Environmental Utilities Department
Engineering Division
2005 Hilltop Circle
Roseville, California 95747

Date: September 18 2007

Subject: Area E Evaluation per Element VIII of the California State Water Resources Control Board Order No. 2006-0003, Statewide General Waste Discharge Requirement (WDR) for Wastewater Collection Agencies

Attached, please find the Technical Memorandum titled: *Area E Sewer Capacity Evaluation*. This technical memorandum was prepared by the Environmental Utilities Department, Engineering Division to further evaluate potential capacity deficiency in Area E as defined in Appendix H-1, Parts (c) and (d). The findings presented in this Technical Memorandum addresses the capacity deficiency issues and therefore establishes compliance with Element VIII of the California State Water Resources Control Board Order No. 2006-0003, Statewide General WDR for Wastewater Collection Agencies.

The analysis conducted and processes used are included herein.

The conclusions obtained, per our analysis, are summarized as follows:

1. Under the conditions analyzed, Area E will not surcharge during a design storm event at ~~buildout~~build out.
2. There are no capacity issues associated with Area E
3. No relief sewer improvement project is required in Area E.

With regards to the Roseville Model Project, at this time, there have not been any CIP projects identified.

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City of Roseville Wastewater Collection System Study

TASK 3. RMC SYSTEMS EVALUATION REPORT/TM 3b – AREA E EVALUATION

TITLE: AREA E SEWER CAPACITY EVALUATION

EXECUTIVE SUMMARY

The purpose of this technical memorandum (TM) is to implement recommendations provided by RMC regarding Area E, located within Basin 7 in the City of Roseville service area. Per the South Placer Wastewater Authority (SPWA) Wastewater and Recycled Water Systems Evaluation Project (TM No. 3b), RMC identified potential sewer capacity constraints in Area E and recommended the City conduct further infiltration and inflow (I/I) studies to evaluate this area prior to considering the relief sewer improvement project with a proposed budget cost of $1,888,000. This TM presents the results of the I/I evaluation.

RMC performed a capacity analysis of the collection system using a computerized hydraulic model to simulate flow conditions in the system. The model was used to determine peak hydraulic flows in each pipeline segment and compare them to the available capacity. Capacity shortcomings were identified by RMC but further investigation of the area was recommended prior to any potential improvements.

Approach and Analysis - The model determines peak flows using a combination of unit wastewater flow criteria and peak rainfall dependent infiltration and inflow (I/I) criteria. The analysis presented herein was conducted by evaluating the sensitivity of the model to varying R values and to determine if a reduced R value would result in lesser surcharging or lesser required improvements to the system. Further, the system in Basin 7 was evaluated to determine if a reduced R value is justified.

Determination of R Value – To assess the validity of the model analysis, the magnitude of pipe flow was measured in the field during a rainfall event. The rainfall event was simulated in the model and the resultant depth ratio measured in the field was compared to the modeled depth ratio to gain a correlation. I/I data included in the model was adjusted slightly to determine the differences in pipe flow depth. The sensitivity of these adjustments to variations in depth was determined. Visual field inspections of actual pipe flow were conducted during storm events between February and May 2007. The winter of 2007 did not yield significant storm intensities or rainfall volumes so the storms observed were not comparable with the storms RMC utilized (March 2005 storms) for calibration of the model during the RMC study. The measured storm (winter 2007) intensity was approximately 4 times less than the March 2005 storms. Regardless, the data obtained from the storm (observed between February and May 2007) with the highest peak intensity was used to calculate pipeline hydraulic values [referred to as the depth-to-diameter (d/D) ratio]. These values were compared to capacity values obtained from hydraulic model simulations. Multiple model simulations were performed with varying R values (ranging from 0.5 to 3) to calibrate the R value for the storm event measured to that used with the model. Five pipe segments from Area E were selected for the

study. The hydraulically modeled d/D was found to be larger than the d/D from the visual field inspections (approximately in the range of 122-200% greater) when an R value of 3 was used. This difference progressively reduced as smaller R values were used. For the final simulation with an R value of 0.5, the hydraulically modeled d/D was still larger than the field obtained d/D data by approximately 13 to 55 percent. The trend of a reduced d/D differential correlating to a reduced R value indicates that a very small R value is likely reflective of the system in Area E. This difference is likely a reflection of an overestimated R value as determined by RMC in their study.

Sensitivity of R Value to Surcharging – A sensitivity analysis was conducted using the City's buildout model for peak wet weather flow. This analysis was conducted to determine whether the R value was appropriately responding to the hydraulic activity in the collection system and subsequently to correlate the R value with the potential to surcharge the system. The R factor for Basin 7 was varied, and the corresponding d/D obtained was observed and noted. Values of R ranging from 0.5 to 3.0 were used. These maximum and minimum values were used since 3.0 was the value utilized for Basin 7 when the model was calibrated in the RMC study and 0.5 was the lowest value utilized for the City's basins per the RMC study. The model results indicate that all five segments selected for the evaluation would surcharge at an R value of 3 and d/D values would decrease with a corresponding decrease in the R value. Below an R value of 2.5, none of the segments surcharged.

Correlation to Age of Infrastructure - The approximate age of infrastructure in the various basins was identified and compared with the R values utilized in the RMC study for the respective basins. Based upon a qualitative inspection, the following general trends were noted.

- Infrastructure installed prior to the 1960s had an R value of 3 or greater
- Infrastructure installed from the 1960s to 1980s had values in the range of 0.75 to 1
- Infrastructure installed from the 1990s to 2000s had the lowest R values ranging between 0.5 and 1.

Area E infrastructure was constructed within the 1980s to 1990s and would be expected to produce an R value between 0.5 and 1 as RMC modeled throughout the system. However, RMC modeled an R value of 3 in Area E which is significantly higher than the remainder of the system. This indicates that the surcharging in Area E, described in the RMC study, is likely based on unreasonably high I/I.

Interviews were conducted with the City's wastewater collection system staff to obtain an event history for Area E. Staff indicated that there had not been any history of surcharging in Area E.

Conclusions & Recommendations - The following conclusions were derived from this analysis:

- Peak flows and related surcharging are directly related to the R value as used in the model. Model sensitivity analysis showed that below an R value of 2.5, none of the segments in Basin 7 surcharged.

- The significant difference between visually obtained d/D values in comparison with d/D values hydraulically modeled is likely due to an overestimated R value utilized for Basin 7. In this study, the R value was reduced to 0.5 to bring the modeled and visually obtained values within a 55 percent difference. The R value of 3 utilized by RMC for Basin 7 can likely be reduced.

- Qualitative observations of the correlation between infrastructure age and R values for the entire City showed that the utilization of an R value of 0.5 to 1 for Basin 7, based on the infrastructure installation time frame, would provide much more consistency with the R values utilized for the City's basins per the RMC study.

- Interviews conducted with wastewater collection system staff indicated that there had not been any known surcharging events in Area E during the winter of 2005, when the RMC study was conducted.

- Even though a specific R value could not be selected for Basin 7, based on the above observations combined with engineering judgment, the R value is more likely in the range of 0.5 to 1.0 and quite possibly less than 0.5.

- Area E is not likely to surcharge from a design storm event provided the R value for the area is 2.5 or less. Since the analysis indicates the R value for Area E to range from 0.5 to 1.0, and quite possibly less than 0.5, it is not likely that surcharging will occur from a design storm event.

- With the absence of any potential surcharge conditions under a design storm event, no improvements are required at this time.

- No conclusion has been drawn for why RMC needed to simulate an R value of 3.0 in Area E. RMC concluded in TM 3B that extraneous inflow may have occurred through an open manhole causing a higher calibrated flow from the storm. Such a condition was not evident during our field walks.

- Staff should accelerate the condition assessment of pipe segments in Area E by performing video inspection and defect coding to investigate any potential for increased I/I not observed by this evaluation.

BACKGROUND

This TM is to implement recommendations provided by RMC regarding Area E, in a report titled TM3B. Area E is located in the Pleasant Grove Wastewater Treatment Plant basin in the City of Roseville along McAnally Drive. The entire City of Roseville service area is subdivided into drainage basins. The study area for this analysis (Area E) falls within Basin 7. This study area was selected as the domain for the analysis. Figure 1 shows a map of the study area.

Per the South Placer Wastewater Authority (SPWA) Wastewater and Recycled Water Systems Evaluation Project (TM No. 3b), RMC identified potential sewer capacity constraints in Area E and recommended that the City conduct further I/I studies to evaluate this area prior to considering an improvement project in Area E, to extend over a 4,000 foot segment from MH D03-100 to D02-353. The proposed budget cost for this improvement project was $1,888,000.

This TM is presented in four parts.

The first part includes verifying model calibration: this involves analyzing data obtained from visual field inspections and comparing this data with hydraulically modeled data to determine the accuracy of I&I assumptions used in the hydraulic model.

The second part is a model sensitivity analysis, which was conducted to determine the models sensitivity to d/D values for varying R values in Basin 7.

The third part involves conducting a qualitative inspection of the correlation between infrastructure age and R values (defined in the following paragraphs). This inspection is to determine whether the R value utilized by RMC for Basin 7 is consistent with R values used for other similar basins in the City.

The final part of this TM includes conducting interviews with the City's wastewater collection system staff to obtain an event history for Area E.

Legend

- Manholes
- Mains

Study Area Location Map –
Pipe Segment from MH D03-100 to D02-356
Figure 1

N
W E
S

1 inch equals 300 feet

The magnitude of the resulting rainfall dependent infiltration and inflow (RDII) response is typically described by the percentage of the rainfall volume (called the R value or R factor). The R value can vary from storm to storm, depending on such factors as the degree of soil saturation (due to antecedent rainfall) prior to the storm event. R values also vary by area depending on the age and condition of the sewer system, depth of pipes, pipe materials, and hydrogeologic and topographic characteristics. The H2OMap Sewer Professional software uses the R value in simulating the effect on flow due to wet weather events.

The amount of infiltration and inflow produced during a storm consumes pipeline capacity and reduces the ability of the pipeline to convey municipal wastewater. The collection systems capacity for different segments is measured as the depth of water in the pipe (referred to as the d/D ratio). For the City, the d/D criterion for design is a 0.7. Once the design criterion is exceeded, a replacement of the segment is considered. The replacement criteria d/D for the City is 1.0. Pipe capacity d/D values have a maximum value of 1.0. The pipe is considered as being surcharged at a d/D of 1.0.

Since the R factor utilized in the hydraulic modeling impacts the collection systems capacity, this factor was analyzed.

PART 1: MODEL CALIBRATION VERIFICATION - FIELD INVESTIGATION & ASSOCIATED MODELING

Visual field inspections were conducted during storm events that occurred between February and May 2007 to measure flow depths in pipe segments in the project area. The purpose of obtaining this data was to confirm the R value used in the model.

A total of three storms (occurring between February and May 2007) were observed for the study. Data was collected during the storms by dipping a rod into various manholes and measuring the depth of flow in the pipes.

Table 1 shows the data collection dates for this study and the data used for the RMC study.

Table 1. Rainfall Data

Date	Duration Recorded (hours)	Total Rainfall (inches)	Peak Hr Intensity (in/hr)
Feb 9th 2007	8	0.12	0.04
Feb 22nd 2007	9	0.44	0.08
May 2nd 2007	9	0.28	0.04
Calibration Storm*	9	1.0	0.3**

*Storm utilized by RMC in their study for calibration of RDII factors. This was the storm event of March 1-2, 2005.
** The peak hour intensity of the RMC calibration storm is approximately four times that of the most intense storm observed between February and May 2007.

Although the three storms measured yielded relatively short durations, low rainfall and low peak intensity, the February 22, 2007 storm was selected for this study because it provided the greatest peak hour intensity. Five of the segments which provided the greatest pipe capacity (d/D) values in the RMC study under design storm conditions, were selected for the study. Pipe capacity values, were also computed for these segments with data obtained from the field. Table 2 shows this field data.

Table 2. Pipe capacity data for the storm event of February 22 2007

Pipe Segment	Diameter (inches)	Slope	d/D from Visual Inspection of Flow Depth	Estimated Flow (MGD)*
D03-100 to D03-099	15	0.0029	0.43	2.2
D03-099 to D03-086	15	0.0030	0.40	2.3
D03-031 to D03-030	18	0.0020	0.33	3.0
D03-030 to D03-029	18	0.0020	0.33	3.0
D03-069 to D03-072	18	0.0014	0.35	2.5

*Flow calculated based on pipe slope, pipe diameter and Manning's of 0.013

The d/D values based on the visual field observations were compared with the d/D values obtained from the hydraulic simulation of the current scenario model described below.

Comparison of Model Output (Current Scenario) and Field Data - The rainfall event with the highest intensity during the February to May 2007 field investigation (the February 22, 2007 storm) was selected and modeled for the current scenario.

A hyetograph was developed based on this rainfall data for a 2.5 hr duration. Rainfall data, in the form of storm intensity (in inches per hour) over specific time duration, was obtained from a permanent rain gauge station (Fire Station No. 2) located in the Basin 7 area and maintained by the City. This data was loaded into the hydraulic model, then applied to manholes in the selected domain in Basin 7 and modeled. Using the hydraulic model, peak wet weather flows for this scenario were simulated using an R value of 3 (the value utilized for Basin 7 per the RMC report). Additional iterations were performed as necessary, with varying R values, and are discussed below. The five study segments were selected, and analyzed.

As shown in Table 3a, the d/D obtained for the current scenario model run (with R=3) was compared with the d/D values obtained from the visual inspection

- The hydraulically modeled d/D was found to be larger than the d/D calculated from the visual field inspections approximately 122-200% greater.

Table 3a. Comparison between field obtained and hydraulically modeled pipe capacity values using an R=3.0

Pipe Segment	d/D from Visual Inspection	d/D from Modeling, R=3.0	Approximate Percent Differential (%)
D03-100 to D03-099*	0.45	1.00	+122
D03-099 to D03-086	0.40	1.00	+150
D03-031 to D03-030	0.33	1.00	+200
D03-030 to D03-029	0.33	1.00	+200
D03-069 to D03-072	0.35	0.82	+135

Since the difference in the modeled data and field data was very large, a second iteration was performed with a lower R value. The reason for lowering the R value was an attempt to simulate reduced d/D results for the hydraulically modeled data to obtain a closer comparison to the visually observed data. An R value of 2.5 was selected and modeled.

- As shown in Table 3b, the hydraulically modeled d/D was still found to be much larger than the d/D calculated from the visual field inspections (approximately in the range of 80-130% greater).

Table 3b. Comparison between field obtained and hydraulically modeled pipe capacity values using an R=2.5

Pipe Segment	d/D from Visual Inspection	d/D from Modeling, R=2.5	Approximate Percent Differential (%)
D03-100 to D03-099*	0.45	0.81	+80
D03-099 to D03-086	0.40	0.80	+100
D03-031 to D03-030	0.33	0.76	+130
D03-030 to D03-029	0.33	0.76	+130
D03-069 to D03-072	0.35	0.72	+105

With the difference between the hydraulically modeled the field data still being very large, a third iteration was performed, and again, the R value was lowered for this run. An R value of 1.0 was selected and modeled.

- As shown in Table 3c, the hydraulically modeled d/D was found to be still larger than the d/D calculated from the visual field inspections (approximately in the range of 20-57% greater).

Table 3c. Comparison between field obtained and hydraulically modeled pipe capacity values using an R=1.0

Pipe Segment	d/D from Visual Inspection	d/D from Modeling, R=1.0	Approximate Percent Differrential (%)
D03-100 to D03-099*	0.45	0.54	+20
D03-099 to D03-086	0.40	0.54	+35
D03-031 to D03-030	0.33	0.52	+57
D03-030 to D03-029	0.33	0.52	+57
D03-069 to D03-072	0.35	0.50	+43

Since there was a significant difference between the modeled data and field data, a fourth and final iteration was run with an R value of 0.5. A minimum value of 0.5 was selected because from the RMC study of all the City's basins, the lowest R value was a 0.5.

- As shown in Table 3d, the hydraulically modeled d/D was found to be larger than the d/D calculated from the visual field inspections for four out of the five segments (approximately in the range of 13-55% greater). For one segment however, D03-100 to D03-099, field data and hydraulically modeled data were the same.

Table 3d. Comparison between field obtained and hydraulically modeled pipe capacity values using an R=0.5

Pipe Segment	d/D from Visual Inspection	d/D from Modeling, R=0.5	Approximate Percent Differential (%)
D03-100 to D03-099*	0.45	0.45	0
D03-099 to D03-086	0.40	0.45	+13
D03-031 to D03-030	0.33	0.43	+30
D03-030 to D03-029	0.33	0.51	+55
D03-069 to D03-072	0.35	0.43	+23

The difference in d/D values between modeled and field data progressively decreased with decreasing R values. However, with an R value of 0.5 the difference in d/D values was still significant (up to 55%), over some segments in the domain. To further investigate the correlation of R and d/D will asymptotically approach a value of R not much lower that 0.5. This suggests it is sufficient to cease further analysis and conclude that R is significantly lower than a value of 3 as assumed in the model by RMC and is likely at a value significantly less than 1 and likely less than 0.5.

PART 2: MODEL SENSITIVITY ANALYSIS

The model sensitivity analysis was conducted to determine how the R value affected the potential to surcharge the system during a design storm event. The R factor for Basin 7 was varied, and the corresponding d/D was observed and noted. The R value at which a surcharge condition is indicated was then determined. The existing buildout model developed by RMC for the City of Roseville Sanitary Sewer Model Development Project (Sewer Project) was used for this analysis.

Sensitivity Test - Buildout Scenario - Peak wet weather flow scenarios (for buildout) were modeled. Values of R ranging from 0.5 to 3.0 were used. The five study segments, selected in the Visual Field Investigation section, were analyzed and results plotted. A plot showing the pipe capacity (represented as d/D) with varying R's for the study segments is shown in Figure 2. A legend of plotted segments is presented in Table 4.

Figure 2. Sensitivity Analyses for R factor

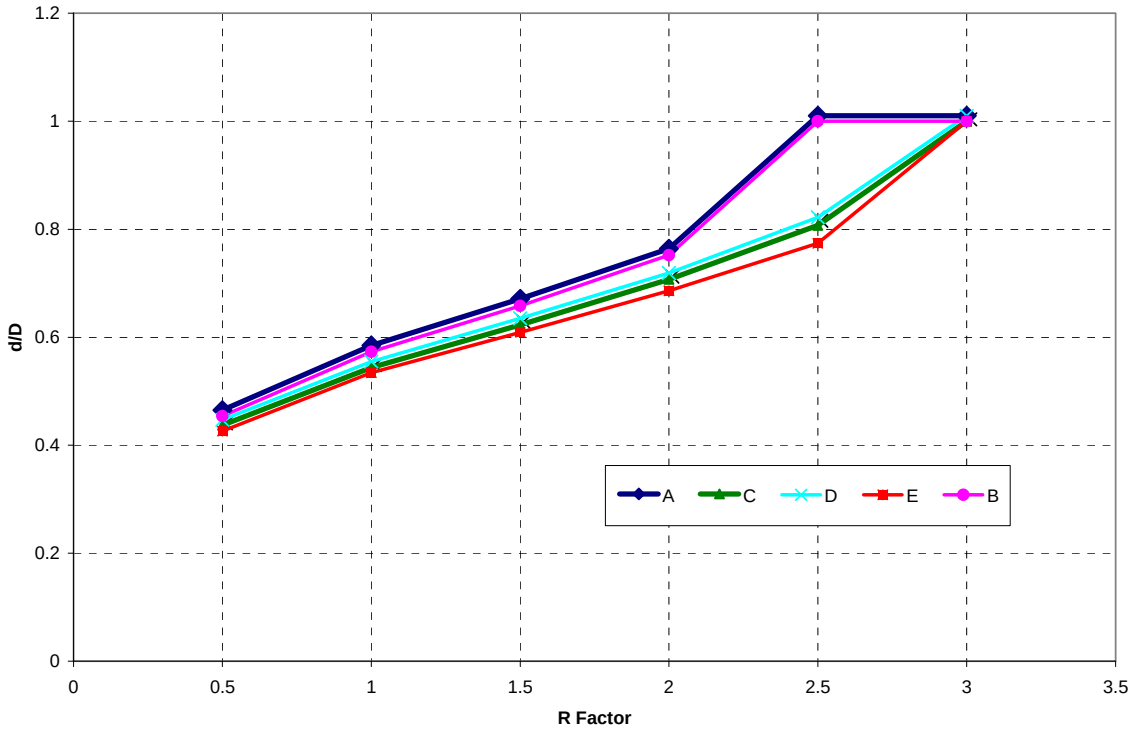

Table 4 presents a legend for this chart.

Table 4. Legend for Plotted Segments

Plotted Curve	A	B	C	D	E

Pipe Segment	D03-100 to D03-099	D03-099 to D03-086	D03-030 to D03-029	D03-031 to D03-030	D03-069 to D03-072

From the data (see Figure 2), the following observations were made

- All five segments selected showed a decrease in d/D values with a corresponding decrease in the R value

    - All five segments surcharged at an R value of 3.
    - Three out of the five segments, curves C, D & E, showed a steady decrease in the d/D value with a corresponding decrease in the R value.
    - The other two segments (curves A & B), surcharged for R values between the range of 2.5 to 3.0. For R values below 2.5, there was a steady decrease in the d/D values with a corresponding decrease in the R value.

PART 3: INFRASTRUCTURE AGE AND R VALUE INSPECTION

As previously mentioned, the entire City of Roseville service area is subdivided into twenty-three drainage basins. The approximate age of infrastructure in the various basins was found and compared with the R values utilized (in the RMC study) for the respective basins. The data is shown in Table 5.

Table 5. Infrastructure Age and R factors for City of Roseville

Basin	R value	Approximate Installation Dates
1	0.5	1990s to 2000s
2	0.5	1990s
3	1	2000s
4	1	1970s to 1980s
5	3.5	1950s to 1960s
6	0.5	1990s to 2000s
7	3	1980s to 1990s
8	1	1970s to 2000s
9	0.75	1990s
10	0.75	Late 1980s
12	3	1980s to 1990s
14	1.5	1950s to 1960s
15N	3	1910s to 1920s
15S	1	1960s to 1990s
17	1	1960s to 1980s
18	1	1980s to 2000s
19	1	2000s
20	1	1990s to 2000s
21	0.5	1990s
22	0.5	1990s to 2000s
23	0.5	1990s
24	0.75	Late 1980s to 2000s
25	0.5	1990s to 2000s

A qualitative inspection was conducted and a correlation between R value and installation date of infrastructure was observed.

The data showed the following general trends[1]:

- Infrastructure installed prior to the 1960s had an R value of 3 or greater.
- Infrastructure installed from the 1960s to 1980s had values in the range of 0.75 to 1.
- Infrastructure installed from the 1990s to 2000s had the lowest R values ranging between 0.5 and 1.

The R value utilized for the Area E study area was compared with these general trends and an inconsistency was observed. The infrastructure in the study area was constructed within the 1980s to 1990s time frame. Infrastructure installed in this time frame was shown to typically have a maximum R value of 1. However, the RMC report utilized an R value of 3, which seemed high from these initial observations.

PART 4: STAFF INTERVIEWS

Interviews were conducted with the City's wastewater collection system staff to obtain a history of any probable surcharging events that may have occurred in the past, and specifically during the winter of 2005, the period over which the RMC study was conducted. Staff indicated that there had not been any known incidence of surcharging in Area E since the sewer infrastructure in that area was installed.

Conclusion & Recommendations - The following conclusions and recommendations were derived from this analysis:

- Peak flows and related surcharging are directly related to the R value as used in the model. Model sensitivity analysis showed that below an R value of 2.5, none of the segments in Basin 7 surcharged.

- The significant difference between visually obtained d/D values in comparison with d/D values hydraulically modeled is likely due to an overestimated R value utilized for Basin 7. In this study, the R value was reduced to a 0.5 to bring the modeled and visually obtained values within a 55% difference. The R value of 3 utilized by RMC for Basin 7 can likely be reduced.

- Qualitative observations of the correlation between infrastructure age and R values for the entire City showed that the utilization of an R value of 0.5 to 1 for Basin 7, based on the infrastructure installation time frame, would provide much more consistency with the R values utilized for the City's basins per the RMC study.

- Interviews conducted with wastewater collection system staff indicated that there had not been any known surcharging events in Area E during the winter of 2005, when the RMC study was conducted.

- Even though a specific R value could not be selected for Basin 7, based on the above observations combined with engineering judgment, the R value is more likely in the range of 0.5 to 1.0 and quite possibly less than 0.5.

- Area E is not likely to surcharge from a design storm event provided the R value for the area is 2.5 or less. Since the analysis indicates the R value for Area E to range from 0.5

[1] Only one basin, basin 12, did not follow these general trends. The R value for this basin could be overstated in the RMC study.

to 1.0, and quite possibly less than 0.5, it is not likely that surcharging will occur from a design storm event.

- With the absence of any potential surcharge conditions under a design storm event, no improvements are required at this time.

- No conclusion has been drawn for why RMC needed to simulate an R value of 3.0 in Area E. RMC concluded in TM 3B that extraneous inflow may have occurred through an open manhole causing a higher calibrated flow from the storm. Such a condition was not evident during our field walks.

- Staff should accelerate the condition assessment of pipe segments in Area E by performing video inspection and defect coding to investigate the potential for increased I/I not observed by this evaluation.