A Road Map for Sewer Rehab *

A ten-step strategic plan

PRESENTED BY
George Kurz, P.E., DEE
George.kurz@comcast.net

* A significant portion of this work was conducted with CTE AECOM as part of the Nashville Overflow Abatement Program 1991-2005.
Do we *REALLY* have an I/I Problem?

**IS SEWER REHABILITATION EFFECTIVE?**

**WHAT LEVEL OF REDUCTION DO WE REASONABLY EXPECT?**

**HOW DO WE ACHIEVE SUCCESS?**
Domestic Sewage “Strength”:

- **Weak**: 100 – 150 mg/l
- **Medium**: 150 – 200 mg/l
- **Strong**: 200 - 250 mg/l

**Strength of Domestic Sewage:**

~ 350 mg/l
Magnitude of the I/I Problem

Average Municipal BOD Concentrations in 228 Tennessee Treatment Plants (mg/l)

- 69% < 200 mg/l
- 85% < 250 mg/l
- Average Domestic: 350 mg/l
Annual % I/I in 238 POTW's Influent

2/3rds > 50%

Annual I/I = 45.3%
All roads look relatively equal if there is no track record of success.

So, what approach do you use to achieve I/I reduction?
Successful Sewer Rehabilitation

- Based on **actual field results** in Nashville & Brentwood
- **Largest published database** for measured I/I reduction in the US
- Analyzed **126 miles of rehabilitation** (282 miles total - ~ 11% system)
- I/I cut in half
- **123 overflows eliminated**
- EPA commends **stream improvements**
REHABILITATION EFFECTIVENESS

BRT P.S. Annual I/I for Progressive 365-day periods
Oct 2014, ~851 MG reduction - 50% [base flow 2014, BRT rain gauge]
Effectiveness (a “rule of thumb”)

15-20% (Minimum) REHABILITATION INTENSITY
(including MH & laterals, & in deteriorated areas)

~ 6 million Gallons annually
(Per 1,000 ft. Lining or Replacement)
Successful Rehab Factors

- Define goals
- Extensive flow monitoring & standard procedures for analysis
- System approach – lateral & manhole rehabilitation
- “Targeting” – stop water migration
- Accountability – verify desired results
Ten Step Strategy

- Identify Goals
- Select Target Area
- Quantify Problem
- Locate Defects
- Select Pipe Segments
- Estimate Cost-Benefit
- Design & Install
- Verify Performance
- Follow-up Flow Monitoring
- Calculate O & M Savings
1 – Identify Community Goals

“Eliminate overflows and basement backups”

- Period of time: 2 years?, 5 years?
- Relate time to rainfall event return interval
- No overflows legally sanctioned
2 – Select (and Characterize) Target Area

- Flow monitoring network (~100,000 L.F.) – subdivide the system
- Identify capacity problems
- Calculate observed & potential I/I
- Hydraulic model

- Prioritize tributary areas
Results of the Flow Monitoring

- Three Perspectives
  - Wet Weather
  - Dry Weather
  - Year-round (Annual I/I)
Wet Weather Problem

REGRESSION ANALYSIS
PEAK I/I vs 24-HOUR RAINFALL

ROCKFORD INTERCEPTOR
(2011-12)
Dry Weather Problem

Characteristic Base Flow Curve - Full Week

ROCKFORD SCHOOL

Average Flow, MGD

0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00

Total Dry Flow
~5.5 mgd

Wastewater
~2.5 mgd

Dry Weather Infiltration

Total Dry Flow
~5.5 mgd

Wastewater
~2.5 mgd

Dry Weather Infiltration
Year-Round Problem

- I/I: 71% (2.3 MG)
- Wastewater: 29%

Nearly $\frac{3}{4}$ of Annual Flow is Rainwater or Groundwater

(this equates to 2.4 gal I/I per gallon of wastewater)
I/I measurements based solely on Treatment Plant influent data will usually underestimate system I/I due to overflow losses and hindered flow.
2 – Select Target Area (Cont.)
Total System: Pick Priority Area

Criteria:
- Overflows
- Annual I/I
- Peak I/I
- Condition

Knock it Out!
3 - Quantify Problem Conditions
(refine the process for the target areas)

- Intensive monitoring in top priority tributary areas (8,000 - 15,000 LF)
- Observed and potential I/I
- Additional capacity problems
Monitored Depth & Velocity Vs. Mannings Curve (variable "n" factor) Mar-May 1996

11.88 in Dia.

Calibrations

3.2 mgd

0.74 mgd

Dry

Wet

Lost
Capacity

Full
Pipe

CC-03
Quantify the I/I  (Observed and Potential)

REGRESSION ANALYSIS
PEAK I/I vs 24-HOUR RAINFALL

PEAK INFILTRATION/INFLOW RATE (mgd)

Projected event I/I
Surcharge
Restricted flow

24 HOUR RAINFALL (inches)

r = 0.97, 95% CONF. = 26%

Potential I/I
3 - Quantify Problem Conditions (cont.)
“Potential” I/I

- I/I which cannot enter the sewer because the pipe is already overloaded!
- Obscures overall I/I removal goals
- Monitor depth & velocity
- Extrapolated

Monitoring in the upper reaches of a basin (upstream of significant hindered flow conditions) allows a more realistic estimate of I/I!
Data Interpretation

- **Need to standardize criteria**
  - 24-hour rainfall more reliable than peak hour rain for predicting peak design I/I
  - AMC – Antecedent Moisture Condition is critical for selecting valid rainfall events
  - **Hindered flow** - Potential I/I There are ways to correct for this, however the analyst must be aware of this condition
  - Underestimating the peak flow can result in the inadequate design of new facilities
Which type rainfall pattern puts the most stress on the system – for a standard return interval, design storm? Summer? Or Winter?
Typical Rainfall

Type II Rainfall* – Characterized by short-term, high intensity thunderstorms and also by long-duration frontal storms.

*USDA-SCS 1986
NASHVILLE
5-Year, 24-Hour & 3-Hour Design Rainfall

Depth (inches)

5-YEAR, 3-HOUR
Peak Rain = 1.97"

5-YEAR, 24-HOUR
Peak Rain = 1.26"

24-Hour rain
3-Hour Rain
2-Year Design Storm Peak: 24-Hr vs. 3-Hr

Peak hour I/I from 2-Yr, 24-Hr Storm is 3.89 mgd with good level of confidence.

Peak hour I/I from 2-Yr, 3-Hr Storm is 2.35 mgd with poor level of confidence.
4 - LOCATE & IDENTIFY DEFECTS

- Televise target area system (may be concurrent with monitoring)
- Categorize defects with respect to I/I potential
“Invisible” defects – electric field leak detection, segmental isolation
Gross inflow (roof drains, etc.)
Electroscan
5 - Select Segments For Rehabilitation

- Categorize & color code lines
  - 3 or more major defects
  - 1–2 major defects
  - No major defects
- “3 or more” – renew!
- Check adjacent segments
- Renewal “intensity” – range of 15–20% (or greater) in first round
Connect The Dots

> 3 Defects
< 3 Defects
0 Defects

25% intensity

Rehabilitate

Meter
Sewer Rehab Strategy: Halt Migration!

- Invisible defect
- "Dry" defect Potential leak
- "New" leaks revealed following traditional repairs
- Lining or repair
6 - ESTIMATE COST-BENEFIT

- Compare renewal costs to: O & M costs ($1.73 – $1.87/1,000 gal)
- At least 50% I/I removal
- Costs:
  - Lining (8–10” cipp) ~ $43 / lf
  - Laterals ~ $2,500 ea. (1/200 lf)
  - Manholes ~ $1,000 – $1,300 ea. (1/200 lf)
  - Engineering ~ 12% – 15% of total
  - Owner’s expenses (admin, etc.)

(Gross= ~$100 to $132/ft rehab)
7 - Design and Install Rehab

- Halt migration from outside pipe
- Halt migration (“tracking”) inside pipe
- Provide seal at manhole junction
- Renew service laterals

Over 10,000 service laterals rehabilitated in Nashville’s Program
Peak Hour I/I Reduction with Lateral Rehab

Oak Valley Peak-hour I/ Reduction

24-hour Rainfall (in) vs. Peak-hr I/I (mill gal)

- Before Rehab
- After Mainline
- After Laterals
- Capacity for I/I

Linear regression lines for:
- Linear (Before Rehab)
- Linear (After Mainline)
- Linear (After Laterals)

55% reduction in I/I before rehab.
84% reduction in I/I after lateral rehab.
8 - Performance Testing

- Air-test sewer service connection!
  - Most vulnerable part
  - Not accepted until performance verified
9 - Follow-up Flow Monitoring

- Quantify I/I reduction
- Standardized I/I analysis
- TV during wet weather
- Rerun hydraulic model
- Determine if design goals met!
E-11 Before-After Peak-Hr I/I Reduction 2007-2011

- PEAK HOUR INFILTRATION/INFLOW RATE (mgd)
- 24 HOUR RAINFALL (inches)

- 2011 capacity
- 2007 capacity

- 62% Reduction

- 95% CONFIDENCE
- post peak
- post 95 up
- post best fit
- post 95 down
Possible 10-13 Year payback (on installation, design, investigation costs – TOTAL PROGRAM)

Provides data for future program planning

Accountability to community

- Brentwood is saving ~ $1.6 million/year by eliminating 851 million gallons of I/I annually – pays for the program in 13 years
PROGRAM PAYBACK COMPARED TO O&M CHARGED

8 Mill Gal Removed per Year/1,000 ft Lining
Total Program costs ~ $700,000/ mile
20% intensity

Years to Payback

$0.80  $1.00  $1.20  $1.40  $1.60  $1.80  $2.00
O & M ($ per 1,000 gal)

Payback years
Successful Rehab Factors

- Extensive flow monitoring
- Lateral renewal to easement
- “Targeting” — lining selected by observed defects, age, proximity, migration potential, surface water
- Performance (air) test line and lateral
Questions ?