4.0 Basis of Capacity Analysis

Hydraulic modeling is used to determine the hydraulic capacity of each pipe segment in the system. Pipe capacity is compared to the actual or predicted flow loads to determine if sufficient capacity exists. The following sections discuss the various assumptions related to the flow loads to be conveyed and the calculation of pipeline capacity. Of special note is that these calculations are based on the underlying assumption that the pipe is clean and unobstructed.

4.1 Flow Rates

To determine the operation of the system under a variety of flow conditions, three primary flow scenarios were considered. These are:

(1) Average Dry Weather Flow
(2) Future Dry Weather Flow
(3) Future Wet Weather Flow

The hydraulic model requires the flows to be described as an average daily volume and as an hourly variation. This allows the system capacity to be tested at all flow variations from low to peak. The hourly variation is also called the diurnal curve or shape.

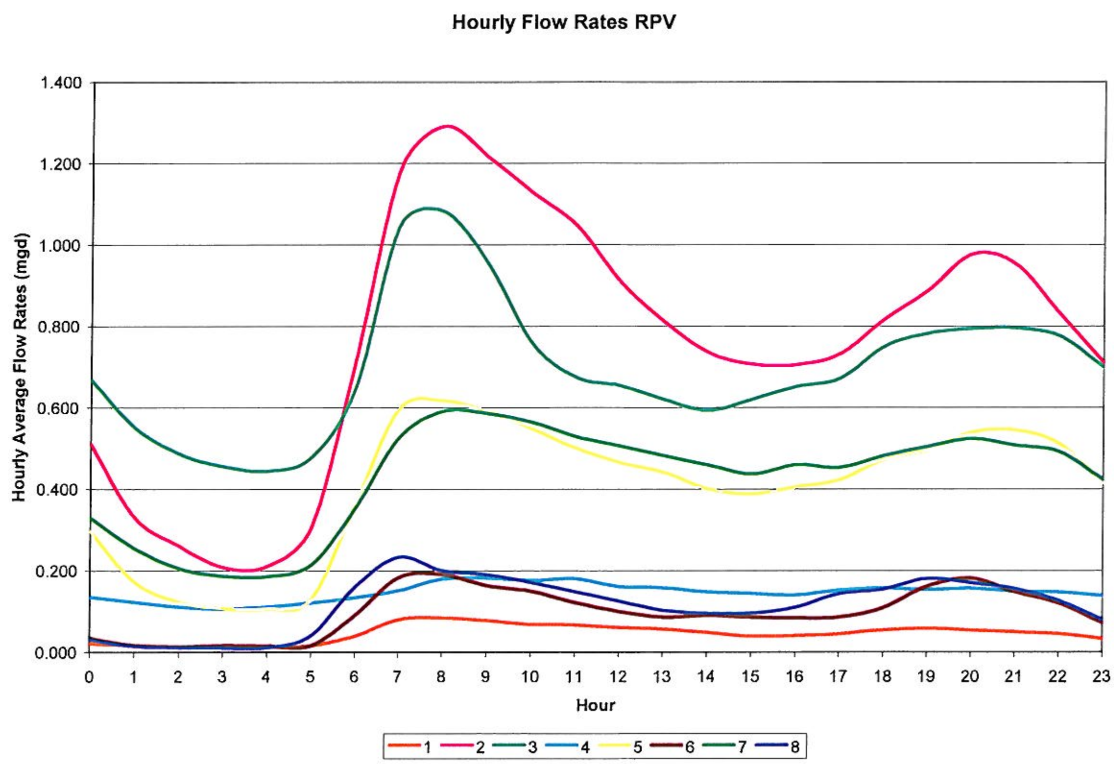
To determine the Average Dry Weather flow, the 2004 flow measurement data was collected and analyzed at eight (8) key locations in the City for a period of one week. The eight locations sampled represent the general character of flow throughout the entire system. Approximately 60% of the piping system was measured through these eight locations.

Table 4-1 Flow Measurement Data (From 7-Day Average)

Meter ID	Flow Rates (mgd)			Peaking Factor
	Maximum	Minimum	Average	
1	0.083	0.011	0.044	1.9
2	1.290	0.208	0.756	1.7
3	1.080	0.444	0.693	1.6
4	0.180	0.105	0.145	1.2
5	0.617	0.105	0.401	1.5
6	0.190	0.012	0.096	2.0
7	0.590	0.184	0.426	1.4
8	0.232	0.009	0.114	2.0

Note that this data is derived from the seven day average. In addition to defining the general characteristics of each basin the flow data is used to determine the hourly variation of flow that is observed in each basin. This is a single characteristic that is analyzed for consistency across the entire set of basins that were measured. The following graph shows how the flow varied throughout the day for each of the sites.

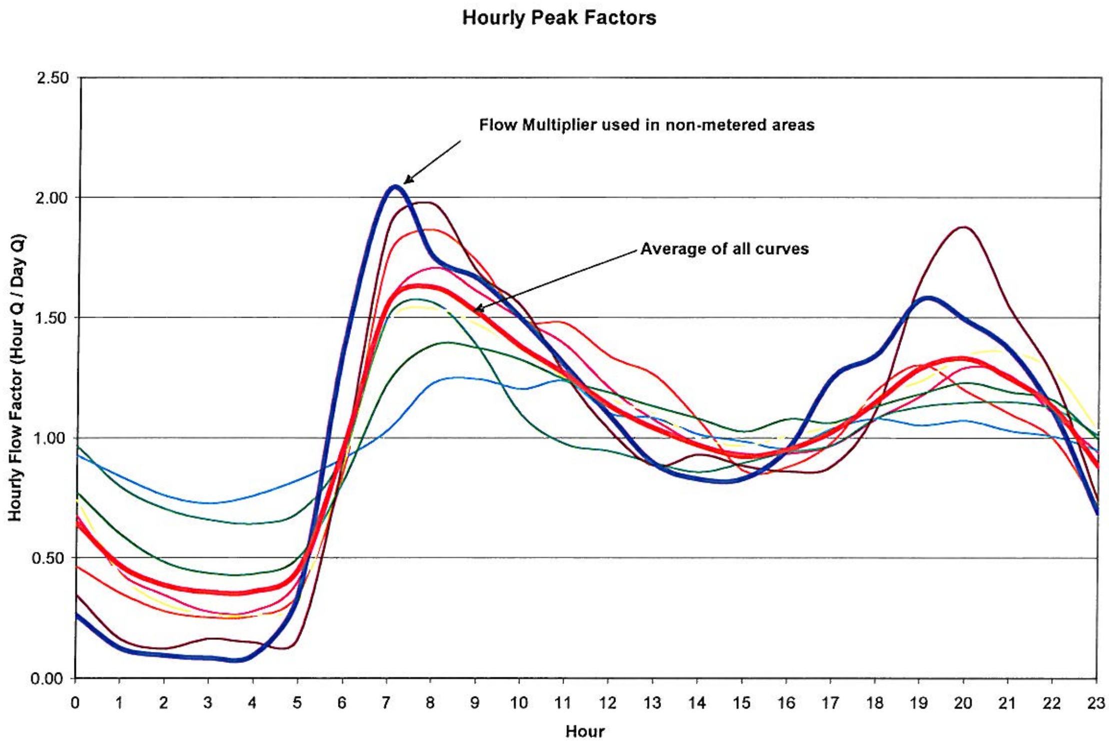
Figure 4-1 Flow Measurement Results



The Y values of the graph are the hourly flow rates measured in millions of gallons per day (mgd); the X axis is the time of day. Due to the wide variation in the actual flow measured at each flow meter the hourly flow factor (HFF) is calculated for each basin.

The hourly peaking factor is calculated by dividing the average hourly flow rate by the average daily rate. In this way, all measured system flow variations can be directly compared. This is done to determine if there is a single diurnal pattern that could be used for all basins. The following graph shows the hourly peaking factors for all sites.

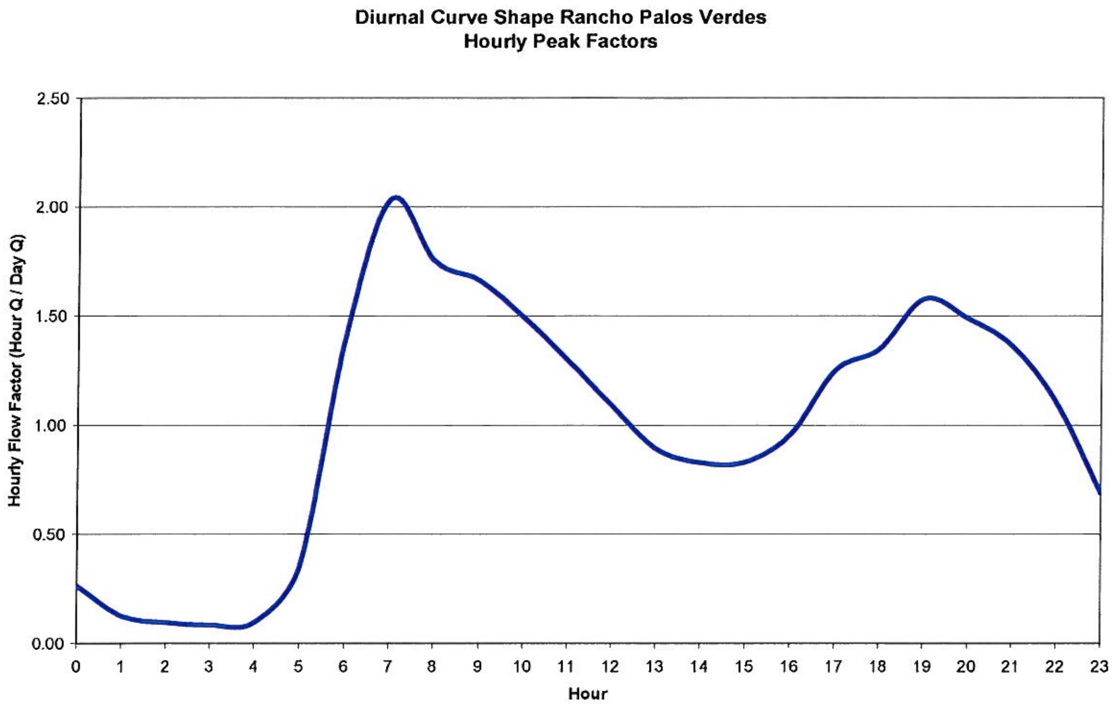
Figure 4-2 Hourly Peaking Factor



The red line is the average of all flow curves. Because of the variability of the measured curves the average of all curves was not used as the default pattern. This would have resulted in a peak factor of 1.62 which is significantly less than the county peaking factor of 2.0.

The peak flow factor for the Average Dry Weather Flow is then 2.0 for each parcel in the City. To determine the Future Dry Weather Flows census projections were used to describe the increase in population expected over the next 20 years. The population is expected to increase by only 1.07% in this time. To assess the future dry weather performance of the system a peaking factor of 1.017 was multiplied times the existing system flows. This increase is insignificant compared to the impact of simulating wet weather flows. Wet weather flows enter the system through direct or indirect connections with the surface. This is known as inflow and infiltration respectively. Inflow has a significant impact on the system capacity. Since no wet weather flow records are available for the collection system, wet weather conditions were simulated by using a multiplier of 2.5 times the average dry day flow rates. This is a widely accepted multiplier when combined with the hourly peak flow rate. This safety factor simulates each connection in the system at a load of 5.0 times (peak hour multiplier of 2.0 X wet weather multiplier of 2.5) the average dry day flow. The following figure shows the diurnal flow pattern that was used to assess system performance in the Average Dry Day condition.

Figure 4-3 Diurnal Hydrograph for RPV

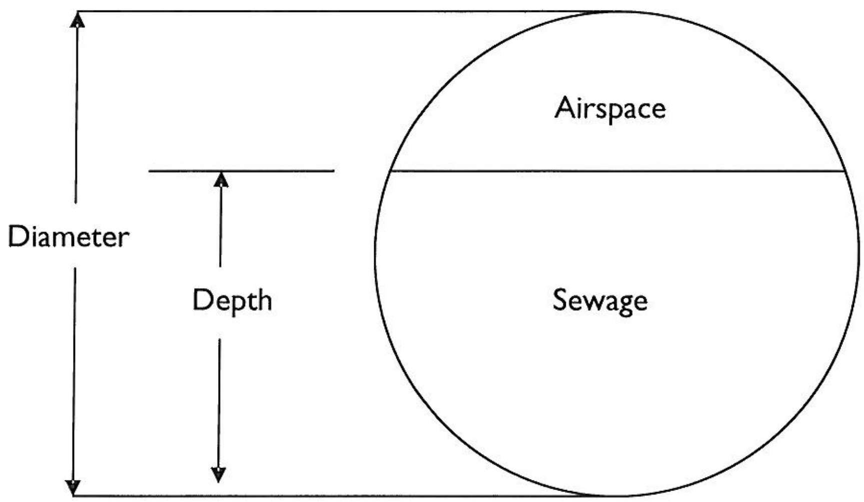


4.2 Pipeline Performance Criteria

Sewer collection systems are designed to use gravity to convey the fluids from homes and businesses to the wastewater treatment plant. Sewer pipelines are designed to operate in free flow conditions which assures that sufficient airspace is provided to maintain oxygen in the system. This airspace also provides an extra buffer for additional flows that may come from rainfall or unanticipated increases in flow. To provide this buffer, sewer pipes are regularly designed to operate at a depth that is less than the diameter of the pipe. The ratio of depth to diameter is used as the primary indicator of gravity pipeline capacity.

The depth is calculated using the Manning's equation for full and partially full pipes. The Los Angeles Bureau of Engineering (BOE) standards require that the depth/diameter ratio must be less than or equal to 0.75 for average dry weather flow in pipes larger than 12 inches and less than or equal to 0.50 for smaller pipes. These are design standards applied to new pipe. Considering existing pipe in place, during the simulated wet weather a pipe depth to diameter ratio of 0.9 is allowed for determining pipe capacity. The following figure shows the depth to diameter ratio used for determining hydraulic capacity.

Figure 4-4 Depth/Diameter Ratio



In addition to the depth/diameter criteria for capacity, the standards also require that the flow achieve a velocity of three feet per second (3 fps). This velocity insures that the system is adequately cleaned and that solids are regularly flushed from the system. The overall grade of the Rancho Palos Verdes gives velocities that are generally much higher.

In the measurement of system performance, a capacity analysis was performed based on the average dry weather flow (ADWF) and predicted wet weather flows of 2.5 times the ADWF. For Wet Weather flow scenario, the depth to diameter ratio was raised to 0.9.

As is shown in Figure 4-5, when the depth to diameter ratio is 0.9, the pipe is at a capacity of slightly less than maximum open channel flow and slightly more than full pipe capacity. At full pipe capacity the actual capacity is slightly less due to the additional friction from the top of the pipe. At flow regimes between a d/D of 0.9 and 1.0 flow is inherently unstable, for these reasons the maximum pipe capacity is calculated at d/D = 0.90.

In other words if the hydraulic model predicts a pipe segment d/D of more than 0.9 then the capacity of that pipe segment is deficient. Hydraulic capacity deficiencies are addressed by creating projects of closely grouped pipes into logically constructed projects.

Figure 4-5 Flow Depth Relationships