewickley Hills	639	2.5	256	0	46	(46)
Bell Acres	1,388	5.2	267	0	46	(46)
Kilbuck Township	697	2.6	268	0	46	(46)
S. Versailles Township	351	1.0	351	0	49	(49)
West Deer Township	11,771	29.0	406	0	51	(51)
Aleppo Township	1,916	4.7	408	0	51	(51)
Indiana Township	7,253	17.7	410	0	51	(51)
Marshall Township	6,915	15.6	443	0	52	(52)
Harmar Township	2,921	6.4	456	123	52	71
Neville Township	1,084	2.2	493	62	54	8
Collier Township	7,080	14.2	499	204	54	150
North Fayette Township	13,934	25.1	555	36	56	(20)
East Deer Township	1,500	2.6	577	65	56	9

Elizabeth Township	13,271	23.0	577	0	56	(56)
Jefferson Hills	10,619	16.6	640	116	59	57
Springdale Township	1,636	2.4	682	18	60	(42)
Pine Township	11,497	16.8	684	0	60	(60)
South Fayette Township	14,416	21.0	688	0	60	(60)
Ohio Township	4,757	6.9	689	0	60	(60)
Fox Chapel	5,388	7.8	691	120	60	60
Rosslyn Farms	427	0.6	712	0	61	(61)
Richland Township	11,100	14.6	760	0	63	(63)
Robinson Township	13,354	14.9	896	172	67	105
Glen Osborne	547	0.6	912	79	68	11
Plum	27,126	29.0	935	126	69	57
Edgeworth	1,680	1.7	988	79	70	9
Franklin Park	13,470	13.6	990	0	70	(70)
Moon Township	24,185	24.1	1,004	89	71	18
Leet Township	1,634	1.6	1,021	79	71	8
Leetsdale	1,218	1.1	1,107	79	74	5
Thornburg	455	0.4	1,138	36	75	(39)
Hampton Township	18,363	16.0	1,148	64	76	(12)
Crescent Township	2,640	2.3	1,148	0	76	(76)
O'Hara Township	8,407	7.3	1,152	319	76	243
Bradford Woods	1,171	1.0	1,171	0	76	(76)
White Oak	7,862	6.7	1,173	24	77	(53)
N. Versailles Township	10,229	8.3	1,232	97	78	19
Harrison Township	10,461	7.7	1,359	18	83	(65)
Churchill	3,011	2.2	1,369	136	83	53
Kennedy Township	7,672	5.5	1,395	148	84	64
West Mifflin	20,313	14.4	1,411	524	84	440
McKeesport	19,731	13.9	1,419	292	85	207
Monroeville	28,386	19.8	1,434	258	85	173
Wall	580	0.4	1,450	0	86	(86)
South Park Township	13,416	9.2	1,458	103	86	17
Dravosburg	1,792	1.1	1,629	96	92	4
Reserve Township	3,333	2.0	1,667	58	93	(35)
Liberty	2,551	1.5	1,701	0	94	(94)
McCandless	28,457	16.6	1,714	154	95	59
West Elizabeth	518	0.3	1,727	0	95	(95)
Ben Avon Heights	371	0.2	1,855	0	99	(99)
Braddock Hills	1,880	1.0	1,880	77	100	(23)
West Homestead	1,929	1.0	1,929	0	102	(102)
Upper St. Clair	19,229	9.8	1,962	118	103	15
Green Tree	4,432	2.1	2,110	180	108	72
Ross Township	31,105	14.4	2,160	204	110	94
Penn Hills	42,329	19.3	2,193	150	111	39
Clairton	6,796	3.0	2,265	97	113	(16)
Trafford	3,174	1.4	2,267	51	113	(62)
Glassport	4,483	1.9	2,359	35	116	(81)
Wilkins Township	6,357	2.6	2,445	70	119	(49)
Shaler Township	28,757	11.2	2,568	64	123	(59)
Bethel Park	32,313	11.7	2,762	424	130	294
Stowe Township	6,362	2.3	2,766	168	130	38
Duquesne	5,565	2.0	2,783	187	131	56
Cheswick	1,746	0.6	2,910	65	135	(70)
Oakdale	1,459	0.5	2,918	0	135	(135)
Versailles	1,515	0.5	3,030	52	139	(87)
North Braddock	4,857	1.6	3,036	260	139	121
Pleasant Hills	8,268	2.7	3,062	242	140	102
Springdale	3,405	1.1	3,095	65	141	(76)
Tarentum	4,530	1.4	3,236	65	146	(81)
Baldwin	19,767	5.9	3,350	337	150	187
Port Vue	3,798	1.1	3,453	0	153	(153)
Sewickley	3,827	1.1	3,479	141	154	(13)
Emsworth	2,449	0.7	3,499	100	155	(55)
Oakmont	6,303	1.8	3,502	76	155	(79)
Ben Avon	1,781	0.5	3,562	100	157	(57)
Blawnox	1,432	0.4	3,580	47	157	(110)
Braddock	2,159	0.6	3,598	240	158	82

Elizabeth	1,493	0.4	3,733	62	163	(101)
Whitaker	1,271	0.34	3,738	158	163	(5)
Coraopolis	5,677	1.5	3,785	62	164	(102)
Baldwin Township	1,992	0.5	3,984	227	171	56
Chalfant	800	0.2	4,000	38	172	(134)
Forest Hills	6,518	1.6	4,074	152	174	(22)
Verona	2,474	0.6	4,123	48	176	(128)
Heidelberg	1,244	0.3	4,147	90	176	(86)
Whitehall	13,944	3.3	4,225	187	179	8
Rankin	2,122	0.5	4,244	185	180	5
Scott Township	17,024	4.0	4,256	280	180	100
McDonald	2,149	0.5	4,298	0	182	(182)
Etna	3,451	0.8	4,314	111	182	(71)
East Pittsburgh	1,822	0.4	4,555	166	190	(24)
Bridgeville	5,148	1.1	4,680	166	194	(28)
Munhall	11,406	2.4	4,753	209	197	12
Carnegie	7,972	1.6	4,983	348	205	143
Edgewood	3,118	0.6	5,197	267	212	55
Castle Shannon	8,316	1.6	5,198	369	212	157
Homestead	3,165	0.6	5,275	455	214	241
East McKeesport	2,126	0.4	5,315	24	216	(192)
Millvale	3,744	0.7	5,349	101	217	(116)
Turtle Creek	5,349	1.0	5,349	90	217	(127)
Crafton	5,951	1.1	5,410	318	219	99
Brackenridge	3,260	0.6	5,433	18	220	(202)
Mt. Lebanon	33,137	6.1	5,468	374	221	153
Wilmerding	2,190	0.4	5,475	51	221	(170)
McKees Rocks	6,104	1.1	5,549	210	224	(14)
Sharpsburg	3,446	0.6	5,743	167	230	(63)
Brentwood	9,643	1.5	6,429	338	253	85
Pennsbury Village	661	0.1	6,610	0	259	(259)
Avalon	4,705	0.7	6,721	226	263	(37)
West View	6,771	1.0	6,771	208	265	(57)
Swissvale	8,983	1.3	6,910	664	269	395
Wilkinsburg	15,930	2.3	6,926	1221	270	951
Aspinwall	2,801	0.4	7,003	301	272	29
Pitcairn	3,689	0.5	7,378	51	285	(234)
Bellevue	8,370	1.1	7,609	298	293	5
Ingram	3,330	0.4	8,325	452	317	135
Mount Oliver	3,403	0.3	11,343	381	418	(37)
Dormont	8,593	0.7	12,276	260	450	(190)

In order to use this information as a service evaluation tool, PAAC will need to look at the excess or insufficiency of bus and rail trips and make a determination of whether any of its transit service should be modified by adding or subtracting service to/from each municipality. For a municipality with “too many” trips, could/should any service be reduced? Should service be added to a locality with “too few” transit trips?

There can be a dichotomy in the analysis to be done, one that would apply to municipalities currently with no or little transit service, the other to municipalities with a significant number of transit trips serving.

Assessment of Transit Serving High-Density Municipalities

As an example of evaluating transit service to municipalities, we begin with analysis of the highest-ranked municipalities by population density. Table 4 (towards the end of this paper) presents the top 20 municipalities ranked by population density. The data shown is similar as for prior tables, including routes serving, number of trips per day, quota of trips, and the excess or deficiency of trips comparing actual trips with suggested number

of trips. The last two columns of Table 4 present the results of a qualitative assessment of the transit service, which was done by taking into account area coverage of the routes, number of bus/rail trips, frequency of service, and the population, area, and population density of the municipalities. Shown in the last column are the specific routes that might be adjusted for that municipality.

Based on the table, the following provides examples of the assessment of service for some of the high-density municipalities:

- Dormont – According to the table, there are too few bus/rail trips serving the borough. However, the RED line LRT serves Dormont and traverses along the centerline of the borough. The positive service attributes of the LRT along with its central location are such that additional transit service is not recommended despite the “shortfall” of trips
- Mount Oliver and other municipalities – The actual number of bus, rail trips is close to the number recommended according to the regression equation, therefore no service changes are indicated by the data
- Wilkinsburg, Ingram and other municipalities – The actual amount of service is significantly greater than the “quota” indicated by population density. These areas benefit from the proximity of the fixed guideway transit service
- Pitcairn – The current number of bus/rail trips is insufficient according to the equation. Furthermore, perusal of the schedule for Routes 69 and P69 serving the borough indicate that the service could be more frequent during certain times of the day.

Increments of Transit Service for Low-Density Areas

Looking at the top of Table 3, one can see the low-population density municipalities and the number of bus/rail trips per day “recommended” by the regression equation. It is seen that a minimum of 41 trips per day is recommended even for the low-density municipalities.

At this point, it is useful to understand the kind of service that can be provided when there are relatively few bus/rail trips in service on a route. A “minimum” amount would be to provide hourly service during peak periods (6-9 am, 4-6 pm) in the peak direction (inbound during a.m., outbound during p.m.); that would result in four a.m. trips and three p.m. trips for a total of 7 vehicle trips per day.

Adding non-peak direction trips during the peak hours, or retaining peak-direction-only service but improving the headway to ½-hour, would double the number of trips provided in this hypothetical scenario to 14.

Expanding on this approach, the following table gives the parameters for service on a transit route (time of day of service coverage, headway per hour), and the number of transit vehicle trips per day that result from the given parameters:

Table 5: Increments of Transit Service and Bus/Rail Trips per Day for Low-Frequency Routes

<u>Parameters of Transit Service on a Route</u>	<u>Trips/Day on Route</u>
Hourly peak-direction only service during peak hours	7
Hourly peak and non-peak direction service during peak hours	14
1/2-hourly peak-direction only service during peak hours	25
Hourly peak and non-peak direction service during peak and midday hours	25
1/2-hourly peak-direction-only service during peak and midday hours	25
1/2-hourly peak and non-peak direction service during peak and midday hours	50
1/2-hourly peak and non-peak direction service from 6 am to 10 pm	66

In effect, the parameters of Table 5 prescribe potential “policy” service levels for lower-density areas that can be adjusted based on population density and other factors.

According to Table 5, it is possible to conceive of a route that has as few as seven transit vehicle trips per day by providing hourly service in the peak direction during peak periods. The table also shows the number of daily transit vehicle trips on a route for various assumptions regarding time of day coverage, direction of service, and frequency of service.

This information will be used herein in considering minimum levels of transit service to low-density municipalities, but can also be used for higher-density areas.

Review of Low-Population-Density Areas

As indicated at the top of Table 3, use of the equation yields at least 41 daily transit vehicle trips even for very low-density areas. Under the assumption that many of these areas do not warrant transit service, a second regression equation (with a y-intercept of zero) was created in order to produce low trip quotas for low-density areas. The last two columns of Table 6 show the results of applying the two regression equations to the 40 municipalities with the lowest population density.

Table 6: Introducing a Second Trips Quota for Low-Density Municipalities

<u>Municipality</u>	<u>2010 Population</u>	<u>Area (Sq.Mi.)</u>	<u>Population Density</u>	<u>Daily bus. rail trips</u>	<u>1st Trips Quota</u>	<u>2nd Trips Quota @ 0-intercept</u>
Sewickley Heights	810	7.3	111	0	41	5
Frazer Township	1,157	9.4	123	0	41	6
Findlay Township	5,060	32.6	155	112	42	7
Forward Township	3,376	19.9	170	0	43	8
Fawn Township	2,376	12.9	184	0	43	9
Glenfield	205	1.0	205	79	44	10
Lincoln	1,072	5.0	214	0	44	10
Haysville	70	0.3	233	79	45	11

Sewickley Hills	639	2.5	256	0	46	12
Bell Acres	1,388	5.2	267	0	46	12
Kilbuck Township	697	2.6	268	0	46	13
S. Versailles Township	351	1.0	351	0	49	16
West Deer Township	11,771	29.0	406	0	51	19
Aleppo Township	1,916	4.7	408	0	51	19
Indiana Township	7,253	17.7	410	0	51	19
Marshall Township	6,915	15.6	443	0	52	21
Harmar Township	2,921	6.4	456	123	52	21
Neville Township	1,084	2.2	493	62	54	23
Collier Township	7,080	14.2	499	204	54	23
N. Fayette Township	13,934	25.1	555	36	56	26
East Deer Township	1,500	2.6	577	65	56	27
Elizabeth Township	13,271	23.0	577	0	56	27
Jefferson Hills	10,619	16.6	640	116	59	30
Springdale Township	1,636	2.4	682	18	60	32
Pine Township	11,497	16.8	684	0	60	32
S. Fayette Township	14,416	21.0	688	0	60	32
Ohio Township	4,757	6.9	689	0	60	32
Fox Chapel	5,388	7.8	691	120	60	32
Roslyn Farms	427	0.6	712	0	61	33
Richland Township	11,100	14.6	760	0	63	36
Robinson Township	13,354	14.9	896	172	67	42
Glen Osborne	547	0.6	912	79	68	43
Plum	27,126	29.0	935	126	69	44
Edgeworth	1,680	1.7	988	79	70	46
Franklin Park	13,470	13.6	990	0	70	46
Moon Township	24,185	24.1	1,004	89	71	47
Leet Township	1,634	1.6	1,021	79	71	48
Leetsdale	1,218	1.1	1,107	79	74	52
Thornburg	455	0.4	1,138	36	75	53
Hampton Township	18,363	16.0	1,148	64	76	54

The last column of Table 6 utilizes the second equation to provide a relatively low “quota” of transit vehicle trips for low-density communities. The third municipality listed on Table 6 (Findlay Township) has seven trips/day recommended based on the second equation. Looking at Table 5, seven trips would equate to a route that has hourly service operated during peak periods in the peak direction. It can be asked in this case: does Findlay Township warrant a route with minimal service?

The 11th municipality listed, Kilbuck Township, has 13 trips/day recommended, which is approximately enough trips to be able to provide hourly service operated during peak periods in the peak direction and the non-peak direction.

In such a fashion, Table 6 can be used in conjunction with Table 5 to identify a level of service that might be appropriate for low-density municipalities that do not have existing transit service.

Table 7 lists the 25 municipalities ranked lowest in terms of population density. This table is similar to Table 4, which provided an analysis of the top-ranked municipalities in terms of population density, but it differs from Table 4 in that it utilizes the second regression equation to compare with existing number of bus and rail vehicle trips serving in order to calculate an “excess” or “deficiency” of transit service. In addition, the next-to-last column of Table 7 provides an evaluation of existing transit service, for those

municipalities that currently have transit service; and the last column lists routes for which adjustments have been identified for consideration.

Based on the table, the following provides examples of the assessment of service for some of the low-density municipalities:

- Springdale Township – The actual number of bus/rail trips is close to the number recommended according to the regression equation, therefore no service changes are indicated by the data
- Jefferson Hills is served by 116 bus trips per day and its quota based on population density is 30, thus there is an excess of 86 trips per day. However, it is noted that Jefferson Hills benefits from the transit service along Route 51 and transit service serving Century III Mall, thus no service changes are recommended
- Collier Township – There is excess identified of 181 bus trips per day. There is substantial transit service in the township, but it serves only the southeast corner of the township, along Washington Pike where there is significant activity. In addition, there are fewer trips than indicated because not all Route 38 trips serve Collier. On the other hand, there may be too much service on Route 31

It is also instructive to look at Route 29 as an example of a route that traverses a number of suburban municipalities with varying densities (also connecting with Downtown Pittsburgh), providing a level of service (service frequency and time of day coverage) that is not a large amount of service but is more than the minimum service (i.e., peak period only). Route 29 serves the following municipalities: Pittsburgh, Ingram, Crafton, Thornburg, Robinson, N. Fayette, and Findlay. Similarly, Route 28X provides express-type service in the same general corridor as Route 29. In addition to providing express-type service, Route 28X also has the benefit of providing transit service until late at night as well as on Saturdays and Sundays. Routes 29 and 28X currently operate with 36 and 76 bus trips per day. This range of daily bus trips can be considered medium to high in terms of quality of service.

Port Authority should investigate the extent to which it currently provides a combination of local service and express service, with time-of-day coverage, to the following “corridors” that comprise the transit service area:

- East
- North
- Northeast
- Northwest
- South
- Southeast
- Southwest
- West

To the extent it is found that such coverage is not provided, PAAC should consider whether it is feasible to provide such service in each corridor.

Applying the Method to Corridors Instead of Routes

It is possible to utilize the information of Table 3, which evaluated transit service of municipalities, in order to aggregate the municipalities to derive the “excess” or “deficiency” of transit vehicle trips by corridor.

Using the eight corridors identified previously, the following table provides the existing trips in each corridor, the quota by regression equation, the deficiency or excess of trips, and the percentage deficiency or excess. It should be noted that the data for the eight corridors represents the sum over all the municipalities in each corridor.

Table 8: Number and percentage difference of actual transit vehicle trips in the corridors compared with the recommended number of trips**

<u>Corridor</u>	<u>Daily bus, rail trips</u>	<u>Trips Quota, by Equation</u>	<u>Too (few), many trips</u>	<u>% Difference: actual transit vehicle trips from “quota”</u>
E	3,117	2,595	522	20%
N	752	1,184	(432)	-36%
NE	1,727	2,503	(776)	-31%
NW	1,989	2,575	(586)	-23%
S	4,000	2,656	1,344	51%
SE	2,924	3,077	(153)	-5%
SW	2,074	1,848	226	12%
W	409	553	(144)	-26%

** Number of trips per corridor from which the calculations were made is the sum over all municipalities in each corridor

The three corridors with an excess of transit vehicle trips are South, East, and Southwest. These three corridors each have fixed transit facilities: LRT and South Busway in the South, East Busway in the East, and West Busway in the Southwest; the presence of these facilities with their large allocation of transit service likely has something to do with this. In addition, the Southeast corridor has a small “deficiency” of trips, although the comparison is quite close which leads to the conclusion that this corridor has the appropriate number of transit vehicle trips.

The North and Northeast corridors have the greatest deficiencies in number of trips. This leads to a conclusion that the transit service in the municipalities in these three corridors should be reviewed from the perspective that the existing transit service may be insufficient. This type of investigation can be similar to what was done in deriving Tables 4 and 7 of this report, covering some of the high-density and low-density municipalities in Allegheny County. Expanding the analyses portrayed in Tables 4 and 7 to all the municipalities, not just the highest and lowest density areas, would help in this regard.

Table 4: Evaluation of Transit Service in 20 High-Population Density Municipalities

<u>Municipality</u>	<u>Routes Serving</u>	<u>2010 Population</u>	<u>Area (Sq. Mi.)</u>	<u>Population Density</u>	<u>Daily bus, rail trips</u>	<u>Trips Quota</u>	<u>Too (few), many trips</u>	<u>Evaluation of Transit Service in the Municipality</u>	<u>Routes to Improve</u>
Dormont	36, 41, RED	8,593	0.7	12,276	260	450	(190)	RED line LRT provides fixed guideway serving the centerline of Dormont, and its positive service attributes make up for the fewer trips serving the borough	
Mount Oliver	44, 48, 51, 51L, 54	3,403	0.3	11,343	381	418	(37)	The amount of transit service is appropriate to the population and density	
Ingram	26, 27, 28X, 29, G2, G31	3,330	0.4	8,325	452	317	135	Ingram benefits from having a W. Busway station which provides it with many bus trips. It also has buses on arterials that serve many other areas	
Bellevue	13, 14, 16, 19L	8,370	1.1	7,609	298	293	5	The amount of transit service is appropriate to the population and density	
Pitcairn	69, P69	3,689	0.5	7,378	51	285	(234)	Area coverage of the densest part of the borough is good. Investigate improving 69 and P69 headways	69, P69
Aspinwall	1, 71B, 91	2,801	0.4	7,003	301	272	29	The comparison is actually closer than 301 actual trips vs. quota of 272 because not every 71B trip serves Aspinwall (fewer than 301 daily trips actually serve Aspinwall)	
Wilkinsburg	61A, 67, 68, 69, 71C, 71D, 78, 79, 86, P1, P2, P3, P12, P16, P68, P69, P71, P76, P78	15,930	2.3	6,926	1,221	270	951	Wilkinsburg benefits from the many buses using the East Busway. It also has buses on arterials that serve many other areas	
Swissvale	59, 61A, 61B, 71, P1, P3, P7, P71	8,983	1.3	6,910	664	269	395	Swissvale benefits from the many buses using the East Busway. It also has buses on arterials that serve many other areas	
West View	8, 13	6,771	1.0	6,771	208	265	(57)	West View has a deficiency of service, but the shortfall at 22% is not large. Routes serving the borough provide good coverage of main streets and populated areas. There is no route coverage of Route 19 in the north part of the borough, but that area is within walking distance of the routes serving the borough	
Avalon	14, 16, 19L	4,705	0.7	6,721	226	263	(37)	The amount of transit service is appropriate to the population and density	
Pennsbury Village		661	0.1	6,610	0	259	(259)	Pennsbury Village is very small and has small population despite the relatively high density. Investigate instituting transit service on Campbells Run Road which is a short distance away (though there are no sidewalks)	Possibly add to Campbells Run Road
Brentwood	51, 51L, Y1, Y46, Y49	9,643	1.5	6,429	338	253	85	Many Route 51 trips don't go beyond Brentwood Loop thereby serving only a portion of Brentwood.	

Sharpsburg	1, 91	3,446	0.6	5,743	167	230	(63)	Routes serving Sharpsburg provide good coverage of main street and populated areas. The borough is narrow and has good proximity to the service along Main Street.	
McKees Rocks	20, 21, 22, 24	6,104	1.1	5,549	210	224	(14)	The amount of transit service is appropriate to the population and density	
Wilmerding	69, P69	2,190	0.4	5,475	51	221	(170)	Routes serving the borough provide good coverage of the main street and populated areas. The borough is narrow and there is good proximity to the service along Middle Avenue. Investigate improving 69 and P69 service	68, P69
Mt. Lebanon	36, 38, 41, RED	33,137	6.1	5,468	374	221	153	RED line LRT provides fixed guideway service to the northeast portion of the municipality. The bus routes provide good service to other parts of the municipality. Investigate whether bus service can be reduced	36, 38, 41, RED
Brackenridge	P10	3,260	0.6	5,433	18	220	(202)	Population density and population appear to justify extending Route 1 to Brackenridge	1
Crafton	28X, 29, G2, G31	5,951	1.1	5,410	318	219	99	Crafton benefits from the many buses on the W. Busway. In addition, Route 29 provides pretty good service to Crafton, and Route 31 though not directly serving Crafton, is within walking distance of parts of Crafton	29
Turtle Creek	68, 69, P68, P69	5,349	1.0	5,349	90	217	(127)	Area coverage near the main streets of the borough is good. Investigate adding more buses	68, 69, P68, P69
Millvale	1, 2	3,744	0.7	5,349	101	217	(116)	Route 2 provides good service on the main streets of Millvale. Given the population density, improving frequency of Route 2 or extending some other route to Millvale should be considered	2

Table 7: Evaluation of Transit Service in 25 Low-Population-Density Municipalities with Focus on Those With Existing Transit Service

Municipality	Routes Serving	2010 Population	Area (Sq. Mi.)	Population Density	Daily bus, rail trips	Trips Quota, 2 nd Equation	Too (few), many trips	Evaluation of Transit Service in the Municipality**	Routes to Improve
Pine Township		11,497	16.8	684	0	32	(32)		
Springdale Township	P10	1,636	2.4	682	18	32	(14)	The amount of transit service is appropriate to the population and density	
Jefferson Hills	55, Y1, Y46	10,619	16.6	640	116	30	86	Jefferson Hills benefits from the transit service along Route 51 and transit service serving Century III Mall	
Elizabeth Township		13,271	23.0	577	0	27	(27)		
East Deer Township	1, P10	1,500	2.6	577	65	27	38	East Deer benefits from the transit service along Freeport Road. Route 1 serves the busiest part of the township	
N. Fayette Township	29	13,934	25.1	555	36	26	10	The amount of transit service is appropriate to the population and density	
Collier Township	31, 38, G31	7,080	14.2	499	204	23	181	This is substantial transit service, but it serves only the southeast corner of the township, along Washington Pike where there is significant activity. There are fewer trips than indicated because not all Route 38 trips serve Collier. There may be too much service on Route 31	31
Neville Township	21	1,084	2.2	493	62	23	39	Neville Township is narrow and is well served by Route 21. Just considering Neville, there may be too much service on Route 21	21
Harmar Township	1, 78, P16, P78	2,921	6.4	456	123	21	102	Just considering Harmar Township, there may be too much service on the combination of Routes 1, 78, P16, and P78	1, 78, P16, P78
Marshall Township		6,915	15.6	443	0	21	(21)		
Indiana Township		7,253	17.7	410	0	19	(19)		
Aleppo Township		1,916	4.7	408	0	19	(19)		
West Deer Township		11,771	29.0	406	0	19	(19)		
S. Versailles Township		351	1.0	351	0	17	(17)		
Kilbuck Township		697	2.6	268	0	13	(13)		
Bell Acres		1,388	5.2	267	0	13	(13)		
Sewickley Hills		639	2.5	256	0	12	(12)		

Haysville	14	70	0.3	233	79	11	68	The formula indicates that Haysville has too much transit service. However, Route 14 serves only the south edge of the borough and the purpose of Route 14 is to serve the overall Ohio River Blvd corridor not just Haysville
Lincoln		1,072	5.0	214	0	10	(10)	
Glenfield	14	205	1.0	205	79	10	69	The formula indicates that Glenfield has too much transit service. However, Route 14 serves only the south edge of the borough and the purpose of Route 14 is to serve the overall Ohio River Blvd corridor not just Glenfield
Fawn Township		2,376	12.9	184	0	9	(9)	
Forward Township		3,376	19.9	170	0	8	(8)	
Findlay Township	29, 28X	5,060	32.6	155	112	7	105	Findlay benefits from having a West Busway station at the airport served by many bus trips. Route 29 serves a small portion of the township along the southern border; Route 29 has a moderate amount of transit service
Frazer Township		1,157	9.4	123	0	6	(6)	
Sewickley Heights		810	7.3	111	0	5	(5)	

** Note: This table includes an evaluation of routes only for municipalities that currently have transit service. See text for proposed methodology to evaluate potential transit service for those municipalities currently without service

