

Technical Memorandum

Date: January 16, 2008, rev. 1
To: Clarksville Gas and Water
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From: Metcalf & Eddy|AECOM
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Subject: Sanitary Sewer Master Plan and Hydraulic Model
Population and Wastewater Flow Projections

This Technical Memorandum (TM) presents draft wastewater flow projections for the City of Clarksville's sewer service area. Wastewater flow projections establish the basis for future sewer system planning; as a result, it is essential that these projections be agreed upon prior to proceeding with the project. This document provides a detailed summary of the projections that were presented to Clarksville Gas and Water (CGW) staff at the Projections Workshop on October 30, 2008. Upon Clarksville's review and acceptance of these projections, alternative collection system strategies to convey the future flows will be developed with input from CGW staff, analyzed, and compared to develop a recommended plan.

INTRODUCTION

The City of Clarksville is the county seat of Montgomery County, located in northern Tennessee. Clarksville is home to Austin Peay University and the Fort Campbell Army Post, which comprises a large portion of Montgomery County. The Post is just 10 miles from downtown Clarksville; a significant number of assigned military personnel choose to reside in Clarksville.

CGW provides sewer service to the City of Clarksville as well as some unincorporated areas in Montgomery County adjacent to the City. Fort Campbell, which has its own collection and treatment systems, is not served by CGW. Figure 1 provides the proposed sewer service area boundary, which is based on the existing sub-basins delineated by CGW. Included in the proposed service area boundary are currently unsewered portions of Planned Growth Areas 1,3, and 4, as well as some rural areas defined in the 2000 Clarksville Montgomery County Growth Plan. Specific exclusions to the service area are Fort Campbell Army Post, East Montgomery Utility District, Woodlawn Utility District, and the areas south of the Cumberland River.

The study area is made up of the current 243 delineated sub-basins. Sub-basins range from 1 acre to 9,200 acres, with a median area of 113 acres. Figure 2 provides the sewer sub-basin boundaries grouped by sewersheds as well as the existing gravity line and force main.

Figure 1: Clarksville Sewer Service Area

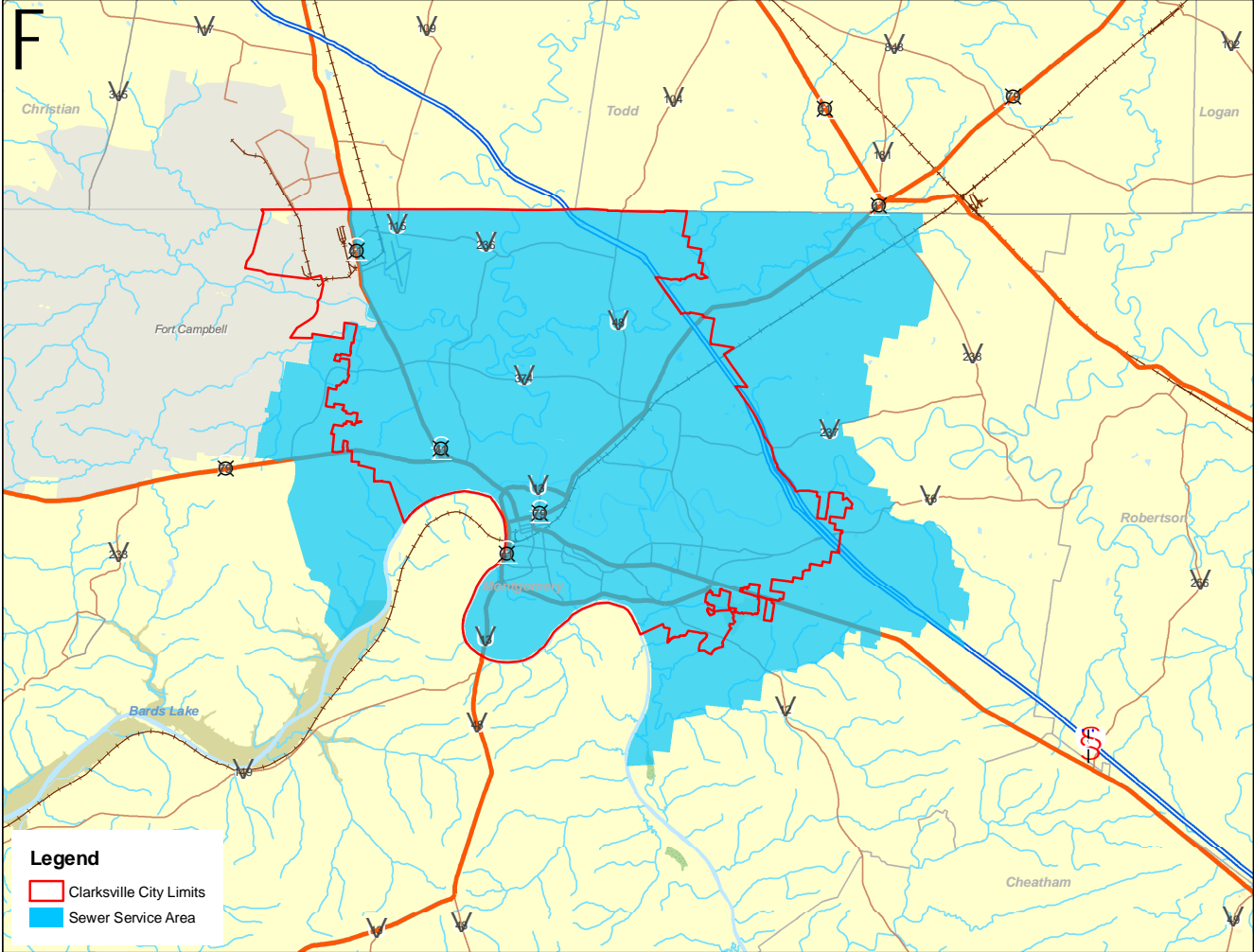
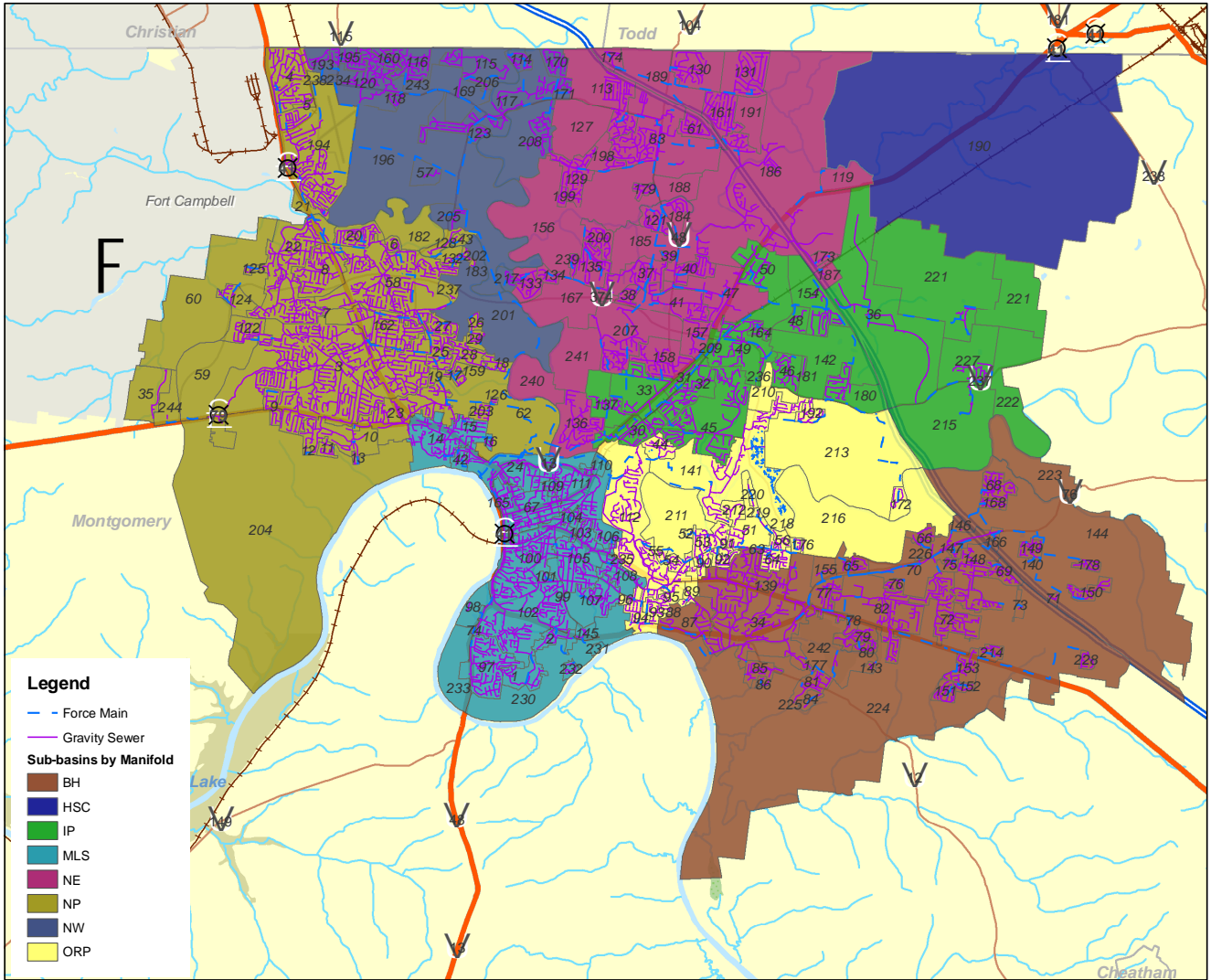


Figure 2: Clarksville Sewersheds



INFORMATION SOURCES

Information from CGW, the Clarksville-Montgomery County (C-MC) Planning Commission, and the U.S. Census was used to establish current wastewater generation statistics and projected population and employment to forecast future flows. The following list of information was used to forecast future wastewater flows:

- Water billing data for year 2007 (monthly usage for each account by billing category)
- Daily influent and effluent flows at the Clarksville wastewater treatment facility for years 2004 – 2008
- Geospatial information
 - Sewer infrastructure - gravity line, force main, pump stations, etc.
 - Roads, political boundaries, planning boundaries
 - Locations of building permits
 - Census block boundaries
- Historical population data
 - Years 2000 through 2007 US Census data (city-, county- and block-level)
 - Clarksville 2003 Land Use Update
- Population and Employment projections provided by Traffic Analysis Zone (TAZ), updated in year 2002 by the Clarksville-Montgomery County Planning Department
- Information on Fort Campbell and associated deployments were provided through conversations with the Fort Campbell Planning Department, as well as the Clarksville-Montgomery County planning department.

POPULATION

Historical and Current Population

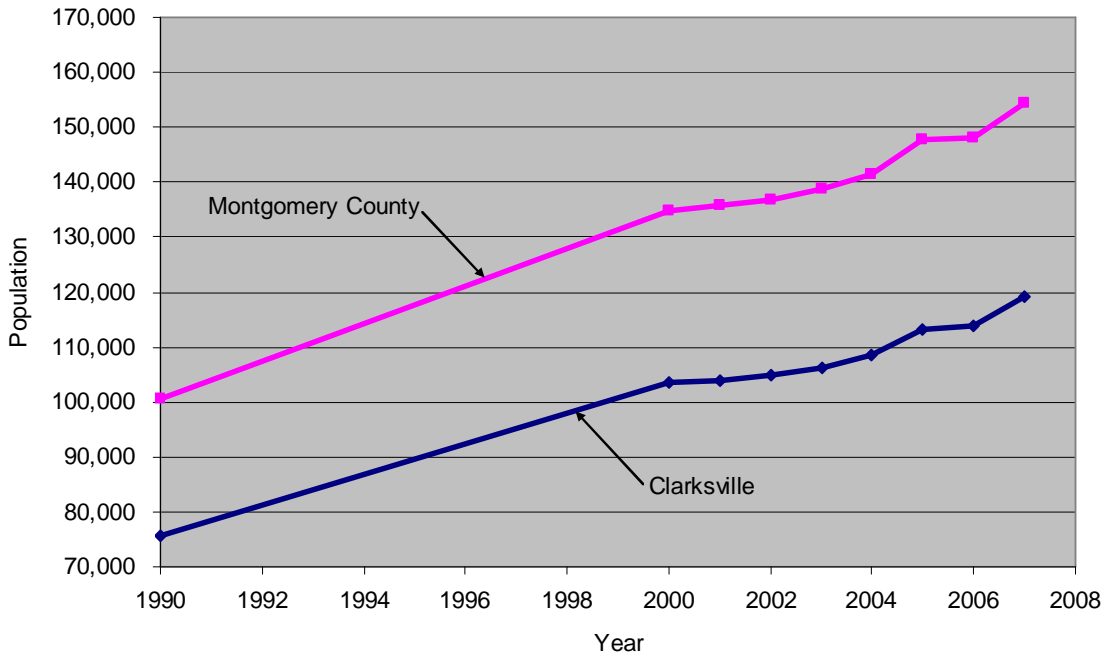
Since 1990, Clarksville and Montgomery County have grown steadily. The rate of growth for the City of Clarksville was 3.7% annually between years 1990 and 2000 and 2.2% annually between years 2000 and 2007. Figure 3 provides historical populations for Clarksville and Montgomery County.

Growth rates between years 2000 and 2007 have varied substantially, between 1% and 5% annually. The presence of Fort Campbell is believed to have a significant effect on recent population estimates. There were approximately 14,000 troops deployed between late 2005 through 2006, and 9,600 troops deployed in the Fall of 2007.¹ With troops deploying and

¹ WBIR News (<http://www.wbir.com/news/local/story.aspx?storyid=45014>) May 9, 2007. “Nearly 10,000 Fort Campbell soldiers given new Iraq orders”

redeploying, there will still be a net of about 8,000 of the total 30,000 troops stationed at Fort Campbell deployed by the beginning of next year.²

Figure 3: Historic Population in Clarksville and Montgomery County

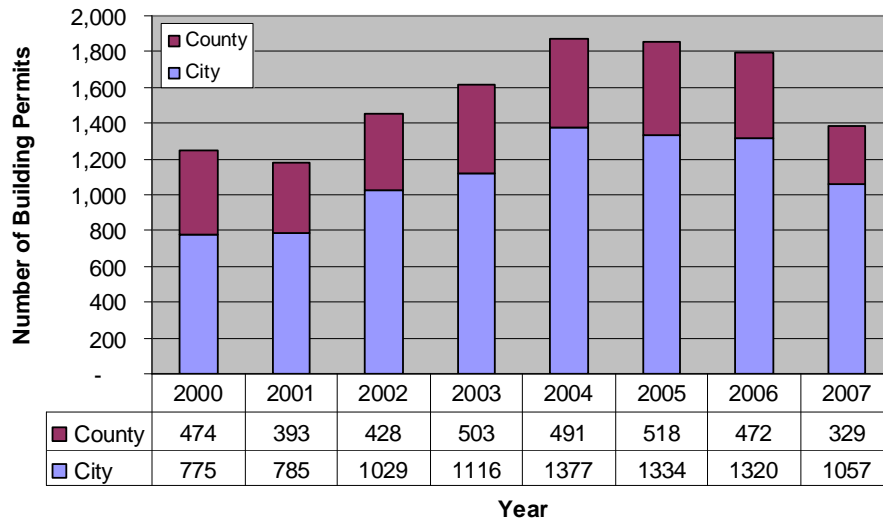


Sources: 1) *Land Use Plan Update Clarksville-Montgomery Co., TN 2003-2023*. 2) *US Census*.

Another indicator of growth is the rate at which building permits are issued. As shown in Figure 4, annual building permits in Clarksville ranged from 775 in year 2000 to a maximum of 1377 in year 2004. The majority of the permits within Montgomery County have been for single-family homes, and were located within Clarksville city limits.

² Conversation with Kathy Grambling, Fort Campbell Public Affairs, 11/25/2008.

Figure 4: Issuance of Building Permits in Clarksville and Montgomery County, 2000-2007



Year 2007 Population

Year 2007 was selected as the base year for defining current sewer use profiles because sewer billing data was provided for that year. Year 2007 population estimates on a detailed level were not available to correlate the sewer billing data for the same year. Therefore, year 2007 populations were estimated for each sub-basin by escalating year 2000 population in proportion to building permits that have been issued between 2000 and 2007. The following methodology was used:

1. Year 2000 census blocks were used as the starting point for the 2007 population estimate.
2. Year 2000 population density was calculated for each census block.
3. In a geospatial analysis, this census block density layer was overlain with the sub-basin boundaries.
4. The census block Year 2000 population densities were then applied to each sub-basin to generate a Year 2000 population for each sub-basin.
5. To account for growth in each sub-basin since 2000, additional population was estimated based on building permits for years 2000 through 2007. According to the year 2006 U.S. census for Clarksville, the average household size in Clarksville was 2.48 people. Thus, for single-family home permits, a population of 2.48 people per permit was assumed. For multi-family home permits, which were predominantly zoned R-4 (multiple family residential district), population was estimated in a number of ways. For some R-4 permits, the number of units per building permit was provided. For other permits, year 2007 aerial imagery was used to estimate number of units. Still for other units, water billing information was used to estimate the number of units. Lastly, if no information was available, an assumed 11.14 units per acre was assumed. Non-residential building permits were not considered to add population. Resulting year 2007 populations are shown in Table 1, summarized on a sewershed basis.

Table 1: Year 2007 Population in Clarksville Sewer Service Area by Sewershed

| Sewershed | 2007 Population |
|-----------------------------|-----------------|
| Beacon Hills (BH) | 18,216 |
| Hemlock Semiconductor (HSC) | 621 |
| Industrial Park (IP) | 7,539 |
| Main (MLS) | 18,144 |
| Northeast (NE) | 23,391 |
| New Providence (NP) | 45,612 |
| Northwest (NW) | 11,641 |
| Old Russelville Pike (ORP) | 10,922 |
| Total | 136,085 |

Population and Employment Forecasts

Traffic Analysis Zone (TAZ) data provided the basis for population and employment forecasts in the Clarksville Sewer Service Area. Estimated population and employment for year 2002 and projected population and employment for year 2030 were provided for each TAZ boundary by the C-MC Planning Department. There are 120 TAZ boundaries that were partially or wholly within the Clarksville sewer service area. Figure 5 presents the TAZ boundaries. These population and employment numbers were converted to densities on a per acre basis, as shown in Figure 5, and overlain with the sub-basins to estimate future population and employment for each sub-basin. Population estimates were made for years 2015 and 2020 by linear interpolation between years 2007 and 2030, and by extrapolation for year 2040. Because no detailed employment information was available for year 2007, years 2007, 2015 and 2020 were linearly interpolated between estimates for years 2002 and 2030. Employment was extrapolated to year 2040. Population and employment projections by sewershed are provided in Table 2. It is important to note that recent developments within the Hemlock Semiconductor (HSC) sewershed have outdated the employment projections for that sewershed. Non-residential flow projections for that sewershed are based on anticipated development of an industrial megasite.

Figure 5: TAZ Boundaries in Clarksville Sewer Service Area

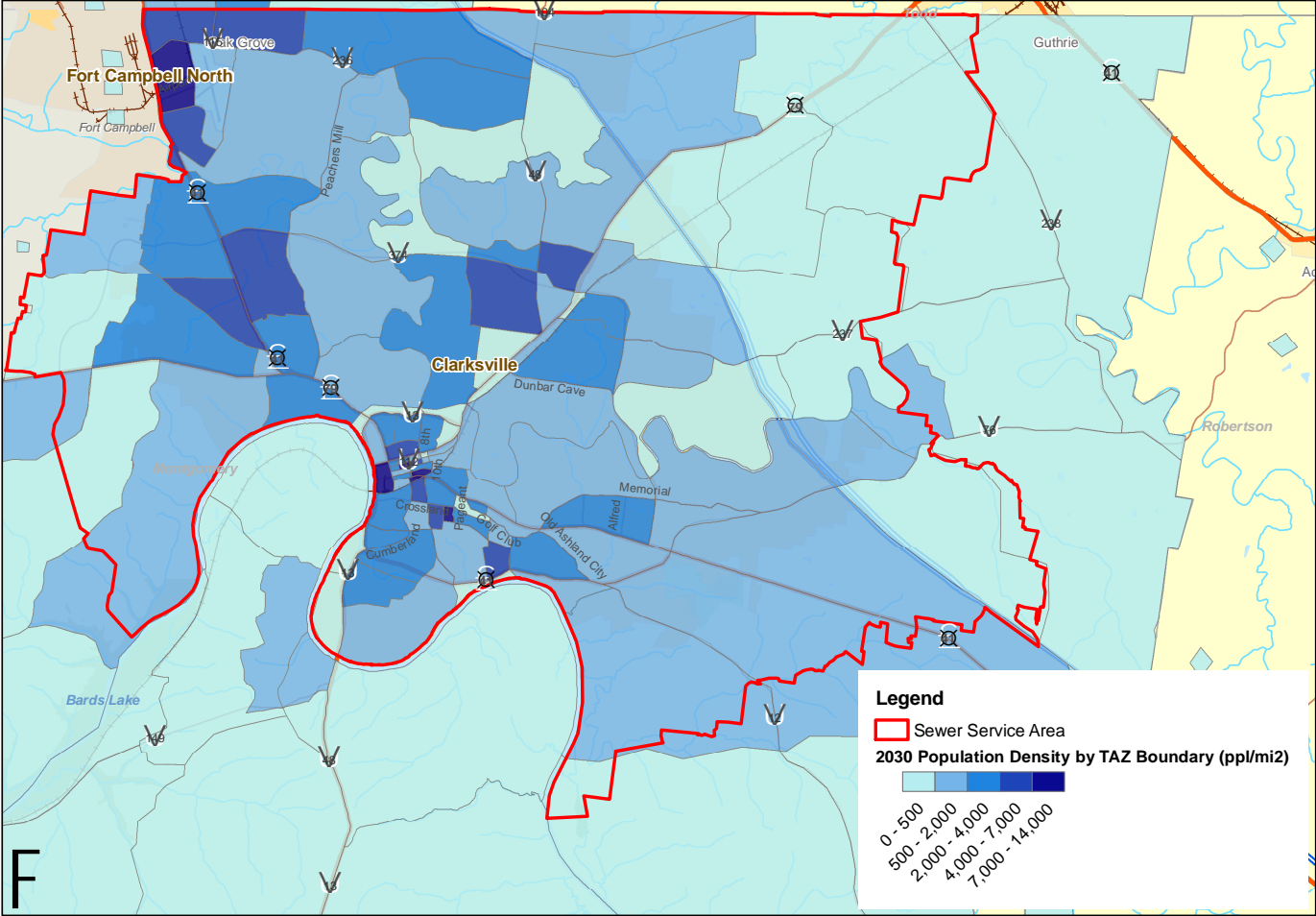


Table 2: Population and Employment Forecasts in Sewer Service Area

| Sewershed | Population | | | | |
|-----------------------------|------------|---------|---------|---------|---------|
| | 2007 | 2015 | 2020 | 2030 | 2040 |
| Beacon Hills (BH) | 18,216 | 21,982 | 24,335 | 29,042 | 33,748 |
| Hemlock Semiconductor (HSC) | 621 | 963 | 1,177 | 1,604 | 2,032 |
| Industrial Park (IP) | 7,539 | 8,771 | 9,541 | 11,081 | 12,621 |
| Main (MLS) | 18,144 | 19,295 | 20,015 | 21,454 | 22,893 |
| Northeast (NE) | 23,391 | 29,823 | 33,843 | 41,883 | 49,923 |
| New Providence (NP) | 45,612 | 52,809 | 57,307 | 66,303 | 75,300 |
| Northwest (NW) | 11,641 | 15,363 | 17,690 | 22,343 | 26,997 |
| Old Russelville Pike (ORP) | 10,922 | 12,949 | 14,216 | 16,750 | 19,283 |
| Total | 136,085 | 161,955 | 178,123 | 210,460 | 242,797 |

| Sewershed | Employment | | | | |
|-----------------------------|------------|--------|--------|--------|--------|
| | 2007 | 2015 | 2020 | 2030 | 2040 |
| Beacon Hills (BH) | 3,750 | 5,048 | 5,860 | 7,483 | 9,107 |
| Hemlock Semiconductor (HSC) | 1,462 | 1,565 | 1,630 | 1,759 | 1,888 |
| Industrial Park (IP) | 15,283 | 16,984 | 18,047 | 20,174 | 22,300 |
| Main (MLS) | 16,797 | 17,547 | 18,015 | 18,952 | 19,889 |
| Northeast (NE) | 5,996 | 7,253 | 8,039 | 9,610 | 11,182 |
| New Providence (NP) | 6,063 | 6,891 | 7,408 | 8,443 | 9,478 |
| Northwest (NW) | 935 | 1,206 | 1,376 | 1,714 | 2,053 |
| Old Russelville Pike (ORP) | 4,659 | 5,615 | 6,212 | 7,407 | 8,602 |
| Total | 54,945 | 62,109 | 66,587 | 75,542 | 84,498 |

Wastewater Flows

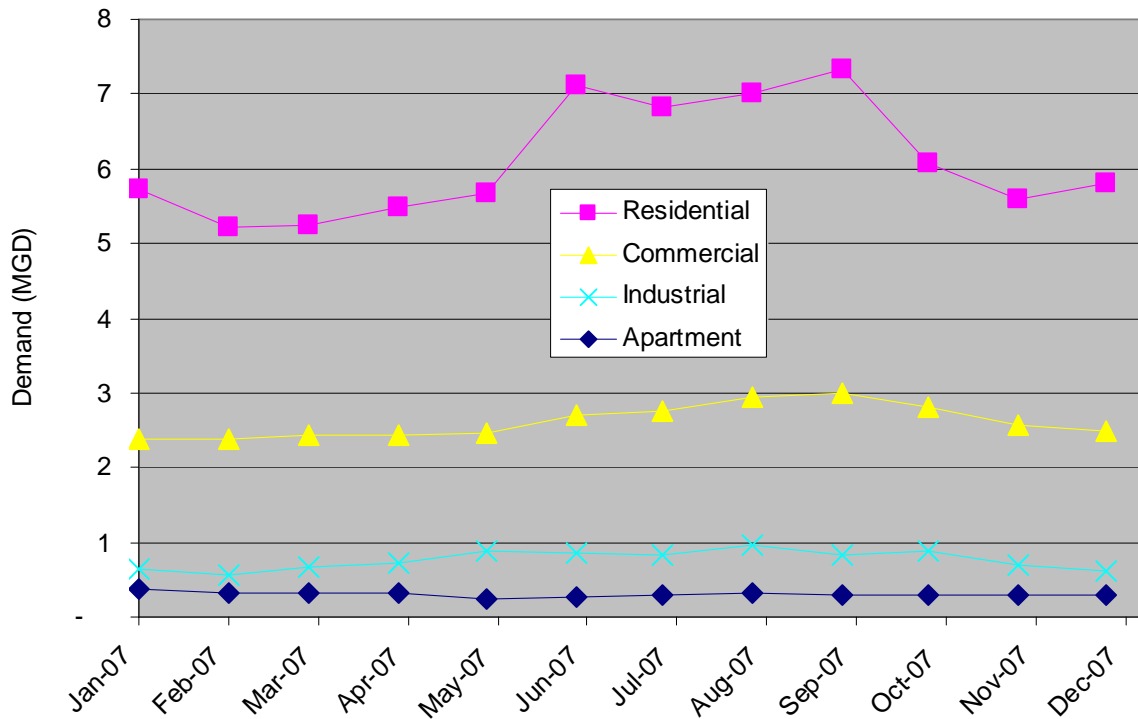
Current Wastewater Flows

When forecasting wastewater flows, it is essential to establish a representative base year on which to project forward. Projections are made by applying new growth to current levels of use. It is quite possible that future levels of use, on a per capita basis, could be reduced through water conservation efforts implemented by local governments, coupled with potential changes in the national plumbing code. However, for purposes of planning, no reductions in per capita wastewater generation will be assumed. An important element of establishing the baseline is to estimate the population that currently has sewer service, as not all the population within the existing service area is currently sewered. The percentage of population in each sub-basin that had service was approximated through analysis of CGW's water billing data for year 2007. Monthly water usage was provided for all accounts with access to sewer service. These records were geocoded within the service area map, based on service address. Any accounts that would not be expected to generate return flows to the sewer were purged from the collection; namely wholesale water sales to other utility districts, yard hydrants, trackable loss or non-revenue water, and accounts that are not

within an accessible distance from gravity sewer line. For the accounts on sewer, water use over the year was tracked and summarized by customer type: residential, apartment, commercial or industrial.

As shown in Figure 6, single-family residential accounts make up nearly two-thirds of use in the area, averaging 6 million gallons per day (MGD) of use over the year. Total average annual water use for all sewer customers was 9.8 MGD for year 2007.

Figure 6: Year 2007 Water Use from Sewered Population in Clarksville



To estimate the amount of wastewater that is returned to the sewer, it was assumed that the minimum water use month returned 100% of water billed to sewer. In other words, it was assumed that there was no outdoor water use in the month of minimum water usage. This is a typical assumption for winter months in the Southeastern United States. For year 2007, the February billing information (which corresponds to January usage) had the minimum usage, at 8.5 MGD. Assuming that the volume of wastewater generated was constant over the year at 8.5 MGD, then return rate of water to sewer is estimated to be 87%. Estimated sewage generation by customer type for year 2007 is provided in Table 3.

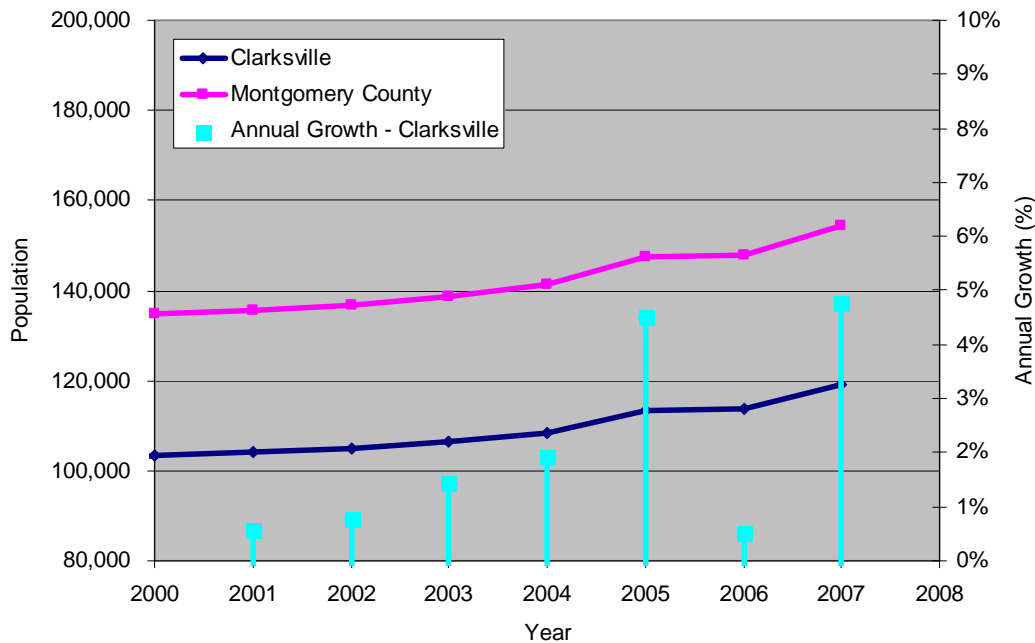
Table 3: Year 2007 Sewage Generation Estimates in Clarksville Service Area

| Customer Type | Number of Accounts | Sewage Generation (MGD) | Percent of Total | Sewage Generation per account (gpd) |
|---|--------------------|-------------------------|------------------|-------------------------------------|
| Single-family residential and individually metered multi-family | 38,620 | 5.23 | 62% | 135 |
| Master metered apartments or multi-family | 86 | 0.33 | 4% | 3,822 |
| Commercial | 2,559 | 2.39 | 28% | 935 |
| Industrial | 23 | 0.52 | 6% | 22,476 |
| Total | 41,288 | 8.5 | | |

Impact of Fort Campbell and Current Deployments

As shown in Figure 7, population growth in the past seven years has fluctuated more than was typical for the prior 7-year period. This is thought to be due largely to troop movement at Fort Campbell, including deployments to and returns from overseas missions. Average and peak month flows at the wastewater plant, as well as average and peak day water pumped from the water treatment facility decreased slightly from year 2005 to 2006, even though Clarksville population grew during that period. The Clarksville-Montgomery County planning department has indicated that traffic volumes have been reduced by 25% in the past 2-3 years due to troop deployments.³

Figure 7: Population Growth in Clarksville and Montgomery County (Years 2000-2007)



³ Conversation with Stan Williams of C-MC Planning Department (telephone) 11/06/08.

The majority of the 30,000 active duty soldiers at Fort Campbell live on the base, which is not served by Clarksville Gas and Water.⁴ However, the troops have a major impact on businesses in the area when they are stateside. Although it is impossible to determine exactly what impact troop deployments have on the generation of wastewater, it is worth incorporating a safety factor into the non-residential flows to account for commercial flows that would be generated by soldiers if they were all stationed at the base. Commercial flows were augmented by an assumed 10%, increasing year 2007 commercial flows to 2.6 MGD.

Percent Served and Per Capita Rate

To establish the percentage of the population in the sewer service area that is currently served, water billing data records for customers on sewer were compared to total population within the service area. To estimate the population with single-family residential accounts, 2.48 people were applied to each active account. The residential per capita rate was estimated by dividing the total single-family residential wastewater generation (in gallons per day) by the number of people with the single-family accounts, resulting in a per capita generation rate of 55 gallons per capita per day, or gpcd. Estimation of this per capita rate was used for two purposes: 1) the rate was used to estimate the population with multi-family accounts, as described below, and 2) the rate was used to forecast future residential generation rates, given future population forecasts.

Estimating the population on multi-family or apartment accounts was less direct. The number of people on one multi-family account could vary substantially; thus, no predefined population per multi-family connection could be assumed. For this reason, the per capita usage that was estimated for single-family accounts was used to deduce the population associated with multi-family accounts. The total wastewater generation from active multi-family accounts was divided by 55 gpcd to estimate the population served on multi-family accounts.

Total sewered population is simply the sum of the single-family account population and the multi-family account population. Percent sewered was calculated on a sub-basin level by dividing sewered population by total population. Table 4 provides a summary of sewered populations by sewershed.

Table 4: Year 2007 Clarksville Percent Sewered Estimates by Sewershed

| Sewershed | 2007 Population | 2007 Sewered Population | % Sewered |
|-----------------------------|------------------------|--------------------------------|------------------|
| Beacon Hills (BH) | 18,216 | 12,807 | 70% |
| Hemlock Semiconductor (HSC) | 621 | 0 | 0% |
| Industrial Park (IP) | 7,539 | 5,776 | 77% |
| Main (MLS) | 18,144 | 13,987 | 77% |
| Northeast (NE) | 23,391 | 18,102 | 77% |
| New Providence (NP) | 45,612 | 36,654 | 78% |
| Northwest (NW) | 11,641 | 7,760 | 67% |
| Old Russelville Pike (ORP) | 10,922 | 7,669 | 70% |
| Total | 136,085 | 101,754 | 75% |

⁴ Conversation with Chris Brown of Fort Campbell's Planning Department (telephone) 11/06/08

For non-residential flows, 100% of business and industry in the service area was assumed to have sewer service. The non-residential usage based on billing records was then translated to a unit basis: gallons per employee per day (gped). Expressing the generation rate on a per employee basis allows for the projection of future non-residential flows, given forecasted employee growth. The number of employees in the sewer service area for year 2007 was linearly interpolated from the TAZ data, which provided an estimate for year 2002 and a forecast for year 2030. As shown in Table 5, the total number of employees in the sewer service area in 2007 was estimated at 54,945 employees, correlating to a unit wastewater generation rate of 53 gped (not including the adjusted commercial flow from Fort Campbell).

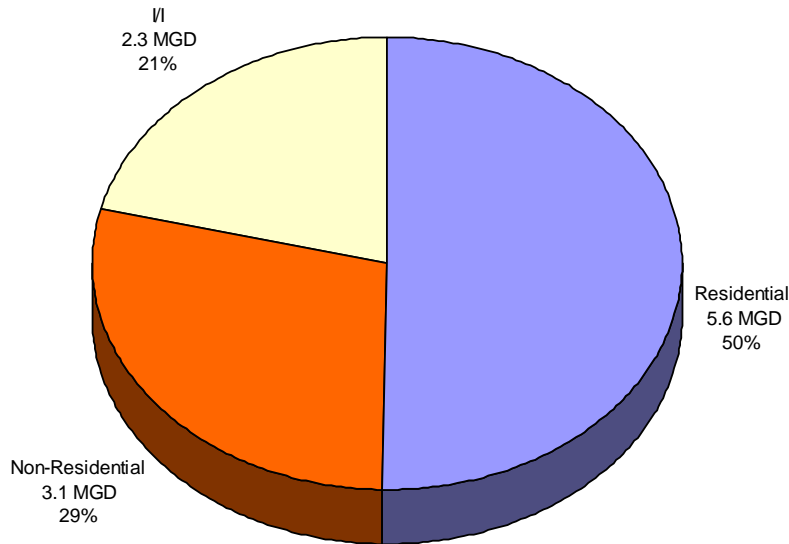
Table 5: Year 2007 Clarksville Sewer Service Area Employee Estimates

| Sewershed | Number of Employees (2007) |
|-----------------------------|----------------------------|
| Beacon Hills (BH) | 3,750 |
| Hemlock Semiconductor (HSC) | 1,462 |
| Industrial Park (IP) | 15,283 |
| Main (MLS) | 16,797 |
| Northeast (NE) | 5,996 |
| New Providence (NP) | 6,063 |
| Northwest (NW) | 935 |
| Old Russelville Pike (ORP) | 4,659 |
| Total | 54,945 |

Inflow and Infiltration

To estimate the inflow and infiltration (I/I) component of the total wastewater flow to the WWTF, sanitary flow estimated from billing data was compared to measured flows into the WWTF over year 2007. Because year 2007 rainfall was a dry year in terms of rainfall (45 inches for year 2007 compared to a long-term normal of 52 inches), an adjustment was made to normalize flows to a typical rainfall year. Year 2004 was the most recent year with normal rainfall with a total of 56 inches. Thus, the year 2004 total flows were used to estimate the I/I contribution to the total flow for year 2007 while increasing the year 2004 flow of 10.3 MGD to account for additional sanitary flow from growth since 2004. This was done by considering that Clarksville had a population growth of 9,000 people between years 2004 and 2007. An additional 55 gpcd was added to the flow per additional person, or 0.495 MGD. To account for additional non-residential flow, a flow of 0.247 MGD was assumed, or half of the additional residential flow. The total year 2007 flow, adjusted for normal rainfall was then calculated by summing these components as follows: $10.3 + 0.495 + 0.247 = 11$ MGD. For a year 2007 sanitary flow of 8.7 MGD (including the Fort Campbell adjustment), the annual average I/I contribution to the total system wastewater flow is estimated to be 2.3 MGD, or 21% of total flow. Figure 8 provides a pie diagram of adjusted year 2007 flows.

Figure 8: Adjusted Year 2007 Annual Average Day Flows to WWTF



Flow Forecasts

Flows were projected to year 2040 under the following assumptions:

- Although per capita residential flows were estimated to be 55 gpcd, future per capita rates for all residential flows were estimated using a generation rate 60 gpcd. This slightly higher generation rate adds a small safety factor for future flows.
- The population in the sewer service area that is currently unserved is assumed to remain unserved for the duration of the planning period. Although some residents currently on septic systems will undoubtedly convert over to sewer in the future, it is felt that the number of conversions and resulting additional flows to sewer will be statistically insignificant.
- All new population within Clarksville city limits is assumed to be connected to sewer. All new developments within the service area but outside of the city limits will be considered for sewer service on an individual basis.
- All employees in the future, with the exception of employees in the HSC sewershed, are assumed to generate the same flow rate as is currently generated: 53 gallons per employee per day (gped). Commercial and industrial flows were combined into one category of non-residential. Employees within the HSC sewershed will generate an estimated 640 gallons per employee per day (gped).
- Per CGW direction, a non-residential flow was assumed for the Hemlock Semiconductor proposed industrial site. Average flow is estimated to be 120,000 gpd by year 2010, with an ultimate flow of 1.0 MGD by year 2016. This flow will likely be served by an offsite regional lift station tied to the Steelstock lift station in the Industrial Park manifold.

- The additional non-residential component attributed to Fort Campbell soldiers was assumed to stay constant over the planning period. Fort Campbell’s planning department indicated that the base expects to remain at current levels of personnel for the foreseeable future.
- In any given sub-basin, if flows projected from future populations and/or employment were lower than current flows as derived from billing data, the current flows were assumed to stay constant, rather than to decrease over the planning period.
- I/I, as a percentage of total annual average flow, was assumed to stay constant at 21% of total flow over the planning period. Although reduced I/I is expected in some areas from rehabilitation efforts, those gains could be offset by aging infrastructure in other parts of the system. A portion of the downtown area is currently combined sewer. If the storm and sanitary sewers were separated, I/I would be greatly reduced. It is important to note that these I/I estimates will not be used in designing improvements to the conveyance system. Calibration of the hydraulic model is required to determine peaking conditions based on system response to wet weather events.

Based on the assumptions listed above, annual average day wastewater flows are expected to approach 25 MGD by year 2040 within the Clarksville service area. Figure 9 provides flow forecasts through year 2040. Projected flow by sewershed is provided in Table 6.

Figure 9: Clarksville Service Area Flow Forecasts (AAD-MGD)

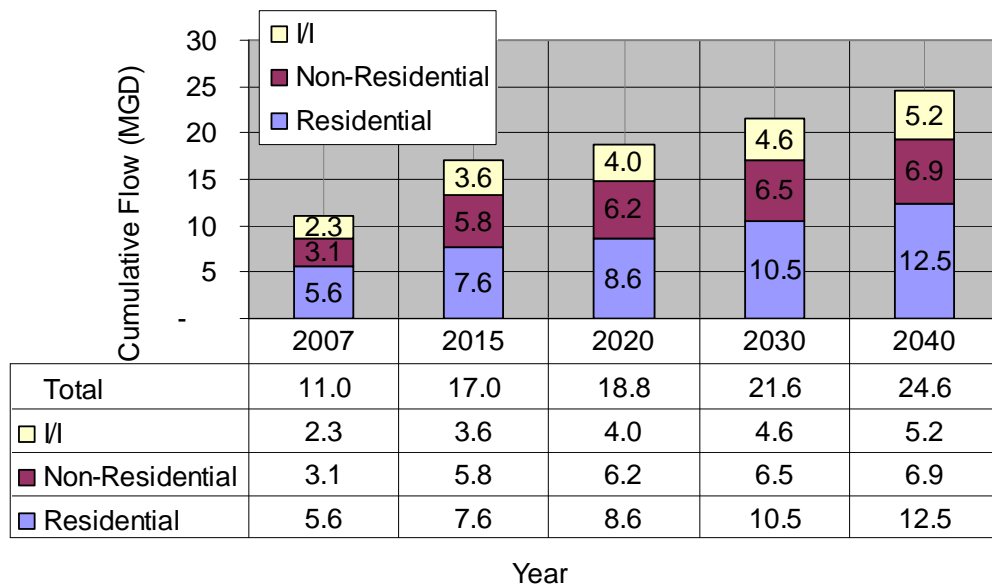


Table 6: Sanitary Flow Projections by Sewershed (AAD-MGD)*

| Manifold | Year 2007 | Year 2015 | Year 2020 | Year 2030 | Year 2040 |
|-----------------------------|-----------|-----------|-----------|-----------|-----------|
| Beacon Hills (BH) | 0.96 | 1.38 | 1.56 | 1.91 | 2.26 |
| Hemlock Semiconductor (HSC) | - | 0.85 | 1.12 | 1.15 | 1.18 |
| Industrial Park (IP) | 0.89 | 1.71 | 1.81 | 1.99 | 2.18 |
| Main (MLS) | 1.55 | 2.05 | 2.10 | 2.22 | 2.35 |
| Northeast (NE) | 1.72 | 2.34 | 2.61 | 3.13 | 3.66 |
| New Providence (NP) | 2.36 | 3.16 | 3.44 | 4.02 | 4.59 |
| Northwest (NW) | 0.45 | 0.77 | 0.92 | 1.21 | 1.51 |
| Old Russelville Pike (ORP) | 0.78 | 1.14 | 1.24 | 1.44 | 1.63 |
| Total | 8.7 | 13.4 | 14.8 | 17.1 | 19.4 |

* Does not include I/I.

Treatment capacity is often based on the maximum month average day flow. Table 7 shows a summary of flow at the treatment facility from the last four years, with maximum month average day to average annual day ratios ranging from 1.22 to 1.32, averaging 1.26.

Table 7: Maximum Month Average Day and Annual Average Day Flows at Clarksville WWTF

| Year | Maximum Month Average Day Flow (MMAD-MGD) | Annual Average Day Flow (AAD-MGD) | Ratio: MMAD/AAD |
|---------|---|-----------------------------------|-----------------|
| 2004 | 13.20 | 10.79 | 1.22 |
| 2005 | 13.58 | 10.58 | 1.28 |
| 2006 | 11.66 | 8.82 | 1.32 |
| 2007 | 11.59 | 9.47 | 1.22 |
| Average | | | 1.26 |

This peaking factor was used to estimate future maximum month average day flow to the treatment facility (or facilities). Assuming a maximum month to annual average peaking factor of 1.26, the year 2040 maximum month average day flow would be 31 MGD. Table 8 provides a summary of annual average and maximum month average day flows for each time interval.

Table 8: Forecasted Maximum Month Average Day Flows in Clarksville Sewer Service Area

| Year | Annual Average Day Flow (AAD-MGD) | Maximum Month Average Day Flow (MMAD-MGD) |
|------|-----------------------------------|---|
| 2007 | 11.0 | 13.9 |
| 2015 | 17.0 | 21.4 |
| 2020 | 18.8 | 23.6 |
| 2030 | 21.6 | 27.3 |
| 2040 | 24.6 | 30.9 |