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Final Report
Management Audit of
PROJECT*pipes*

Public Version
Confidential Material Redacted

Presented to:

District of Columbia
Public Service Commission

Presented by:

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I. Executive Summary

A. Scope of Our Study

1. Background

The District of Columbia Public Service Commission (Commission) requires annual audits of the PROJECT*pipes* program of Washington Gas Light Company (WGL) and program expenditures, to ensure timely work performance and fair and accurate recording of costs. PROJECT*pipes* includes three categories of authorized projects

- Program 1: Bare and/or unprotected steel services
- Program 2: Bare and targeted unprotected steel mains and affected services
- Program 4: Cast iron mains and affected services.

Four Commission Orders bear upon the scope, timing, and other key parameters of the audit. Order No. 17789 granted final approval of the program generally, and specifically for its first five years. That Order addressed the PROJECT*pipes* audit required by the Commission. The Commission required audit completion in two parts, or Tasks, each with a separate report:

- **Task 1 (Accuracy of the Cost Recovery Mechanism)** – This task was to focus on whether the APRP project costs being recovered through the surcharge mechanism are accurate, and include a review WGL's books and records to ensure that the cost of capital, depreciation and plant costs are properly computed and flowed through the mechanism.
- **Task 2 (APRP Project Selection and Management)** - This task, a management audit, was to focus on ensuring that the APRP projects that were completed and being recovered through the mechanism:

  (1) are timely
  (2) are consistent with the Annual Project List submitted by WGL
  (3) include projects from Programs 1, 2 and 4 that meet the four requirements set forth in Paragraph 68 of Order No. 17431.

Major focuses of Task 2 work fell on determining whether projects subject to the established accelerated rate recovery methods:

1. Were consistent with the Annual Project Lists submitted by WGL
2. Included Program 1, 2, and 4 projects meeting four requirements imposed by Paragraph 68 of Order No. 17431, as amended in Paragraph 18 in Order No. 17500
   a. Incurred expenses on or after June 1, 2014
   b. Did not involve assets included in WGL's rate base in its most recent rate case
   c. Did not increase revenues by directly connecting the infrastructure replacement to new customers
   d. Were needed to reduce risk and enhance safety by replacing aging, corroded or leaking cast iron mains, bare and/or unprotected steel main and services; copper services; and black plastic services in the distribution system.

Subsequent Commission Order No. 17885 provided additional details about the audits, segregating the required examinations between the management audit and the performance of a set of Agreed Upon Procedures (AUP). A separate firm was engaged to perform the AUP work. Liberty was selected to perform the management audit for each of the two fiscal years ending September 30, 2016 (the Audit Period). The first year included an additional four earlier months. Based upon the work assigned to the Agreed Upon Procedures, we were left with the requirement to respond, to questions 1, 2a, 2c, and 2d from the preceding list. Our work addressed a specific series of objective questions and it addressed the more subjective matter of the quality of WGL's management and completion of work. That element of our audit addressed key elements of program and project management, including, but not limited to:

- Use of sound engineering judgment
- Construction integrity, including the quality of installation and construction
- Accuracy of the cost estimates
- Reasons for cost overruns
- Reasonableness of actual costs.

Order No. 18270 and Order No. 19323 expanded the scope of our work to consider actual results from Year 3 (October 1, 2016 through September 30, 2017) and part of Year 4 (October 1, 2017 through April 30, 2018, which we later expanded to June 30, 2018). This expansion included: (a) an analysis of the implications of that performance for the future of the program, (b) consideration of program management improvements made by WGL following Year 2, and (c) analysis of their effectiveness and their impact on our conclusions and identified improvement opportunities identified as part of the examination of Years 1 and 2.

PROJECT*pipes* comprises the WGL program to accelerate replacement of at risk services - - all of its bare-steel mains, a portion of its unprotected coated steel mains, and all cast iron mains within the District of Columbia. WGL listed 23,600 services at risk in 2013. Overall expectations slate 23,600 services and about 54 miles of bare or unprotected coated steel mains (not all the existing unprotected coated steel) for replacement across 15 years, and replacement of all 428 miles of cast-iron mains within 40 years. The first, formally-authorized, five-year phase allows $20 million in annual expenditures for accelerated rate in each of the first three years and $25 million in each of the remaining two. The next table summarizes the year-end 2013 inventory of leak-prone and at-risk mains and services covered by the program. The table's listing of at-risk services includes some 3,400 copper services, which the scope of PROJECT*pipes* excludes, but which we consider to be at-risk facilities.

2013 Year End Summary of Facilities Encompassed by PROJECT*pipes* and Leak Status

Bare Steel (miles)	29
Coated Steel (miles)	64.508
Cast Iron (miles)	428
At Risk Services (estimated number)	23,600
Main Corrosion Leaks (number)	121
Service Corrosion Leaks (number)	159
Main – Non-Third-Party Damage Leaks Less Corrosion (number)	357
Service- Non-Third-Party Damage Leaks Less Corrosion (number)	199
System Leak Backlog - - Unrepaired Leaks (number)	738

2. Answers to the Objective Questions Required by Commission Orders

Question 1: We performed a broad review of projects conducted during Years 1 and 2, finding all of them included on Annual Project Lists for each year.

Question 2a: Our examination of project work performance records confirmed that projects involved work performed on or after June 1, 2014, with limited exceptions. Records for six projects indicate completion of at least some project work activities prior to June 1, 2014. We did not examine financial and rate accounting records, but understand that work under the Agreed Upon Procedures audit has done so. Chapter VIII , Scheduling describes these projects in more detail.

Question 2b: Project records did not address rate recovery status - - we did not examine cost accounting records that do so. The AUP engagement addressed this matter.

Question 2c: We performed a sample review of project work and new customer documentation, finding no case where recorded project work involved new customers.

Question 2d: All work recorded involved projects addressing the listed facility types, selected by a valid risk ranking process, and appearing in the proper Program (1, 2, or 4) on annual WGL lists.

3. Broader Review of Program Management

We broke the subject of overall program management into logical categories, each of which this report addresses in a separate chapter. Our work scope expansion's nature led us first to summarize conclusions about performance and our identification of improvement opportunities specific to Years 1 and 2. Then, to address the specific subset of questions raised about Years 3 and 4, our report chapters generally describe changes made in that period. We close each chapter with an identification of those recommendations that we believe WGL should implement on a going-forward basis. We were able to treat Risk Ranking and Prioritization and Field Execution without so firm a separation between the two periods we examined - - Years 1 and 2 and Years 3 and 4.

4. Order 18503

The Commission's August 23, 2016 Order 18503 (which reviewed the Formal Case No. 1027 Vintage Mechanical Coupling and Replacement Program Management Audit Report) addressed a number of issues affecting PROJECT*pipes*. Examples include, directives to create a program charter, a program implementation plan, and estimates prepared according to defined industry standards. The order also addressed a number of internal management tools, such as original to as-built cost comparisons, project reauthorization, and use of a project management tool that would work with WGL's work management system. The order also addressed the inclusion of additional information (for example, cost and schedule variance explanations) in annual program reports.

Management addressed these matters, particularly in connection with its Year 2 establishment of the Corporate Program Strategy and Management (CSPM) group. Progress, however, was not well advanced overall, as the group became established, but improved more significantly in Years 3 and 4. We consider all of the areas addressed in Order 18503 material to effective program management. We considered them all in our broad review of WGL's management of the program

in Years 1 and 2. Our evaluation of Years 3 and 4 addressed management activities to continue addressing those areas, among the others important to effective program management. The recommendations made in our report identify improvement opportunities remaining in most or all of them.

5. Program Management Effectiveness Overall

We did not find during Years 1 and 2 a sufficient program management concept, structure, staffing, methods, activities, and controls fully commensurate with the requirements imposed by WGL's pipe replacement program. WGL managed PROJECT*pipes* as an integrated part of similar programs in Maryland and Virginia, making it appropriate to view collectively the challenges and needs of all three (augmented by the other, large work requirements engaging crews in WGL construction work). Two principal elements of WGL's thinking led to gaps in Years 1 and 2 program management from what we would have expected to see: (a) the belief that replacement work represented no more than an increase (albeit a large one) in construction "business as usual," and (b) a tendency to conflate program management with regulatory reporting.

The Years 1 and 2 weaknesses in program management were consequential, raising the question of their impact on what proved to be very low rates of work completion. Those low rates occurred despite expenditures of close to the full annual $20 million qualifying for accelerated rate treatment. Expenditures as expected, but very low rates of performance relative to production expectations meant very high unit costs for service and main replacements. Our Years 1 and 2 field work came well after management had completed the work, thereby eliminating our ability to examine its performance as it occurred in the field. However, the methods described by management and by procedures conformed generally to what we view as industry norms. We did have that ability in Years 3 and 4, which confirmed their general suitability, and made clear the large impacts that developing government requirements have had on productivity. Our most important conclusion about field performance is that it did not suffer material deficiencies - - expectations about estimated unit costs are what proved unreasonable.

It is usual to find a material level of improvement in performance after a multi-year start-up period on large-scale replacement programs. We credit that phenomenon as a material cost contributor, but tempered by the fact that management had the encapsulation program as a potential guide. In any event, WGL made significant strides in program management in Years 3 and 4 - - particularly after establishment of the CSPM group. WGL has brought management of PROJECT*pipes* under essential control. We address below the improvements that management has made to do so. Those improvements continue, and as management has advanced their implementation, the quality of WGL's management of the program has improved commensurately.

However, as the list of recommendations set forth below indicate, management needs to continue work in a number of organizational, staffing, methods, and activities to turn program management into a strength. Year 4 has seen improvement in some key unit performance and rates, and therefore costs. That improvement provides one indicator of the effects of improvements WGL has made in program management. We have not seen reason to believe that continuing large improvements in unit costs can occur in the future. Nevertheless, completion of the agenda set forth by our recommendations and continuing execution of management's current activities can be expected to produce additional improvements in cost and schedule performance.

We also think that two changes in project prioritization will accelerate the pace of risk elimination under PROJECT*pipes*: (a) consolidation of Program 1 service replacements into Programs 2 and 4, and (b) elimination of the "top 3" risk-ranked replacements (which have to date universally involved cast-iron replacements) as an override to risk rankings, as discussed in Chapter II, Risk Ranking and Project Prioritization.

The next sections provide more detail structured according to the major areas into which we categorized our review of program management.

B. Program Prioritization

Each year, WGL proposes, stakeholders examine and provide input, and the Commission approves a list of projects classified into three types:

- Program 1 - - Services designated as at-risk divided into "quads"
- Program 2- - Unprotected bare and coated steel mains
- Program 4 - - Cast-iron mains.

Management develops annual lists under established risk criteria. Leak rates by quad (2,000 by 2,500 foot areas) determine Program 1 priorities. A WGL risk model employs Optimain, an industry-standard tool, to rank Program 2 and 4 risks. It applies defined factors to calculate each main segment's probability of failure, then multiplied by the consequence of failure (again based on clear factors). WGL adjusts steel-main (Program 2) priorities to account for other factors, producing risk-reduction rankings per dollar spent. However, each annual project list must include the Optimain-identified top-3 projects (which have proved largely to comprise large-diameter cast-iron main segments to date) drawing the highest raw risk scores. This override brings in large-diameter cast-iron mains with low failure probability, but high consequence following a leak or break.

WGL has effectively and robustly designed and applied risk ranking tools in setting yearly program priorities. WGL's team had sufficient experience to operate the model, account for its factors, and "tune" it to meet a current understanding of risks involved in the distribution system. However, as our work addressing Years 1 and 2 was ending, WGL made a management change in its DIMP organization. It produced a loss of knowledge and experience with DIMP regulations, through replacement by a person without prior gas distribution experience. We did not consider the position one well-suited to developing experience through "on-the-job" training.

It is timely to re-evaluate prioritization methods. We discuss below: (a) extremely high unit rates (to-date and expected) for service and main replacement, and (b) management's policy not to spend above annual dollar limits qualifying for accelerated rate recovery. These factors produce a gulf between planned and actual replacements sufficient alone to justify revisitation of prioritization methods. - - to ensure limited expenditures continue to go to the most important work.

Program 1 service replacements have occurred at rates far less than needed to eliminate them in 15 years. Consideration should be given to eliminating service replacements as a separate program, consolidating their modeling as part of the Program 2 and 4 mains to which they attach.

We found continuation of Program 2 as currently prioritized appropriate. The overall rate of main leaks has stabilized. Added funds produced by elimination of Program 1 would increase both main retirements and replacement of the services connected to them. It has become appropriate to consider elimination of the "Optimain top-three" replacements. Expenditures on these larger-diameter facilities tend to "crowd out" funding for small-diameter pipes - - facilities industry experience shows as subject to higher failure rates. Some other replacement programs consider main size, first targeting smaller mains (less than 6 or 8 inches in diameter).

WGL's prioritization methods also have implications for the company's broader program to increase distribution pressures across its system, whether supplied by high-risk mains or not. WGL is conducting efforts to increase supply pressures on new mains to medium level (20 to 30 psi), while also moving meters from inside to outside customer premises. Risk modeling, however, requires some replaced mains to continue operating at lower pressure. The resulting proximity of low and medium pressure components in proximity to each other can increase risk of inadvertent over-pressurization situations resulting from operator error.

Management has been correcting records, with the effect of producing a net gain in numbers of at-risk services, even after replacing a substantial number of them. It also has procedures and practices in place to identify risk areas in the field and on maps and records. Management has identified information issues involving services and mains, but needs to ensure that it has fully captured all facilities that fall into the Program categories considered appropriate for replacement.

C. Summary of Performance for Years 1 through 4

Progress, measured by work units accomplished or by the costs of those accomplishments, has fallen well short of expectations across the first four years of PROJECT*pipes*. A June 2018 internal management report came about three quarters of the way through the 64-months of the program's first five-year window. The report made clear that, for the dollars spent, management accomplished roughly half of the amount of work anticipated at program outset. Moreover, with Year 4 rates showing some, but not large improvement, it has become reasonable to expect future performance to continue at roughly this cost rate (about double initial expectations), should the program continue in generally its current form and scope. Future planning needs to recognize the reality that WGL cannot meet early unit rate assumptions, nor is it likely to prove successful in improving current rates substantially. This recognition has substantial cost and schedule implications for the program's future.

Reported Program Work Completed - - June 2018

Factor	Amount
Time	77%
$ Spent	64%
Mains	38%
Services	23%

The history of performance to date makes clear that the assumptions underlying PROJECT*pipes* no longer have validity as a planning basis. Total PROJECT*pipes* costs and schedule duration have vastly exceeded the expectations underlying the first five-year window, and will certainly continue to do so under program continuation. Even before accounting for performance variations in the first, five-year phase, the program began from a view of the future that did not include one inevitable knowable at the time - - escalation (increases in the cost of products, services, and labor,

largely driven by inflation). Accounting for that factor alone (at 3 percent) would raise the initial estimate to $1.8 billion.

Another, overarching factor emerged as well. By the end of Year 2, management was estimating doubled costs for mains and nearly tripled costs for Program 1 services. By the time that Year 4 concluded, no material relief became apparent. Drastically higher costs and the resulting delay implicit in a $20/25 million per year expenditure pace put total costs at program completion far in excess of even $1.8 billion.

With Year 3 and 4 data showing no more than moderate improvement likely, recent unit cost rates offer a sound marker for gauging those that can be sustained (assuming work proves similar overall in nature) for the future. We recommend what we consider a benefit to future planning for main and service replacement:

- Sound forecasting of final cost to install the full scope of the Five-Year Plan.
- Project uninstalled quantities of main and services at the end of Year 5, assuming the whole $110 million budget is consumed.
- Assessing schedule impact of uninstalled quantities from the first five years
- Calculating the resulting cost impact in escalated dollars.
- Providing a credible estimate for the life of the Program (40 years) in escalated dollars.

D. Overall Program Management

Overall program management comprises the process by which leadership must provide for elements necessary for successful performance of a long, complex program like PROJECT*pipes*, operated concurrently with other ongoing activities and programs. We looked for a formal, structured program management plan, effective management systems, a program of producing and using regular and insightful reports and analyses of performance, metrics for measuring cost, installation performance and schedule, and systems for the management of the program.

Program Year 1 alone slated 124 projects, a major management challenge in their own right, complicated by continuation of encapsulation work and by companion, large-scale pipe replacement programs in Maryland in Virginia. Management described its overall approach as one focusing on management at the "program" rather than at the individual project level.

Our initial work found that project-level management in a structured, comprehensive fashion did not exist. We looked therefore at how WGL did manage work under the program. Management's initial view of the program, since changed, treated its very substantially increased construction requirements as incremental to existing work - - not as presenting fundamentally different needs or requiring a separate management structure or resources. It continued reliance on the different functions with roles on program projects (like engineering, procurement, permitting, and construction) to carry out their activities without a project management source responsible for ensuring their coordination. Instead, coordination came through interaction among senior management of the functions involved, supported by what we found to be fairly general indicators of progress.

Principal among those progress measures was the annual $20 million spending limit (increasing to $25 million for each of the remaining two plan years). Those expenditures produced little of the production (replacements) anticipated by the five-year plan - - a phenomenon clear to management early in Year 1 and eventually recognized as continuing inevitably through time, given the circumstances in which the work is performed and the public requirements and limitations surrounding it. Nevertheless, management has since Year 2 made improvements designed to achieve moderate levels of performance improvement available.

Efforts to control cost growth should have formed a central element of program management, but we did not find clear responsibility or accountability for measuring performance (unit rates or costs per installation), analysis of drivers of that performance, or substantial reporting of its implications. Closer attention to these matters was important and could well have produced a level of productivity change and cost mitigation at the margin. Even so, the clear, fundamental driver of the mismatch between performance and expectations lay not in performance as accomplished, but in expectations about performance. The lack of an effective estimating process and the inability to take, analyze, and address detailed measures of performance in revising those estimates caused unreasonably low cost estimates to persist through the first two years of program execution.

Management conducted Year 1 and 2 work without a fully developed program management approach, and lost the opportunity that application of a robust range of project management activities and techniques brings. Before Year 1 ended, it was clear that the mismatch between dollars spent and units replaced would persist, making focus on quantities and their costs and production schedules the central baseline for controlling performance. That focus was not evident.

Our initial work found a need for clear delineation of program management approach, describing how management intended to implement it, and how it would specifically act to measure and promote effective and efficient performance. A new Construction Program Strategy and Management organization (CPSM) group existed at that time. We considered it a vehicle for creating and executing that approach. For it to do so, however, management needed to build out the organization, and enhance its project management skills and capabilities.

Great difficulty in producing effective expectations about unit production rates and resulting costs, combined with the nature of the ongoing work should also produce changed focus - - from estimate variances to replacement quantities and their costs and production rates. Estimates have formed a major area of discussion among stakeholders before the Commission. We found that management has accurately estimated quantities on - - the problem we found with estimates arose from the work inputs assumed in making them.

As Year 2 ended, we also found a need for measures to increase management focus and oversight on District of Columbia replacement work - - work being carried out as part of a multi-state effort and, as noted above, on the premise that PROJECT*pipes* did not present challenges beyond added volumes to work already on the roster.

WGL has made large strides in developing a program management approach and program since CPSM group creation. At the top level, a single executive has clear, single accountability for program performance. A revised Program Implementation Plan is under preparation. The CPSM

group has been fully staffed, its members having defined responsibilities for supporting those providing program governance, and for performance tracking, planning and execution. Monthly program progress reports have been developed to show status and progress, providing a basis for analyses of scope, cost, and schedule variances. Advancements in the cost area include full-scale implementation of an electronic log for managing contractor requests for payment for work. It has brought more timely verification and control of work performed, and it lays a foundation for improving cost and performance control. It has access to comprehensive performance data.

Where management focus lies has become much clearer, although CPSM management acknowledges that the group remains in the process of "coming up to speed," now that it has become fully staffed and stabilized. The group still needs to advance in important areas, perhaps most so in an area it acknowledges - - developing and using data to analyze and attack major cost drivers. Management appears to agree that a control focus on planned versus unit costs is in order, and is reportedly preparing a first set of metrics to use in doing so.

Remaining needs, largely designed to build upon Year 3 and 4 improvements made or initiatives underway, include:

- Developing fully integrated schedules that take projects from design, through construction, and close-out
- Incorporating material enhancements to routine measurement of actual versus planned unit costs as part of ongoing performance measurement, and making analysis of its drivers a regular part of monthly reports and management and executive review meetings
- Identifying and developing the data to employ additional metrics at the more detailed level - - to expand control points for cost, schedule, and quality performance, and to incorporate fully measurements under them into regular reports
- Accompanying quantitative reporting against objective metrics with insightful analysis about what drives apparent problems, what underlies emerging trends before they become concerns, and addressing means for addressing them timely
- Completing the updated version of the Program Implementation Plan
- Conducting individual skills assessments and producing development and training plans for program management personnel, specifically tailored to changed or increased roles and responsibilities for enhanced program management.

E. Project Authorization

Project authorization processes generally applied in the industry have an important funding role. They play a different, but sufficient PROJECT*pipes* role. "Funding" approval broadly came with the annual $20 or $25 million limit management imposed on program work addressing projects making annual approved lists. In creating the annual project lists for stakeholder and commission review, management employed a clearly-defined and well-documented and understood "BCA" authorization process. Making the approved list has essentially made eventual, formal authorization to spend inevitable, but each project still required pre-spending "sign-off" by the level of management required by its dollar value.

Each program year's list of approved projects included estimates for each. However, management did not treat those estimates as limiters on funded amounts on a project by project basis. Once

work began, management in effect committed to finish a project at whatever cost required, without need for recourse to additional funding authorization. Put another way, WGL managed to a single, total annual expenditure limit, not to an authorized amount for individual projects.

F. Cost Estimating

The program's estimating process has undergone much scrutiny. Year 1 and 2 estimating processes were overly simplistic for significant projects. Management did not agree that good estimates enhance the effectiveness of project and program management, leading to a conclusion that a detailed estimating process was unnecessary. We generally agree with the recommended use of Class 3 estimates, but would exclude the smallest Program 1 projects. The program includes many smaller, repetitive projects addressable effectively through less sophisticated estimates.

The simplicity of project estimates weakened their value on the larger, more complex projects. WGL experienced extremely large variances and very low numbers of projects completed at or under budget. These variances did not trigger notable management analysis or response, apart from the updating of historical unit rates in a July 22, 2015 analysis.

WGL has made efforts to improve estimate quality. Management evaluates unit rate variances annually. Cost estimate variances in Years 3 and 4 dropped overall, but materially better Program 1 and 2 performance should be sought. Moreover, it is not yet clear that management intends to use estimates beyond producing documentation required by outsiders. It will take buy into the concept that well-prepared estimates serve internal, for estimate enhancement to bring management improvement. The changes need to begin with a formal process for addressing significant estimate variances, and should include the Technical Conference's reported initiatives.

G. Cost Management

WGL considered reaching without exceeding annual expenditures of $20 million its most central cost control aspect. After a slow start, total Year 1 and 2 spending neared $20 million annually. Spending came within $2.3 of the $40 million total for the two years. More than half of Year 2 spending went to Year 1 projects, Unit rates deteriorated in both Years 1 and 2, producing far higher than expected costs and far lower rates of replacement. In Years 3 and 4, management began a more structured consideration of cost performance (specifically, unit rates). Year 1 and 2 reports focused on spending levels, but did not address costs as performance indicators. Employee goals used only spending indicators. High-level oversight from the Operating Committee addressed only spending. Cost effectiveness appeared implicitly accepted as sound. Reporting against the annual spending target made sense, but what we did not see was attention in calculating and displaying through specific metrics linkages between spending and accomplishments - - mains and services put into operation and completed, and the sizes, trends, and anomalies in cost drivers.

At the execution level, management has applied an effective system for controlling the costs of contractors, who perform all replacement work. WGL has used competitively bid contracts, entered with a range of contractors sufficient to provide the required numbers of crews. Those contracts contain very detailed lists of defined "Pay Items." While employing an industry-standard unit rate approach, the system's particular strength lies in the great scope and depth it reaches in defining the units of work compensable at fixed rates. WGL's approach minimizes contractor

incorporation of "allowances" in unit costs for basic work units (like feet of mains or numbers of services). The system, however, is not self-executing. It takes effective, accountable supervision of contractor work to function effectively. Even where effective, however, the system substantially reduces, but does not eliminate contractor claims for work "changes," as we address below under *Field Execution.*

The link between spending and the results produced from that spending sets the most basic foundation for effective cost management. Focus on total spending rather than on that linkage comprised a significant gap in WGL's management of Year 1 and 2 costs, with management reporting that it, "has not previously had a need to track spend to replacement unit progress at the program level." We consider such tracking a fundamental element of management from start to finish on a program like PROJECT*pipes*, not a developing need based on subsequent events or conditions.

WGL did not in Years 1 and 2 employ common industry approaches to cost management, including detailed reporting of a range of key performance metrics, variance analysis, and accountability for cost "overruns," but initiated efforts to do so thereafter. Commonly used cost management systems revolve around the setting of performance expectations, measurement of performance against those expectations, analysis of deviations and implementation of mitigating or corrective actions as appropriate. Based on our Year 1 and 2 work, we found a need for WGL to develop a formal cost management process designed around credible performance expectations and measurement and analysis of performance against those expectations. Tying planned expenditures to tangible production goals, in terms of mains and services would benefit the execution of that process, accompanied by tracking of unit rates on a real-time basis.

Management made progress in establishing better definition of its cost performance expectations. Some sound baselines now exist for regular progress measurement, reporting, and analysis. Promoting visibility and performing analysis can improve further. Specifically, management needs to make cost performance more structured, and support it with visible, actionable analyses of major cost drivers, identification of root causes, and appropriate corrective actions. WGL should also add qualified costs analysts or cost engineers to its program management team.

H. Scheduling

Through June 2018, WGL began only 29 percent of projects on schedule, completing even fewer (9 percent) on schedule. Those numbers fell as the four years progressed. These extraordinarily low numbers show that WGL really did not manage to schedule, as opposed to budget. That concept consisted of producing from the approved annual project lists enough construction-ready project work to support spending the annual $20 or $25 million. Engineering supported this "scheduling" approach by providing a large backlog of approved-list work for construction to perform. This approach also promoted flexibility (and therefore efficiency as well) by permitting alternate work to take the place of projects deferred for unexpected reasons.

Management used an extremely simplistic process during Years 1 and 2, producing schedules lacking detail or significant documentation. Neither management nor contractors appear to manage work or judge its performance according to schedule milestones. In any event, schedule performance fell extremely short of expectations during Year 1 and it declined further in the next

two years. Year 2 saw fewer projects completed on-time than did Year 1 and the median duration of Year 2 projects expanded by 43 days. Nevertheless, the work accomplished, while well less than expected, did follow priorities for them for Programs 1 and 2. WGL did not finish any of the planned Year 1 and 2 Optimain top-3 projects in the years included in an approved annual plan.

Management has developed a process for expediting project closeout, but significant work in the scheduling area remains. WGL needs to create and document processes for creating a program master schedule, assigning accountability for schedule performance, providing for ongoing analysis of schedule variances, and developing means to control them. WGL should also develop an organizational structure and discipline, supported by strong skills and capabilities, to perform accurate, insightful scheduling and analysis of project and program schedule performance.

Our Year 1 work encountered a narrow start-date issue. Order 17431, Paragraph 68 requires that all projects must have started on or after June 1, 2014 to qualify for accelerated rate recovery. WGL supplied data showing projects with apparent earlier start dates. Management cited Order 17500, Paragraph 21, which addresses activities like advance materials acquisition, as addressing the issue of their qualification for recovery. Five projects display WGL "Construction Start Dates" prior to June 1, 2014. These start dates do not appear to involve advance acquisition of materials. WGL defines the quoted term as the "earliest date a construction unit (CU) was completed on a BCA in WMIS." Three of these projects, plus another having no listed Construction Start Date show actual completion dates prior to June 1, 2014. We did not address the financial accounting and rate recovery circumstances involving these projects but understand that work under the Agreed Upon Procedures has done so.

I. Resource Planning

As noted, contractor crews perform all replacement work. Overall, WGL has had access to sufficient resources to spend close to the annual amounts qualifying for accelerated rate recovery. However, six factors bear important consideration for the future. Five are internal to WGL:

- A gap in the spending pace appeared in Year 3, expanded through the Year 4 months we examined (but appears to have narrowed somewhat across the remaining three months)
- Management has cited resources or the need to address non-replacement work more than half the time in explaining delays
- WGL is conducting replacement programs in two other states, each of which presumably will expect a priority on safety work under their jurisdictions
- WGL has stated that it plans significant increases in work (beyond PROJECT*pipes*) that will require large numbers of added construction crews in coming years
- Bringing the pace of replacements into closer alignment with original expectations will require an increase in crews.

The sixth factor arises from concurrent, major replacement programs in the region; they have been growing and, even at current levels will create great demand for resources in an economy already experiencing full employment.

These factors make it important for WGL to re-examine objectively its long-standing approach to using contractors for work of this and many other forms of construction. That examination needs to consider potential economies (either directly performing replacement work or releasing

contractors from other work to do replacements). Expanding the use of internal resources, even at very moderate, levels can prove a source for mitigating future delays, given an industry facing significant expansion in resource requirements. It would also substantially complement over time the backgrounds and experience of internal resources responsible for program oversight and management in the field. The long length of the program (approaching or exceeding that of individual career lengths) also offers an unusual opportunity to develop future managers and leaders with strong operational backgrounds. These considerations should form central components of long-term, company-wide resource modeling and planning.

J. Program Oversight

Years 1 and 2 were characterized by a shared accountability for PROJECT*pipes* performance among senior-management (director) level personnel responsible for the major functions involved (*e.g.*, engineering and construction). That has changed, with focused accountability now clearly residing at the vice president level.

The directors and top executive management did not receive PROJEC*Tpipes* information at a level of detail commensurate with the need for ensuring effective top level oversight of program performance against plans and expectations. Management has made a number of changes to improve reporting detail. As noted earlier, the need for further performance metric development, performance reporting and analysis, and responsive action planning remain. Top leadership should hold program management accountable for rapid deployment of reporting and analysis and it should require insightful analysis of data, not its mere presentation, to serve as a basis for meaningful discussion of successes, failures, and opportunities regularly

K. Field Execution

Our work addressing Years 1 and 2 came well after construction completion, precluding direct observation of work methods and practices. The documentation and descriptions of them conformed to industry practice generally. We did observe work directly in 2018, finding no concerns about efficiency or effectiveness of the methods and practices employed.

As described earlier, the lack of detailed performance measurement and analysis did not contribute to performance optimization, and has likely left marginal cost savings "on the table." However, we found it very clear that a combination of external influences and poorly selected unit rates (and resulting costs) for estimating - - not large field execution flaws - - have dominated as the causes of drastically higher than expected costs. As or after program ramp-up occurred, government changes restricted work to six hours per day, and cut into that by requiring set-up and tear-down within that period. Other emerging requirements included creation of temporary bicycle and pedestrian lanes and chain-link fencing around all trees.

Contractors, who perform all replacement work, secure payment against an extensive, well-developed list of pay items by submitting lists of work items completed. Those lists undergo verification by both WGL construction supervision and contract administration before invoicing can occur. Effectively administered (which includes close, timely oversight by construction supervisors), the WGL system provides for effective control of contractor work and payment.

Our sampling of the "paperwork" involved showed overall care in controlling payment, but an increasing gap between contractor work performance and construction supervision sign-off dates as PROJECT*pipes* work levels increased. Management has addressed the risks that such delays present in late 2018, commencing strict adherence to an electronically supported log system. This system calls for very prompt contractor and construction supervisor completion of required entries. While not yet tapped, the system also enables management to develop readily (as we believe it should do) measures useful for: (a) validating effective, good faith administrative performance by contractors and employees, and (b) developing ways to use the massive amounts of data collected for measuring performance substantively as well.

Management has also reoriented its construction supervisors to provide for an increased level of effort dedicated to work in the District of Columbia. Those resources now can spend more time on site and with the crews and their supervision/management.

Specific opportunities management should examine promptly and on a structured basis include:

- Working closely with public authorities, supported by clear and convincing data on the costs involved, to secure maximum working condition flexibility consistent with public requirements and expectations
- Cooperating with other underground utilities to update construction maps with existing and abandoned facilities along planned main and service replacement routes
- Designing and executing a directional drilling pilot program for residential streets - - to take advantage of economies that such a technique often affords (design and execution of this option will require close cooperation with and direction from District officials to ensure consistency with public requirements and expectations)
- Conducting a structured, quantitative evaluation of converting to digital GPS mapping, as many other urban and suburban gas distribution companies and other utilities have done to save costs and provide greater accuracy.

The U.S. Department of Transportation requires a formal operator qualification program to ensure that those performing covered tasks are currently qualified to do so. We found appropriate program design and execution at WGL.

L. Summary of Recommendations

Chapter II: Risk Ranking and Project Prioritization

1. **Prepare for stakeholder dialogue a proposal to eliminate service-only replacements (Program 1), making them part of main replacements under Programs 2 and 4.**

2. **Prepare for stakeholder dialogue a proposal to eliminate the "Optimain top-3" component of replacements, employing a prioritization method that emphasizes small-diameter pipes subject to much higher failure rates.**

3. **Continue to account for pressure differences that result when replacements produce pressure increases in only part of contiguous areas or neighborhoods.**

4. **Enhance efforts already underway to provide a full and accurate identification of the types and materials employed in underground infrastructure.**

Chapter III: Program Management

5. **Promptly complete the described program management measures now underway.**

6. **Conduct skills assessments and development plans to further the project management skills and capabilities enhancement now underway.**

7. **Incorporate routine measurement of Actual versus Planned Unit Costs as part of ongoing performance measurement, and, as it continues to examine performance variances, identify, report on, and analyze other metrics material to ensuring continuing program success.**

8. **Complete measures underway to increase focus on D.C.-specific performance.**

9. **Re-define "normal" replacement in light of experience and current infrastructure and risks and evaluate the institution of a work completion condition to expedited recovery of program expenditures.**

Chapter V: Program Planning

10. **Complete efforts to produce a series of program plan documents, forecasts, performance projections, and a life of program plan (40 years) using soundly derived unit rates and escalated costs, including an appropriately-derived contingency element.**

Chapter VI: Cost Estimating

11. **Expand use of cost estimates in cost management and in the project cost estimate process and the revised Program Implementation Plan to incorporate explicit statements about expectations and intended use.**

12. **Undertake a series of additional actions to optimize preparation and use of estimates.**

13. **Evaluate elimination of Class 3 Cost Estimate requirements on smaller projects, to exclude most of Program 1 projects and those in the other two Programs with comparatively very low costs and standard execution requirements.**

Chapter VII: Cost Management

14. **Enhance the provision of insightful analysis of cost performance issues and provide cost management support to the program.**

15. **Promptly complete development of a process for regularly measuring planned and actual expenditures to production for terms of mains and services.**

Chapter VIII: Scheduling

16. Implement an organizational structure and discipline, supported by strong skills and capabilities, to perform accurate, insightful scheduling and analysis of project and program schedule performance.

17. Create and document processes for creating a program master schedule, assigning accountability for schedule performance, and providing for ongoing analysis of schedule variances and means to control them.

Chapter IX: Resource Planning

18. Regularly prepare ground-up analyses of crew requirements that consider a range of work levels consistent with new business and regular replacement uncertainties, that use sound expectations about future unit rates, and that objectively re-evaluate an approach that excludes use of in-house crews for replacement work.

19. Strongly support and participate in work force development efforts undertaken in cooperation with government and public-interest resources.

Chaper X: Oversight

20. Much more proactively report program progress, problems, and action plans to senior leadership, which needs to remain significantly engaged in challenging management's performance in managing the program.

Chapter XI: Field Execution

21. Work with public authorities to secure as flexible a set of working conditions as conforms to government's requirements and expectations.

22. Work with other underground utilities to update construction maps to contain all existing and abandoned facilities along planned main and service replacement routes

23. Develop and execute a directional drilling pilot program for residential or side streets.

24. Conduct a structured, quantitative evaluation of converting to digital GPS mapping.

II. Risk Ranking and Project Prioritization

A. Background

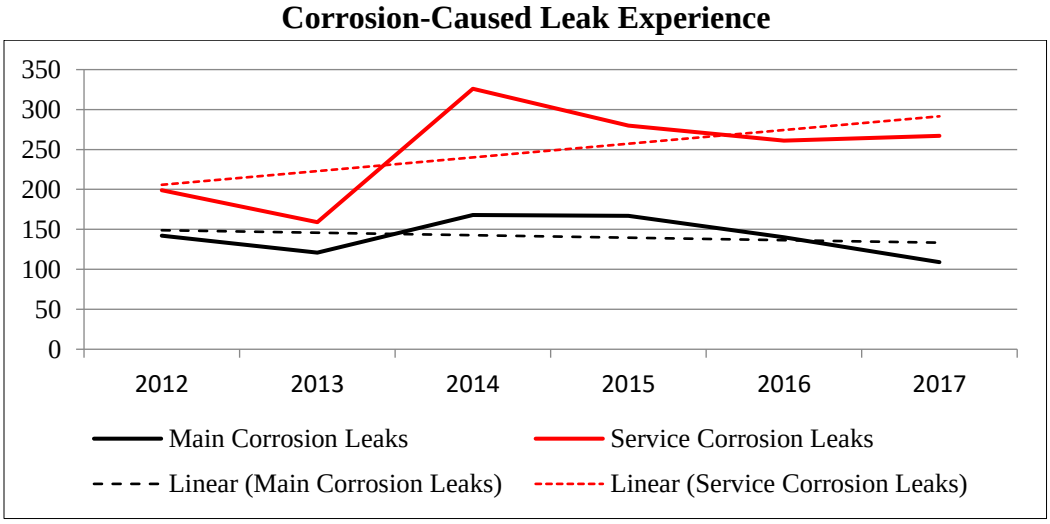
The scope of PROJECT*pipes* includes acceleration of the replacement of at-risk services, some bare or unprotected steel mains, and all cast iron (CI) mains within the District of Columbia. In 2013, WGL had 23,600 services at risk. Adding copper services, excluded from the program, brought that total to 27,000. The plan called for replacement of the 23,600 services and about 55 miles of bare or unprotected steel mains (not all the existing unprotected steel) within 15 years. The plan anticipated replacement of all 418 miles of cast-iron mains within 40 years. The plan's first, five-year phase called for expenditures subject to accelerated rate recovery of $20 million in each of the first three years and $25 million in each of the remaining two. The next table summarizes the inventory of covered, leak-prone and at-risk mains and services at the end of 2013.

2013 Year End Summary of Facilities Encompassed by PROJECT*pipes* and Leak Status

Bare Steel (miles)	29
Coated Steel (miles)	64.508
Cast Iron (miles)	428
At Risk Services (estimated number)	23,600
Main Corrosion Leaks (number)	121
Service Corrosion Leaks (number)	159
Main – Non-Third-Party Damage Leaks Less Corrosion (number)	357
Service- Non-Third-Party Damage Leaks Less Corrosion (number)	199
System Leak Backlog - - Unrepaired Leaks (number)	738

WGL does not include copper services among the 23,600 at risk services slated for replacement under PROJECT*pipes*. The program also includes a portion of the coated steel mains without cathodic protection that WGL operated at the time.

Factors described in the following chapters of this report explain the much slower than expected rate of replacement progress in the current five-year plan window. The pace of work to date on the facilities planned for replacement within 15 years (services and bare or unprotected steel mains) extrapolates to a duration of 30 or more years to completion. Work on the cast-iron mains would also take much more than the planned 40 years, given current annual rates of expenditure. More encouraging, however, is the fact that, despite the much slower than expected pace, the number of corrosion leaks for both mains and services has not increased; it has remained flat for services, and has decreased for mains. Corrosion offers the leading cause of leaks not caused by third-party damage. The next chart summarizes corrosion-caused leaks.



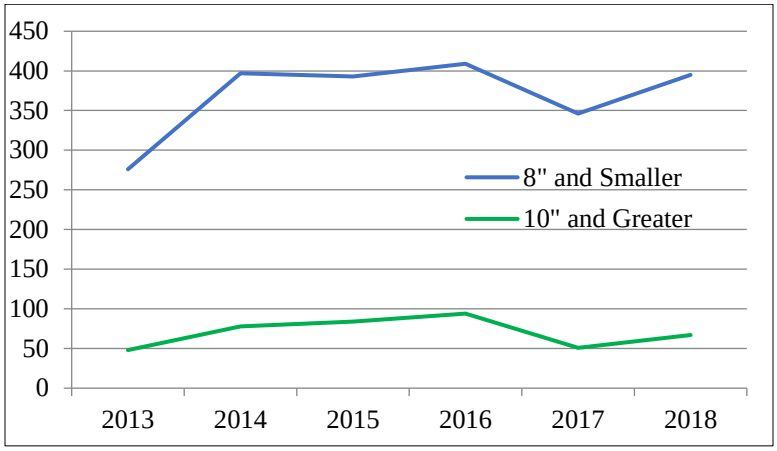
B. Findings

The service replacement program, ***Program 1*** under PROJECT*pipes*, prioritizes replacements using the leak rate for at risk services in a small geographic area. The program divides main replacement into two programs, ***Program 2*** (unprotected bare and coated steel mains) and ***Program 4*** (cast-iron mains). These three programs comprise the principal elements of PROJECT*pipes*. Program 2 and 4 prioritization uses a risk model that calculates the risk (probably of failure times consequence of failure) per main segment. WGL modifies main risks rankings calculated this way to account for other factors, such as cost savings available when it can coordinate replacement with other work performed, such as paving other utility work. Applying these factors to the base risk calculation yields a risk reduction ranking per dollar spent. However, an override exists - - the annual project lists for each one of the programs five project "Years" must include the Optimain top-3 projects drawing the highest raw risk scores, without adjustment for other factors, such as risk reduction per dollar spent. This override has resulted in inclusion of large-diameter cast iron mains that may have low failure probabilities, but high risk factors, due to the consequence of a leak or break.

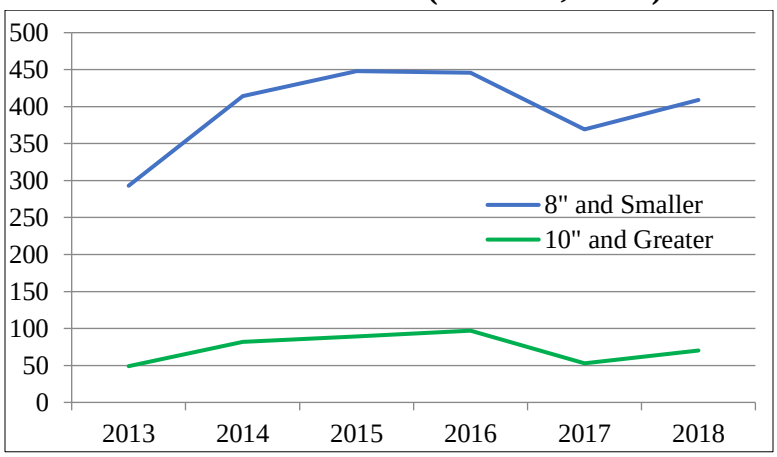
1. High Small-Diameter Cast-Iron Leaks

The next graphs of hazardous leaks (Grades 1 & 2) and total leaks (Grades 1, 2, and 3) leaks by relative size show that small-diameter cast iron pipes have more failures (leaks) than do their larger-diameter counterparts. The higher consequence in the event of lower probabilities of failure drive the inclusion of the larger-diameter CI mains on annual program lists.

Cast Iron Hazardous Leaks (Grades 1 & 2)



Total Cast-Iron Leaks (Grades 1, 2 & 3)



Grade 3 leaks typically include joints that have started leaking, but do not pose a threat of migrating into a building. By sheer numbers, the smaller-diameter mains appear to have eight times the number of leaks, as compared with their larger-diameter counterparts. It costs several times more per mile to replace larger- versus smaller-diameter mains. Therefore, the level of risk reduction per dollar spent on large-diameter cast-iron main replacement is lower. Moreover, large-diameter cast iron mains generally have many fewer at risk services attached. Therefore, replacing them, does not provide the additional risk reduction benefits of replacing small-diameter mains, along with the many more services attached to them.

2. WGL's Risk Model

The Optimain model used by WGL permits 82 inputs; management uses them all to develop a relative risk score based on likelihood of failure times the consequence of failure. The model uses these inputs to develop algorithms that drive its replacement prioritization process. The inputs related to likelihood of failure include Breaks, Corrosion, Joint type, Strikes (excavation damage), Leak, Pipe Corrosion, Other Corrosion, Excavation, Equipment, Weld Joint Material, Weld Material Other, Natural Forces, Operations, Outside Force, and Other. Many of these lend themselves to combination, such as excavation and strike, among other corrosion-factor combinations. These factors mirror the threats to a system as documented in ASME B31.8S

(Managing System Integrity of Gas Pipelines) for low-stress piping systems. B31.8S applies to, gas pipeline systems constructed with ferrous materials and is designed to provide operators with information to develop and implement effective integrity management programs.

The next set of failure factors provide modifiers for this first group. This set consists of Corrosion Extent, Chronically Down Cathodic Protection, Dry Gas Supply, Depth of Cover, Joint Type, Coating Condition, Recent Days w/o Cathodic Protection, Repair Type, and Soil Type.

The following factors drive the consequence side of the equation - - Building Class, Cover Type, Service Control Fitting, Install Method, Mercury Regulator, Extended Meter Supply Line, Maximum Flow Rate, Meter Flag, Meter Location, Population Density, Pressure Risk, Service Length Risk, Subject Matter Expert Value, and Volume Pressure Risk.

WGL's model considers other factors as well, including, Base Material, Base Size, Base Pressure, and Building. The latter factor addresses, for example, public assembly buildings, hard-to-evacuate facilities, such as schools and day-care facilities, and single-family and high-rise units. WGL also considers other failure-likelihood drivers that it can modify; *e.g.*, cover type and corrosion issues.

During our work addressing Years 1 and 2, WGL modified some of the weighting based on expert input. The modification included, for example, weighting recent leaks higher than prior leaks. Management also increased the weighting applied to schools, adding day care centers at the same weighting. The modifications also addressed certain types of corrosion, and increased weightings for mechanical and fusion joints and for coating conditions.

Optimain's developer conducts on roughly five-year cycles major reviews and updates. These updates consider data gathered from a users' group, changes in Distribution Integrity Management Program (DIMP) requirements, and input from major customers. The federal Pipeline and Hazardous Materials Safety Administration (PHMSA) established integrity management requirements for gas distribution pipeline systems in December 2009. Upon the developer's issuance of updates, WGL installs (most recently around 2015) an updated model as part of its model maintenance program. In addition to these major updates, management adjusts its weightings annually, based on internal reviews.

C. Conclusions

1. WGL needs to re-evaluate the methods used for each of the three replacement programs to better align them with reality that the original time frames for completing work remain unrealistic.

WGL has used an industry-leading model (Optimain) to drive risk assessment for Program 2 (unprotected steel mains) and Program 4 (cast-iron mains), including at risk services on each main segment. Management does not employ Optimain in prioritizing service replacements (Program 1) not associated with main replacements. For projects involving just service replacements, WGL employs quads (2,000 by 2,500 foot contiguous areas), considering leak rates in each. Overriding these factors, WGL is required to include in each Year of the current, five-year window, the three highest risk-scored main replacement projects, regardless of cost (which have been large diameter cast iron mains with few at risk services).

Each year, management's DIMP subject-matter-expert team meets to verify current weightings and other factors, and to fine-tune model results.

Taking the Optimain top-3 replacement projects as a given, management next adjusts the project lists for remaining steel and cast iron mains to produce a level of risk expected to be reduced per expenditure blocks of $10,000. These resulting rankings produce a recommended list, which undergoes stakeholder review and Commission approval, as described in later chapters of this report. As those chapters describe, the approved yearly lists contain far more work than WGL has been able to accomplish. Management expends funds on projects from the approved list until it reaches the annual spending limit on accelerated recovery ($20 million per year for Years 1 through 3 and $25 million for the remaining two).

The low rates of production and the decision not to spend above these limits, has produced a wide gulf between planned and listed work and replacements actually accomplished. The mismatch is so great as to justify a re-visitation of prioritization, in order to make sure that limited expenditures continue to go to the most significant work - - from the perspective of public safety.

2. WGL's methods for prioritization encumbers its ability to increase supply pressures to 20 to 30 psi.

Management has a program underway for increasing pressures across its system to medium levels (20 to 30 psi). That program also calls for movement of meters to outside customer premises across the system. Replacements of high-risk mains and services have implications for this system-wide pressure-increase program. Application of the risk model requires some replaced mains to continue operating at lower pressure, because they have no source of supply at medium pressure. The risk model addresses individual main segments, not broader "areas" as required to optimize pressure increase efforts. For example, supply may differ from one block to another even when mains serving both have been replaced in the same time frame. Future problems can occur, should crews find themselves unsure of pressures in mains in the same vicinities, risking an over-pressure situation resulting from a failure to properly set a regulator or failing to install a service regulator on a medium pressure service, depending on which side of a block or which street is involved.

3. Year-over-year growth in the number of at-risk services (after accounting for at-risk services replaced) during the first two years of the program indicates material gaps in management's ability to fully identify the number of at-risk services in its system.

Management regularly found errors in its understanding of the composition of existing services. In updating its database, for example, in 2015, management discovered, even after substantial removals of over 1,000 in Year 1 (which includes 2015), a net addition of 17 at-risk services, as it corrected its data. Incomplete knowledge about the materials used in existing services occurs commonly in the industry. Nevertheless, the situation here evidenced a continued need for thorough records review to identify discrepancies and data gaps. The failure to do so and to develop an action plan following that review creates a substantial risk of failing to focus on most critical replacements.

Management has identified information issues involving services, but needs to ensure that it has fully captured all facilities that fall into the Program categories considered appropriate for replacement.

4. We found sufficient experience at WGL for overseeing risk, but we had concern about the replacement decision on replacing a departing, key manager.

The results of management's prioritization undergo scrutiny by stakeholders and the Commission. We found no gaps or errors in our review of the projects included in programs for each of the three categories for each of the two audit periods. However, as noted, the net increase in at-risk services (even after accounting for those replaced) reflects a need for better information or use of information about the composition of services throughout the system.

We found during our work addressing Years 1 and 2 that WGL's DIMP team had sufficient experience to understand the need to "tune" the model to meet their current understanding of the risks involved in the gas distribution system. WGL employs a council that combines significant experience and focus on risk modeling and prioritization.

The number of DIMP group employees has remained the same, but the manager who replaced the group's head came on board after Year 2 without DIMP or natural gas distribution management experience. The person remains in the position, benefitting from a year of experience, but at the time of hiring did not meet (or at most barely met) minimum job requirements for this position. The position is too important to rely on such on-the-job training, even in the context of having a strong support group within which to operate.

D. Recommendations

1. Prepare for stakeholder dialogue a proposal to eliminate service-only replacements (Program 1), making them part of main replacements under Programs 2 and 4.

Three distinct programs apply, one for at risk services, one for steel mains, and the third for cast iron. Management uses different parameters for setting the priorities for replacement under each program. Program 1, applicable to services alone, uses quad areas selected on the basis of leak history. Program 1 projects replace all at-risk services in the selected quads, but exclude replacement of mains in the quad, unless independently selected under Programs 2 or 4.

Program 1 replacement rates occurred at far less the rates required to meet a goal of elimination in 15 years. Program 1 also does not include some 3,400 copper services, which we consider to be at-risk facilities as well. WGL, the stakeholders, and the Commission should consider elimination of Program 1, not to eliminate service replacements, but to consider their replacement as part of the Program 2 and 4 mains, to which they attach. A majority of the at risk services attach to mains eventually requiring replacement. Costs encountered to date make it more cost effective to replace mains and services at the same time, except when an individual leaking service creates a safety hazard. Eliminating Program 1 will make more dollars available to replace more feet of mains and the attached at-risk services.

Program 2 replacement of all bare steel and some unprotected coated steel mains prioritizes projects on the basis of risk score adjusted for amount of risk reduction for each $10,000 spent.

Program 2 projects include the replacement of all attached at-risk services as crews replace the mains. The adjusted risk scores take into account other work at the location, such as municipal repaving and other utility work. We find continuation of Program 2 as currently prioritized appropriate. The overall rate of main leaks has stabilized. Added funds produced by elimination of Program 1 would increase both main retirements and replacement of the services connected to them.

2. Prepare for stakeholder dialogue a proposal to eliminate the "Optimain top-3" component of replacements, employing a prioritization method that emphasizes small-diameter pipes subject to much higher failure rates.

The mandated inclusion of the Optimain top-three main segments in annual plans (again, including the services attached to them) substantially drives Program 4 work. Risk scoring is calculated as the product of failure likelihood times its consequences. This calculation basis often causes large diameter cast iron mains to secure higher risk rankings, compared to smaller diameter mains. Many studies have shown these smaller mains much more prone to cracking, making them relatively more likely to fail.

We have observed other replacement programs that apply main size to rank replacement. They first target the smallest mains (less than 6 or 8 inches in diameter), leaving larger-diameter mains to later replacement. Replacing large-diameter mains proves much more costly, often leaving little of a replacement budget for the smaller mains that can be many times more likely to cracking. Small-diameter mains prove more likely to crack because their thinner walls means that it takes less wall loss over time to weaken them to the point of failure. For the same reason, thinner steel service lines fail before mains in the same environment. Many other eastern and Midwestern urban gas distribution utilities cities prioritize cast-iron replacement on the basis of pipe diameter, deferring larger-diameter replacements, or including them as specific problems arise.

3. Ensure full accounting for pressure differences that result when replacements produce pressure increases in only part of contiguous areas or neighborhoods.

WGL's planning for replacements at the same time it seeks to increase distribution pressures can produce low and medium pressures in the same area, or even street. Converting every replaced main to medium pressure requires not only conversion of mains to supply increased pressure, but also new or altered pressure-reducing stations. Converting an existing station to medium pressure requires that conversion (and very often replacement) of all mains the station serves. WGL's approach of replacing mains on the basis of levels of risk reduced per units of $10,000 spent, can produce replacement of isolated segments that cannot be fed with medium pressure; *i.e.*, they remain in low-pressure operation.

Management correctly tests the ability of all new mains to handle future operation at medium pressure. Service lines, already tested to this pressure, can undergo modification to handle the increased pressure. The challenge lies in meeting the requirement that very accurate and current records exist to ensure proper marking of areas that have undergone replacement, but remain at low pressure, in order to permit correct setting of pressure reduction devices. A recent example of devastating consequences resulting from supply at the wrong pressure to a low-pressure system occurred recently in Massachusetts, with the explosion of a number of homes the result.

Excess flow valves (EFVs) comprise an additional safety device on new services. The WGL system requires medium pressure for EFVs. WGL therefore cannot install EFVs when it makes replacements that will continue to operate at low pressure. A later increase to medium pressure may require installation of EFVs, but current regulations permit substitution of a shut off, or "curb" valve.

Other utilities addressed similar issues through use of a neighborhood concept, starting at a supply point - - typically a regulator station. Work proceeds downstream, addressing the main and services in order. This approach does not necessarily reach the highest-risk main first, but it promotes efficiency and full coverage with respect to pressure increases.

Knowing exact supply pressure is critical for safe operation. Implementation of a GIS system and GPS on main installations could help in making the system pressure at every location more apparent.

4. Enhance efforts already underway to provide a full and accurate identification of the types and materials employed in underground infrastructure.

Our review of PHMSA annual gas distribution submissions for the District of Columbia service territory showed growth rather than decline in numbers of at-risk services despite meaningful numbers of replacements. The net increase arose through management's efforts to identify and correct all errors or omissions in the main and service inventory. These efforts produced more newly identified at-risk services than had been replaced for the year involved.

This outcome reflects gaps in WGL's database on service materials and locations, highlighting the need to continue aggressive efforts to identify all failing materials and their locations. Management advised that the PHMSA service database allows for listing only a singled type of material, even where some instances may involve multiple material types. Multiple types produce discrepancies where the longest part of the service was replaced previously. Management needs to continue its work to validate the information in the database, if necessary performing exploratory excavations to confirm, identify and substantiate existing data. Services containing any at risk material should in their entirety be classified and listed as at risk.

We did not observe any issues involving mains, but one cannot therefore assume a correct listing of materials without validation there as well. A substantial increase in the number of at-risk services or mains makes program costs and dates even more unrealistic, and indicates a greater than expected level of risk overall in the system.

III. Program Management

A. Background

Program management brings together all elements of a complex challenge like a large-scale pipe replacement program, with the goal of delivering the promised results in a manner consistent with the established plan. It is critical to define the "program" as well as the framework within which it is to be managed. This is especially critical for a company like WGL, which operates in several jurisdictions.

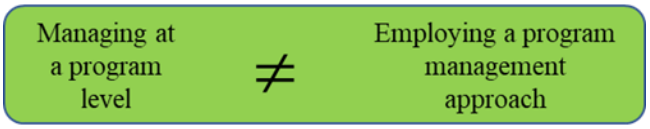
B. Findings - - Years 1 and 2

1. Defining Program Management

WGL offered two key cornerstones in defining its overall approach to PROJECT*pipes*:

- It manages at the program level, not the project level
- It employs a program management approach.

The two principles mean different things to us. The first concerns the *level* at which management focused its attention and management systems. The second concerns *how* WGL managed the Years 1 and 2 work we examined. WGL's managing at a program level approach can mean that management does not place an emphasis on each and every project in measuring performance, looking instead at projects collectively. This interpretation has substantial support. Management had 124 Year 1 projects alone - - many of them very small in scope. Managing commonly across three jurisdictions, these numbers become several hundreds. An accepted school of thought would find a focus at that level simply impractical. We do not therefore question management's desire to manage at the program level.



We did find concern - - not on the "level" but the "how" of program management. We did not find a suitable array and depth of program-level reports, nor did our examination disclose substantive, regular analyses at the program level. The attributes whose existence and rigorous application we sought to verify include the following (and they apply regardless of the level at which the work is managed):

- A person, persons or entity with the defined role of program manager
- A formal, structured process for managing the program
- The routine application of project management skills and capabilities to the management of the work.

We did not find these attributes clear and entrenched during Years 1 and 2, either at the project, District of Columbia, or corporate levels. We will, however, describe changes in the process of implementation at the end of Year 2, now that we have had an opportunity to see them actually deployed, in contrast to their early developmental stages at that time.

2. The "Functional" Approach to Project Management

Organizational Choices in Program / Project Management

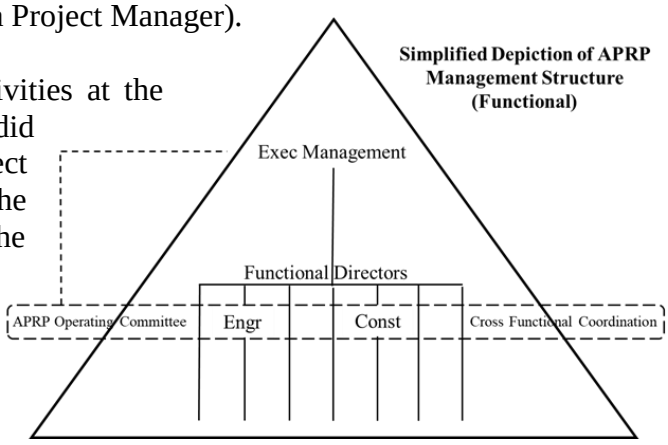
Functional	Matrix			Projectized
	Weak	Balanced	Strong	

Management described its organizational approach to management as a *matrix* organization, but it might be more accurately characterized as a *functional* organization. We use the Project Management Institute definitions, which distinguish the terms as a function of where resources that work on a project reside, and how those resources are coordinated across different functions.[1]

In a functional organization, cross-functional activities for a program or project are coordinated by the senior managers (director level); *e.g.*, engineering, construction. If instead, project or program coordination takes place at a lower level, and specifically at the level of individuals within a functional area assigned to that project, the organization can be either a matrix structure or projectized structure.

Further definition comes from the degree of control included in the coordination process. If the personnel report directly to a Project Manager, and indirectly or not at all to the functional manager, the structure is "projectized." If instead the project personnel report to the functional manager, we have a matrix organization that is either weak, balanced or strong, depending on the authority of the coordinating agent (typically a Project Manager).

WGL coordinated programs and project activities at the level of the functional directors. Management did not employ project managers or a project management function. Coordination across the functions came from a committee and the functional directors themselves. Functional personnel mostly were not dedicated to a project, but rather worked on multiple projects. These characteristics all define a functional organization.



3. The Project Manager's Importance in a Functional Organization

The absence of a project or program management function, though problematic, does not represent a flaw. WGL used a functional structure, which made the project manager role, by definition, weak (an industry-accepted definition of a management approach, not a pejorative term). Focusing on the various functions involved in ensuring project success makes the project manager's role less meaningful than it is in the other organizational choices. A fundamental lack of project management therefore has much greater likelihood of producing adverse performance consequences in structures that rely on a strong project management role. Moreover, another vehicle, such as WGL's operating committee (discussed below in the Oversight chapter of this

[1] Refer to "A Guide to the Project Management Body of Knowledge" (also known as PMBOK), Section 2.4.2, for a detailed discussion.

report) can at least partially compensate for a less robust project manager in the weak project manager construct.

We therefore focused more on the degree to which we saw the application of project management skills, actions, and techniques, whether or not performed by a single individual called the project manager. "Project Management," as applied to large engineering and construction projects, operates as a well-developed and defined science. Ample room exists for many approaches, varying levels of sophistication, and degrees of formality. The common ingredient, regardless of approach, is the application of project management actions and techniques using appropriate skills and capabilities. The level at which the program is managed, or the titles of the people, have less significance than the actions and techniques used, the tools supporting them, and the sufficiency of the skills applied.

We discuss in the next sections the many areas where these aspects of project management apply to PROJECT*pipes*. As those chapters describe, we did not see their regular use in managing the program during Years 1 and 2 at the project, program, or corporate levels. Therefore, our greatest concern during Years 1 and 2 was with respect to the activities performed (and how) and not performed regularly, not with the project manager role per se.

Nevertheless, it is hard not to take the next step - - concluding that sound scoping and resourcing of a project management function would likely have led to differences in the "how" of WGL's PROJECT*pipes* project management during Years 1 and 2. WGL did decide to create a program management organization, whose operation has jelled and matured in the Year 3 and 4 period we discuss below. That creation continues to apply the weak project manager approach, which is an acceptable solution, but, as we will discuss, has led to significant change in the activities, techniques, skills, and capabilities.

4. WGL's Implementation of the Functional Approach

Successfully implementing WGL's choice to carry out PROJECT*pipes* within a functional program structure required means for addressing those areas where it is subject to execution risk, particularly on large programs or projects. For example, responsibility for executing program functions (*e.g.*, engineering or construction) lies with directors of those functions - - directors who have many projects and programs requiring contribution from the resources they direct, making coordination of a particular program at their level difficult or impractical. A project manager is considered "weak" in this structure because the role does not permit direction of the program activities of the resources of the various functions involved.

The role of the project manager nevertheless remains an important coordinating and reporting one. During Years 1 and 2 we did not find such a project manager role. An operating committee consisting of those who directed project functions provided some level of coordination, but we did not find it focused on issues of program performance, cost effectiveness, project completions or program production.

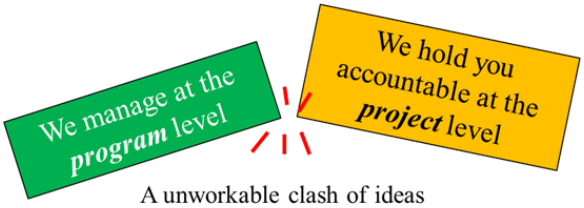
The coordination role of project management in such a structure includes development and use of integrated schedules that address details of each functional organization's deliverables and priorities, with specific attention to required handoffs. We did not find such schedules. Similarly,

program status reports providing visibility on progress and performance at the program level are an important requirement. Their absence restricts the ability to ensure effective work coordination. We did not find robust program status reports. Mutually understood and accepted priorities must be in place. There was no mechanism for identifying and communicating priorities or for managing to such priorities.

We did not find defined focal point(s) for accountability of the DC APRP. Moreover, an overall program plan, to which all of the participating functions can align, must be in place. The replacement plan for the District of Columbia, as we will explain, effectively ceased to provide meaningful performance measuring points as early as Year 1.

5. The Focus on Project Estimates

Discussions among the District of Columbia stakeholders about estimates have settled on the notion that estimates should be prepared at the individual project level. Notably, the degree of detail and accuracy in estimates has been elevated to AACE Class 3 as a result of recent dialogue and resulting agreements. We understand management's reluctance in getting there without the benefit of outside urging, given its stated approach at the time of managing only at the program level. Class 3 estimates by definition focus on management at the project level.



A unworkable clash of ideas

We believe that the much-discussed estimate issue has much to do with management's lack of specificity and detail in explaining exactly how it "manages at a program level." Management has not succeeded in the past in producing confidence that its approach had full substance and vitality. The lack of confidence makes understandable gravitation by others to more familiar management approaches, including measuring variances against estimates and holding management accountable for unexplained deviations.

Greater clarity on the "how" of program management would go far in building confidence in its effectiveness. As we will explain, changes whose impacts we began to see after Year 2 began to do so. We think more remains to be done, but we believe WGL's approach can work if it continues along the path it began with the creation of its program management organization. If fully successful in bringing its approach to full maturity and robustness, WGL's approach can and in some respects, we believe, should diminish the focus on estimates (as we explain in the estimating chapter that follows.)

6. Establishing Quantities as the Primary Focus of Project Management

In examining project costs (individual or aggregated) as the primary control base and management focus for PROJECT*pipes* one should not neglect other parameters linked program goals and more directly connected to the physical work being done. Doing so, in our view points to bulk replacement quantities as the central control parameter. Getting those "quantities" (*i.e.*, mains and services not subject to high failure risk) in place comprises the central purpose of PROJECT*pipes*.

A focus on these replacement quantities should hold far greater interest for management and for stakeholders as well than does the cost of a specific project.

Even under a construct making replacement quantities, not projects, the control focus, the notion of a "project" would still be important, but not as the basis for program management and control. Defined projects would still form geographic identifiers, create collectors for cost accounting (a BCA# - - a numeric identifier for projects as recorded and tracked in WGL's work management system), provide dimensions for engineering "packages," and basis for work scheduling, prioritization, and other necessary functions. Management reports, however, would not focus on specific projects, because they are not key to primary management and control parameters. Those reports would use information built up from project details, but would present data aligned by the parameters of bulk quantities of mains and services (sorted into meaningful classifications) and the costs and schedule associated with their installation. Cost analysts would study data at the project level, but not to highlight how particular projects have gone, but to identify the forces, factors, and events driving rates, costs, and paces of installation.

7. Managing to Expenditure Levels, Rather than Quantities

We will present schedule data later that demonstrates that PROJECT*pipes* fell well short of production requirements. We will further discuss the degree to which management tried to correct such deviations from plan. In the case of schedule issues, the primary, although not the only, option is generally added effort, whether in the form of more people, overtime, shifting of resources, or any other mechanism that directs a faster pace.

The recovery mechanism led WGL to decide to limit spending annually to $20 million for the first three years and $25 million for the next two. Any overage would have to secure recovery under traditional methods. When it became clear that the planned production quantities were going to fall far short, both for the audit period and beyond, it would have been logical to consider an increased level of spending. Management suggests that this would not have been feasible in Year 2 because of resource availability issues. It would not have been possible to obtain new resources or shift resources from elsewhere to PROJECT*pipes*. In fact, resources were moved from PROJECT*pipes* to other projects, specifically Formal Case 1027, in Year 2.

C. Conclusions - - Year 1 and 2

1. Years 1 and 2 of PROJECT*pipes* operated without a fully developed program management approach and did not benefit from the application of a robust range of project management activities and techniques.

Management did make changes to its program management approach, beginning to establish the features generally seen in program management schemes. We address their maturation and effectiveness in our discussion of Years 3 and 4.

Application of project management skills remain essential whatever the overall approach, and whether or not a distinct project management office exists. That application in cost management, planning, scheduling, and performance analysis were not priorities during Years 1 and 2.

2. A focus on replacement quantities and their costs and production schedules forms a better baseline for control than does a focus on variances from individual project estimates.

The focus on individual project cost variances as the basis for management is a traditional, widely accepted, and well-proven approach. We do not criticize that approach, although we do question the manner in which it has been implemented. This should not, however, rule out alternates that can be more effective. In the case of WGL and PROJECT*pipes*, we consider a different focus appropriate. The *purpose of the program is* to replace leak-prone pipe, and to do so prudently and effectively. In this context, the consideration of project details, whether costs or quantities, is not necessarily helpful or practical given the large number of projects and the very small size of many of them. We discuss the size of projects in more detail in the estimating chapter. Some 60 percent of Year 1 project estimates fell under $100,000.

3. Management of PROJECT*pipes* as part of an integrated WGL-wide replacement effort covering all its operating utilities did not promote full visibility on drivers of performance in the District of Columbia.

WGL had active accelerated pipe replacement programs in each jurisdiction. Many such multi-jurisdictional firms choose to manage large efforts at the corporate level. We find the approach sound as a means for optimizing effectiveness and efficiency overall. However, the approach can tend to obscure performance drivers of interest to the stakeholders of individual jurisdictions,

It is critical that programs of the size and importance of accelerated pipe replacement receive a high level of management attention and focus, regardless of the number of such programs a utility has. This can be accomplished in many ways, including the assignment of a program manager, preparation of suitable status reports, definition of accountabilities and many other vehicles. Our Year 1 and 2 work with management showed it to be closely focused on regulatory reporting requirements, which is understandable. However, we did not find management as conversant with or its performance data focused on unique factors, forces, and performance factors unique to work in the District of Columbia.

D. Improvement Opportunities - - Year 1 and 2

1. Our work identified a need, going forward, for management clearly to delineate in detail the objectives, components, and activities encompassed within its "a program management approach", how that approach was to be implemented, and how it specifically sought to promote and measure effective and efficient performance.

Responsibility and accountability changes we discussed with management included:

- A project manager or similar entity for enhanced coordination among the functional groups
- Defined focal point(s) for accountability of PROJECT*pipes*
- Mutually understood and accepted priorities

Specific aspects we discussed with management in strengthening its functional approach to management included the key success factors of:

- Integrated schedules - - The complete scheduling system should cover projects from design, through procurement, contracting, construction, and close-out.

- Monthly Program status reports - - Various levels of reports generated should regularly track status of active individual projects and of the program overall. Reports presenting only numbers have limited value; they should include analyses, confirm positive directions and developments of projects and the Program, and identify adverse performance or declining trends, addressing means to resolve them timely.
- An overall and well structure program plan - - This plan should delineate how WGL intends to manage the program and its projects, specifically addressing objectives, overall approach, major processes, descriptions of key elements (*e.g.*, project authorization, cost estimating, design and engineering, procurement, work management, progress reporting, project scheduling, contract management, resource planning, cost management, and performance measurement).
- Measures that relate production to costs - - More effective than employing separate production and expenditures metrics would be to add measures relating production to associated costs for mains remediated and services installed.
- Insightful analysis that leads to corrective actions - - It is not sufficient merely to identify an overrun and explain the obvious facts surrounding it; management must investigate, document, plan to remediate through corrective actions, and report on the effects of such actions on performance issues identified.

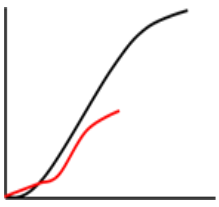
2. We found a need for management to enhance project management skills and capabilities, and expand the application of such skills in the management of programs and projects.

An assessment of the program management skills of each manager and supervisor in key positions forms a central aspect of meeting this need. Despite generally strong capabilities, it is unreasonable to assume that all possess the capabilities and skills necessary for effective program management in all its aspects, for example, project planning, cost control, variance analysis, work management, integrated scheduling, resource planning, contract management, and performance analysis. An initial formal assessment of managers and supervisors comprises an important early step in identifying areas where management can provide program management personnel with the resources and opportunities to upgrade their skills. This step should be followed by the establishment of individual training plans to address skills enhancement needs identified for managers and supervisors in key positions. Plans should be documented and funded through annual training budgets.

3. Replacement quantities and their associated costs and production rates offered significant appeal as the central basis for controlling PROJECT*pipes* performance.

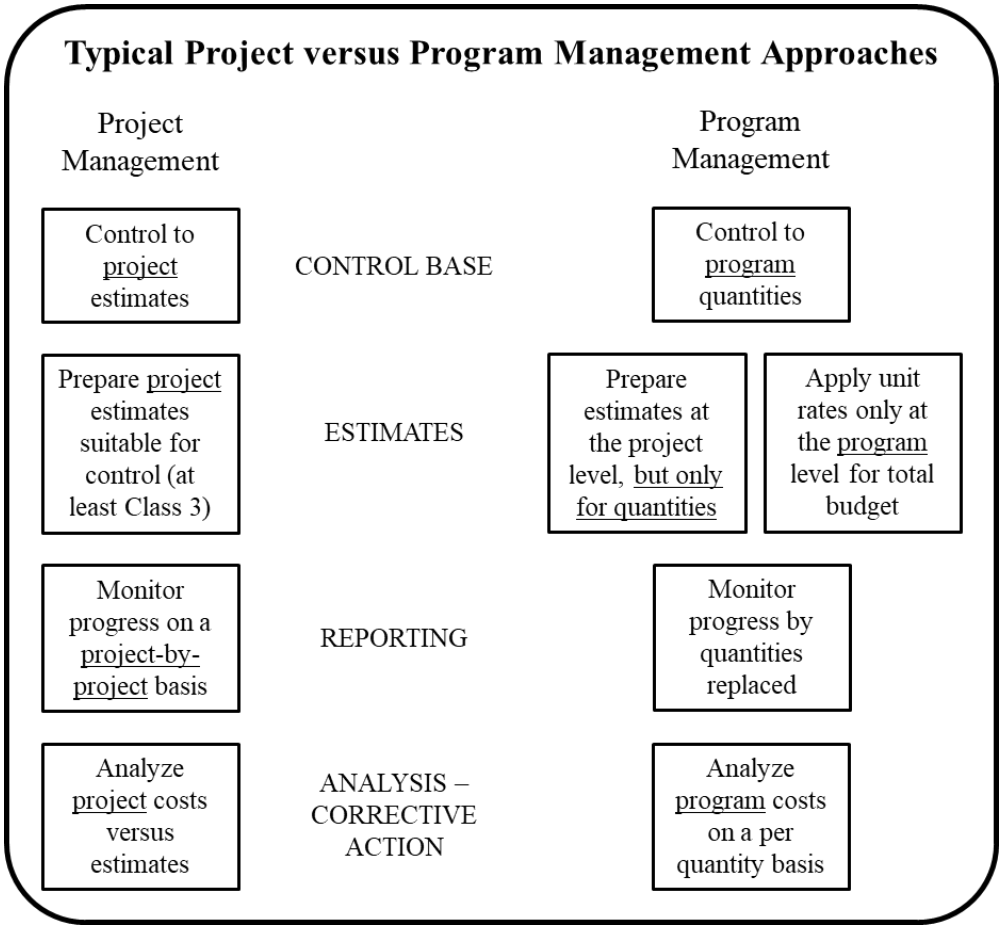
A focus on bulk replacement quantities, as well as their associated costs and production requirements, appeared to us more effective than a focus on cost of projects as demonstrated by cost variances from estimates. The primary performance indicators in this different approach include:

- Planned versus actual replacements in selected categories (*e.g.*, size), shown as "S-curves" - - This type of curve depicts the progress of main and services replacements at the annual as well as Program level.
- Planned versus actual cost of replacements in selected categories, shown as dollars per foot or dollars per service at the aggregated PROJECT*pipes* level - - This is an effective measurement that provides



high level visibility of how the Program is performing in terms of production versus costs on a unit cost basis. This measurement should be used to show performance on an annual basis and also Program-to-date basis.

The next illustration depicts a sample management scheme using the changed control base.



4. We observed a need for management to implement specific measures to increase management focus on and oversight on the District of Columbia pipe replacement program.

Management's focus at the time of our Year 1 and 2 work was on the overall corporate pipe replacement program. We did not find systems or tools that focused on performance in the District of Columbia. Such reporting schemes would benefit both internal management as well as external parties such as the Commission and other stakeholders. We found no monthly executive reports with overall program performance and insightful analysis of positive, and negative aspects of and trends in project and program performance. WGL already captures in its existing systems the essential information for supporting this enhancement.

E. Developments - - Years 3 and 4

1. Defining the Program Management Approach

Management strengthened its program management approach by implementing the following changes:

- Program accountability designated - - The WGL Vice President, Construction, Compliance & Safety clearly accepts accountability as the program's single executive manager, and is fully engaged in the execution of the PROJECT*pipes* plan.
- CPSM Group fully staffed - - WGL created the group to facilitate overall governance, program management, performance tracking, planning and execution of accelerated pipeline replacement program; the group's staffing now includes one director, one manager, one lead of regulatory analysis and replacements, one senior specialist, and two specialists. All have appropriately defined responsibilities.
- Monthly BCA Progress Reports developed - - These reports address program and project status and progress, and document analyses of scope, cost, and schedule variances.
- Electronic log for field changes developed - - Management, following a trial period, began full scale use in November 2018 of Daily Pay Item logs that create a consistent, readily-usable, timely process for logging and securing pre-invoicing approval of contractor pay items.
- Cost estimating process established - - Acceptable procedures address the processes for developing cost estimates for replacement projects; historical data extracted from the Work Management System establish exist for various types of work categories; *e.g.*, main replacement, planned service replacement, service abandonment, service changeover, and commercial service replacements.
- BCA Reauthorization Process enhanced - - Management has updated the procedure to reflect the incorporation of Class 3 Cost Estimates as the project baseline.
- Program Implementation Plan (PIP) updates - - Management is updating the PIP to incorporate lessons learned and essential levels of details, such as scope assumptions, cost and schedule baselines, Governance Committee charter, roles and responsibilities, program management methods, the BCA reauthorization, compliance, reporting and analysis requirements, and metrics to monitor progress and productivity.

2. Enhancing Project Management Skills and Capabilities

The next chart shows the current staffing of the Construction Program Strategy and Management organization (CPSM), which, following Year 2 has played a growing role in PROJECT*pipes*.

CPSM Organization – Year 4
(the following chart is confidential)

During Year 1 and part of Year 2, managing WGL's accelerated pipe replacement program rested with multiple functions, with program "management" requiring coordination by senior management of those functions, and required WGL to create the new, CPSM group in Year 2 to support program governance, management, performance tracking, and reporting. By the time we were completing work on Year 2, we understood generally what WGL intended to do with the new group, but we did not at that time see already substantial change or impact.

The CPSM group added four members in 2017 to carry out functions associated with regulatory compliance, performance reporting, support for audits (such as ours), and testimony preparation and coordination. The new positions included the following persons having program management and reporting responsibilities:

- CPSM Manager - - regulatory analysis, interpretation, reporting, and support for program governance
- Lead Reporting Specialist - - data management and analysis
- Senior Reporting Specialist - - report creation and data analysis.

Priorities for the new group included streamlining and improving the tracking and closure of BCAs, improving coordination of WGL functional groups (like engineering and construction), in taking projects from planning to execution, enhancing the tracking of work units accomplished and spending to accomplish them, and ensuring timely and complete responses to Commission inquiries.

Management intended the resources added to the CPSM group to provide :

- More dedicated focus to each jurisdiction
- A change from the prior approach of identifying variances at year end to capturing them on a continual basis, in order to make more promptly adjustments to the work or to expected cost changes from those estimated and expected.

The CPSM group has taken actions to more promptly and thoroughly capture cost and performance results. It has introduced monthly dashboards that track this information, supported by variance meetings to address the data. The dashboard tracks PROJECT*pipes* progress against projects on the lists for each Year and against the overall five-year plan. These monthly dashboards also support monthly executive governance presentations. The CPSM group has also created Monthly Work Request Closure reports that assign responsibility, and track project completion. CPSM leads cross-departmental lessons-learned and variance meetings.

Senior leadership describes the group in the context of a change in WGL's conception of the program as merely adding work to the normal flow to one of treating it as a program requiting its own program management approach and structure. The change grew out of a 2015 strategic planning meeting, with consideration at that time to placing the structure under regulatory affairs. During our work occurring in Year 2, the focus on regulatory reporting and analysis (versus work designed to enhance management of the work) was clear. Senior leadership views the principal effect of the changes made as moving from the past's reactive approach to what has become a proactive one - - supported by a "regular cadence" of data compilation, discussion, and deep dives into performance and cost issues, involving regular meetings to address those issues.

The management focus has become much clearer in our work addressing Years 3 and 4, although group management acknowledges that the CPSM remains in the process of "coming up to speed" now that it has become fully staffed and stabilized. For example, management recently reported that it is "continuing to move towards the stage of discovering root causes for variances, as well as strategizing and applying corrective actions based on these causes." The group's principal short-term priorities lie on the regulatory processes associated with the program phase coming after the end of Year 5, and on enhancing the content and use of the dashboards and metrics now in use.

The CPSM group added a fifth position in Year 4, the Program Development and Management Specialist, to provide analysis and to assist in regulatory reporting. The data analysis function has focused on faster BCA closure by identifying remaining BCA work items and the functions responsible for them. The new specialists work in support of regulatory request responses has also allowed the other CPSM resources to focus more on direct program management activities.

Management has established the CPSM organization, and filled the key positions with capable personnel. All the positions have well defined roles and responsibilities. Management has yet to formally assess their individual skills relative to short- and long-term program needs. Management may from time to time conduct workshops to upgrade their skills on specific topics on a collective basis.

3. Changing Control Focus to Quantities and Installation Rates

Management has recognized the benefits of this control focus, and has analyzed the trends in its Planned Unit Costs (used in yearly program estimates). It has produced the following information about these unit costs across the four years of experience under PROJECT*pipes*.

(the following table is confidential)

Evolution of Projected Cost *Estimates (in millions)*

For Service replacement, unit costs for programs 2 and 4 seem to have stabilized at about $5,000/service. For Services under Program 1, the Year 4 rate of $14,000/service is about three times the Year 1 rate and two times the Year 2 rate. For main replacement, the Year 4 unit cost of about $500/ft for both programs 2 and 4 reflects a doubling of the Year 1 rate.

Management developed its Planned Unit Costs using adjusted historical data. Understandably, Year 1 data is subject to more questions, given the need to annualize the 16 months of data, and the level of consistency of data collection over historical years. We asked that management prepare a sample report showing actual unit costs versus planned ones. The next chart shows the WGL product for main and services.

WGL's Actual versus Planned Unit Cost Sample Depiction

(the following illustration is confidential)

Program 1 consists of only services; its measure is dollars per service. Programs 2 and 4 consist of main and services; their measure is dollars per foot of main replaced. In terms of comparing performance at the end of Year 4 to the end of Year 2, the data show marked increases in Year 3, followed by notable Year 4 declines in Programs 2 and 4.

4. Increased Focus on D.C.-Specific Performance

Management has improved visibility on program performance from the top down, implementing several improvements. WGL established revised executive reports, monthly executive dashboards in Year 3 to monitor key Program components: actual spend versus the 5-Year Program total of $110 million, mains installed and retired versus plan, services replaced versus plan, separate charts that show the main quantities and services quantities installed versus the five-year plan, chart that shows the Program-to-date spend versus the five-year plan, Program BCA status, key milestones for the next 90 days, and the fiscal year-to-date installation and spend status. The next illustration shows how the reports portray summary data.

Executive Dashboard Depiction
(the following illustration is confidential)

Management has also incorporated focusing on discussion of the dashboards and on overall program progress, completed projects, and financial status.

F. Recommendations

5. Promptly complete the described program management measures now underway.

Following progress since the end of Year 2, the following needs remain:

- Integrated schedules - - The complete scheduling system should cover projects from design, through procurement, contracting, construction, and close-out.
- Monthly Program status reports - - Various levels of reports generated should regularly track status of active individual projects and of the program overall. Reports presenting only numbers have limited values; they should include analyses confirms positive directions and developments of projects and the Program, and identify adverse performance or declining trends, addressing means to resolve them timely.
- Measures that relate production to costs - - More effective than employing separate production and expenditures metrics, these should relate production to associated costs for mains remediated and services installed, as shown in the template management.
- Insightful analysis that leads to corrective actions - - It is not sufficient merely to identify an overrun and explain the obvious facts surrounding it; management must investigate, document, plan to remediate through corrective actions, and report on the effects of such actions on performance issues identified.
- Overall Program Plan - - Management needs to complete its updated version of the Program Implementation Plan - - this plan should delineate how WGL intends to manage the program and its projects, specifically addressing objectives, overall approach, major processes, descriptions of key elements (*e.g.*, project authorization, cost estimating, design and engineering, procurement, work management, progress reporting, project scheduling, contract management, resource planning, cost management, and performance measurement).

6. Conduct skills assessments and development plans to further the project management skills and capabilities enhancement now underway.

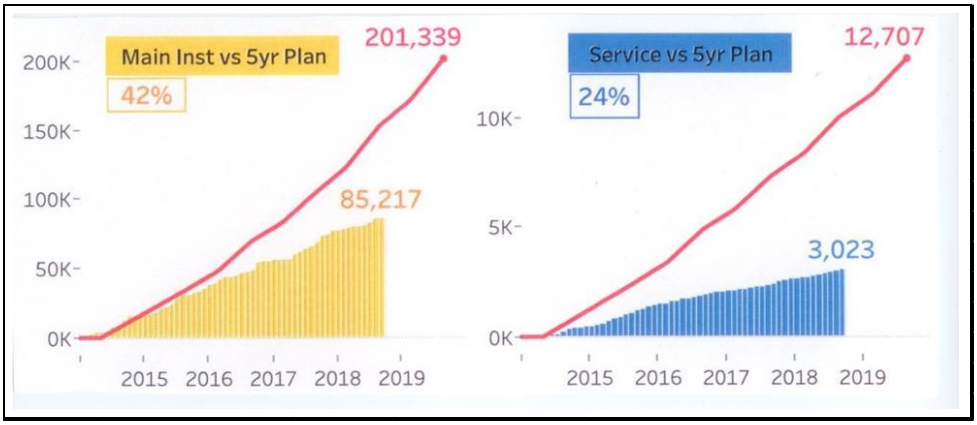
The specific needs include:

- Assessment of program management skills of each manager and supervisor in key positions
- Establishment of individual training plans to address skills enhancement of those managers and supervisors.

7. Incorporate routine measurement of Actual versus Planned Unit Costs as part of ongoing performance measurement, and, as it continues to examine performance variances, identify, report on, and analyze other metrics material to ensuring continuing program success.

Management has made the change in control focus to quantities and their installation rates. The next illustrations show management's current measurement of main and service installation versus the five-year plan. These two charts highlight the program's production lags. They highlight the need to improve productivity or manage costs more effectively to optimize production.

Actual versus Planned Main and Service Installation



Management has also performed an annual Unit Cost Study (summarized in the following illustration) for planning purposes. This information will provide another baseline for monitoring production.

Unit Cost Study Illustration

(the following illustration is confidential)

Management needs to supplement its tracking and analysis of performance metrics by continually measuring and analyzing the trends in actual unit costs across a variety of performance units and elements and variances between and actual and planned unit costs. An appendix shows mock-ups illustrating the concept, bases, and assumptions, and provides examples of the metrics at the summary and detailed levels, using some WGL data.

8. Complete measures underway to increase focus on D.C.-specific performance.

Efforts are underway to improve reporting accuracy and provide more comprehensive, detailed, insightful, actionable analyses. Management plans for the executive summary section of the Monthly ARP Executive Dashboards to provide more narrative addressing positive and negative performance elements, trends that may suggest emergent problems, analysis of the causes of negative performance indicators, plans for addressing them, and monitoring of the effectiveness of changes to address performance issues.

9 Re-define "normal" replacement in light of experience and current infrastructure and risks and evaluate the institution of a work completion condition to expedited recovery of program expenditures.

Years 1 through 4 performance have fallen extraordinarily short of expectations set by the approved five-year plan. Management did not succeed in performing work at rates (measured by time or cost) at all close to expectations. Those time and cost rates have not materially improved in Years 3 or 4. Actual accomplishments fell short of goals in every category and versus every parameter. Management has offered two explanations. First, it considers the first five-year plan an unsuitable basis for setting appropriate expectations. It was, however, its plan - - and a plan that underwent dialogue and an ultimate level of acceptance to secure approval. Management did not present an alternate set of measures it deemed preferable.

Second, management points to the many uncertainties associated with urban utility construction, including fast-changing permit requirements, that can greatly influence the work. We agree with the exposures created by such uncertainties. As we describe in the *Field Execution* chapter, we acknowledge their overriding impacts on work costs and schedule. In any event, and more importantly, we have seen no apparent means to alter the unit rates radically (absent changes in public requirements) although moderate improvement can occur even in current circumstances.

The persistence of unit rates at roughly the current magnitudes raises important questions when considering the future of the program. Customers simply have not gotten, nor will they get the level or pace of risk reduction previously expected for $20 million in incremental replacement expenditures per year. Moreover, the current method of accelerated rate recovery qualifies recovery on the basis of dollars spent - - not high-risk pipe amounts removed from service. It is appropriate therefore to consider a more direct linkage between accelerated recovery and removal of high risk pipe.

Four program years have passed with replacement of far less high-risk mains and services than expected. At the same time, the remainder of the system continues to age, as knowledge of its condition and risks continues to be monitored and as other drivers of customer rates and their "affordability" evolve. What constitutes "normal" would appear to require re-examination and clear definition under these circumstances. A related question becomes how, given consideration of the critical consideration of affordability, annual expenditures beyond "normal" should be sized and directed. These questions should undergo dialogue based on a completely new and revised program estimate to completion.

Project expenditures have run at anticipated annual rates, but high-risk pipe removal has proceeded much slower. Many projects remain in progress as project years come and go. We believe it has therefore become appropriate to consider the establishment of a performance condition to qualification of expenditures for accelerated recovery. We understand that longer projects proceed in stages, with new pipe being gassed in and customers being re-connected with new services in groupings that cross sometimes longer project durations. We considered a method for tying expenditure recovery to customers gassed in, but have concern that such an approach could incent sub-optimal work planning and performance. We therefore consider a holdback of a percentage of costs incurred, pending project completion.

IV. Project Authorization

A. Background

A technical process drove project selection, focusing risks associated with leaks and the assignment of priorities based on those risks and other considerations. Chapter III addresses the design and execution of the process. Our review here examined how formal initiation and expenditure authorization on projects identified through that technical process occurred.

B. Findings - - Years 1 and 2

WGL's "BCA Authorization Work Flow" document details its process for formal project authorization. Authorization, as is typical of most processes WGL applied to PROJECT*pipes*, had no "process manager" per se; each organization attended to its own defined responsibilities. In such an organizational approach, process definition must be complete and clear. The flow chart provided met these requirements.

Two organizations served as the primary contributors to the authorization process:

- Replacement Engineering - - staffed with internal personnel
- Engineering Design - - managed by WGL personnel and partially staffed with contractors.

System Planning and Construction performed a contributing role. The project or work to be authorized was packaged under a BCA" number, which served as the numeric identifier for the project as recorded and tracked in WGL's work management system. All projects within the scope of our work had an assigned BCA#, except for "scattered" projects. These projects involved unplanned work added to meet other priorities. The traditional technical selection process did not therefore apply to them. However, given their eligibility for accelerated recovery, our work addressed them.

1. Project Initiation and Scoping

Risk comprised the primary parameter for selecting and defining projects. Replacement Engineering qualified projects based on the potential for leak reduction, after which they entered the authorization process, with assignment of a BCA#. Replacement Engineering defined the scope of the work.

Many projects required a Piping System Integrity Analysis (PSIA). Following scoping by Replacement Engineering, the System Planning group performed that analysis. Some projects qualified for funding support from others. Estimates of the funds required from the responsible parties were prepared. These estimates prepared for this purpose included an amount for contingency, differing them from management's estimates for other projects. The actual cost and the amounts paid were trued up after the completion of the project.

A designer prepared preliminary construction drawings and submitted them to System Protection, Construction and Environmental for review. The designer then completed final construction drawings and permit applications.

2. Authorization

After completion of design, each potential project returned to Replacement Engineering to undergo a sequence of operations. These sequences included simple listings of perhaps 10 key project activities. After assembly of the required documents into a BCA authorization package, formal authorization steps began. Designated managers had authorization authorities categorized by project estimate amounts - - larger dollar amounts requiring higher level authorization. The estimates presented for authorization included simple statements of quantities and unit rates. Where a differing prior estimate (the "original" estimate) existed, it was noted, with the new estimate designated as the "revised" estimate. In these cases, we observed no discussion of differences in original and revised estimates and no reconciliation of quantities or amounts. With projects presumed necessary based on risk determinations, management did not consider review necessary in the case of increases in estimated costs.

Approval by the appropriate managers approved the package, it proceeded to construction. At times the authorization was held by Replacement Engineering in order to provide for an orderly release and suitable backlog of work for construction.

3. The Role of the BCA Process

We assessed the effectiveness of the authorization process in place. Projects first proceeded through a technical risk analysis. With risk the accepted key decision parameter in project selection, it is not surprising the decisions, although made very early and with little input other than risk, will generally prove sound.

The projects so selected became part of a proposed project plan for the coming fiscal year. Several months before program year inception on October 1, a review by stakeholders and the Commission produced a finalized list of projects for the coming fiscal year's program.

However, the list was not intended to serve as a roster of work amounts to which WGL would manage or that management expected to accomplish. Instead, WGL managed to total annual spending ($20 million per year). The list of approved projects therefore represented work elements to be performed up to but not (combining expenditures on all of them) in excess of $20 million for the year. In other words, producing enough work to ensure the ability to spend $20 million determined the length of the project list. The cost was not set after creation of a list of work expected and planned to be performed did not produce a final total budgeted cost.

As of the start of the program year, work could begin on the projects on that year's approved list, but work first required release to construction, which did not happen until completion of the BCA authorization process. BCA authorization completions occurred both before the program year (to establish a suitably long backlog for construction) and during the year. For example, we examined a sample BCA authorization package (BCA# 261060) for Year 2, which began October 1, 2015. That package's authorization came in January 2016. Thus, from a *funding* perspective, BCAs have no major role, but each individual project has required sign-off by the appropriate level of management (based on dollar size) before charges against its BCA# could occur. The annual funds, including the share intended for BCA#261060, were already in place and committed. That work

on a particular project could not start until release to construction illustrates the role of the BCA authorization process.

Management designed the BCA authorization process to fill a number of purposes, with funding not among them. Those purposes include design, technical reviews, documentation of approvals, and work release. This leads us to characterize the BCA authorization process as a construction release process. Following project identification, risk parameter definition, an incorporation in the approved project list for a given program year, the BCA process did not revisit the commitment to proceed with the project.

C. Conclusions - - Years 1 and 2

1. The authorization of project funding for PROJECT*pipes* followed an approach inconsistent with several of our traditional evaluation criteria, but which we nonetheless find sufficient.

It is common in the industry to select leak reduction projects based on risk, and to give cost less weight in the selection process. WGL's approach tracked the industry in this regard. WGL varied from typical industry practice after initial selection, however, in the way it funded projects.

Individual projects were not specifically funded in the usual sense. Instead, they had already been funded on a de facto basis when selected, added to the project list for the coming program year, and then appearing on the finally approved list after stakeholder and Commission review. A project's estimate typically serves as its funding basis in the industry, but not for PROJECT*pipes*. Management placed little value on project estimates; following authorization, they proceeded without the need for subsequent review in the event of scope or estimate changes. Accordingly, WGL's approach did not meet three of our criteria:

- Estimates used in the authorization process should be reasonably accurate.
- Project authorizations should be revisited if major cost, schedule or scope changes were identified
- Authorized amounts and the associated production expectations should serve as a basis for subsequent management of the work.

Some of these criteria became inapplicable because WGL chose to manage at a program level rather than a project level. The materiality of our criteria also diminish for very small projects, of which PROJECT*pipes* has many. Such projects often do not lend themselves to traditional controls. We address these issues further in following chapters, but from a funding perspective, the WGL approach functioned sufficiently.

2. WGL employed a clearly-defined and well documented BCA authorization process.

The detailed flow chart and required forms were clear and were well understood by managers. The path was logical and efficient, with no unnecessary paths and hand-offs. The final deliverable, the release of the work to the field, was well defined and conclusive.

3. The BCA process satisfied technical, documentation, and work release needs but did not operate in practice as an authorization for funding for specific projects.

Two types of funding need to be considered here - - one direct and one indirect. First, annual aggregated funding authorization directly came via the program commitment of $20 million per year in Year 1 and 2. Second, individual projects became for practical purposes "funded" by inclusion on the approved project list for the given program year. There was, however, a requirement that formal sign-off pursuant to WGL's "Procedure for the Evaluation of a Replacement Project Business Case Authorization" occur by the required level of management. The BCA authorization process did not question the need to proceed with a project, regardless of cost and scope changes, making that project's funding a closed issue by then, even where a project's BCA followed long after the creation of the approved list. The BCA process thus "authorized" projects, principally in terms of release for construction. It technically authorized charging, but not in a way used to control program funding in a substantial way.

4. Project funding thus implicitly accepted a "whatever it takes" basis.

Each program year's list of approved projects included estimates for each listed project. However, management did not treat those estimates as limiters on funded amounts on a project by project basis. The only funding limiter was total annual spending of $20 million on projects on the approved list. Thus, funding for projects was fully authorized by inclusion on the list, could carry over to subsequent years, and could increase in cost without limits requiring further approval.

The implicit acceptance of "whatever it takes" at the individual project level does not accord well with traditional project management notions. However, if we confine the question narrowly to the PROJECT*pipes* authorization context we found it acceptable. When the risk scores were calculated and project selection was complete, the decision-makers were confident that subsequent changes in project costs, however great, should not change the decision to proceed. Given the circumstances upon which projects were selected in the first place, this was a reasonable assumption.

WGL's logic perhaps weakens as project size and cost risk grow for larger projects, but that raises a cost management issues, which we address below. From the narrow authorization point of view, especially recognizing the finality of the project lists after their approval, we did not see value in adding controls not likely to make a material difference.

D. Improvement Opportunities - - Years 1 and 2

We identified no opportunities for improving the BCA authorization process.

E. Developments - - Years 3 and 4

We did not find a material change in the authorization process.

F. Recommendations

None.

V. Program Planning

A. Findings

Our Years 1 and 2 review addressed the first two years of the initial five-year plan, with Commission review of a second five-year plan imminent. We did not examine the five year plan's creation, but rather its execution for the first two years, followed by an examination of Years 3 and 4 to assess changes in program management and the implications of current performance metrics for the future. WGL has proposed multi-year plans, consisting of lists of projects, stakeholders have examined them, and the Commission has ultimately approved final project lists yearly.

We did, however, find program planning over the long-term a matter of significant interest - - as it has proven in our other examinations of long-term, very costly replacement programs. We believe that shorter term planning, like that created by five-year windows or by annual, detailed project lists, needs to consider the full program of which they form part. In turn, how management has laid out the work over the future, estimated and assigned resources, and adapted and revised the plan as actual performance and results vary from expectations become matters of interest as well - - particularly where performance falls well short of initial expectations, and is likely to continue operating at the performance levels being achieved now.

Replacing leak-prone pipe in the District of Columbia will prove a multi-billion-dollar, decades long endeavor. The safety benefits, or more precisely the consequences of inaction, are enormous, as the Commission's endorsement of an accelerated replacement program clearly evidences. Breaking down such a program into shorter timeframes (five years in this case) does effectively provide a more manageable scope and horizon, but the magnitude of the full job needs to remain clear. Customer affordability clearly requires consideration in setting short-term spending parameters. However, there remains a pivotal balance to be struck between cost and results (perhaps best measured here by the duration over which risk reduction deemed actionable will remain).

To summarize, customers can neither afford too great a spike in rates nor too great a retention of safety risk. They cannot have both low cost and materially advanced risk reduction. How much of each they should have is the question. Answering it calls for the full picture (all costs over total program duration). We believe that always to be true, requiring continual efforts to look not just at how well the five-year program is going, but where completing it will leave customers and the pubic when the next stage commences, and the one after that, and (…).

We would say so were performance during the first five years at or above the expectations underlying it. With the case so far different and so unlikely to change, the question of accelerated pipe replacement in the District of Columbia, and its relationship to other drivers of customer costs for that matter is compelling.

Grasping - - not to mention tackling - - that real magnitude can be difficult. Today's management, stakeholders, and regulators across the country, as here, are making commitments that will:

- Require large amounts of capital for decades
- Boost customer costs materially for decades

- Most critically, have a major bearing on threats to public safety, the reduction of which will prove directly proportional to the pace of the program - - with pace driven fundamentally by annual expenditure levels.

Moreover, the length of these programs and their effects will outlast the voices of those with a say now (inside and outside WGL). Often the most difficult decisions to be made are those with an easy solution that leaves greater challenges for those to come. Therefore, we stress the need not to avoid short-term phases (like the five-year window applicable here) but to establish them from the perspective of the long-term. Again, this perspective is virtually always the right one, it is all the more compelling where, as here, extrapolating performance of the first four years makes clear that the investment levels expected to complete replacement will only address a fraction of the facilities deemed appropriate for accelerated retirement.

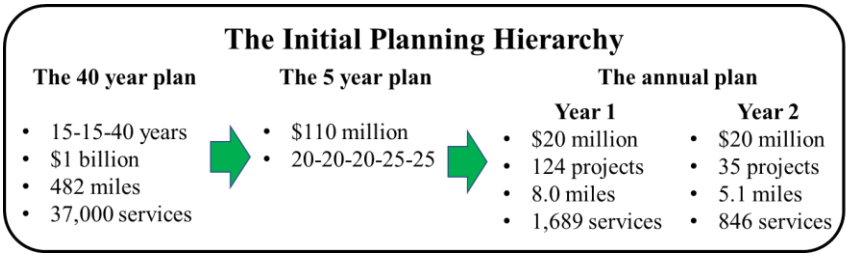
There is no proposition in this business that has higher stakes, nor is one likely to emerge in the foreseeable future. This all makes it essential that the course charted is clear to everyone, without exception. Course changes, as Years 1 through 4 make abundantly clear, are inevitable. Gauging their impact timely and effectively requires a clear, up-to-date understanding of all the work that remains and what will be required to accomplish it. Confusion over rules, objectives, expectations, historical performance levels, or expected ones should not obscure where things stand or how to move them forward. Nor should they give comfort that mere continuation of a path charted five years ago is good enough for now.

The touchstone for making clear these all-important rules, expectations, objectives, terms, values, and other parameters associated with such a massive commitment lies in our view in a comprehensive, up-to-date, "program plan" that sensitively addresses uncertainties. We consider the creation and currency of such a plan the most important of the business processes and outputs among those we are reviewing. The long-tern planning process and its results build the framework for all that will follow.

B. Findings Years 1 and 2

We begin with a broad definition of the term "plan" in evaluating the effectiveness of WGL's program planning process. We define an effective plan as including a definition of the work to be completed, the expected costs (including escalation), contingency, the timing for completion, key cost and schedule assumptions, a description of how the work will be managed, resource requirements, discussion of risks, organizational and work allocation framework, and any other topics necessary to illustrate the roadmap for how the program will be successfully carried out. Applying that definition, we did not find such a plan associated with the WGL pipe replacement program, over any timeframe. Recognizing the dynamics that went into creation of the first five-year plan, we focus on establishing what we think is the best framework for moving ahead, recognizing that WGL, the stakeholders, and the Commission will address the next planning phase with recognition that the expectations underlying the first one are no longer "real world."

The accompanying diagram illustrates the elements of the initial plan for PROJECT*pipes*. The 40-year overall duration established the framework for defining the programs' long-term requirements. The intermediate (five-year) plan broke the program into a more manageable first segment and provided a "gate" for assessing and tailoring its continuation. The Year 1 and 2 annual plans provided specific details of the work to be accomplished. WGL, the stakeholders, and the Commission established hereby a good hierarchy, but actions WGL took to address the details of each element would diminish its effectiveness.



1. The Long-Term Plan

We sought documentation underlying the creation of the original plan. Curiously, all had a regulatory, or "public facing" nature. We expected to find the kinds of documentation that management would use itself to document a program plan and supporting information for use internally in managing the work, even down to the day-to-day level. As we continued to seek such documentation, management continued to cite regulatory filings and Commission Orders. We built the accompanying table from various documents, including Orders 17431 and 17789. Sources of this type gave us the most meaningful, available documentation of the long-term vision and plan for accelerated pipe replacement. The lack of internal documentation recognized by management as critical to its management of the program was very unusual.

(the following table is confidential)

[redacted]

Management has stated that its formulation of a long-term plan used a pace of construction of roughly three times "normal." Initial discussions of the sufficiency of that pace observed that would produce a 40-year result for Program 4 (cast iron). The decision to settle on that pace followed a process engaging stakeholders and the Commission. We accept it as a given, but do note that continuation of expenditures in the range of $110 million every five years will not come close to producing that duration.

(the following table is confidential)

[redacted]

Historical data also indicates a more modest than three-times-normal pace. In addition, it appears that the ratio of accelerated replacements to normal replacements in Virginia and Maryland well exceeds that of the District of Columbia.

We found other plan assumptions less clear. First, costs shown did not include escalation. Escalation forms a normal part of cost estimates (the more so for longer duration projects or programs) to reflect the tendency of costs to increase over time through inflation and other natural forces unrelated to the management of the work. Best practice requires its inclusion in estimates, except for very short duration projects, whose cost growth will not be material.

This is not to say that publishing a long-term estimate without escalation is incorrect. It proves beneficial in some circumstances. Using "present day" or "current" dollars, as opposed to an escalated estimate, makes an estimate more meaningful to some observers, who find it more tangible and meaningful as an expression of a commitment's magnitude, as compared with less tangible inflated dollars existing far out in the future. However, we find two important criteria applicable when excluding escalation. First, management should clearly communicate the use of present-day dollars, which do not fully reflect the magnitude of the commitment. Second, whatever form of expression serves public purposes, management planning must use real-world conditions - - meaning inflated dollars.

Adding a three percent per year escalation factor to the PROJECT*pipes* estimate brings the program total as originally contemplated to nearly twice the published $1.015 billion. An original estimate that correctly used real dollars and management's expectation at the time about unit rates would have forecast program costs of over $1.8 billion. (Note that this estimate would no longer apply, given the much higher unit rates experienced (driving up costs directly) and schedule delay (subjecting costs to escalation for a much longer time).

It would take speculation to determine if and how decisions about the annual pace of spending and construction would have changed under an estimate of $1.8 billion. Four things are, however, now clear:

- Even under management's unit rate assumptions (and we recognize that it takes some hindsight to challenge them now, based on what has happened through Year 4), the original plan's cost estimate had no real chance of attainment as measured in dollars actually spent
- It no longer takes hindsight, but only extrapolation of now well-embedded, and, we feel, predictive, unit rates, to conclude that work will cost far more than anticipated, even measured in present-day dollars
- Expending $20 million per year will drive the real-dollar cost even higher because a 40-year total duration is no longer even close to achievable at that pace.

The telling message of these three observations is that WGL, stakeholders, and the Commission should undertake planning for the future of PROJECT*pipes* on the basis of a lifetime estimate and schedule that employs realistic unit rates and escalation. Management has told us that the stakeholders are already well aware of the un-escalated nature of the program estimate. Regardless, the combination of far lower than expected unit rates and the lack of escalation make clear that planning for the future requires more.

2. The "Five-Year" Plan

Order 17789 approved "the APRP in general and the first five years of the plan in particular", reflecting an underlying settlement agreement. We find it appropriate to sub-divide long-term projects such as PROJECT*pipes*, into manageable windows. Doing so permits more meaningful commitments and accountability and it provides finite goals and targets by which to measure performance granularly. Theoretically, it becomes more feasible to hold management accountable for performance across more discretely defined, shorter durations.

Annual Expenditures (millions of dollars)						
	2014 [1]	**2015**	**2016**	**2017**	**2018**	**Total**
Program 1	the following Septemer 30					40.0
Program 2						32.5
Program 4						37.5
Total	20.0	20.0	20.0	25.0	25.0	110.0

[1] 16 months ending September 30, 2015. All other years are 12 months ending the following September 30

One benefit of the use of a five-year window should come in the form of more detailed plans. We did not find that level of detail. Plans for the first five-year window identified specific projects only for Year 1. They did not break spending down by each of the programs involved. Thus, explicit production goals did not exist. The limits on content made the first five-year documentation more of a description of from what list management would decide what to do and when, limited by a single spending limit for work in all of the programs covered, and expressing aggregated per-program limits only for the five years in total. It did provide management with wide flexibility, but few tangible details from which to manage or by which to measure performance effectiveness through unit costs (as opposed to meeting total expected dollar spend).

3. The "Current" Plan

The "current plan" as we understand its dimensions from discussion with management differs from the five-year plan (its foundation) only by the list of projects on the current year's approved list and those from prior year lists yet to be completed. As the fourth year approached conclusion, management has seen a large loss of schedule time, as many projects remain incomplete from year to year, and low production relative to expectations, meaning much less work installed for the dollars spent. The static elements of the plan for the first five years thus is not and for most of the four years has not been a real plan from which to manage, other than providing a backlog of high-priority work safety-wise well beyond what needs to be on the approved list to produce spending at the established $20 to $25 million annual rate.

During Year 1, it became clear that project costs were and would remain well over plan, with installed quantities well below expectations. The plan became visibly unrealistic in its earliest execution phases. Instead of revising the five-year plan early, based on adjusted performance expectations, management retained it, using the project lists year over year as sources of expenditures required to get the $110 million allotted for the five years spent on approved work. Management did not re-baseline plans to reflect achievable results. With a role limited to providing a source of chargeable, high-risk-reduction work, there was no need for revision - - slower, more expensive than anticipated work left a list better populated with work from which to select.

We did not see in any documented data and analysis, a focus on factors like degree of intended versus actual leak reduction after five years, numbers of mains and services replaced in five years, overall portion of total program (40 year) goals expected to be accomplished in five years, or expected versus actual unit rates by work type. We have seen regular reporting of the pace of expenditures versus the annual amount allowed for accelerated rate treatment. While not comforting, we did find that work performed occurred on work appearing on the annual plans - - work on the whole that management, the stakeholders, and Commission appear to agree is of the highest priority.

C. Conclusions - - Years 1 and 2

1. Total PROJECT*pipes* costs and schedule duration will vastly exceed the expectations underlying the first five-year window.

A better view of PROJECT*pipes* estimated costs at completion at the beginning of the first five-year window ***was*** $1.8 billion, based on escalating the initial estimate at 3 percent per year. The unit costs management used in project estimates near the end of our examination of Year 2 were double for mains and nearly triple for Program 1 services when compared with the expectations underlying that initial estimate. Those drastically higher costs and the necessary duration extension resulting from a $20 million per year expenditure pace promised a vast increase in the $1.8 billion. Extrapolating them make the cost and duration of PROJECT*pipes* untenable, and cause major acceleration of replacement to raise customer affordability issues as well.

Cost and schedule to reach program pipe-replacement goals were not calculable in the absence of a much improved level of confidence in the Company's unit rates and ability to execute in alignment with those estimates. The combination of escalation, increased unit costs and added costs due to schedule delays seems likely to increase program costs into the several billion-dollar range, based on what was knowable at Year 2 and the many uncertainties that still lay ahead.

2. WGL did not employ a program planning process or develop a PROJECT*pipes* plan commensurate with the scope, size, and duration of the program.

Organizations use the term "plan" in different ways. We believe that a meaningful plan for a large-scale venture should be extensive; others might interpret a simple list of the tasks to be done as an acceptable plan. Despite the latitude that exists for varying interpretations, we did not find what we would view as a planning function per se. WGL's conception of a plan seems centered on the regulatory framework, not its internal program management needs or context.

We did not see evidence of robust:

- Preparation of achievable plans
- Monitoring status against them
- Analyzing and reporting program ramifications for major plan deviations
- Recovery or mitigation of plan deviations
- Revising the plan as it became outdated

PROJECT*pipes* planning focused on reaching the $20 to $25 million annual spending limit through creation of a backlog of projects sufficient to produce spending that ran very close to but not over

the amount qualifying for accelerated rate recovery. We did not see focused attention on measuring performance accomplished from that spending, measuring and analyzing the size or drivers of costs and schedule, or program-management directed efforts to address variances.

D. Improvement Opportunities - - Years 1 and 2

1. We found a need for WGL to implement a formal planning capability and supporting processes.

PROJECT*pipes* required a life-of-program plan, setting credible expectations for long-term, intermediate and short-term results at the program level, supported by clear means, methods, and resources to monitor and react to plan deviations. Particular elements required included:

- Establishing primary elements including organization structure, roles and responsibilities, methods of program management, scope assumptions, cost analysis and schedule baselines, authorization process, compliance, reporting and analysis requirements, and metrics to monitor progress and productivity
- Developing a Program Implementation Plan fully documenting communicating program objectives, management approach, and procedures for processes employed to optimize performance.

2. A completely revised estimate of PROJECT*pipes* scope, quantities, costs, and schedule, using realistic unit rates and incorporating escalation was in order.

Well before Year 2's end, basic assumptions underlying the estimate for PROJECT*pipes* through completion were far too optimistic. Unit rates experienced had doubled or more, and there were indications at the time that they might increase yet again. Moreover, the lack of escalation in the estimate meant that the "real" dollars management was spending as the first five-year window progressed would "buy" ever less production, even before considering the far lower than expected unit rates. At the same time, continuing to limit annual expenditures to $20 million per year pushed program duration out further, and subjected it to continuing escalation.

The program estimate had lost usefulness by Year 2, other than continuing to serve as management's single, clearest plan element - - to spend as close to but not to exceed the annual amount of expenditures on properly approved projects, considering "best efforts" but not the meeting of tangible performance metrics the proper means for judging management effectiveness.

Needs at that time included:

- A soundly-developed forecast of final cost to install the full scope of the Five-Year Plan.
- Projecting uninstalled quantities of main and services at the end of Year 5, assuming the whole $110 budget is consumed.
- Assessing schedule slippage impact of uninstalled quantities of main and services in the first five years
- Calculating the resulting cost impact in escalated dollars.
- Providing a credible estimate for the life of the Program (40 years) in escalated dollars.

E. Developments - - Years 3 and 4

1. Creation of a Formal Planning Capability and Program Plan

Management has been developing and enhancing several support processes to establish a formal planning capability, largely under the CPSM organization, whose Year 3 and 4 development we discussed in the Program Management chapter of this report. For example, procedures now exist or are being developed to enhance the cost estimating process, scheduling coordination among the functions who have material program roles, work management process, cost reporting, procurement strategies, and contracting management.

WGL also filed with the Commission in 2017 a Program Implementation Plan, which described program scope, organization, communication, purposes, stakeholders and participants, funding, risks, and milestone schedules. This high-level plan's definition of commitments comprises a sound first step. Yet to be completed is the execution plan required to detail program management approach, roles and responsibilities of participating groups, cost management techniques, scheduling and schedule control, resource planning, procurement strategies, oversight of progress and performance reporting and analysis, for example. Management is now updating the Program Implementation Plan is currently being updated to include these elements.

2. Revised PROJECT*pipes* Estimate and Schedule

Management has undertaken a number of actions to enhance key program planning processes:

- Cost estimating process
- Cost analysis methods and capabilities
- Scheduling process
- Developing an actual unit cost database.

Management had, per a June 30, 2018 report, expended 64 percent of the $110 million 5-Year budget, while installing 38 percent of planned main replacement and 23 percent of planned services. The information from Years 3 and 4 show that, while moderate improvement may be possible, the rates obtained to date offer a fairly sound indication of those that can be sustained (assuming future work proves similar overall in nature) for the future. The persistence of these rates showed a continuing need for reforecasting final 5-Year costs and replacement levels. For the same reasons, a need for re-forecasting total program length and costs, using escalated dollars, remained as well.

F. Recommendations

10. Complete efforts to produce a series of program plan documents, forecasts, performance projections, and a life of program plan (40 years) using soundly derived unit rates and escalated costs, including an appropriately-derived contingency element.

Management should include the following elements in these efforts:

- A fully integrated, formally documented scheduling program and capability
- The revised Program Implementation Plan

- A forecast of estimated costs to install the full scope of the current 5-Year Plan based on soundly derived, projected unit rates and escalated costs
- A projection of uninstalled quantities of main and services (versus plan) at the end of Year 5
- An assessment of the schedule slippage impact of uninstalled quantities of main and services in the first five years, and the resulting cost impact in escalated dollars
- A life of program plan (40 years) using soundly derived unit rates and escalated costs, including an appropriately-derived contingency element.

VI. Cost Estimating

A. Background

Cost estimates can serve multiple purposes for construction projects. They can provide a control base, a tool for defining resource and material needs, a check on bid adequacy, and a basis for preparation of schedules, prioritization, and authorization of funding. Evaluating their sufficiency must occur in the context of their intended use on the work involved.

The actual costs of PROJECT*pipes* projects work completed during Years 1 and 2 far exceeded their estimates. Management concluded that its estimates would not serve for project control purposes or as a basis for measuring and analyzing project performance. This position prompted considerable attention to the estimating process and a call from stakeholders for improvements to the process and the underlying accuracy of the estimates. Presumably the underlying reason lay in a belief that better estimates would produce a greater level of accountability.

The use of estimates as a baseline for performance monitoring and analysis has near-universal application in the construction industry, making WGL an outlier in rejecting the value of variance analysis using project estimates and costs. Management was not necessarily wrong in taking a non-traditional view. One has to consider other factors that may limit the value of such analysis. They include estimate quality, project size, and the cost management approach chosen. Rejection of estimate variance analysis, however, does require explanation of: (a) if and how estimate quality can and should be improved, and (b) what alternate approaches satisfy the need effective cost management. We address the estimating question in this section and the cost management question in the next chapter.

B. Findings - - Years 1 and 2

1. The Estimating Process

Management employed a simplistic estimating process for Year 1 and 2 projects, applying historical unit costs to the quantities of mains and services estimated by engineering. Dollars per foot of main and dollars per service comprised these unit rates. Separate percentage adders to these unit costs covered paving and overhead costs. This approach had the effect of treating all projects essentially the same, except for scale. The only variables affecting estimates became the unique quantities of mains and services of the project involved. The next example (PROJECT*pipes* BCA# 261060) shows the limited nature of WGL's estimates. Management provided it in response to a request for a "sample of a cost estimate prepared during the audit period."

Sample Project Cost Estimate

Main = \$402/ft (Loaded)
Service Replace = \$2,525/service (Loaded)
Service Transfer = \$1,874/service (Loaded)

$$545 \times \frac{\$402}{ft} + 1service\frac{\$2,525}{service} + 2service\frac{\$1,874}{service} = \$225,363$$

A mere three variables define the whole of this estimate (mains: 545 feet, service replacements:1, and service transfers: 2). Such a simplified approach proves appropriate and cost effective in certain circumstances, sometimes appearing during PROJECT*pipes* Years 1 and 2:

- Generally similar projects, with limited differentiating characteristics
- Small projects, making more sophisticated approaches not cost effective
- Short-duration projects and programs, which do not involve enough time to identify and correct issues suggested by variances
- Where management employs other cost management approaches not dependent on estimate quality.

The more typical estimating approach, a fairly standard practice in the industry, involves a detailed project examination, followed by preparation of a project-specific, site-specific estimate. A person with estimating experience, usually a design engineer or professional estimator, prepares estimates. Estimators have procedures, templates, and historical data (regularly updated and analyzed) to support preparations of standard, consistent estimates. WGL did not apply such rigor, structure, or formality. Management's approach left it without tools generally available on large-scale programs. A thoughtfully prepared estimate provides a reliable baseline of performance for project control purposes. It also has other value for management. For example:

- Project authorization - - Bad estimates can produce bad decision-making where cost benefit analysis is critical to project selection (not necessarily the case for PROJECT*pipes*, in that safety criteria appropriately carry far more weight than cost in decision-making).
- Work Prioritization - - With work sequencing seeking to attain the most "bang for the buck," bad estimates lead to wrong priorities.
- Project Scheduling - - Unreliable estimates impair the ability to set realistic schedules.
- Resource Planning - - Management cannot know the level of resources needed to execute the project in the desired timeframe absent a reasonably reliable estimate.
- Bid checks - - Reasonable estimates provide a "sanity check" on bids from vendors and contractors.
- Procurement - - Accurate estimates of material quantities can be critical to timely procurement.
- Contractor Management - - Contractors are more likely to seek change orders when the original base for projects lacks credibility.

Lack of an effective estimating process can therefore have far-reaching consequences, beyond the directly obvious one of promoting accountability. WGL did not use its estimates in such support

roles, telling us specifically that project or program management never formed an intended application of estimates. Management expressed consistent views when we asked about the use of cost estimates in interviews and by formal data requests, the following example (management's response to our Data Request No. 20) typifying those views:

> *The business process/purpose of the cost estimate was to support high level budgeting and the determination of signatory level necessary to approve capital expenditure.*

Presumably, "high level budgeting" means that which occurs above the project level. However, WGL did not aggregate individual estimates to produce an annual budget or authorized spending level. Rather, management set the annual, high-level budget at an annual level of $20 million, independent of any project estimates. Hence, the estimates had no role in the "high level budgeting" process. Moreover, as we explained in the preceding chapter addressing the BCA authorization process, its funding approval role was perfunctory and the estimate had no meaningful role in it.

While not stated in response to Data Request 20, we came to understand that estimates have a role in the project prioritization process. The primary use of estimates appeared to lie in providing an indicator of risk reduction per $10,000 of cost for certain projects. The program data base, however, provided limited such indicators for Program 4, suggesting that the concept, and hence the value added by the estimates, was not large. We discuss this aspect further under project schedules and sequencing).

We therefore found little if any material role management gave to cost estimates, at an individual project level or aggregated to a program level, in managing PROJECT*pipes* during Years 1 and 2. The lack of utility for management in cost estimates corresponds to the lack of effort in preparing them and in their resulting low quality, at least as measured against actual project costs. Accordingly, the issue here is not the estimating process, but the uses that management sees or perhaps does not see in effective program management.

2. Variances from Estimates

(the following table is confidential)

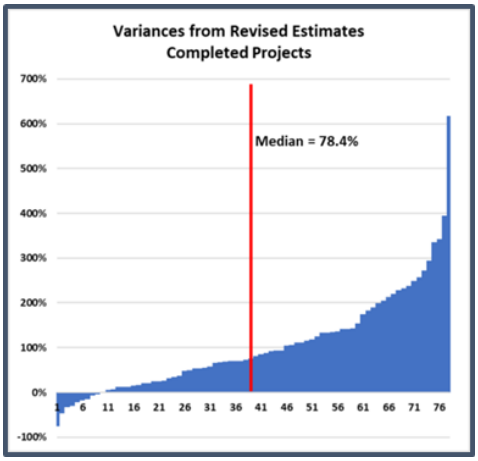
[redacted]

The high level of inaccuracy in WGL's estimates have received considerable attention in recent years. The accompanying table shows the variances (from revised estimates) by program type for projects completed in Years 1 and 2. Management terms the first estimate prepared the "original estimate". In some cases, a "revised estimate" followed. We chose the more conservative approach here of comparing to the revised estimate. The variance was 58 percent at the composite level, with a range of 37 to 103 percent at the program category level. The estimates were already revised, and WGL still experienced this magnitude of overrun, which by any standard, should not be considered as acceptable. We found 42 Year 1 projects completed in Year 1, 32 Year 1 projects completed in Year 2, and 4 Year 2 projects completed in Year 2. These 78 projects in total offer a suitably large sample for examining variances.

This distribution of the variances (excluding scattered projects), illustrated on the accompanying chart show the following measures of interest:

- The variance for the median project is 78%
- Only 9 of the 78 completed projects (12%) finished under their revised estimates
- 33 projects, (42%) more than doubled in cost
- 14 of the completed projects (18%) more than tripled in cost.

The variance data establish that estimates did not provide, for program management purposes, reasonable projections of costs.



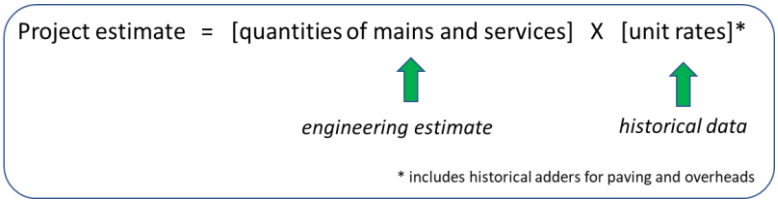
3. Management's Responses to Variances

We did not dismiss out of hand management's view that variances from estimates did not have relevance in managing the program. Reasonable people can differ on the significance of different levels of variance, or on the significance of any variance at all. But the projects in this population were not highly complex or highly uncertain, and they are relatively small. For those reasons, we find concern in their frequency and size, despite management's characterization of them as normal, stating that:

> *Management does not consider actual costs exceeding estimated costs to be "cost overruns", but instead these are within the normal variance given the work oversight and approval process in place for contractor payments."* (emphasis added)

Management later suggested "acceptable" as a more apt term than "normal," but found the point the same - - management did not regard frequent, large, and continuing cost estimate variances material under a program experiencing unit rates and therefore costs well above expectations and increasing.

There seems to be universal agreement among interested parties, including WGL, that PROJECT*pipes* estimates for Years 1 and 2 had low quality. A great deal of stakeholder interaction, including a Technical Conference, focused on a search for improved approaches. Not to diminish that effort, we found, however, that blaming large estimate variances on "bad estimates" deflects attention from the real, and far more consequential issue.



WGL project estimates simplistically multiplied a project's estimated quantities of mains and services by the historical unit rates for installing those mains and services. This binary approach makes the question of which part of the equation - - quantities, unit rates, or both - - caused the

large variances. The accompanying table highlights the simple but surprising answer. Variances in quantities from revised estimates made only a very small contribution to cost variances (+6% for mains and -4% for services). Quantity-driven variances versus the original estimates were greater, but still within the limits for which a typical contingency would have provided. The small variance contribution of quantities leaves the unit rate part of the formula to account for essentially all of the variance.

Completed Year 1 and 2 Projects - Quantities			
	Original Estimate	Revised Estimate	Installed in Audit Period
Mains (miles)	6.28	6.48	6.84
Services	908	1,094	1,046

That unit rate component actually does not comprise an estimate at all, but simply a reflection of actual recent performance. This factor makes the question less about whether a unit rate variance reflects "a bad estimate" versus a "a deviation from last year's performance." The latter better states the question, creating a distinction having has substantial consequences in terms of how one manages costs in general and responds to deviations in particular. We note that:

- A bad estimate precludes effective variance analysis

  ➡ *but* ⬅

- Deviations from last year's performance demand analysis.

We revisit this distinction in the cost management section discussion of how unit rates hold the key to both estimating and cost performance issues. For now, the key point is that, while seeking better cost estimates makes sense, it should not deflect attention from the real cost problem - - the continuing, substantial year-over-year growth in unit rates we saw in Years 1 and 2. That growth was substantial enough to cast doubt on the affordability and viability of the program.

4. Improvement Initiatives

To the extent that stakeholders have been dissatisfied with the quality of the estimating process, a number of relatively straightforward improvements exist, some of which were already in progress. There should be no argument that smaller projects do not warrant sophisticated approaches, but simple, widely-used tactics that can be implemented with minimal effort. For example:

- The inclusion of contingency in an estimate is standard practice, but costs nothing, and substantially improves the accuracy of the estimate. From an estimating practice perspective, exclusion of contingency is not considered acceptable. It is a legitimate line item and part of any good estimate and estimating process. In some cases, management may choose to exclude contingency from individual projects and instead add a contingency below the line, applicable to the full program budget. This is a different, and acceptable manner of including contingency.
- The use of "productivity multipliers" as a low-cost alternate to a finely detailed estimating process is a wide-spread and acceptable practice. It requires a knowledgeable engineer or estimator who can apply his or her experience to assess any unusual conditions present that might drive unit costs up or down.
- Estimates of project risk can also benefit from discussions with knowledgeable people, including design engineers, construction managers, cost engineers and contractors. A detailed and lengthy review is not necessary to identify how a project differs from "typical" and hence how a unit rate should change.

- The maintenance of an effective database with frequent updates of historical costs, and analysis of that data to frame its uses, is yet another low-cost method for improving estimate quality.

WGL's "Report on Technical Conference" defines some of these and other new approaches. Such proposed changes appear to be positive, including more frequent updates and analysis of estimates, the addition of contingency, the addition of complexity factors, and periodic reports on estimates versus actual. Management also committed to AACE Class 3 estimates, which provide the minimum quality suitable for project control.

Even after making improvements, the issue that remains is management's intended use of resulting, higher-quality project estimates. An enhanced estimating process gives management new and better tools for program management, but they will do little other than add costs if improved estimating occurs solely to respond to regulatory pressure, and is not followed by management's embrace of changes to enhance program management capabilities and actions.

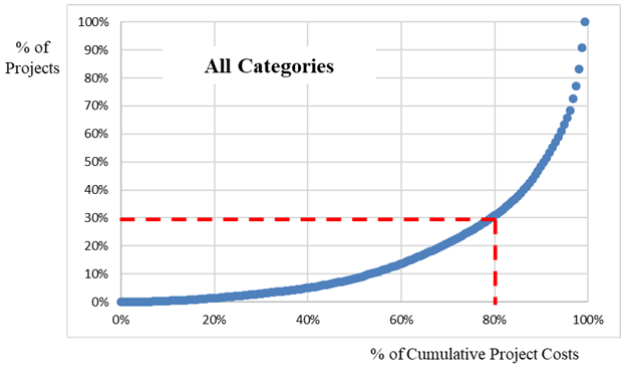
5. Placing Need for Project Estimates into Perspective

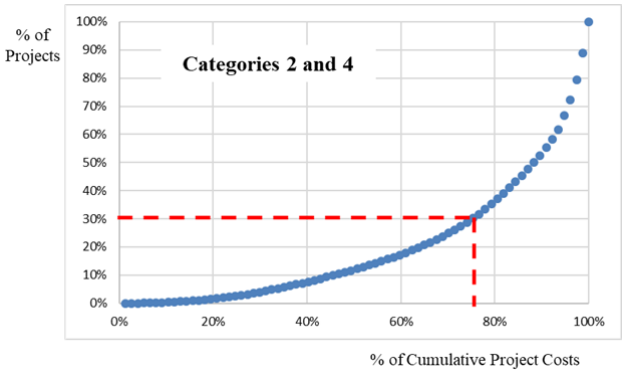
It was not clear during our work with respect to Years 1 and 2 that preparation of better project estimates would best serve in controlling project costs. The preceding chapter addressing program management discussed a shift in the control base for PROJECT*pipes*. The de facto control base was project cost, as defined in the new estimating process and as reported and analyzed in the annual reconciliation report. We considered replacement quantities a potential substitute control base, suggesting that only the quantity portion of a project be estimated. The quantity portion is the easier and more accurate element of current estimates. It would not be necessary to prepare the harder part of the estimate, unit rates.

Median Project Original Estimate				
	Year 1 Costs	Year 2 Costs	All Costs	Number of Projects
Program 1	44,001	44,176	44,001	82
Program 2	142,191	232,755	149,436	33
Program 4	158,406	511,859	206,047	44

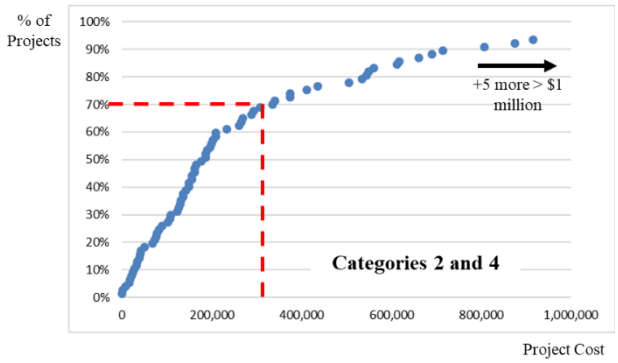
Such a change would not mean that management could ignore unit rates. As the later chapter addressing cost management describes, the change would make unit rates the key to cost control. We mean here only that unit rates need not be estimated for individual projects under the changed scheme. However, even if management should choose to stay focused on project costs, there remains a reason to forego estimates on most projects. Consider the number and size of projects shown on the accompanying table. The 82 Program 1 projects had a median value of only $44,000 each. We do not find it practical to prepare quality, detailed estimates for such small projects or to manage them against those estimates.

Program category 2 and 4 projects were fewer in number, higher in median cost, and growing very substantially, indicating merit in moving from a "program" to a "project" approach to managing significant subsets of them. The Pareto principle, or the 80-20 rule would suggest that roughly 80 percent of the effects (costs) likely result from 20 percent of the causes (projects). The next chart shows that 30 percent of the projects made up a very large fraction of total costs.





The "all categories" chart shows that, based on original estimates, 30 percent of projects made up 80 percent of costs. The second chart's elimination of Category 1 projects shows that 30 percent of projects produced 75 percent of costs. Eliminating detailed estimates for all Program 1 projects and requiring them for Program 2 and 4 projects exceeding some reasonable threshold before requiring estimates has merit. The chart to the right shows just one example - - setting that limit at about $300,000. It would capture 30 percent of projects and 75 percent of costs.



Taking this approach to PROJECT*pipes* management would effectively produce a hybrid of project- and aggregate-level focus. This approach would maintain the tie to project costs as the primary cost focus and control base.

We address this option here in examining the question of the appropriate requirements for the preparation of estimates. The answer to that basic question depends on the future management employed by WGL. A focus on the project level makes project costs the control baseline, and requires an estimating approach like that defined in the Technical Conference and including the minimum acceptable estimate quality for control purposes; *i.e.*, AACE Class 3. Other approaches substantially reduce the burden that preparing and using such estimates imposes. Of course, such approaches need to provide logical control parameters for all work. The next table summarizes the estimating ramifications for the options we have discussed.

The management approach dictates requirements for estimates

	Management Approach		
	Project Level - Costs	**Program Level – Hybrid[1,2]**	**Program Level - Quantities**
Control Base	Individual project costs	80% aggregated projects / Top 20% of selected projects	Replacement quantities
Control estimates required	Costs for all projects	For top 20% of projects	Bulk quantities for projects
Program estimates required	Sum of project estimates	80% aggregated projects / Top 20% of selected projects	Quantities times program unit rates

[1] In the hybrid approach, only the larger projects are estimated at the project level, while the others are aggregated.
[2] The percentages would be selected based on management preferences, and Program 1 might be excluded.

C. Conclusions - - Years 1 and 2

1. The estimating process that WGL employed for Years 1 and 2 was not sufficiently detailed or developed for significant projects.

WGL's pipe replacement program has several characteristics that justify, for at least a portion consisting of small, short-duration projects of the program, a less-than-sophisticated approach to estimating. The industry generally rejects such estimates for larger, more complex projects. WGL's cost experience on them during Years 1 and 2 called for approaches more consistent with industry experience.

In any event, cost estimates played little or no meaningful role in program management during Years 1 and 2. Management defined a very narrow mission for estimates (authorizations and high-level budgets), but cost estimates did not appear to contribute to authorizations or budgets. We found no role for estimates in management support activities.

The simplicity of project estimates weakened what project management generally views as a valuable tool. The management benefits that flow from a strong estimating process can include enhanced schedules, strengthened resource planning and management, improved bid-process controls, optimized procurement processes and material availability, and improved contractor management. WGL management had other tools and capabilities in these areas, a good estimating process would have improved their effectiveness.

WGL management did not buy-in to the notion that good estimates enhance the effectiveness of project and program management, leading to a conclusion that a detailed estimating process was unnecessary. Management saw limited use for cost estimates and if that were to remain the case, it is difficult to see how improved estimating would make a difference.

2. Management's approach led to the acceptance of the very large Year 1 and 2 deviations between estimated and actual costs as normal or acceptable.

The large cost variances and the very low percentage of projects completed at or under budget were neither normal or acceptable. Results comparing extremely unfavorably to expectations became obvious early, as evidenced by the Year 1 results in the accompanying table. One would reasonably expect that this would trigger some response in terms of examination of both the estimating process and program performance. To our knowledge, the only action was the updating of historical unit rates in a July 22, 2015, analysis.

(the following table is confidential)

[redacted]

Year 2 projects, whose estimates were more recent, had the benefit of increased experience, and included updates to historical unit rates, actually experienced even greater variances than those of Year 1 projects. Note, however, that WGL completed very few Year 2 projects, limiting the strength of observations form what is limited data.

Year 2 Variances Were Greater than Year 1 Variances

	Year 1 Variance	Year 2 Variance
Program 1	47%	150%
Program 2	49%	200%
Program 4	68%	101%
All	58%	149%

We understood the weak stature of the estimating process at PROJECT*pipes* inception, but found management's acceptance of increases a matter of concern. for the reasons we have previously discussed. The failure to act when that original process was proven inadequate, however, was less understandable.

3. An inability to perform work at the same unit rates historically experienced, not "bad estimates" was the paramount reason for substantial estimate variances in Years 1 and 2.

If unit rates had not been increasing, estimate variances would have been at levels even good estimates would recognize as largely "conforming." Main and service quantity estimates (miles and numbers) simply did not contribute materially to variances. Unit rates did, but management did not estimate them, merely applying actual historical rates to those quantities. One should therefore characterize the Year 1 and 2 variances as deviations from prior year performance, not variances from unit rates developed through a forward-looking examination of what was driving them.

4. Management analyzed estimate deviations and cost drivers, but did not follow up in Years 1 and 2 to garner benefits from that analysis.

Management conducted two analyses of unit rates as part of estimate updates. These studies, discussed later in the cost management chapter, produced some valuable insights into the drivers of unit cost increases. Actions typically taken in the wake of such analyses include a focus on the drivers by the management team to: (a) isolate reasons why specific costs are increasing, (b) examine applicable management systems to see where they may be failing, (c) devise ways to

contain further increases, and (d) improve estimate drivers. We did not see examples of such follow-up from the two analyses.

5. A number of near-term opportunities to improve the quality of the estimating process existed and management had begun work on a number of them.

Management's "one-size-fits-all" approach taken for Years 1 and 2 likely did not have adverse consequence for small, short-duration projects, like many forming part of Program 1. Wide variability in the actual costs of larger, more complex projects, however, indicate that unique factors are at play, and require discrete examination, if estimates are to have any credibility. We consider a focused look at each large project to identify its special characteristics, risks, and variance drivers appropriate.

6. Paving costs represent a large enough component of project costs to justify more than a percentage adder to estimates.

Paving costs represented about one-third of project costs on average. Estimating costs on a standard percentage basis makes more sense when the element does not vary greatly or when its costs represent a relatively small portion of total project costs. Management should make the decision after analyzing the relationship and its consistency as a predictor of final costs. It is not clear that management's study that produced new paving estimates considered such variability. However, its results, presented by category, showed considerable variability, ranging from a multiplier of 8 percent for service pipe in Categories 2 and 4, to 29 percent for mains, to 39 percent for service pipe in Category 1. In addition, the value to which the multiplier was being applied (WMIS costs) itself exhibited high volatility.

Such factors made careful study of the basis for estimating paving costs appropriate. WGL was in the process of improving its estimating process, making it timely to consider the available data in determining whether and how to prepare paving estimates from assumed quantities.

7. The lack of a clearly expressed change in intended use of estimates called into question how proposed improvements in process or quality would enhance performance or increase accountability.

The focus on improving estimates appeared implicitly to anticipate expanded use of them, but it was not clear to us that such a result would necessarily follow. We saw a need to address explicitly how estimates should and would be employed as part of a comprehensive program management structure. Material from the Technical Conference referred to intended uses, but did not define them. We did not learn about any intended change in their use by management to manage. WGL also did not indicate how performance or accountability would improve or change as a result. It was unclear whether, if estimate quality were substantially enhanced, management would begin using them as a cost management tool. We also heard nothing suggesting that improved estimates would be accompanied by holding management accountable to meeting them, at least from the perspective of variance analysis.

One suggestion that such changes were not likely came in management's response to our question about design estimates:

These Design Estimates were prepared solely to support the reporting requirements of the DCPSC and played no role in the construction process per se and therefore their use by management in this capacity did not directly impact the Program Management process in place at that time.

We credit management's responsiveness to regulatory requests, but that is not the management issue here; what matters in that respect is intent to make use of such improvements for performance improvement or accountability enhancement. We were not at the time of our Year 1 and 2 review prepared to accept that better estimates would necessarily produce those benefits. Management had not accepted the use of estimates to measure performance.

8. Particularly given management's approach and structure for managing at a higher, program level, excepting small PROJECT*pipes* projects from detailed estimate requirements appeared to hold promise.

Were we tasked with designing a program management structure from the outset, we may have charted a different course. However, we considered it appropriate to begin from what the culture, background, and thinking of WGL has produced, because its overall choice falls among a reasonable range of alternatives. The more pertinent question became how to ensure that its content provided for all factors necessary in ensuring accountability, measuring performance effectively, and identifying and responding promptly to factors affecting work quality and safety, cost, and schedule.

While showing that deference, we had no question about requiring for large projects a detailed estimate suitable for project control (AACE Class 3 minimum). Equally certainly, we did not consider universal application of such a requirement practical in an environment including many small projects with largely repetitive tasks. We did not consider either estimating or managing many small projects at an individual project level likely to prove cost-effective.

PROJECT*pipes* includes a wide distribution of projects. Category 1 projects generally prove very small (median of $44,000) and are numerous. Managing such populations at an aggregated, not individual level can be effective. Some Category 2 and 4 projects are also small. The wide diversity in the size of projects led us to conclude that the Pareto principle had utility in determining how to determine how to apply detailed estimating requirements.

D. Improvement Opportunities - - Year 1 and 2

1. We found a need for WGL formally to identify its expectations and intended use for estimates, given the significant interest in changing the PROJECT*pipes* estimating process.

The Technical Conference notes suggested that this change had already occurred, but we did not learn from management that it intended any change in its expectations or intentions about how to use improved estimates. Clarity in this matter is important, given that making a difference requires more than just the creation of better estimates. WGL needed to review its management support processes with the objective of determining how enhanced use and quality of estimates would improve performance and enhance accountability. In particular, we believed that addressing the management processes we described as being enhanced by better quality estimates (but that WGL

was not achieving) would prove beneficial. The Project Cost Estimate Process and the revised Program Implementation Plan should include sections setting forth expectations for and intended use of estimates.

2. We found that WGL needed to establish a formal process for dealing with widespread and significant estimate variances, whether caused by performance issues or a weak estimating process.

The first-year of results for completed Year 1 projects showed extreme increases in Programs 1, 2, and 4 costs - - increases calling for management examination and response. Deviations of this magnitude should prompt an examination of potential problems and unacceptable conditions, either in terms of performance, estimating, or something else.

We believed that management should expand its DC PROJECT*pipes* 2015 Unit Cost Study (dated May 25, 2016) estimate analysis for use as a continuing process would form a useful element of such a formal process. The analysis was sound, but it ended prematurely. The insights produced could provide enhanced understanding of variance drivers and of how management might influence those drivers positively. This technique can be adopted without expensive or overly-sophisticated techniques. The analysis performed in 2016, for example, pointed to just a few major drivers. We considered further analysis of those drivers, with an eye towards improving management of them, likely to produce tangible benefits. We felt that conducting such analyses annually, until rates stabilize, and every two or three years thereafter would prove beneficial.

3. We generally found the improvement initiatives reported at the Technical Conference appropriate and believed that management should adopt them, along with other estimating-related changes.

We considered it important for WGL to fully buy in to the estimating improvements recommended in the Technical Conference and in this report, and implement them with the intent to make them central to program management. The proposed improvements included:

- Creating AACE Class 3 estimates where appropriate
- Conducting more frequent program updates and analysis of estimates
- Adding contingency - - an amount added to a project estimate to allow items, conditions, or events for which for uncertain states, occurrences, or effects that, based on experience have a reasonable likelihood of occurrence
- A robust approach and methods for adding complexity factors
- Producing periodic reports comparing estimated versus actual costs
- Performing construction reviews
- Enhancing data and its analysis
- Directly estimating paving.

4. We believed that WGL should internalize improved estimates and the processes for producing them, considering them more than just responses to regulatory and stakeholder expectations.

It is not uncommon for utility management to agree to change following regulatory pressure without incorporating those changes into how it conducts business. We had concerns about the robustness of WGL's acceptance of change in areas including reporting, estimating and the annual

reconciliation analysis. We found merit in considering a hybrid approach, under which not all projects would require detailed estimates. Category 1 projects would likely not require them, and a Pareto approach for Category 2 and 4 projects appeared appropriate. Areas of focus included:

- Documenting bases and assumptions when preparing a cost estimate
- Developing and maintaining a credible cost estimating database with historical productivity data and multiplying factors for indirect costs
- Applying contingencies to account for uncertainties within the scope and assumptions of a project
- Conducting cost estimate reconciliation for project cost deviations that exceed ±30%
- Assigning clear accountability for various aspects (design, procurement, construction, indirect costs, overheads) of the cost estimates

5. We believed that WGL needed to define its program management approach in detail and to follow that definition with a corresponding and compatible determination of the projects requiring detailed estimates.

We formed this belief on the bases that estimating requirements need to be tied directly to their use and functionality in a well-defined and structured management approach and structure.

Good estimates provide a reliable baseline of performance for project control purpose. A strong estimating program also brings to management the following areas of sound management, namely, project authorization, work prioritization, project scheduling, resource planning, bid checks, procurement strategies, and contract management.

We found that the procedures for the following Program management processes should include a section that relates how cost estimates are essential to their effective execution:

- Project Authorization
- Design and Engineering
- Procurement
- Work Management
- Resource Planning
- Construction
- Contract Management.

E. Developments - - Years 3 and 4

1. Expectations and Intended Uses of Project Estimates

Management made very substantial progress in preparing Class 3 Cost Estimates. The information undoubtedly promotes authorization of funding, schedule preparation, and contract management. However, management's understanding of the importance of cost estimating as a cost management tool remained unclear. Asked about intended use of estimates and expected improvement in terms of project cost control, management noted their use in assessing cost performance against the estimate as projects close, but no expected changes for cost control. The ARP Project Cost Estimate Process discusses cost estimate preparation, but fails to convey that cost estimates can serve multiple purposes for construction projects.

2. Establishing a Formal Process for Dealing with Estimate Variances

Management began to perform variance analyses at the project level, providing information about those analyses in in the Monthly BCA Progress Report. The analyses are not in-depth, but comprise a sound start. If management remains committed to their use, experience should bring variance analysis improvement as the process matures and professional skills and experience in performing it progress. Management has stated that it intends to perform cost-estimate reconciliation on every project. Variance Analysis at the project level comprises an essential element in overall program management.

A comparison of actual Year 1 and 2 project costs with their revised estimates showed the following increase levels:

- Program 1 65 percent
- Program 2 103 percent
- Program 4 37 percent
- Overall 58 percent.

The next table shows the same comparison through June of Year 4.

Actual Versus Estimated Project Costs through June 2018
(the following table is confidential)

The cost estimate variances have shown significant improvement:

- The overall level of 19% shows a significant drop from Years 1 and 2
- Program 1, however, showed no improvement
- Program 2 showed material improvement to 63 percent, but that level remains extremely high
- Program 4 variances were all but eliminated.

Program 4 costs comprised two-thirds of the total costs for completed project costs, leading to much lower variances overall. Nevertheless, significant room for improvement remains for Programs 1 and 2. We note again that the 2016 and 2017 DC PROJECT*pipes* Unit Cost Studies, whose continuation we consider very important, provide valuable information in assessing and addressing the cost drivers of estimate variances.

3. Technical Conference and Other Improvement Initiatives

Management has undertaken substantial efforts in the following areas, but the full implementation of some will continue to take time. Management's efforts include: creating AACE Class 3 estimates where appropriate, conducting more frequent program updates and analysis of estimates, adding contingency, adding complexity factors, producing periodic reports comparing estimated versus actual costs, performing construction reviews, and enhancing data and its analysis.

WGL made a change in Year 4 to its paving estimation method - - an issue addressed by the Technical Conference. WGL had applied the same factor of 29 percent for paving to each project estimate, deriving this factor from historical averages. Following the change in Year 4, management began to estimate paving costs individually for each project.

Management also began in late 2017 to reduce contractor work activities ("pay items") measured on a time and material (hourly) basis. Such work units, or contract pay items typically address unexpected items or work units for which management does not want to disclose to contractors ahead of time (lest they become in essence self-fulfilling expectations). Pay items changed to fixed rates include traffic control setups, backfill, dump fees, tree-protection set ups, and trucking. Like all pay items, they require pre-approval by WGL construction supervision.

4. Internalizing Estimating Process Improvements

Management has upgraded its cost estimating capabilities in multiple areas. The cost estimating procedure has been issued. Class 3 estimates are now prepared for all projects. Contingency is being applied. Construction management reviews cost estimates before they are finalized. The cost estimating database is being developed. Some scope and assumptions are captured in the remark column on the cost estimate form. Plan is in place to reconcile all project cost estimates, as they are completed. The cost estimating system has advanced considerably, and should offer a good cost management tool as the information is more credible and the users more knowledgeable.

With respect to using a different estimating approach on smaller projects, we found the results shown in the following table for median project costs in Years 3 and 4.

Median Year 3 and 4 Original Project Cost Estimates
(the following table is confidential)

The median project sizes have increased, but Program 1 project cost estimates (less than $50,000) remain much smaller than those of the other two Programs. We continue to consider it appropriate to estimate under the unit costing method rather than to prepare Class 3 cost estimates for most Program 1 projects and for selected small projects in the other programs.

5. Use of Definitive Estimates

Management largely limits its use of cost estimates to funding, work planning, and scheduling. As we have discussed, we consider their use essential to robust and effective cost management.

F. Recommendations

11. Expand the use of cost estimates in cost management and in the project cost estimate process and the revised Program Implementation Plan to incorporate explicit statements about expectations and intended use.

Management should adopt and execute measures that make cost estimate use a formal part of key management processes. The procedures for the following program management processes should each include such a section that describes the role and importance of estimates and details their use in: Project Authorization, Design and Engineering, Procurement, Work Management, Resource Planning. Construction, and Contract Management.

With respect to establishing a formal process for dealing with widespread and significant estimate variances, management should perform: (a) variance analysis on main and services replacement (by programs 1, 2, and 4) at the PROJECT*pipes* Program level on an annual basis, and (b) continue its annual DC PROJECT*pipes* Unit Cost Studies to identify major cost drivers and seek solutions to manage those drivers.

12. Undertake a series of additional actions to optimize preparation and use of estimates.

Estimates should routinely and consistently document the bases and assumptions critical to monitoring and evaluating performance against them. WGL should maintain an up-to-date, credible cost estimating database with historical productivity data and multiplying factors for indirect costs.

The CPSM should regularly conduct status updates and analyses of estimates, and produce regular reports comparing estimated versus actual costs. Management should clearly assign accountability for various aspects (design, procurement, construction, indirect costs, overheads) of the cost estimates.

13. Evaluate elimination of Class 3 Cost Estimate requirements on smaller projects, to exclude most of Program 1 projects and those in the other two Programs with comparatively very low costs and standard execution requirements.

WGL should promptly develop a specific proposal, with objective dimensions separating projects proposed to be excluded from Class 3 cost estimates. The proposal should describe estimating and cost control measures applicable to the excluded projects. We believe that the requirement can be eliminated for a substantial body of low-cost projects without impairing project management effectiveness.

VII. Cost Management

A. Background

The cost management process, as generally applied to large programs and projects, encompasses those steps intended to contain spending within predefined bounds while accomplishing the program's objectives. We examined the specific question of how management plans, monitors, analyzes, and controls program costs consistent with management expectations, constraints and objectives.

B. Findings - - Years 1 and 2

1. Program Cost Summary - - Years 1 and 2

a. Spending

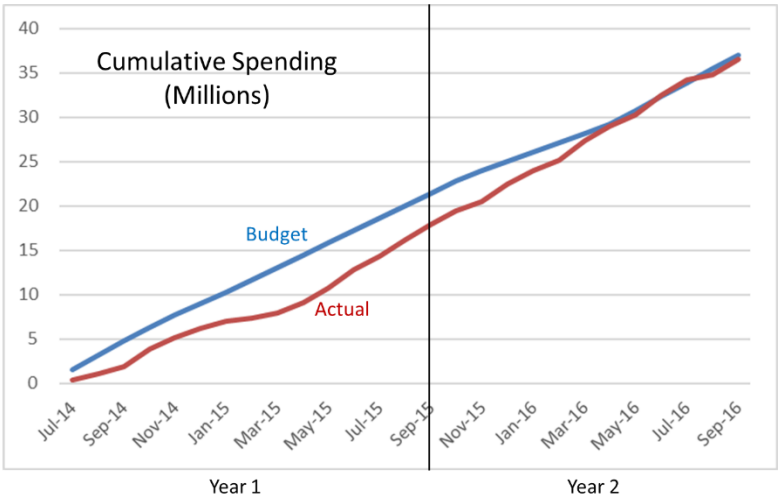
The approved five-year plan stipulated a spending target of $20 million for each of the first three years. Year 1 consisted of 16 months and Year 2 a normal 12-month period. The $20 million in the plan represented an agreed-upon ceiling in terms of accelerated recovery. Spending in excess of that could be recovered through other ratemaking methods, but not on the same real-time basis afforded spending within the limit.

The accompanying table provides details on planned spending in relation to budgets, project estimates and total program spending. The chosen budget was high for Year 1, but that makes sense for at least two reasons. First, some degree of over-production might be desirable to assure a suitable backlog for the field. Second, Year 1 was 16 months in duration.

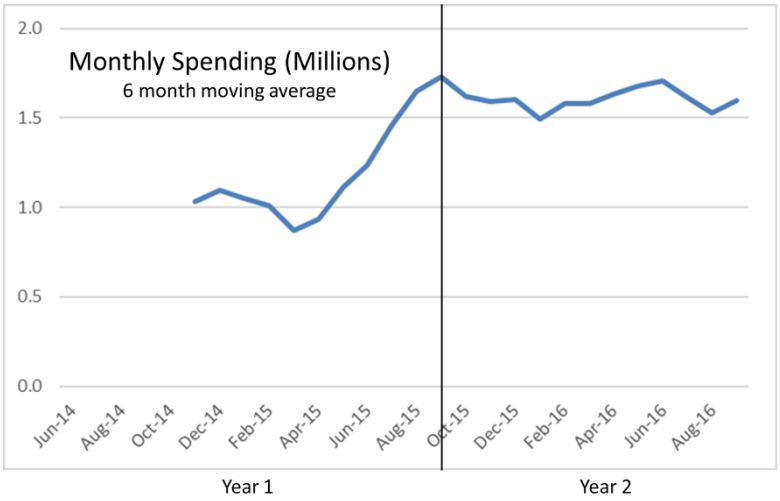
Audit Period Spending (millions)			
	Year 1	**Year 2**	**Total**
Plan	20.0	20.0	40.0
Budget	22.9	15.7	38.6
Projects (Original Estimates)	23.1	17.2	40.3
Actual	19.5	18.2	37.7

WGL chose projects slotted into Years 1 and 2, including scattered projects, to produce the full $40 million. Actual spending ran close to the budgeted amount - - $2.3 million (6 percent) short of the plan.

The accompanying chart shows that Year 1 spending lagged the plan considerably, which in part explains lower than expected physical progress during that time. In the spring of Year 1, however, spending accelerated considerably, eventually bringing total program spending over Years 1 and 2 in line with budget.



The next chart depicts monthly spending during the audit period on a 6-month moving average basis. We found the long period required to reach desired spending notable. It took about nine months to reach the $1.5 million per month level which, given the advanced state of engineering, seems long. Some of the delay in reaching a sustained level of expenditure may have resulted from program startup and the learning curve. However, management's experience with FC 1027 work should have mitigated that effect.



We did not see evidence that management secured visibility to the issue, or took early corrective measures, but spending eventually increased to catchup levels. The more important question, of course, is not the ability to spend money, but to spend it productively. We address that issue later in this chapter.

Year 1 spending of $19.5 million ran $500,000 under the $20 million accelerated recovery limit. Year 2 spending of $18.2 million, included only $9.2 million spent on Year 2 approved projects, with the balance spent on carryover of approved Year 1 projects. The Year 2 project list did not include the unfinished Year 1 projects.

Projects completed during Years 1 and 2 exceeded their revised estimates by an average of 58 percent, and their original estimates by more than that. One cannot dismiss the significance of increases of this magnitude. Warranted or not, they have invalidated both the five-year and 40-year plans, driven the likely cost up by another billion dollars or more, and extended the likely duration well beyond the expected 40 years. Management faced a compelling need during Years 1 and 2 to determine the reasons for variations of this size, seek to mitigate their impact, and address their implications for the overall cost and schedule underpinnings of PROJECT*pipes*.

2. Cost Analysis – Unit Rates

As we detailed earlier, management did not establish a Year's unit rates through detailed analysis, but by employing recent historical ones. They in effect apply not to this year's estimate, but to the previous year's actual performance. Thus, a failure to achieve "estimated" unit rates in any given year represents a decline in actual performance, recognizing that declines can result for many reasons.

(the following table is confidential)

[redacted]

The unit rates, as shown in the accompanying table, proved erratic. Costs for mains approximately doubled between 2014 and 2016. Costs for services varied widely, with Program 1 nearly tripling, Program 2 rising by about a third, and Program 4 declining by about 10 percent. The bar chart below depicts the changes graphically.

This extreme change in unit rates underlies the much poorer than expected performance, from both cost and schedule perspectives.

(the following charts are confidential)

[redacted]

We examined the degree to which management recognized this evolution and acted upon it. We found analyses prepared by management addressing the work elements (pay items) driving unit ratge changes. The next two charts below, constructed from the WGL analysis, display the major drivers of unit rate increases for mains (separated by Programs 2 and 4). Unit rates consist of costs from WGL's work-management information system (WMIS), with percentage adders for paving costs and overheads. The charts that follow illustrate breakdowns of the WMIS portion only. For practical purposes, there is essentially only one pay item driving the increases, and that is the Time and Materials category, shown as "T_M" on the charts. Traffic control costs actually declined, interesting because management cited it as a reported cause of increases on many projects. The data suggests otherwise for services, but we will see below that traffic control is indeed a major component for mains.

(the following charts are confidential)

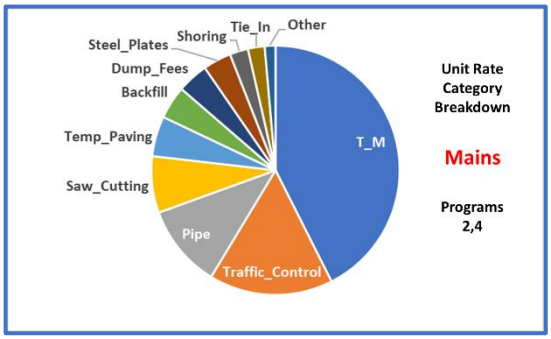
[redacted]

The next two charts show the unit rate drivers for services, separated by Programs 1 and 2. We provide no chart for Program 4 because no categories reached the $10 cutoff we established. Again, the dominant role of Time and Materials is clear, with the next most impactful category roughly a fifth as material. Note, however, that, unlike mains, traffic control proved a significant factor for services.

(the following charts are confidential)

[redacted]

The preceding main and service unit-rate bar charts all show changes over management's 2015 analysis, making them rough indicators of the growth in unit rates from Year 1 to Year 2. The next chart shows the contribution of each of the categories shown to unit rates. The accompanying pie chart makes clear that time and materials comprises by far the largest component of the cost of mains (43 percent of total costs, compared to the next highest category, traffic control, at 16 percent).



Contractors performing the work charge both T&M and traffic control on the basis of hours worked, as opposed to level of production. They have more of the nature of "cost plus" rather than of "unit price" elements. They still result from firmly established bid prices, but their measurement basis is hours, not physical units of production. The pie chart's other pricing elements find measurement in physical production quantities. An extensive matrix of chargeable work units or

pay items (like those shown in the chart) forms the basis of WGL's approach to managing construction and its costs. Its central concept is that contractors get paid for units of work performed - -work whose need and propriety is validated by WGL construction supervisory personnel engaged with contractor supervision and in the field to verify performance of pay items. However, more than half of payments (59%) to contractors for main replacement work was not linked to physical quantities and can be characterized as cost plus. In significant part, this high percentage arose because of the failure to incorporate allowances for support activities into rates for installing feet of pipe or numbers of services. WGL's approach held that paying for them as incurred and under oversight from its construction supervisors would in the long run produce lower costs than incorporating allowances for them into base installation rates.

The large contribution of hours-based pay items also affected the unit rates for services, although to a lesser extent. They accounted for just under half in Programs 1 and 2. Program 4 spending for T_M and traffic control was negligible. It is not clear why Program 4 services should have proven so different, unless such costs were assigned to mains there, given that 94 percent of the Program 4 services rate is made up of the pipe and meter categories.

Fraction of Unit Rate in T_M and Traffic Control		
Program	**Mains**	**Services**
1		49%
2	58%	41%
4	59%	3%

From a cost management perspective, the high level of cost plus work is suggestive of change orders or, because WGL does not use that term, unexpected new work or circumstances. On programs employing traditional contract management methods, Liberty has seen change orders amount to a substantial portion of final project costs. Accordingly, we found no surprise here, although they are described in different terms. In any event, the data indicate that the equivalent of change orders drive a substantial portion of program costs.

3. Paving and Overheads

The use of WMIS-level costs above excluded the impacts of paving and overhead changes. The next table shows their impacts from 2015 to 2016. The pink-shaded cells indicate areas experiencing substantial impacts. Paving amounted to more than a quarter of the WMIS costs for mains and about 40 percent Program 1 services, highlighting, the need for close analysis of them.

(the following table is confidential)

[redacted]

4. Cost Management Practices

The common approach to cost management in most construction and process industries builds around a framework of defining standards, or goals, or targets that generally represent performance expectations. Management then creates a process for measuring performance against those expectations and for giving those measurements visibility. To the extent that the measurement process identifies significant performance deviations, analysis of the underlying causes of those deviations follows. Completing the loop, actions to correct or mitigate resulting issues ensue, with

monitoring of their effectiveness in addressing the deviations found. In cases where those deviations prove unalterable, revision of the organization's performance expectations should follow, after which the measurement "standard" changes, but the process repeats.

Organizations design and employ such a process differently, but the organizations we have examined use this process in one form or another. The process supports effective cost management, and its basic components apply as well to the schedule management, project management, process management, total quality management, and continuous improvement initiatives. In the latter, total quality-oriented cases, names such as "plan-do-check-act," the Deming wheel or the Shewart cycle, are common. At its most basic construction, this approach applies common-sense, hence its near-universal application, even in organizations that apply it intuitively, as opposed to a formal, sophisticated structure.

In the case of cost management, the performance expectation takes the form of a budget, a project or program estimate, pre-defined unit rates, or any other metric to which the organization will hold itself accountable. System effectiveness breaks down where: (a) the standard is not credible, and hence represents an unrealistic performance expectation, or (b) management declines, for whatever reason, to hold personnel accountable. In this context, "holding personnel accountable" may simply be the requirement of an awareness of expectations and a required analysis of deviations. Deviations do not necessarily reflect performance failures or require treatment as such; nevertheless, the burden of explaining such deviations must lie on an appropriately designated manager.

Friction has arisen between WGL and its stakeholders over its departures from common practice. Management, for example, consistently took the position that it should not be held accountable to its project cost estimates, for reasons addressed in the chapter on estimating. It is common practice to prepare estimates of suitable quality to serve as credible standards of performance on many projects. WGL did not hold itself accountable to its estimates, and management did not hold itself or its employees to such standards.

Management described what it considered to be its preferable approach to cost management: "the work oversight and approval process in place for contractor payments." We began by agreeing with management that estimates not considered credible do not provide a sound basis for costs management. That one should not be held accountable to a flawed standard seems clear.

Management stated that the Commission's timing requirements preclude effective estimates. We do not agree. A Year's proposed project list came on June 1 and became finalized July 31, only 60 days prior to the start of the project year. Management emphasized its policy of early releases to the field in order to maintain a substantial backlog for construction and provide flexibility in adapting to field conditions. Engineering's goal was to have 50 percent of the projects released by July 31. Sixty days before construction starts, with half the projects released is not too early to prepare credible estimates. Even were July 31 too early, no barrier prevents later, more accurate estimates. The correct inference to draw from the circumstances is that management did not prepare better estimates for lack of time, but for lack of belief that they were useful in managing projects. Certainly, management was, as the estimating chapter described, not lacking in sound knowledge of quantity requirements - - estimate elements requiring engineering information, like

quantities of mains and services, proved relatively accurate. It is not clear what later estimates would have added regarding them. The real problem underlying estimate accuracy was actually the failure to "estimate" forward looking unit rates, but to "plug" historical performance into estimates.

Management's estimates were indeed credible in the sense that, on balance, the failure to perform at the historic level correctly reflected a declining level of performance. That, in itself, could be based on factors outside of management's control. But one will never know if the estimate is rejected out of hand and the analysis to demonstrate management prudence is not done.

5. WGL's Contractor Cost Management Approach

WGL contractor management comprised the central component of its cost management program. We credit management with a comprehensive program, unique in its breadth in our experience. It has a number of strong features. The concepts and principles that underlie the process and drive its application in some respects comprise "best practices."

WGL lets contracts on a blanket, not project-by-project basis. Typical durations were three years with expansion likely to five years for trusted contractors in the future. The core element of the contracts are their total focus on unit pricing. Unit price contracts reflect the rule and not the exception in the industry. What makes WGL contracts less typical is the level to which they go in defining unit prices. Management explains that the list of contract unit rate covers *all* work chargeable by the contractor. That approach produces a long list of unit rates.

The typical contract consists of a Master Construction Agreement, an attached package of pay item definitions, and an attached pricing workbook. The pay item definition sample shown came from one of the contracts we examined. It ran to 39 pages, and included 30 categories of work. The contract covered work in all WGL jurisdictions. We found pay items detailed, and the accompanying "pay units" (the specific measure used to determine payment) well-specified. WGL's objective to put all work under unit rates demands this level of detail and management has gone to considerable lengths to fulfill that objective.

Pay Item Definitions	Page No.
Pipe Installation / Abandonment	3
Pricing Tiers, Service Pricing	5
Directional Drilling, AUGER Boring w/Casing	11
Gas Light Service	12
Meter Build-up, Conversion from Low to High Pressure/High to High Pressure, and Inside and Outside Meters	13
Overdepth / Trench, Dump Fees	14
Paving Breakage	15
Table of Standard Excavation Dimensions for Pipe	16
Prefabricated Regulator Station	17
Protective Systems, Trench Jacks	18
Rock Removal	19
Saw Cutting	20
Select Backfill	21

The pricing workbook, a sample of which we illustrate below (from the 11 pages in total), provides bid prices for the contract. It employs units like tons (TN), cubic yards (CY), loads (LD), and linear or square feet (LF or SF), and provides for per item pricing (EA) where applicable. The workbook was 11 pages in the sample we reviewed. Most of the entries included specific production units as

expected, but the last two pages included only hourly rates for personnel and equipment. Needless to say, an "hour" is not a unit of production, and work charged under these pricing conditions would generally be characterized as "cost plus", and not "unit pricing". Many of these units address activities generally involved in support of main and service installations.

A fundamental concept underlying WGL's approach is to avoid incorporating "allowances" for such activities into per foot or per unit installations for mains and services. The concept holds that too broadly pricing work units causes contractors either to build too great a level of allowances or to seek change orders when such work proves greater than contemplated in bid prices. WGL considers it preferable to exclude as many of these types of allowances as possible, producing a lean bid for the central work units (feet of main; numbers of installations). Turning what would have been these allowances into separate work elements, or "pay units" then allows contractors to charge only for what they do, with the necessity for doing it and the number of units required approved by WGL construction supervisors monitoring contractor work.

To the extent that management supports the system with effective, accountable supervision of contractor work, the approach has merit. It nevertheless still requires regular measurement, reporting, analysis, and response to problems, because human elements of contractor and construction supervision still bear upon performance.

Description	Unit	Price	Pay Item Definitions Reference Page
Meter Build-up	EA		Page 12
Meter Set	EA		Page 29
Meter Move	EA		Page 12
Select Backfill	TN		Page 20
Trench Jacks	EA		Page 17
Dump Fees - Small	LD		Page 13
Dump Fees - Large	LD		
Protective Systems (shoring) 0' - 10'	SF		Page 17
Rock Removal	CY		Page 18
Overdepth / Trench	CY		Page 13
Silt Fence	LF		Page 27
Extra Hole Service Insert	EA		Page 7
Steel Plates / Day	EA		Page 24
Meter Guard	EA		
Traffic Control - 3 Man Crew	HR		Page 24

The WGL system seeks to limit contractor claims for work "changes," but does not eliminate it. A particularly great challenge in cost management of contractor work lies in how the process addresses such changes. Changes in scope, including expansion of work, more involved work methods, and other factors fundamentally changing the rules and assumptions relative to what was planned and included in contract pricing very commonly proves the largest and frequently the dominant driver of added costs on large projects. We have not found it unusual to see change orders on major pipe replacement programs levels at or well above 100 percent of estimated costs.

Management did not believe that what the industry classifies as "change orders" created substantial cost increase risk for PROJECT*pipes*, observing that "WGL does not have change orders per se." Management described its overall approach regarding costs and their management as relying on three key principles:

- Once on an approved annual project list, a project must be completed whether or not subject to changes and cost increases; no option exists to cancel it, or to change or reduce scope
- WGL's pay unit system limits its payment to work actually completed
- Those prices result from competitive bidding, making costs paid for work performed under fixed unit prices effectively managed.

It is inherently troubling to accept the need for completing non-emergency work no matter the cost. For work spread across a 40-year program, this concept becomes the more uncomfortable. Generally accepted principles of project management identify significant scope and cost issues that emerge as requiring a new estimate and a revisiting of project scope, priority and timing. We recognize, however, that for typical PROJECT*pipes*, projects, short durations call for a different approach. Generally speaking knowledge of major deviations comes too late to make the usual approach valuable. Nevertheless, with cost a component of the prioritization system, management should, when it discovers major cost changes early, revisit prioritization, and consider project deferral. This opportunity may not come often, but should be exploited when it does.

With respect to reliance on the pay unit system, we found it strong, but not to the extent of covering 100 percent of work. Not all pay units have physical dimensions, some are measured in terms of hourly crew or equipment costs; *i.e.*, the classic pricing basis for change order costs. The portion of total costs paid under these pay unit types was substantial. Management here thus had the same need for close measurement and monitoring it that exists generally for utility construction work.

Just as importantly, work payable on the basis of physically measurable units has cost risk as well. There are needs for: (a) close assessment of the need for such contractor work as part of day-to-day planning, and (b) timely and accurate measurement and verification of units of work claimed as performed by contractors. These needs place a great burden on WGL construction supervision personnel to make the second of WGL's three key principles a reality.

We give significant credit to WGL's contractor management program, featuring the extensive use of unit prices, in creating a sound tool for cost management. It does not, however, itself provide all that is required for effective cost management.

6. Cost Reporting

WGL management considered approaching annual expenditures of $20 million as the most central aspect of cost reporting. The reports we saw focused on spending levels, and did not address costs as performance indicators. Employee goals related also addressed only spending. The high-level oversight provided by the Operating Committee also addressed only spending. Cost effectiveness appeared to be implicitly accepted as sound, and certainly not in any way demonstrating reportable deficiencies or variances requiring cause identification and management response. Against this metric, management succeeded, matching spending closely to the $20 million annual levels of Years 1 and 2 without exceeding them.

Reporting against the annual spending target made sense, but what we did not see was attention in calculating and displaying through specific metrics linkages between spending and accomplishments - - mains and services put into operation and completed, and the sizes, trends, and anomalies in cost drivers. Determining whether or not drivers of cost increases prove alterable, depends on first identifying, quantifying, and often trending them. We will describe further in the next chapter, addressing schedule management, that production fell well below expectations, producing only a portion of expected work completion for the costs incurred. Reporting did not display robust attention to this - - the most central - - cost management observation during Years 1 and 2. We did not see assessments of its existence or of its short- and long-term implications. As WGL's internal audit organization concluded in November 2016, "There currently is no formalized analysis and consolidated reporting of program level spend to overall program replacement progress."

The link between spending and the results produced from that spending sets the most basic foundation for effective cost management. Focus on spending to the exclusion of that linkage was a significant gap in WGL's management of costs. We did find curious internal audit's comment that "Management has not previously had a need to track spend to replacement unit progress at the program level." We consider such tracking a fundamental element of management from start to finish on a program like PROJECT*pipes*, not a developing need based on subsequent events or conditions. Treating it as a responsive gesture inevitably tends to make it a tardy one.

C. Conclusions - - Years 1 and 2

1. After a slower start than we would have expected, total Year 1 and 2 spending neared, but did not exceed the $20 million in annual expenditures qualifying for expedited rate treatment.

Management focuses greatly on managing spending to the $20 million targeted for each of Years 1 and 2. Spending fell below that target by six percent - - $500,000 in Year 1 and $1,800,000in Year 2. WGL managed to make these total expenditures despite a very low pace of spending for the first nine months of the program.

More than half of Year 2 spending went to Year 1 projects, raising the question of why such carryover projects were not included on the Year 2 list, and demonstrating that, despite reaching targeted spending levels, replacement performance well underran expectations. WGL completed a small number of Year 1 projects in Year 1. With so much work remaining from Year 1 as Year 2 approached, one might consider it logical to include expected levels of Year 1 completion in Year 2 in the Year 2 filing. That approach would provide stakeholders with a clearer sense of work actually expected to be completed in the coming year. It would also have been useful to provide some basis for determining whether and to what extent Year 1 work would carry out even further, extending into Years 3 and perhaps 4 as well. The yearly lists, under these circumstances have in some respect more the character of a list from management can select work than a plan for what it intends to accomplish.

2. Unit rates for work in replacing mains and services deteriorated in both Years 1 and 2; that deterioration caused far higher than expected costs and far lower rates of replacement, which management knew to be the case.

Program cost increases have primarily materialized through increases in unit rates, as opposed to quantity or scope changes. The very negative deviations from the plan, including cost overruns, schedule delays, and production shortfalls flow from unit rate issues. Management did analyze the problem and collected meaningful data about it, but did not use it to examine the need for changes in practices or in re-baselining overall program replacement rate, cost, and schedule parameters.

Close monitoring of cost performance (specifically, unit rates) and forward-looking estimation of them was called for by these circumstances, but did not occur. More-forward thinking and information sharing about the long-run implications for a program already displaying highly unrealistic expectations did not either.

3. WGL's pay-unit approach to compensating its contractors has a sound foundation, but not the assurance of effective cost management on which management appeared to have relied.

A very large portion of contractor payments continued to rely on hours of crew or equipment use, not linked to physical quantities, making them more typical of the types of "cost plus" features that many construction contracts employ. Time and materials and traffic control costs provide examples of such features. Moreover, even the portion of WGL's system that does use physical units requires that those units be necessary, that not better means for producing them can be built into pricing as contracts come up for renegotiation, that contractors report them accurately, and that WGL's construction supervision validate them before memory or lack of documentation inhibit that validation.

These needs do not even consider the integrity of contractor and employee resources - - a risk that prudence dictates be mitigated. These needs call for a set of reporting measures and analysis that we did not see well developed or frequently used during Years 1 and 2. Our concern here did not extend to the nature of the system management used, but in its execution using reporting, analysis, and (as needed) corrective action planning and performance.

WGL did not use common industry approaches to cost management, including detailed reporting of a range of key performance metrics, variance analysis, and accountability for cost "overruns." Commonly used cost management systems revolve around the setting of performance expectations, measurement of performance against those expectations, analysis of deviations and implementation of mitigating or corrective actions as appropriate. WGL has defined expectations in the form of the five-year plan and more detailed annual plans, produced before the start of each year and including a list of specific projects and their estimated costs and schedules. Ordinarily, such data would be sufficient to serve as a credible basis for subsequent cost management purposes, especially analysis of performance deviations.

Management, however, does not consider these a credible baseline for performance analysis. Further, with the plan losing relevance shortly after work began, no effort to revisit or enhance it followed. With no credible set of expectations, the use of variance analysis became impossible.

D. Improvement Opportunities - - Years 1 and 2

1. We believed that WGL needed to implement a formal cost management process designed around credible performance expectations and measurement and analysis of performance against those expectations.

Such a program would capitalize on opportunities for improvement, and deliver benefits to management in terms of its ability to manage performance. The desired program would begin with improved definition of expectations. Credible five-year and annual plans, along with a process for monitoring and updating those plans should follow, as recommended in the earlier, program planning chapter. Improvements to the estimating process already underway would form a significant component.

We considered it important for WGL to implement the following features:

- Clear and tangible definition of management's expectations for cost performance by establishing baselines for accountable performance, such as the annual budget, the approved estimate used for project authorization, and planned unit costs expected to be met to avoid overruns, for example
- Visibility of program and project cost performance through periodic status review meetings and distribution of monthly cost reports with relevant cost performance information and meaningful analysis
- Insightful analysis of cost performance issues by examining material cost deviations to identify root-causes and recommend appropriate corrective actions in a timely manner; and where adverse trends cannot be mitigated, sound projection of their short- and long-term cost impacts
- Linkages between cost and production through development and use of metrics to measure the relationship between production and associated costs, such as cost per service or work-hours per service for service installation, cost per foot or work-hours per foot for main replacement, cost of backfill per foot of main, and cost of saw-cutting per foot of main, for example
- Defined cost management accountabilities for functional and program managers by specifying for each functional area the individuals accountable; *e.g.,* cost estimators accountable for sound preparation of the cost estimates, design engineers accountable for scope and quantity accuracy, procurement managers accountable for material pricing and contract bids, construction managers accountable for the execution and costs of work in the field.
- Qualified cost analysts or cost engineers to support functional and program managers.

2. We believed that the program should tie planned expenditures to tangible production goals, in terms of mains and services.

In this regard, tracking of unit rates on a real-time basis will be important. This enhancement would produce a timely indication of adverse trends, and provide the data for determination of causes and opportunities for mitigation. Prompt identification of weakening unit rates, early in the year for example, provides an effective predictive measure that allows attention to issues while there remains time to take corrective measures and get the program back on track.

We found it beneficial for management to implement the following actions:

- Monitor Planned Unit Cost (by Programs 1, 2, and 4) for both Main and Service Replacement on both annual and Program-to-date (five-year) basis
- Monitor Actual Unit Cost (by Programs 1, 2, and 4) for both Main and Service Replacement on both annual and Program-to-date (five-year) basis
- Compare Actual Unit Cost and Planned Unit Cost and analyze significant variances.

E. Developments - - Years 3 and 4

1. Formal Cost Management Process

Management made progress in a number of areas. It has established more clear and tangible definition of its expectations for cost performance. Some sound baselines now exist for regular progress measurement, reporting, and analysis. Promoting visibility and performing analysis can improve further. We address a number of the important baselines below.

Program-to-date spend

By Year 2, cumulative spend accorded to the plan, but began to lag in Year 3, as management directed resources to other work. The next table shows spending through the end of Year 4.

Cumulative Program Spending through Year 4
(the following chart is confidential)

Actual costs versus revised estimates on completed projects

Overall performance of 19 percent showed a major reduction, but much greater deviations in Programs 1 and 2 remain, as the next table shows.

Actual versus Revised Estimate Costs – Cumulative through June 2018

Program	Count of BCAs	Revised Cost Estimate	Actual Cost	Variance %
DC PROJECTPIPES 1	44	$1,966,027	$3,252,868	65%
DC PROJECTPIPES 2	28	$6,833,990	$11,132,167	63%
DC PROJECTPIPES 4	33	$18,175,486	$17,596,408	-3%
All Programs	105	$26,975,503	$31,981,443	19%
These 105 BCAs have BCA Close Dates between Jun'14 and Jun'18.				

Actual versus revised estimate quantities

Physical progress continued to lag, with 62 percent of planned feet of main remediated and 75 percent of planned services installed, as the next table summarizes.

Mains Remediated and Services Installed– Cumulative through June 2018

	Mains	Services
Original Estimate	89,964	3,580
Revised Estimate	99,849	3,758
Actual	62,248	2,820

While the data still show performance below expectations, metrics like this provide management with visibility on program status, supporting the ability to hold personnel accountable for performance and to require explanations for variations and a search for solutions to barriers causing deviations from the baselines.

Visibility of program and project cost performance

Management has developed Monthly Executive Dashboards to monitor the overall performance of PROJECT*pipes*, including units completed, total dollars spent, and key milestones. This dashboard forms part of program executive review sessions. Tracking units completed and spend should be a required element of monthly progress monitoring of the conformity of planned spend and installation to plans.

Insightful analysis of cost performance issues

Management has not performed variance analysis at the program level. Efforts to analyze variances in scope, cost and schedule at the project level have begun. Management has identified preliminarily some causes of variances. For example, its work has identified a large number of projects that cannot be closed due to technical or paperwork issues. Management has developed BCA Close-out reports to improve the credibility of forecasted closeout dates and to expedite the closeout process.

WGL documents the variance analyses it performs at the project level in its Monthly BCA Progress Reports. Our review of those provided found them in need of significant further development. The treatment of scope variance includes a list of changes in quantities. Analyzing cost variances is not possible, because there is no breakdown of cost estimate elements. The schedule variance analysis

identified workforce interference problem and customer coordination issues. More in-depth analyses with recommended actionable solutions continue to be needed.

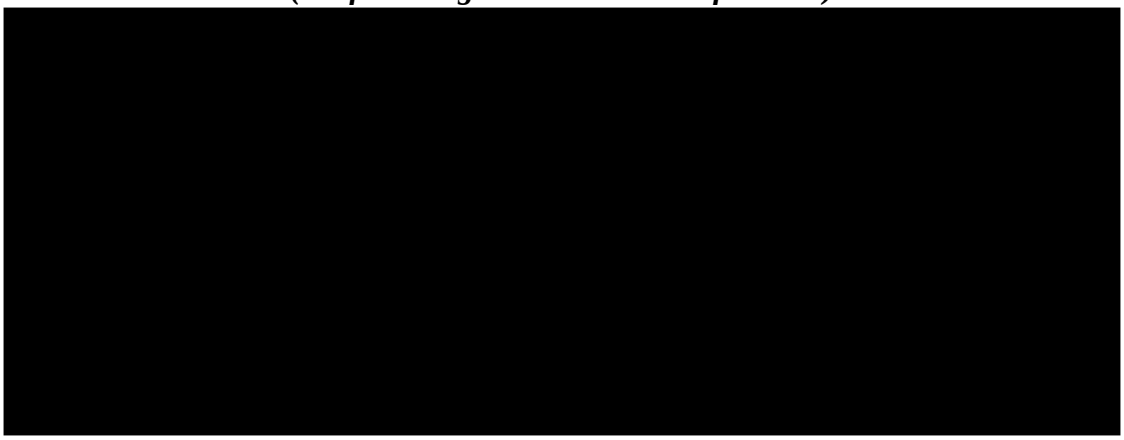
Defined cost management accountabilities for functional and program managers
Management believes that it has clearly designated accountability for all project functions and activities. It holds cost estimators accountable for sound preparation of cost estimates, design engineering accountable for estimated scope and quantities, procurement accountable for material pricing and contract bids, construction management accountable for the execution and costs of the physical work. The Project Implementation Plan currently being updated should explicitly describe where accountability lies for all material program functions.

Support to functional and program managers in the form of cost professionals and systems
Management depends on the functional organization personnel to perform cost management functions. It does not have a plan to engage cost management professionals. This approach can work, but requires that managers and supervisors receive essential cost management training.

2. Tying Planned Expenditures to Tangible Production Goals

Management's annual cost studies, essentially based on adjusted historical costs (using closed BCAs) and other information collected showed the following results through the first four program years.

(the following illustration is confidential)



Such quantified unit costs are valuable for cost estimating, variance analysis, and contract management. Management should continue to conduct studies of these particular kings of cost drivers on a continuing basis.

F. Recommendations

14. Enhance the provision of insightful analysis of cost performance issues and provide cost management support to the program.

Management has substantively addressed six of the improvement areas we identified from work in Years 1 and 2, completing four of them. It has sufficiently addressed needs for clear definition of management's expectations for cost performance, visibility of program and project cost performance, linkages between cost and production, and cost management accountability.

The remaining two needs consist of:

- Cost performance analysis: more structured, visible, actionable analyses of major cost drivers to identify root-causes and recommend appropriate corrective actions in a timely manner, and failing the identification of mitigating actions, reflection of expected impacts on short- and long-term project and program costs
- Cost management expertise: support to functional and program managers in the form of cost professionals and systems by assigning qualified cost analysts or cost engineers.

15. Promptly complete development of a process for regularly measuring planned and actual expenditures to production for terms of mains and services.

The annual unit cost studies reflect a sound first step in management, but more is required. Our last discussions with management indicated some level of agreement on comparing actual unit costs against those planned. An appendix provides illustrations of the concept, bases, and assumptions involved, and provides examples.

Entering the last year of the current five-year window, it has become clear that a significant production shortfall, overall and as measured against expenditures required will remain. Particularly with unit costs having escalated and with prior estimates excluding escalation, we consider it important that consideration of the next phase begin with a frank assessment of the amounts and expected costs of carry-over work that will remain.

Going forward, management should at least twice each year project final costs (five-year window and through-program-end) starting with current unit costs escalated. This exercise will offer meaningful answers to:

- What will not get done after spending the $110 million (the cost of addressing Uninstalled Quantities from the plan)?
- What are the cost impacts of the carryover (Sum of Unmitigated Cost Variances)?
- How to design an annual expenditure pace that, for the future, will provide an acceptable yet affordable pace of remediation?

Appendix - Unit Cost Metrics Development Guidelines

The metrics are first developed at the detailed level and then rolled up to the summary level. For main replacement, metrics are generated for programs 2 and 4. For service replacement, metrics are generated for programs 1, 2, and 4.

I. Definitions and Calculations Formulas
   A. Detailed Level Metrics (for Main and Services):
      1. Five Year Target Unit Cost = Five-Year Spending Target / Five-Year Quantity
      2. Annual Planned Unit Cost = Annual Planned Costs / Annual Planned Quantity
      3. Cumulative Planned Unit Cost = Sum of Annual Planned Costs / Sum of Annual Planned Quantity
      4. Annual Actual Unit Cost = Annual Actual Costs / Annual Actual Quantity
      5. Cumulative Actual Unit Cost = Sum of Annual Actual Costs / Sum of Annual Actual Quantity
   B. Summary Level Metrics (for Main and Services):
      1. Five-year Target Unit Cost = Sum of Five-Year Spending Target / Sum of Five-Year Quantity
      2. Annual Planned Unit Cost = Sum of Annual Planned Costs / Sum of Annual Planned Quantity
      3. Cumulative Planned Unit Cost = Sum of Annual Planned Costs / Sum of Annual Planned Quantity
      4. Annual Actual Unit Cost = Sum of Annual Actual Costs / Sum of Annual Actual Quantity
      5. Cumulative Actual Unit Cost = Sum of Annual Actual Costs / Sum of Annual Actual Quantity

II. Unit Cost Metrics – Summary Level

(the following charts are confidential)

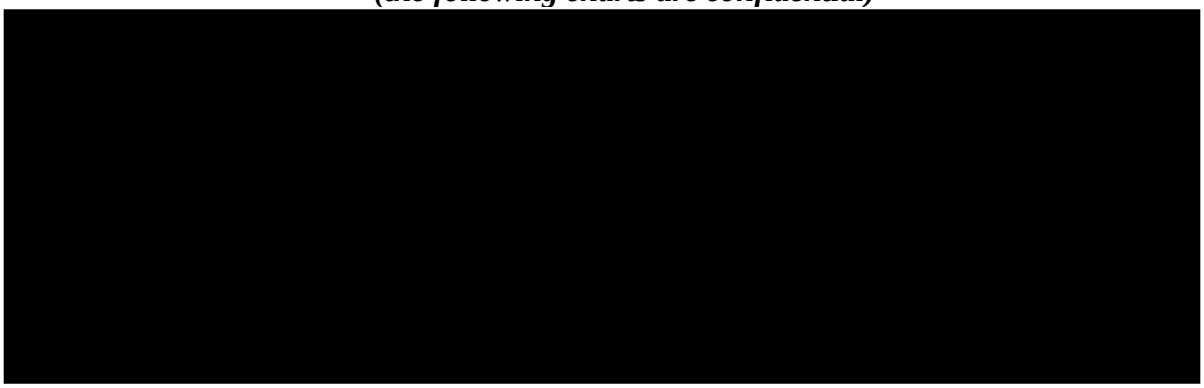
   A. Observations – Main All Program Unit Cost Metrics
      1. Actual Unit Cost in line with Planned Unit Cost for all four years
      2. Actual Unit Cost 25% above Target Unit Cost
      3. Actual Unit Cost 25% higher in Year 4 than Year 2
   B. Observations – Services All Program Unit Cost Metrics

1. Actual Unit Cost consistently 50% higher than Planned Unit Cost and still trending higher
2. Actual Unit Cost 70% above Target Unit Cost
3. Actual Unit Cost 29% higher in Year 4 than Year 2

III. Unit Cost Metrics – Detailed Level

A. Main

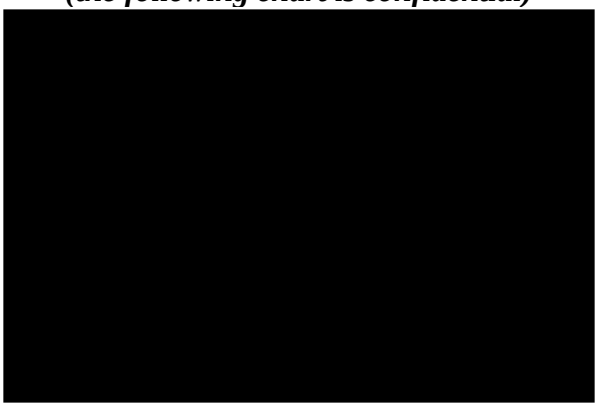
(the following charts are confidential)



1. Program 2
   - Actual Unit Cost in line with Planned Unit Cost for three years and then in Year 4 underrunning Planned Unit cost by 20%
   - Actual Unit Cost 3% lower in Year 4 than Year 2
2. Program 4
   - Actual Unit Cost in line with Planned Unit Cost for three years and then in Year 4 overrunning Planned Unit Cost by 20%
   - Actual Unit Cost 44% higher in Year 4 than Year 2

B. Services

(the following chart is confidential)



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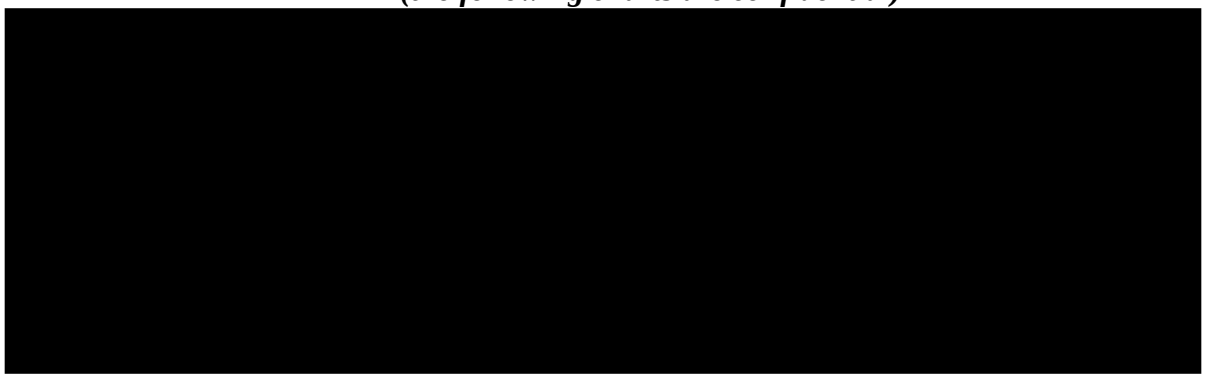


1. Program 1
   - Actual Unit Cost 60% higher in Year 1 but converged towards Planned Unit Cost by Year 4
   - Actual Unit Cost 18% higher in Year 4 than Year 2
2. Program 2
   - Actual Unit Cost 80% higher in Year 1, diverged sharply in Year 2, and tripled the Planned Unit Cost by Year 4
   - Actual Unit Cost essentially the same between Year 4 and Year 2
3. Program 4
   - Actual Unit Cost diverged from Planned Unit Cost in Year 2 and tripled by Year 4
   - Actual Unit Cost 63% higher in Year 4 than Year 2

IV. Conclusions – Actual Unit Costs

A. Summary Level Charts:
   1. Main: 25% above Target (substantial)
   2. Services: 70% above Target (insurmountable)

B. Detailed Level Charts:
   1. Main:
      - Planned Unit Cost very good for first three years
      - Program 2 under Planned Unit Cost by Year 4 (good news)
   2. Services:
      - Program 1 started out poorly in Year 1, but caught up nicely by Year 4 (more good news)

      - Program 4 diverging sharply and tripled Planned Unit Cost by Year 4 (insurmountable)

V. Bases and Assumptions
   A. Actual Unit Cost – actual quantities and costs from WGL backup to Actual Unit Cost Chart
   B. Summary Level Target Unit Cost – Target quantities from Planning Hierarchy slide (only 4 years of data available) and using calculated composite Planned Unit Cost

C. Detailed Level Target Unit Cost – not available (data should be available to WGL)
D. Rolled up Planned Unit Cost – use actual quantities (planned quantities not available) since actual quantities in line with planned quantities
E. Cumulative Planned Unit Cost - use actual quantities (planned quantities not available) since actual quantities in line with planned quantities

VI. General Comments on Unit Cost Concept

A. The cumulative Actual Unit Cost (Program-to-date) versus the Five-year Target is the most important measurement of overall performance because it is concise and telling.
B. Annual and cumulative Actual Unit Costs by program classification are very useful in estimating of project costs, planning of work, and cost forecasting of the Five-year Program.
C. Unit Cost Metrics could be generated to monitor performance on a monthly, annually, year-to-date, or Program-to-date basis.
D. Actual Unit Cost exceeding Planned Unit Cost could be acceptable, as long as they stay below the Program Target Unit Cost line.
E. Only closed projects should be included or the measurements will be distorted, since no equitable methods to consider partial credits are available for open projects.
F. Historical Actual Unit Cost database at the detailed level should be maintained and updated at least annually.

The cumulative Actual Unit Cost at the end of Year 4 is loaded with 4 years of data, which means even a super performance in Year 5 may not improve the situation that easily. (Message: Corrective actions need to start early in the Five-Year Program, like around six months into the Program during Year 1).

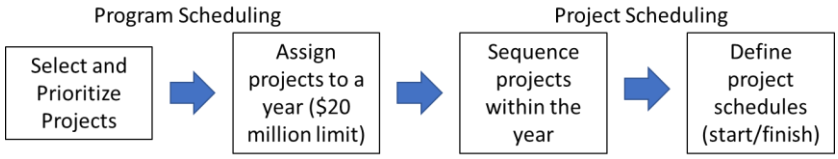
VIII. Scheduling

A. Background - - Years 1 and 2

Utilities take different approaches to scheduling replacement projects and other large construction efforts. Schedules can range from networks containing thousands of activities run on sophisticated scheduling software to simpler task lists tracked on a spreadsheet. The latter, more "back-of-the-envelope" approaches serve far simpler work than here. A sound selection of schedule detail and sophistication depends on many factors, including the size of the program and its projects, the complexity of the work, the number of engaged organizations requiring coordination, the number of restraints present, and the preferences of the management team.

B. Findings - - Years 1 and 2

The next diagram shows the flow of scheduling needs and challenges through a chain of program and project management activities.



1. WGL Schedule Drivers

WGL applied a straightforward process in arriving at planned *PROJECTpipes* program work. Management initially identified leak-prone mains by applying the highest risk score, following application of its Optimain tool. Management developed and prioritized projects including only service replacements based upon a leak-per-geographic-area metric. Chapter II describes WGL's main and service prioritization and selection processes in details.

The earlier Program Planning chapter described development of project lists sufficient to ensure expenditure of the $20 million annually planned for Years 1 and 2. Beginning from annual spending as the key parameter calls for an estimate of the work or production expected to result. Focus on an annual spending limit requires a determination of the greater priority - - to avoid over-spending the budget, or to complete the expected work. Both choices have some foundation in these circumstances. Overspending would affect management's expected degree and method of rate recovery, thus making its risk financial in nature. By contrast, spending beyond the limit, as experience quickly showed, would be necessary to replace high-risk pipe at anticipated rates. The risk of failure to do so was and remains safety in nature (not accounting for the potential financial exposure from future safety incidents).

WGL management's decision between the two was to hold spending at or beneath the $40 million cumulatively for Years 1 and 2. Management's decision and the far lower than expected production rates that soon became evident has significant consequences for program scheduling. With increased spending a primary tool for maintaining schedule, prospects for recovering schedule loss became dim, at best.

2. Scheduling Process

WGL used a very simplistic approach to scheduling for individual projects. Each scheduled project had a start date and a completion date, with no supporting formal or informal detail. A "Sequence of Operations", comprising part of the BCA authorization package, defined intermediate activities between these endpoints, but without dates. There was no specific document properly termed a "project schedule" and management did not require contractors to provide construction schedule details and assumptions. We found that lack of formality and detail in project schedules unique in our experience. The lack left management without the bases normally used to hold program personnel and contractors accountable for schedule performance using only start and end dates. That many of the PROJECT*pipes* projects proved small justified brevity in schedules, but not the lack of any detail at all. Even small projects have some complexity; *e.g.*, permitting and support requirements.

Management applied a "combination of historical project productivity estimates and management judgement and experience to develop projected start and end dates". It did not apply any site-specific considerations, as its cost estimating process excluded these as well. Management explained, again as was true in cost estimating, that schedules came "very early in the process prior to work being approved by the Commission, design completion, permitting received, authorization of the project, reprioritizing projects based on new information or any customer coordination." Management provided schedules, like cost estimates, at the end of July - - 60 days before the start of the program year. We did not find this so early as to preclude more scheduling work on the projects provided for review and approval.

3. Schedule Performance

a. Projects Completed

The next table shows that project schedules slipped greatly in Years 1 and 2, driven by the large production shortfalls (high unit rates) discussed in earlier chapters.

Projects Completed During the Audit Period							
Year 1 Projects					Year 2 Projects		
Planned	Complete in Year 1	Complete in Year 2	Not Complete		Planned	Complete in Year 2	Not Complete
66	24	10	32	**Program 1**	16	1	15
26	12	10	4	**Program 2**	7	2	5
32	12	11	9	**Program 4**	12	1	11
124	48	31	45	**Total**	35	4	31

Completion as defined here uses the latest date of completion of a construction unit (CU). Additional paperwork may remain for before final and full close-out of the project's BCA#. In addition, the table excludes "scattered" projects added to work during the year.

Management did not consider project completion the best measure of either progress or performance. WGL itself chose completion as the relevant metric, defining its plan with the

intention of completing the designated number of projects, making it clearly an appropriate means for measuring schedule performance. Schedule deviations provided pervasive for Year 1 projects. WGL completed 39 percent of them in Year 1, and another 25 percent in Year 2 - - leaving more than a third of them incomplete after Year 2. The completion rate for Year 2 projects dropped precipitously further, with only 11 percent completed in Year 2. Moreover, management did not complete any of the "top 3" (See Chapter II for a description of them) designated projects for Year 1 or for Year 2 in the year of their inclusion in the approved project list.

b. Progress Rates - - Installation Quantities

Particularly given the approach of confining expenditures to a $20 million annual rate, production (feet of mains and numbers of services remediated) offers another perspective on schedule performance. The accompanying table shows that actual work for Years 1 and 2 combined far underran both management's original and its revised estimates.

Years 1 and 2	Mains	Services
Estimates		
Original	68,957	2,535
Revised	79,939	2,898
Actuals		
Total Yr 1 & 2	48,340	1,966
% of Original	70%	78%
% of Revised	60%	68%

These quantities cover the 28-months from June 1, 2014 through September 30, 2016. The next table provides details by program for: (a) actual production in the 28-month period, (b) that same production annualized, and (c) the annual rate of production required by the long-term plan.

Mains Remediated (feet) and Services Installed

		Actual		Annualized			
	Program	Mains	Services	Mains	Services		
Year 1 Projects (28 mths)	1	113	733	48	314		
	2	13,439	239	5,760	102		
	4	26,210	602	11,233	258		
	Total	39,762	1,574	17,041	675		
Year 2 Projects (12 mths)	1	0	141	0	141		
	2	2,681	62	2,681	62		
	4	5,897	189	5,897	189		
	Total	8,578	392	8,578	392	Required	
Year 1 and 2 Projects	1	113	874	48	455		1,573
	2	16,120	301	8,441	164	19,008	304
	4	32,107	791	17,130	447	56,496	216
	Total	48,340	1,966	25,619	1,067	75,504	2,093

Required = Annual rates to support the 15-15-40 year plan

The highlighted line shows that:

- The amount of pipe actually remediated in the 28-month period falls beneath that required for a typical 12-month period
- Service installations ran at about half the required rate
- Main replacement ran at about one-third the required rate
- Failure to increase production rates substantially renders inapt the 15, 15, and 40- year planned durations for Programs 1, 2, and 4, respectively.

c. Schedule Performance Details

The next table shows median planned and actual durations for Years 1 and 2. Management adjusted planned durations for Year 2 projects, extending them to four months. Performance versus planned durations improved in Year 2, whose 38 percent schedule duration overrun fell from Year 1's 108 percent. The lengthening of planned durations contributed to the Year 2's performance improvement, however, Year 2 projects had larger scopes than did their Year 1 counterparts on balance. There were also only four completed Year 2 projects, producing a limited sample size for comparison

Median Durations for Projects (Days)			
	Planned - all projects	Planned - completed projects	Actual - Completed Projects
Year 1 Projects	61	61	127
Year 2 Projects	121	123	170

Few projects started or finished on or near schedule. We counted all actual dates falling within a week of planned as on-time. Only 19 project starts (15 percent) met this criterion for starts and only 17 for completions. In Year 2, fourteen projects (40 percent) met our start and two our completion criterion.

Projects Started or Completed On Time[1]		
	Started	Completed
Year 1	19	17
Year 2	14	2

[1]"On time" means no later than 1 week late

Only 33 of 159 projects started on-time. We credited management for its strong practice of providing a suitable backlog of projects available for construction at all times. Given that backlog, however, the failure to start so large a number of projects on or near schedule becomes puzzling.

Permitting, often mentioned as a reason for schedule delays, provides a legitimate explanation for part of the problem. We understand that permitting issues became especially problematic in the spring and summer of 2016, but that does not explain Year 1 delayed starts. By the spring of 2016, project starts had already fallen a year behind schedule.

The accompanying table summarizes overall start results. A total of 39 projects (25 percent) had still not started after completion of Year 2, at which point, the 18 Year 1 projects still not started had been delayed well over one year. Moreover, five projects started before the commencement of Year 1, as discussed below).

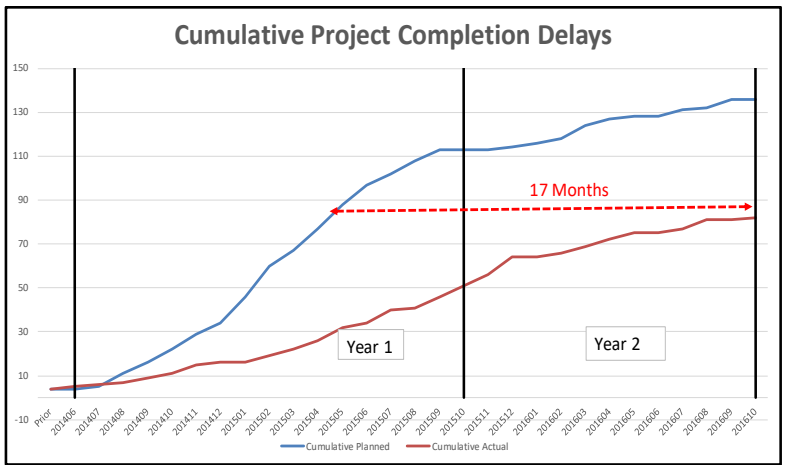
Project Starts	Year 1 Projects	Year 2 Projects	All Projects
Started before Year 1	5		5
Started during Year 1	87		87
Started during Year 2	14	14	28
Not started	18	21	39
Total	124	35	159

The chart on the right perhaps best illustrates the magnitude of the schedule slippage. It shows the number of projects with planned starts in each month on a cumulative basis. This population includes 159 projects slated to start in Years 1 or 2. With all these projects planned for completion by the end of Year 2, all 159 projects were planned to be started by April 2016, leaving six months for completion. Actual starts generally kept reasonably close to planned levels for the first six

months, but began to lag substantially at that point. Program starts lagged by about six months by the end of Year 1 and by 16 months after Year 2.

We understand that the 16 month "year" defined for Year 1 projects sought to facilitate startup and acceleration of replacement pace to the sustained levels required. The "planned" curve reflects this approach, producing a lower slope for the first several months, and then increasing to a faster pace. Note that the "actual" slope, however, stays at the same rate as initially experienced, causing the program to fall further behind each month. The declining slope of the "actual" curve in Year 2 becomes noteworthy, showing either a decision not to address the schedule lags of Year 1, or a failure to produce improvements needed to accelerate project starts. In any event, schedule start performance substantially declined in Year 2.

The accompanying chart illustrates the cumulative results for planned and actual completion of projects. The data here falls slightly short of the 159 Year 1 and 2 projects because we did not find planned finish dates for several projects.



The completion data shows the same patterns, but somewhat more extreme. A lag of about 9 months after Year 1 expanded to 17 months by the end of Year 2. The decline in Year 2 results becomes apparent again in the diminished slope of the "actual" curve in Year 2. We are unaware of any factor that would cause Year 2 results and the pace of completions fall even below those of Year 1, other than perhaps the permitting issue discussed earlier, which did not materialize until the spring of 2016. The flattening of the Year 2 curve resulted from due to fewer projects and longer durations for those projects. Given the flattening "planned" curve in Year 2, and lessons presumably learned from Year 1, it would seem logical that performance versus the plan would improve in Year 2 with a resulting degree of catchup taking place.

In response to questions on the slow pace of the program compared to plan, and the ramifications for long-term production requirements, management cited the much higher overall production rate experienced during Years 1 and 2, considering all other work as well. That work includes vintage couplings work (FC 1027) carried over and producing similar annual demands to those of PROJECT*pipes*. Reference to that work presumably implied a pickup in PROJECT*pipes* work on completion of the couplings work. With all of the PROJECT*pipes* funding ($20 million per year) spent, we found difficult to understand the concept of diversion of resources to meet other needs.

4. Pre-June 1, 2014 Project Starts

Order 17431, Paragraph 68 requires, in part, that all projects must have started on or after June 1, 2014 in order to qualify for APRP funding. Our scope included a review of what project records show, but did not include a review of financial or rate accounting records. We observed from the

data that management supplied a number of projects with start dates before June 1, 2014. Management cited Order 17500, Paragraph 21 as addressing this issue:

> *21. **Decision.** The Commission acknowledges WGL's observation that materials are sometimes acquired in advance of the start of a construction project start and therefore, absent a further clarification by the Commission, would not be eligible for funding under the first criterion (i.e., that "the project is started on or after June 1, 2014,") under one interpretation of the language. We believe WGL's suggested interpretation is reasonable; therefore we clarify that expenses incurred on or after June 1, 2014 for projects that otherwise meet the four (4) criteria for eligibility in Paragraph 68 of Order No. 17431 are eligible for funding under the APRP.*

The accompanying table uses the "start" date termed by WGL as its "Construction Start Date." The 2016 Annual Reconciliation Report (Attachment A, page 3) calls it the "earliest date a construction unit (CU) was completed on a BCA in WMIS." It thus becomes unclear how the fact that "materials are sometimes acquired in advance of the start of a construction project start" is relevant. The dates relate to construction activities, not to pre-construction ones, such as materials acquisition. Of these six projects on which construction began before June 1, 2014, four were also completed before that date. We understand that the Agreed Upon Procedures has audit examined the financial accounting and rate recovery aspects of projects.

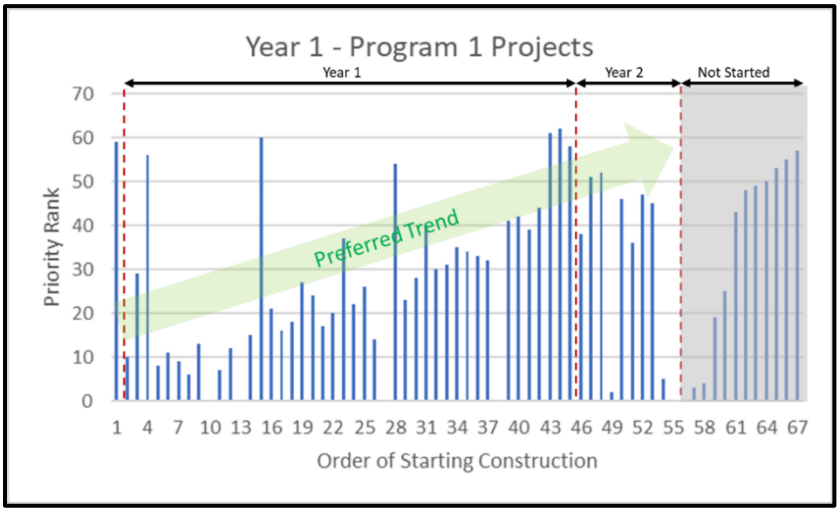
Pre-Program Starts		
BCA #	Actual Start	Actual Complete
75360	4/9/14	4/23/14
87203	4/13/14	12/11/14
116180	12/19/13	4/30/14
127640	4/14/14	6/9/14
151000	Not Stated	4/25/14
169640	4/24/14	5/10/14

5. Project Sequencing

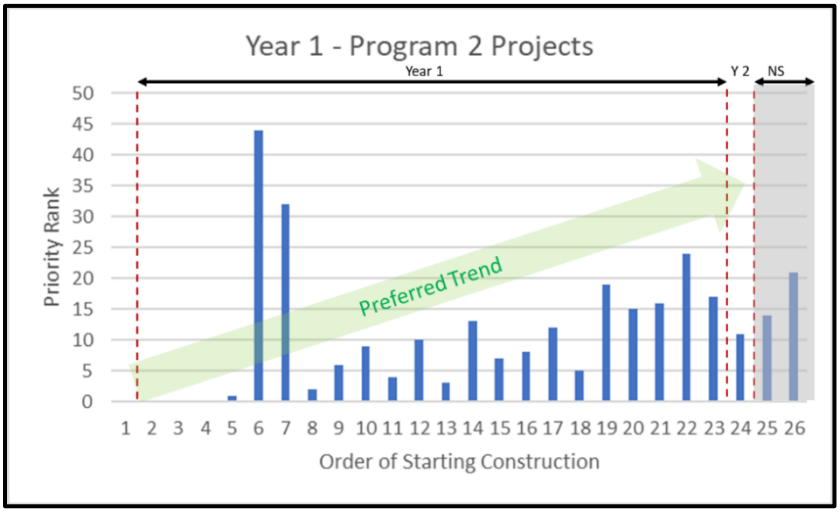
Project sequencing raises important scheduling considerations in large programs. Many considerations drive the sequencing decision; *e.g.*, leak-reduction priorities, interfaces with third parties, efficiency of construction, and the displacement of planned projects by emergent work. WGL described its approach to sequencing as giving first priority to: AOP, Field Operations originated work, the Optimain top-3 main projects. Next in priority order came the remaining approved projects. Management sequenced them based on risk ranking, permitting and contractor resource availability.

Therefore, priority did not occur strictly on the basis of leak-reduction measures, nor could it have. Nevertheless, leak-reduction offers the justification of the program in the first place, making it important to avoid deferring risk-set priority projects for other work. Chapter II addresses risk prioritization. We review here how management applied sequencing criteria, as determined by leak reduction and informed by economic considerations.

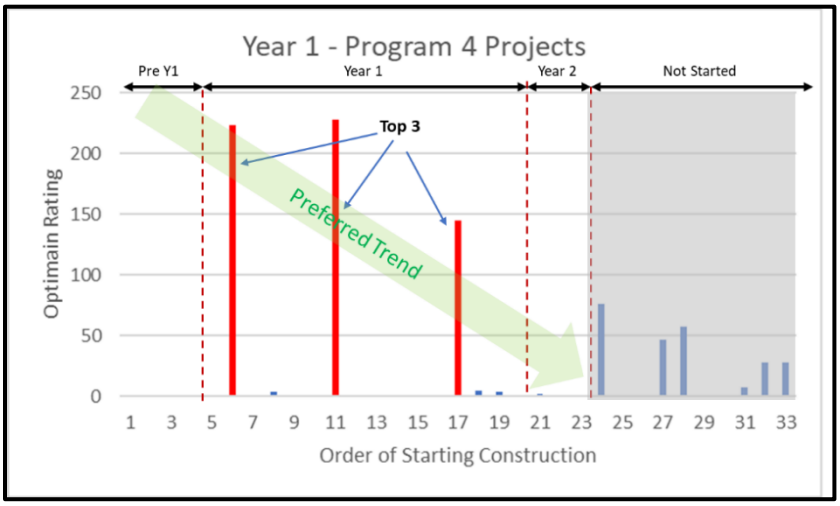
We examined the actual starting sequence of projects as a function of their relative priorities. The accompanying chart illustrates this concept as applied to Year 1, Program 1 projects. Actual sequencing did not match priority perfectly, but one can observe a clear pattern of higher priority projects earlier and lower priority projects later, or not at all. The data reflects that management generally executed Program 1 projects in accordance with the pre-defined priorities.



The accompanying chart applies the same construct to Year 1, Program 2 projects. Here, a number of un-prioritized projects starts led off, followed by two very low priority projects. Thereafter, the same pattern shown for Program 1 begins. Given the kinds of uncertainties that beset work sequencing, including emergent work and third-party coordination needs, for example, the patterns shown reflect successful Program 2 project execution in accordance with priorities as well.



The final chart, to the right, addresses Year 1, Program 4 projects under the same construct. The top 3 priority projects did start during the year, but comprised the only projects of significant pre-defined priority that did start. Moreover, they did not finish in Year 1. The next six highest priority projects did not start in either Years 1 or 2. It is clear that the competing forces we



discussed above won out against the Program 4 projects.

6. Schedule Management

WGL employed in Years 1 and 2 an informal, unstructured schedule management process. We did not find management or contractor progress reports, comparisons of contractor performance to schedules, look-ahead schedules, bulk schedule results (such those shown in the immediately-preceding charts), schedule change notices, alerts or requests, or anything in writing that management used, or could have used, to manage schedules. Management described its schedule management process as follows:

> *Washington Gas holds regularly scheduled workload meetings with each contractor performing the underground replacement activity. During these workload meetings project schedules, productivity, construction issues, customer issues, permitting issues etc. are discussed. During these workload meetings, Contractors and Washington Gas Supervisors discuss all aspects of the project and what is needed for the successful completion of each project, expected completion dates and expected start dates for the next available project.*

Our requests of management did not produce information on the nature or specific content of any documents used in such discussions, action items and outcomes, or any specific steps to hold contractors or anyone else to planned levels of schedule performance.

The Annual Reconciliation Report included comments explaining reasons for delays on projects. We constructed the following table from our examination of comments about 124 delayed projects. Management cited "resources" as a delay cause for 94 (76 percent) of the delayed projects. We describe in the next chapter how this cause does not appear possible. Spending in each of the first two years approached planned levels. Contractor charges comprise the predominant source of program costs to WGL. With all funds essentially spent according to plan, it is not clear how resources could have caused schedule delay.

Years 1 - 2 Cause of Project Schedule Delays

Delayed projects having comments:			124
Delay Cause Cited:	P	Total	% Total:
Resources	1	94	76%
Customer Coordination		29	23%
EMMR		17	14%
Weather	1	15	12%
Permits	1	5	4%
Scope		3	2%
PLUG Work		1	1%

Notes:
(a) Customer Coordination incl. Municipal & Residential
(b) BCA Phasing included in Scope count
(c) EMMR & "Emergency" work grouped
(d) Cancelled projects not included
(e)Data Source: DR 181 Access Table

The best term for schedule loss is not resource availability, but productivity, as reflected in far higher than expected unit rates - - the theme common through the preceding chapters. WGL had access to sufficient resources to meet its annual spending target; they just did not prove sufficient to get expected work completed. Because management treated the $20 million in annual expenditures as a cap, those high unit rates prevented completion of work on schedule. Only if what management termed "resources" really meant "productivity" does its explanation fall within what we construe as accepted usage.

Discussions with WGL managers commonly included "permits" as a primary schedule delay cause and a formal response to our requests ranked it first in a listing of potential delay factors. However, the preceding table constructed from information management prepared cited permits as delays

only four percent of the time on projects. Given our experience elsewhere, we would find it surprising if permits were not a material issue, but one explanation for the seeming conflict in management's expressed views may be that other factors, like unit rates, superseded it. The point of this discussion is not the cause of schedule delays - - which clearly were unit rates. Rather, the lack of consistency in management views, data provided to us, and data reported to the Commission shows that management did not focus clearly on schedule management during Years 1 and 2.

C. Conclusions - - Years 1 and 2

1. WGL Engineering's provision of a large backlog of work for construction comprised a strong practice.

Most organizations try, although not always successfully, to provide a suitable backlog for construction for the purposes of increasing the likelihood of timely projects start and completion, and of optimizing construction effectiveness. WGL's approach also sought to maximize construction management's flexibility. The ability to quickly and effectively shift resources among projects as field conditions, permit issues, or other factors arise has great utility on large, complex programs, particularly those operating in dense urban environments. The approach promotes optimization of contractor resources. The terms of WGL contractor agreements specifically permit such rapid shifts with no penalties for mobilization and demobilization.

2. WGL employed an overly simplistic process for scheduling projects during Years 1 and 2.

Establishing reasonably achievable schedule targets underpins effective management of large projects and programs. The Year 1 and Year 2 schedules contained no schedule detail, and lacked meaningful documentation. The resulting schedules appear to have had little or no meaning to management or contractors. Efforts to maintain progress sufficient to meet schedule dates and efforts to hold anyone accountable to schedule dates or durations were not evident.

We did not find convincing management's statement that one should expect schedule inaccuracy, given the timing of their preparation. As we described in the estimating chapter, WGL provides project estimates and schedules 60 days before the start of the project year. The resulting duration is not so great as to make them early.

3. Schedule performance fell extremely short of expectations during Years 1 and 2.

Our experience leads us to low expectations with respect to utility schedules for large scale pipe replacement and other work. We are therefore not particularly critical of Year 1 and 2 schedule performance deviations. Nevertheless, the size of those deviations was extreme, particularly given the expenditure of nearly the full $20 million per year:

- 36 percent of projects scheduled for completion by the end of Year 1 (September 30, 2015) remained incomplete a full year later
- 39 planned projects had not started by the end of Year 2
- Mains remediated by the end of Year 2 amounted only to 60 percent of the quantities called for by the revised plan

- Services replaced by the end of Year 2 only amounted to 68 percent of those called for by the revised plan.

Schedule performance continued to decline in Year 2. Schedule performance normally improves as a large program passes through its start-up phase. Delays in Year 1 are not abnormal, but their continuation into and through Year 2 produced a number of surprising results:

- Year 2 saw fewer projects completed on-time than did Year 1
- Median duration of Year 2 projects expanded by 43 days
- The slope of the total project start and complete curves flattened in Year 2, signifying less progress and further delay
- The number of project starts and completes slipped almost month-for-month in Year 2, with an additional schedule delay of about 10 months occurring in the 12 months of Year 2.

The decision to fix annual spending at a pre-determined level effectively precluded the most obvious mitigation strategy - - more resources. WGL applied no flexibility in spending, leaving it few if any material options for countering schedule slip. The policy of a firm and fixed limit on spending precluded action, in a sense, justifying a belief that schedules and production were not controllable. Accordingly, schedules slipped and then continued to slip further and further, with no remediation by management.

Despite overall progress well below expectations during Years 1 and 2, the work accomplished generally conformed to WGL's priorities for them for Programs 1 and 2. Program 1 prioritization did not rely on Optimain; management prioritized service replacement based on leak history in geographic areas called quads (addressed in Chapter II earlier). Optimum project sequencing supports leak reduction, construction efficiency and third-party coordination, by taking the raw Optimain risk score and adjusting it to risk reduction per $10,000 in cost. We focused on the priorities established for projects when selected for the program. Outside factors can be expected to disrupt work on priorities from time to time, but we found management generally able to execute work in accordance with its priority system. The priority system seemed less effective and less relevant to cast iron projects (Program 4). Optimain serves as a priority driver for them, considering calculated leak reductions per unit cost, but those priorities appeared to have little application beyond defining the top 3 priority projects in each project year which per agreement were based solely on the raw risk score (risk being defined as probability of failure multiplied by consequence of such failure).

WGL did not finish any of the planned Year 1 and 2 "top 3" projects in the years included in an approved annual plan. Each top 3 project involved large diameter cast-iron and thus costly replacements. We understand that the priority on identification of the top 3 as intending to ensure replacement of these highest-risk pipe segments, regardless of cost. This "regardless of cost" designation would suggest a preferred call on resources. With WGL managing to a fixed total annual budget regardless of the degree of completion, that these high-cost projects overlap years should be expected.

4. WGL did not manage to schedules during Years 1 and 2.

We found in program management documentation little discussion of project schedules. What we encountered came in annual reconciliation reports that WGL considers applicable only in satisfying regulatory requirements - - not in managing the program. We found no other reports, descriptions or discussions of schedule progress or delays, status discussions, plan deviations or any other document that might suggest a system of schedule management. Periodic meetings with contractors to discuss, in part, schedules occurred, but such sessions do not eliminate the need for a formal, structured management approach that gives management progress and problem visibility and as a vehicle for corrective action.

Despite very weak schedule compliance from program start, we did not find evidence of corrective measures taken. We did not find:

- Acknowledgement of awareness of pervasive schedule problems; *e.g.*, internal reports, the annual reconciliation report, or other documentation demonstrating awareness and concern.
- Actions taken to mitigate the past Year 1 delays and the anticipated Year 2 delays.

The lack of effective schedule performance and the resulting lack of clear definition of delay causes impaired management's visibility on the drivers of very large Year 1 and 2 schedule and production gaps. We did not find consistency among WGL managers in their understanding of schedule issues or analytically supported notions of the root causes of the gaps. A consistent, well-informed, analytically founded picture of what is actually taking place in the field and the factors affecting timely execution form pillars of effective construction management.

5. Six projects raise accelerated recovery eligibility questions under Orders 17431 and 17500.

The Company's explanation for justifying recovery was not clear to us in terms of (a) an inconsistent application of the term "construction start date", (b) questions on why material costs are relevant, and (c) the reality that four of the six projects were completed before June 1, 2014.

D. Improvement Opportunities - - Years 1 and 2

1. We believed that management needed to develop an organizational structure and discipline, supported by strong skills and capabilities, to perform accurate, insightful analysis of project and program schedule performance.

WGL does not employ a dedicated scheduling organization, instead matrixing project scheduling duties to various line organizations. Management has not focused attention on schedule performance. We believed that the scheduling function needed to have organizational structure, with roles and responsibilities of the matrixed scheduling personnel fully defined. Schedulers need to be aggressive in holding responsible managers and contractors to schedule commitments and they also need to understand how individual project schedules to integrate with a Program master schedule, which WGL needed to develop.

We found needs for definition of roles of scheduling personnel and enhancement of their scheduling skills and capabilities. Their responsibilities needed to include integrating engineering and procurement activities, considering the drivers of work planning, ensuring activity

coordination, addressing permitting issues, overseeing contractor schedules, and performing schedule variance analysis at the project level as well as the Program level. Individual training plans needed to be developed for schedulers.

2. We also believed that management needed to use the enhanced organization and capabilities needed to develop and implement a formal, structured approach to program and project scheduling.

Management did not find it necessary to include substantial detail in project schedules, or to adopt a project management system such as the kind reviewed and rejected at the Technical Conference. However, the lack of all detail and the decision not to employ any system did not support program needs. As a minimum, the new process we envisioned needed to include formal schedules, suitable schedule detail, routine updating, written procedures, defined accountabilities, and defined performance expectations for managers and contractors.

The program would also benefit from the provision of a level of detail suitable for management and coordination purposes. A minimum of five to six milestones for the smallest projects, growing in number as project size and complexity increases would serve. Management also needed an easy-to-use vehicle for maintaining, updating, and giving visibility to project schedules and performance against them (for example, Microsoft Project).

We perceived a need beyond merely scheduling at the project level. The approach to scheduling needed to include a program master schedule to provide better visibility and insight into of how well the Program was progressing. We considered a master schedule important in managing this five-year program. However, with management opposed to developing or acquiring a new scheduling tool, creating a meaningful master schedule would be very difficult.

3. WGL also needed to establish a formal process for the effective management of program and project schedules.

The previous two recommendations focused on creation of an organization, capabilities and skills, and a sound scheduling process, with a focus on the creation of schedules that facilitate the planning, execution and management of the work. The next logical step for WGL then becomes implementation of a schedule management process. Management's approach during Years 1 and 2 provide informal and largely limited to "discussions" with contractors. The lack of formal reports, accountability for schedule conformance, visibility of project and program status, and required actions to address schedule deviations needed to change.

We observed a need for generation of formal schedules and reports, accountability for schedule performance, schedule status visibility, schedule variance analysis at project and program levels, and a program for and commitment to actions for addressing delays.

E. Developments - - Years 3 and 4

1. Development of a scheduling organization and capabilities

Management did not make progress in developing a scheduling group following Year 2. Personnel with scheduling responsibilities acquired scheduling knowledge informally via program

management meetings, scheduling reviews, construction workload meetings, ad-hoc work studies, schedule updating meetings, and lessons learned meetings.

3. Summary of Performance Against Schedule

The next table summarizes project starts, which remain an issue. With one year to go, one-fifth of the projects still have not started.

Project Starts – Years 1 through 4

Project Starts	Year 1 Projects	Year 2 Projects	Year 3 Projects	Year 4 Projects	All Projects
Started Before Year 1	5	0	0	0	5
Started During Year 1	87	0	0	2	89
Started During Year 2	14	14	0	7	35
Started During Year 3	8	5	14	11	38
Started During Year 4	5	5	6	10	26
Sum of Not Started	5	11	35	0	51
Total	124	35	55	30	244
Percent Not Started	4%	31%	64%	0%	21%

The consistent pattern of delay and its widespread nature demonstrated a continuing need for improvement, making identification and resolution of the drivers of scheduling issues a priority. Principal purposes for such development include applying this capability focus to identifying and analyzing the factors routinely preventing projects from starting on or near schedule, and developing plans for addressing performance-impairing circumstances and concerns.

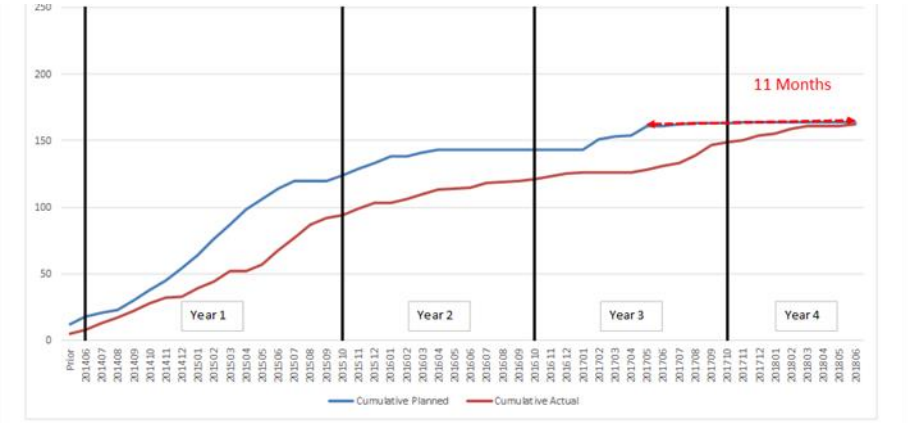
The next table summarizes the numbers of projects started and completed on time. Note that the preceding table addresses projects started during the year (later than scheduled or not). The next table addresses on-time starts. Late start rates of over 66 percent and even higher late-completion rates of over 85 percent show management's lack of focus on scheduling. Further deterioration of the rates through the four years we examined show that management continues not to create sound schedules or manage to schedule.

Projects Started/Completed on Time

Year	Total	Started	Completed	% Started	% Completed
Year 1	124	18	17	15%	14%
Year 2	35	10	2	29%	6%
Year 3	55	28	2	51%	4%
Year 4	30	28	15	93%	50%
All	244	84	36	34%	15%

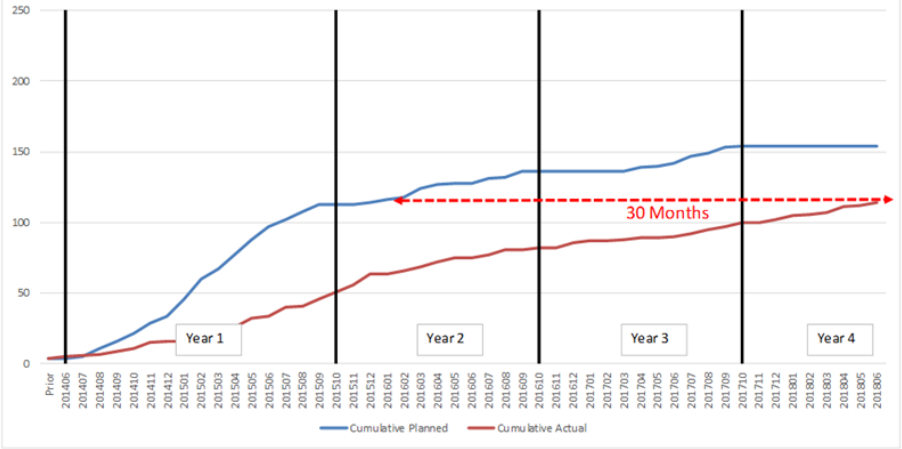
As continued schedule deterioration through the first four years suggests, by the end of Year 4, project start-date slippage grew 11 months, virtually one-fifth of the five-year window.

Cumulative Project Start Delays



The chart excludes cancelled and scattered projects and it holds start dates from the first year's list on which projects appear. Measured similarly, completion dates showed an even greater (30-month slippage), as the next chart demonstrates.

Cumulative Project Completion Delays



The consequences of the delays included:

- Main replacement at 1/5th of the required rate
- Service replacements at 1/3rd of the required installation rate.

Mains Remediated (feet) and Services Installed

	Program	Actual Mains	Actual Services	Annualized Mains	Annualized Services	Required Annual Mains	Required Annual Services
Year 1 Projects (49 mos)	1	0	782	0	192		1,573
	2	13,946	217	3,415	53	19,008	304
	4	18,491	564	4,528	138	56,496	216
	Total	**32,437**	**1,563**	**7,944**	**383**		
Year 2 Projects (33 mos)	1	0	177	0	64		
	2	2,877	68	1,046	25		
	4	19,760	583	7,185	212		
	Total	**22,637**	**828**	**8,232**	**301**		
Year 3 Projects (21 mos)	1	0	165	0	94		
	2	4,249	99	2,428	57		
	4	2,551	41	1,458	23		
	Total	**6,800**	**305**	**3,886**	**174**		
Year 4 Projects (9 mos)	1	0	120	0	160		
	2	374	4	499	5		
	4	0	0	0	0		
	Total	**374**	**124**	**499**	**165**		
All Years	**1**	**0**	**1,244**	**0**	**305**		
	2	**21,446**	**388**	**5,252**	**95**		
	4	**40,802**	**1,188**	**9,992**	**291**		
	Total	**62,248**	**2,820**	**15,244**	**691**	**75,504**	**2,093**

The next table summarizes shows changes in schedule performance since Year 2.

Year 1&2 Versus Year 3&4 Year-End Schedule Performance

Description	Year 2	Year 4	Trend
Projects started on-time	21%	29%	Improving
Slippage of starting projects (from plan)	16 mo.	11 mo.	Improving
Projects completed on-time	12%	9%	Declining
Slippage of completed projects (from plan)	17 mo.	30 mo.	Declining
Projects not started	25%	33%	Declining
Mains replaced vs. annual requirement	34 %	20%	Declining
Services replaced vs. annual requirement	50%	33%	Declining

All but two performance metrics declines and the two improving are nevertheless at levels best described as weak.

4. Recovery Eligibility

We did not undertake further work in examining these completed projects. See the discussion under the preceding sub-section titled *Pre-June 1, 2014 Project Starts*.

F. Recommendations

16. Implement an organizational structure and discipline, supported by strong skills and capabilities, to perform accurate, insightful scheduling and analysis of project and program schedule performance.

WGL continues to need to define the roles of scheduling personnel, enhance their scheduling capabilities, and give them clear and direct responsibility for integrating engineering and procurement activities, considering the drivers of work planning, ensuring activity coordination, addressing permitting issues, overseeing contractor schedules, and performing schedule variance

analysis at the project level as well as the Program level. Individual training plans should be developed for the schedulers to upgrade their scheduling and project management skills.

17. Create and document processes for creating a program master schedule, assigning accountability for schedule performance, and providing for ongoing analysis of schedule variances and means to control them.

Management's approach to scheduling management needs to go beyond just scheduling at the project level to include development of a Program master schedule to offer better visibility on short-term progress and long-term implications of lingering inabilities to meet schedules. Essential features should include accountability of the execution of the master plan, performance of variance analysis at the Program level, assessment of the quantity and cost impacts of schedule slippages, and promotion of a schedule commitment culture.

WGL should adopt a formal process defining the generation of formal schedules and reports, and assigning clear, focused accountability for schedule performance, Program schedule status, the schedule variance analysis at the project and Program level, and the required actions to address unacceptable delays. A scheduling procedure should be prepared to document the process and communicate management expectations about schedule performance. This procedure should be included in the Program Implementation Plan that is currently being updated.

IX. Resource Planning

A. Background

One of the greatest challenges for large scale pipe replacement programs lies in their high demands for skilled resources over a sustained duration measured essentially in lengths reflecting a career-length. The resource planning process should determine these needs and establish long term plans to assure that sufficient resources will be available to support the program fully. Fortunately, utility planners often have considerable experience in resource planning due to the need to plan large projects as well as time-critical tasks such as outages.

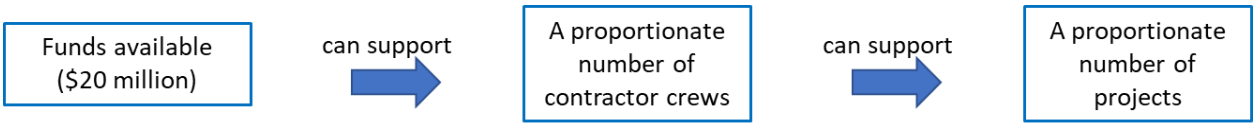
B. Findings - - Year 1 and 2

1. The Role of Resources in Year 1 and 2 Scheduling

WGL's description of how work is planned and executed places contractor resources offers a key determinant of what work it can do and when:

> *Based on the number of resources available at the time of the [annual project] list submittal, Washington Gas Management utilizes management judgment, experience, historic average productivity and number of available qualified resources to build out the start and end dates.*

Management agrees that resources comprise an important determinant, and that attention to resources is essential; however, resources become secondary in the WGL framework, as the next diagram illustrates:



Annual funding consistent with accelerated recovery limits has imposed the primary determinant (and constraint), limiting contractor resource requirements to those needed to spend that annual funding allotment. We did not find availability of contractor resources a limiter in Years 1 and 2, although management did face needs to identify and bring additional qualified personnel to bear on work in the District of Columbia. Nevertheless, WGL did manage to spend the $20 million per year, meaning that it did succeed in finding and applying resources consistent with that amount of expenditure.

2. Implications for the Future

Success in securing resources to date, however, was not necessarily comforting for the future. First, continuing annual expenditures of $20 million (or $25 million for that matter) will provide greatly inadequate in supporting the main and service replacement paces contemplated when that annual pace was established. Poor rates of and trends in productivity during the first two program years made clear that more resources per unit of pipe or services will be needed. As important to this internal resourcing challenge is the environment in which future resource acquisition will

unfold. Pipe replacement programs have been accelerating throughout the region, making increased competition for resources inevitable.

We found management concern about resources well-placed, and likely to become more pressing. Other utilities are taking aggressive steps to expand the resource pool, including agreements with educational and training facilities, joint programs with unions, long-term agreements with contractors, and special apprenticeship programs. While concerned for addressing the issue, we found WGL's approach one of placing the burden fully on contractors, taking a less direct role than others have. This strategy bore revisiting based on conditions and performance we observed in Years 1 and 2, in comparison with the durations for high-risk pipe contemplated at the time of program inception.

3. Optimizing Resource Mix

Utilities generally make frequent, often predominant use of contractors for work of the type PROJECT*pipes* entails. Many good reasons support this approach, including meeting temporary peak resource needs, finding specialized skills, promoting flexibility, and optimizing cost for requirements involving lower-end labor skills. Large projects, such as main replacement initiatives, have a special need and extreme demand for contractors. WGL places unusually high reliance on contractor personnel, using them to perform all physical replacement work. WGL also uses contractors for other work, such as engineering, although not necessarily exclusively.

Steady state performance like that of the first two program years may present no reason for reconsidering this approach, which we understand to be long-standing and well understood by company stakeholders and the Commission. Several factors, however, suggest a re-examination for the future. Continuing to take the current mix as a given, even with a robust study of total future resource needs, can prove suboptimal. Periodic review is appropriate, as circumstances change. One such change - - extremely high unit rates compared to those expected - - has already occurred. A large expansion, perhaps not limited to already planned replacement work, may portend another.

An optimization study under these changed circumstances may tilt in favor of more internal resources. The notion that long-term, base-load work can often be better performed internally, as opposed to fluctuating and short-term workloads better handled externally bears consideration. One benefit might be that applying some level of internal resources may prove cheaper in performing some program work elements. Other potential benefits may exist as well; *e.g.*, (a) use of what appears to have become a career-long program as a source of developing better-rounded and more broadly experienced managers and leaders, and (b) mitigating risks of resource shortages as competition for contractors grow.

C. Conclusions - - Years 1 and 2

1. Resource availability did not appear to impair the ability to spend the annual budgeted amounts substantially during the audit period, but posed future risks warranting careful study and planning.

WGL managed to spend budgeted annual amounts for Years 1 and 2, demonstrating resource adequacy. We nevertheless believed that resources could represent a potentially large constraint in

the future as funding for the program increases and competition for resources in the region grows. If that occurs, these circumstances make reliance on contractors without study unduly risky.

D. Improvement Opportunities - - Years 1 and 2

1. We found it appropriate for WGL to ensure that forecasts of required construction resources were based on current, thorough analysis giving due consideration to risks of greater than expected future work requirements.

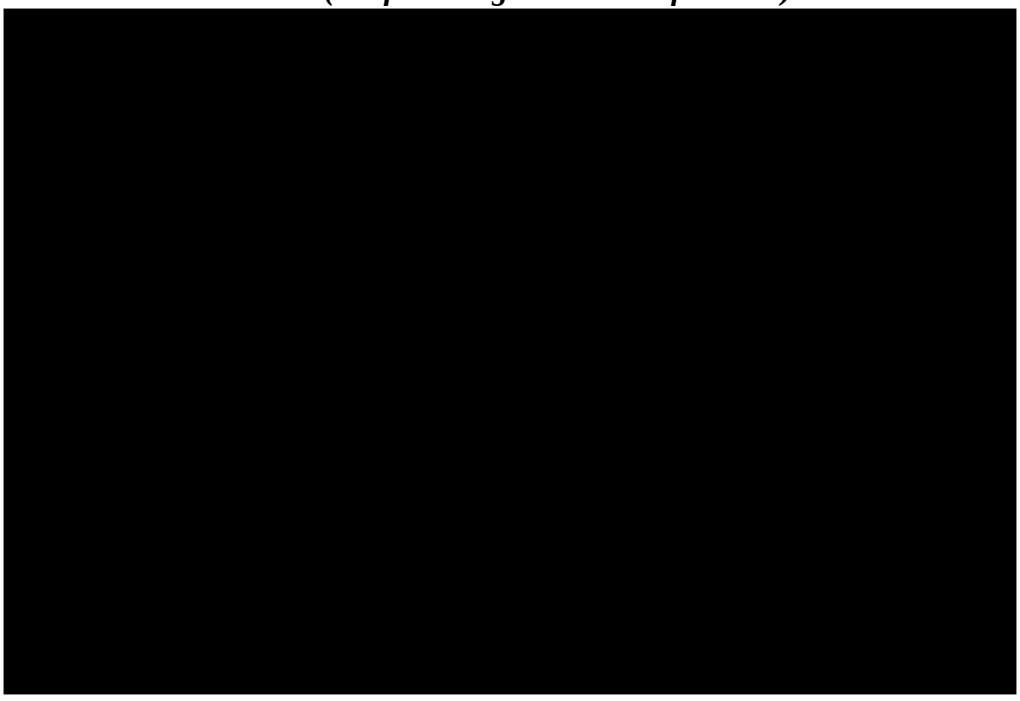
We felt that management needed to study comprehensively, with no bias toward continuing its predominant reliance on contractor-provided resources, whether a revised mix of internal and external resources would serve to optimize program costs, mitigate risks of resource shortages, or promote development of future managers and leaders.

WGL was engaging in a number of activities designed to promote contractor development of resources, but should re-examine the continuing appropriateness of its current resource mix for the future. Whatever it may conclude about contractor versus internal resource use, it should be conducted without a bias toward continuing complete reliance on contractors.

E. Developments - - Years 3 and 4

At the end of Year 2 of the Audit Period, WGL was able to spend to budget, and thus, one could conclude that there appeared to be no resource adequacy issue. The following Cumulative Spending Chart shows how rapidly the situation can change:

(the following chart is confidential)



Actual spending began lag planned amounts at the beginning of Year 3. The shortfall widened to almost $9 million by the end of the June 30, 2018. The gap had closed to $6 million by the end of

Year 4 (September 30), but remained at 24 percent of the Year 4 spending limit. Management reported diverting resources (citing encapsulation work, for example) to other work as the cause. We are not privy to rates of progress in the other jurisdictions, but if the gap between planned and actual installations is similar, then it can be expected that significant pressure will continue to exist on securing sufficient resources to meet PROJECT*pipes* expectations. That pressure will exist even before any planned increases in work that may be in the works.

Certainly, other factors, such as permitting or customer coordination, have played a role in the ability to accomplish work. The accompanying table summarizes management's reported sources of schedule delay through June 2018. Combining the first two ranked causes (Resources at 40 percent and EMMR & Emergency at 29 percent) accounts for over 2/3rd of delay causes. With slow and not substantially improving replacement progress, with competition from similar programs in two other jurisdictions, and with proposed additions to capital work "on the table," and with annual expenditures below Year 4 planned amounts, it has clearly become appropriate to underscore the importance of ensuring adequate resources to accomplish the work involved.

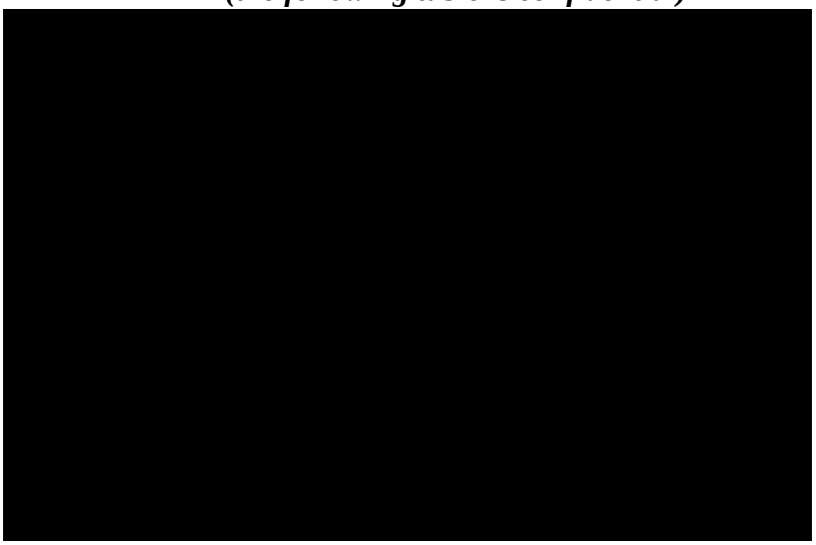
Years 1 - 4 Cause of Project Schedule Delays

Delayed projects having comments:		178
Delay Cause Cited:	**Count:**	**% Total:**
Resources	**72**	**40%**
EMMR	**51**	**29%**
Permits	**43**	**24%**
Customer Coordination	**36**	**20%**
Paving	**9**	**5%**
Weather	**7**	**4%**
Phasing	**6**	**3%**
Scope	**3**	**2%**
Other	**3**	**2%**

Notes
(a) Customer Coordination includes municipal & residential
(b) EMMR & "Emergency" work grouped
(c) Cancelled projects not included
(d) Projects could cite multiple causes of schedule delays

We examined the Year 4 process for resource forecasting. Management conducted a reasonably detailed plan for determining its required numbers of crews for five years. Management supports it with a program for identifying the required numbers of qualified construction supervisors and for developing those qualifications to add personnel consistent with established supervisor-to-crews supervised ratios. We reviewed the plan for the period from 2019 through 2023. It applied spends for the past two fiscal years by work type and jurisdiction to budgets for those work types. It resulted in generating required numbers of crews for each of the five years, broken down by jurisdiction and by each of the three major work types - - new business, normal replacement, and accelerated replacement work. The next table summarizes the expected requirements, which are expected to grow substantially over the five-year period.

Expected System-Wide Crew Requirements
(the following table is confidential)



While large enough to present concern in its own right, a nominal fifty percent increase does not alone fully reflect the significant risk WGL faces in ensuring sufficient resources. Acceleration of the rate of new business (already a major driver of resources) is important. The gas business has experienced massive and continuing change relative to: (a) the prices of fossil-fuel competitors, and (b) its carbon emission differential relative to them. Second, WGL's forecasts employ budgeted costs in the normal (not accelerated) replacement category. If that category's budgets already face constraint by affordability issues, it must be remembered that when other work exceeds expectations a frequent result is crew diversion from accelerated replacement work - - producing another risk in forecasting crew numbers. A third source of risk arises from the unit rates (whether explicit or implicit) built into forecasted ARP crew numbers. Whether or not accelerated replacement eventually continues on a not-to-exceed type annual spending approach, we believe it is important for the stakeholders and management to understand fully the workforce implications of targeted annual replacement quantities achieved. Doing so takes crew numbers forecasting that uses an appropriately conservative range of expectable future unit rates.

F. Recommendations

18. Regularly prepare ground-up analyses of crew requirements that consider a range of work levels consistent with new business and regular replacement uncertainties, that use sound expectations about future unit rates, and that objectively re-evaluate an approach that excludes use of in-house crews for replacement work.

Management believes that it has undertaken sufficiently comprehensive and aggressive efforts to ensure that it can maintain appropriate levels of progress on replacement activities, even as it plans increases in other work. Comprehensive, current resource studies based on future work levels now anticipated should underlie and clearly support the ability to perform accelerated work at planned levels (*i.e.*, conforming to schedules and to realistic unit rates) and despite a reasonable range of uncertainty on work that causes crew diversion from replacement work. The lack of such schedules or unit rates during the period we examined underscores this need. Whether or not accelerated

replacement work continues to be constrained by firm annual spending limits, crew requirements forecasts should show the forces required to execute fully planned annual levels of replacement quantities planned to be accomplished.

We also believe that current study and analysis need to consider objectively the role that internal resources can play and the benefits that they may provide, whether cost, schedule, or internal skills and management talent development. We find it difficult to accept that contractor efficiency is so universal and substantial that it precludes what can be gained from some level, even if very moderate, of internal replacement work performance.

We understand well the concepts of using short-term (*i.e.*, outside) resources on short-term work and on work requiring skills not needed long-term. Those concepts often form the framework, if not an explicit criterion, for using contractors. Those concepts are not fully applicable here. Very-large scale work will continue for what would represent a full career for nearly all those engaged on the project. The work will last longer than the time that even those not yet on the job will spend on it after they come. Developing an in-house element, even if small, and applying it selectively should not, out of hand, be rejected as uneconomical.

Even if they were not to produce a direct dollar advantage, internal resources would provide an understanding of the work not derived just from seeing how and how well contractors perform it, but from having done it. As experience with in-house performance grows, it cannot but help to improve the ability to oversee work, spot issues and concerns, analyze them, and identify corrective actions.

Moreover, as noted, WGL would have what it does not now - - a maturing population of employees who will be developing skills important across the company as they develop the experience and capabilities to undertake management and leadership roles. Certainly, WGL can bring in (and has done so) managers from contractor organizations. While clearly valuable, they come with perspectives developed as contractor personnel. We believe that the further an organization gets from "doing" forms of work, the more difficult it becomes to manage the "doing of it" by others. Moreover, an internal capability can be created without disruption to the fundamental approach of using contractors because it is more efficient to do so. That lack of disruption is not often possible. It takes a large enough program (a "mountain" not a "mole hill")- -what is at issue here certainly qualifies. It also takes a "journey" rather than a "race" to a mega-project-finish - - clearly also the case here.

For the long-term, a company-wide resource planning model should be developed to analyze the internal/external resource mix for various types of work to position WGL to be able to respond effectively and proactively to the anticipating resource-changing situation for what may remain a 40-year or longer journey across terrain that management now understands as steep.

19. Strongly support and participate in work force development efforts undertaken in cooperation with government and public-interest resources.

We asked management about the existence of and its support for such efforts. Management cited the District of Columbia's opening of the DC Infrastructure Academy in March of 2018. It appears to offer a unique opportunity to tie the business needs of WGL with government's timely and

laudable goal of giving "DC Residents a Fair Shot at Careers in the Infrastructure Industry." Management described its support for the academy, and noted that it remains largely in a developmental stage. We strongly urge WGL to do the best it can to help the academy begin producing a pipeline of candidates in a part of the local economy that provides career-length opportunities. We would similarly urge stakeholders to support an effort that has significant consequence for gas supply and for community interests from a broader perspective.

Similar types of programs target other communities in identifying work candidates. WGL participates in efforts to advance women to management positions and in attracting veterans to the company, including reliance on the Center for Energy Workforce Development, a national leader in developing resources for the energy industry. One program we have seen as producing substantial success is a joint program established some 10 years ago by the Utility Workers Union of America (UWUA) (involving its Local 18007) and by Peoples Gas of Chicago to support its Accelerated Main Replacement Program. The UWUA reports that this six-month training-to-placement program at Chicago's Kennedy King College has placed over 500 military veterans. The public-private partnership has been funded by the Chicago Federation of Labor Workforce and Community Initiative, the UWUA Power For America Trust and Peoples Gas in Chicago.

We believe that WGL's major long term needs give it a unique opportunity to play a coordinating role in developing such joint efforts to address its needs for resources and to work with labor, and with local educational and interest groups, to meet broader community objectives. We recommend that WGL conduct a focused, intensive effort to build such a coalition focused on training-to-placement initiatives.

X. Oversight

A. Background

Given the importance of the program to WGL, its customers, and the public, board of director and executive leadership engagement should comprise a high corporate priority. The quality of high-level oversight has a direct bearing on results. When top leadership responsible for overall performance and for the resources it takes to provide it take an exceptional interest in something, those they direct become far more apt to internalize the value placed on producing high quality work efficiently, effectively, and on time. The reverse has equal applicability, marginal or no visibility at the top tells those who manage and perform project work that things other than their performance matter much more to the organization. Given the reasons for, costs of, and duration of PROJECT*pipes*, we find it difficult to imagine what other single effort matters more WGL's provision of public service in the District of Columbia.

Major pipe replacement programs always take massive financial commitments, and typically have left those managing them, particularly in dense urban areas, surprised by their difficulty and by the obstacles to meeting cost and schedule expectations. From program outset, and certainly as first project work began, none of this should have come as a surprise to either the WGL board or its top executives. Therefore, one should expect from them an interest in structured, regular, and continuous measurements of performance, examinations of adverse trends, and clear plans of action for addressing deviations. No less was required for them to have the ability to demand of program management a level of accountability appurtenant to the risks the program addressed, its costs, and the pace of replacements of high-risk facilities (*i.e.*, schedule).

The evaluation criteria we use in examining large-scale utility construction programs include:

1. Top executive and director participation in the program should be proportional to the program's importance to the company and its stakeholders.
2. Program reports to the directors should be timely, candid, accurate, and fully descriptive of performance issues or problems and of trends whose continuation will lead to them.
3. Program reports to executive management should provide accurate descriptions of progress, including much more than simple presentations of data; top executives should demand insightful analysis as be a part of management reports.
4. The directors should hold top executive management accountable for program performance, and that management should hold senior and program management similarly accountable.
5. The directors, acting through the internal audit function, should assure the annual planning and execution of a structured plan for program audits and for complete, prompt management follow-through in addressing their findings.

B. Findings - - Years 1 and 2

One often finds top-level oversight occurring at the full board of director level, in some form of regular executive oversight committee (or equivalent) and through interaction between the most-senior executive(s) and those who have direct responsibility for the executives responsible for key program functions (*e.g.*, engineering and construction). WGL employed two high level committees

in overseeing the program: an Executive Committee and an Operating Committee, the latter also termed the Governance Committee.

We found high-level oversight of PROJECT*pipes* constrained from the start. The structure WGL created for its pipe replacement programs from a high-level perspective treated its three accelerated pipe replacement programs (APRPs) for the District of Columbia, Maryland, and Virginia as one large program. As reporting and conceptualization of the work rises in the WGL organization, the three APRPs look increasingly homogeneous. Upon reaching the board of director and top executive levels, we found little segregation of the three individual jurisdictional programs - - all of them having distinct dimensions whose significance is great for each of those jurisdictions.

1. Board Oversight

We sought evidence of director engagement and participation in PROJECT*pipes* performance information and issues. We requested presentations and reports on pipe replacement provided to the directors during Years 1 and 2. None of the information provided fit this category of documentation. The directors did receive high level performance indicators, but with information on pipe replacement projects sparse and highly aggregated. Most importantly, we did not observe any documented reporting to the board addressing the failure to achieve close to expected results throughout Years 1 and 2. Management provided no documentation, or even verbal assurance, of reports, presentations, analysis, discussion or other communication with the directors that would have alerted the board to the great gap between performance and expectations, despite expenditures at budgeted levels.

We expected that the size, complexity, and risks involved with a massive pipe replacement project would have resulted in regular reviews by internal audit. We requested internal audit plans involving the pipe replacement program during Years 1 and 2. Three audits generally responsive to our request took place during the 28-month period, but only one directly related to accelerated pipe replacement. The other two, broader in scope, addressed construction work in general. The single applicable audit produced limited findings, but did address management's failure to link expenditures to production.

2. Executive Oversight

We did not find substantial documentation of the WGL executive team's oversight responsibilities, nor did they appear universally well understood. Only after extensive discussions at the executive and senior management level could we identify the managers responsible for program management and performance. We did eventually find them to be:

- Director of Engineering - - responsible for program engineering and engineering broadly in all three jurisdictions
- Director of Construction - - responsible for program construction and construction broadly in the District of Columbia and Maryland/

We learned, again only after considerable discussion, that WGL made no single executive or director accountable for program performance at any management level, and the highest level of accountability recognized was at the director level and shared among multiple directors.

The exercise of executive function focused on executive leadership and participation on oversight committees. In this regard, we found the appropriate executives to be engaged and effective. As will be discussed below, however, the subject committees had no clear, defined, direct responsibility for program or project performance. Any oversight relating to the effectiveness of program management or the achievement of program expectations therefore falls back on the directors and their ability to coordinate their efforts only on the program, while they perform their broader responsibilities.

We found it material that WGL executives did not have access to program performance information necessary for oversight, regardless of their presumed roles and responsibilities. The lack of meaningful reports or analyses on cost, schedule, production, productivity, or performance in general at the PROJECT*pipes* level further encumbered an oversight function that did not focus accountability and responsibility.

3. Executive Steering Committee

The highest-level committee, WGL's Executive Steering Committee, had responsibility for making decisions and approve recommendations exceeding the authority of the Operating Committee. The Executive Committee also had the role of providing guidance to the Operating Committee for all the jurisdiction's accelerated replacement programs and strategies, and management of PROJECT*pipes*. The Executive Steering Committee comprised the following individuals:

- VP & Chief Accounting Officer
- VP Construction Compliance and Safety
- VP Rates and Regulatory Affairs.

The Executive Steering Committee made decisions for those items above the commitment authority of the Operating Committee and it provided guidance to the Operating Committee. The Executive Committee's specific responsibilities included changes affecting eligible spend above $500,000 and decisions with significant business risk. All changes were to be documented in the minutes and include basic support. On a regular basis, at least one member of the Executive Steering Committee attended Operating Committee meetings. Executive Committee meetings took place informally.

Liberty interviewed current members of the Executive Committee and also verified their participation through examination of Operating Committee minutes. We found no reason to question the commitment or involvement of the Executive Committee or their effectiveness in executing their responsibilities as defined. We did, however, find notable that the Executive Committee was not charged specifically with overseeing PROJECT*pipes* execution in accordance program plans and expectations.

4. ARP Operating Committee

The Operating Committee, also known as the Governance Committee from time-to-time, played a major role in WGL's management structure. It served the key role of providing cross functional oversight, issue identification/resolution and coordination of the information reporting aspects of WGL's accelerated replacement programs. The committee also established policies and procedures, and maintained documentation of the accelerated replacement programs. We found

the specific reference to the Committees' engagement in "information reporting aspects" key to understanding its role. We came to understand essentially the whole of its actions as occurring within that context. For example, its charter referred to "preparing and monitoring internal reporting of ARP performance," but that reference as interpreted more in terms of providing regulatory information than in addressing project and performance execution versus the plan.

Our interviews with Operating Committee members found them knowledgeable and engaged. They took their responsibilities on the committee seriously and appeared committed. In addition, the committee seemed to function on the basis of frequent meetings, good documentation and meaningful action plans. We found this engagement critical, given that, as far as we could determine, the Operating Committee provided the only unifying source for coordination among the functional groups on whose activities PROJECT*pipes* performance depended.

C. Conclusions - - Years 1 and 2

1. The directors and top executive management did not receive *PROJECTpipes* information at a level of detail commensurate with the need for ensuring effective top level oversight of program performance against plans and expectations.

We did not find effective performance reporting at any level on the program, necessarily including that provided at the highest level. We also found only one audit of replacement programs in Years 1 and 2. The program called for a greater level of scrutiny from outside its management.

2. WGL provided for shared accountability for PROJECT*pipes*, as opposed to what we view as the more appropriate approach of focusing it on a single executive.

The WGL approach is atypical in two ways: it is shared among multiple people, and those people occupy a lower than usual level of management authority. Further, the accountable managers have responsibility for major corporate functions extending to more than pipe replacement and to more than the District of Columbia, diminishing their ability to focus on and prioritize PROJECT*pipes* performance.

D. Improvement Opportunities - - Years 1 and 2

1. We found that both the directors and top executive management should regularly require of program management the preparation of meaningful reporting and analyses of program performance and effectiveness.

Utility boards have taken on far greater roles and responsibilities in recent years, to the extent that the workload of directors is typically far higher than it has been in the past. Board committees and members must therefore choose assignments carefully and define priorities to assure optimum effectiveness. Main replacement programs and the regulatory benefits and commitments that come with them need to remain a first priority. The financial and regulatory stakes are high and the public safety ones even higher. Successful execution of the main replacement programs deserves a high priority and demands continuous, informed, action-oriented oversight, both at the director and executive levels.

All mega projects or programs require regular and comprehensive performance reporting and analysis, which need to be developed and maintained by highly dedicated and experienced group of performance control professionals. WGL adopted a matrixed organizational approach to manage PROJECT*pipes*. The directors and top executive management must dictate performance expectations and reporting requirements, or the responsible personnel in the matrixed environment will not dedicate adequate time and efforts on products that they perceive as nobody is interested in. We recommend the directors and top executive management demand or mandate regular and accurate reports with adequate description of progress and performance. The reports need to be timely and present more than just data. Candid and insightful analysis need to raise performance issues, problems, or disturbing trends that management can respond to in a timely manner.

2. We believed that sound Internal Audit planning relative to PROJECT*pipes* should have produced annual, substantive audits.

The same reasons that demand more aggressive board oversight, also suggest that the internal audit program be expanded in terms of its attention to main replacement. Cost performance, driven predominantly by payments to outsiders, driven by massive numbers of pay items, and requiring vigilance and validation from internal construction supervision call for regular examinations as matters involving significant risk.

3. We also believed that WGL needed to assign a single senior executive accountability for effective, efficient, and timely PROJECT*pipes* performance, to ensure its successful execution.

Responsibility and accountability was at beneath the executive level and shared among multiple persons. Their roles not only extended across multiple jurisdictions, but to other major WGL management functions. The program is too large, complex and important, and it suffered significant failures to meet cost and schedule expectations during Years 1 and 2. Even had performance been closer to expectations, focused accountability at the executive level was appropriate. Experience during the first two years only adds to the propriety for placing accountability on a single, executive level person.

E. Developments - - Years 3 and 4

1. Reporting to Directors and Top Executives

WGL has made very substantial progress in establishing and issuing the Monthly Executive Dashboards on-line to provide a better visibility of Program performance from the top down. The information on the dashboard was used to focus discussions in the monthly ARP Executive Governance meetings, regarding overall Program progress in terms of completed projects and financial status.

This Dashboard was established in Year 3 to monitor the following key Program components:

- Actual Spend versus the 5 Year Program total of $110 million
- Mains installed and retired versus plan
- Services replaced versus plan
- Separate charts that show the Main quantities and services quantities installed versus five-year plan

- Chart that shows the Program-to-date spend versus the five-year plan
- Program BCA status
- Key milestones for the next 90 days
- The fiscal year-to-date installation and spend status.

Presenting tables and charts without explanation or analysis does not serve well in reporting to leadership. Management should offer clearly and explicitly its views of the inferences and conclusions to draw, and should anticipate and answer the questions begged when variances are clear. Even where developing trends have not yet produced enough "white space" between planned and actual lines to make issue transparent, management should address how they arose, what factors drive them, and what implications their continuation may have.

The summary block on top of the dashboard provides some project-related information, but offers no insights about the data presented in graphic or tabular form. Take for example, the Year 4 year-end report depicted below.

(the following illustration is confidential)

The three charts paint a disappointing grim picture with one year to go for the Program, begging many questions:

- The green spend chart may look good to leadership in terms of expenditures producing accelerated rate treatment, but do the last months begin to suggest constraints in ability to spend full amounts of dollars that should be going to system risk reduction?
- What would similar displays in the other jurisdictions and about other capital expenditures (not to mention O&M work keeping crews occupied) tell us about whether the resources exist to do the work planned?
- The yellow and blue performance charts show clearly that not nearly as much is being produced as expected, and lack of spending is not the cause, so what is?
- The performance issue cannot be the allocation of work between mains and services, because both are suffering greatly versus plan; what specifically is driving performance in each?
- The gap is growing steadily and without pause, eliminating start-up or other transitory issues as the cause; what are the drivers?
- Extrapolating the plan and performance lines shows a completely non-workable plan, either short- or long-term; which are you going to "fix" management, the work or the plan?
- With no analysis or efforts to depict planned and actual lines after aggressive management action (*i.e.*, work more efficiently or change the plan), is the inference to be drawn passive acceptance of continuing along as the best that can be?
- There is a deal with stakeholders and the Commission; how do we explain that the expected money is spent but the expected performance has not come?
- With risk reduction an important obligation and with the deal that has been made, what could management do with greater expenditures (the implicit assumption at the leadership level that is would be under the normal rate recovery methods)?
- Who in management stands behind the plans and estimates underlying these graphs?
- What studies has management done about the drivers of cost increases and schedule delays?
- What changes has management made to address cost drivers; what is under consideration?
- Recognizing the low levels of production for high levels of expenditure, how is management measuring the value these expenditures are producing:

These are among the natural questions that arise from the Executive Dashboard. Management should be answering them proactively and with supporting data and analysis, not waiting for questions from the "audience" for them.

2. Single, Accountable Executive

The Vice President – Construction, Compliance & Safety has been assigned as the single accountable senior executive to the planning and execution of PROJECT*pipes*. The CPSM group was fully staffed with qualified professionals to all lead positions. Most of their roles and responsibilities are defined. Key processes, such as project authorization and cost estimating, have been enhanced, and performance reporting is being upgraded. With new focal point of accountability and leadership, Directors should witness a more effective execution of the Program with new defined performance expectations, multiple levels of accountability, greater degrees of commitment, and higher awareness of productivity.

F. Recommendations

20. Much more proactively report program progress, problems, and action plans to senior leadership, which needs to remain significantly engaged in challenging management's performance in managing the program.

The Executive Dashboards reflect a sound step forward, but continue to focus more on unadorned data presentation than on the lessons that data teach and the needs it identifies. WGL has not yet made full use of the performance data, and we have not seen signs that management has yet fully grasped the need to aggressively seek to identify the sources of performance problems and to identify performance improvements through the analysis of such data. Regular reporting needs to continue to advance, providing context (*i.e.*, a basis for judging whether performance is good or bad), provide more granular data about performance and what is driving it, and incorporate metrics suitable to quantitative and qualitative analysis of those drivers.

Most importantly, regular reporting needs to draw conclusions about the attributes of performance that increase or decrease quantity, shorten or lengthen schedule, and drive cost up or down.

XI. Field Execution

A. Background

WGL does not use internal resources to conduct the replacement activities we examined. The use of contractors for essentially all replacement work in all three categories reflects a reasonably well-accepted approach in the industry. This approach, however, makes WGL's activities to oversee contractor work critical to ensuring effective field execution of replacement activities. Full, timely, and documented WGL inspection of contractor work (for quality, quantity, effectiveness, and safety) forms a central element of required oversight

WGL treated replacement work during Years 1 and 2 of PROJECT*pipes* as a sizeable, but nevertheless only as an addition to normal construction work. The program brought a very substantial change to work in the District of Columbia, coming on top of work on the previously-approved couplings program (termed Program 3). During the earliest phase of PROJECT*pipes*, authorities controlling public roads and rights of way (DDOT, principally) added conditions on the permits required for work on District streets. These added conditions notably included narrow, government-imposed time windows allowed for the performance of work each day. Changes also included requiring chain-link fences around all trees in work zones, disallowing the storage of excavation spoils, and installing temporary bike lanes and pedestrian walkways.

These new requirements substantially impaired the productivity of contractor crews who performed replacement work, ultimately driving up costs significantly. The work-hour limitations eliminated overtime as a tool for wrapping up in progress work.

B. Findings

1. Construction Management Approach

WGL has carried out PROJECT*pipes* under an integrated, company-wide construction program. That program:

- Includes substantially accelerated pipe replacement programs in its other two jurisdictions (Maryland and Virginia)
- Operated for a time in tandem with a large District of Columbia encapsulation program (so-called "Program 3," with as compared with PROJECT*pipes* consisting of Programs 1, 2, and 4)
- Includes all of the other, "normal" construction work involved in operating a three-jurisdiction natural gas distribution business.

An earlier chapter discussed WGL's initial approach of treating accelerated main replacement, despite that great scope and complexity it added to "normal" work as an incremental, rather than fundamentally different burden to manage.

Changes made to program management of PROJECT*pipes* have brought a new approach. The organization responsible for managing construction has changed as well, as we describe below. However, its central concepts and elements have remained largely intact. The core concept lies in WGL's use of contractors exclusively to perform project construction work. That approach leaves

day-to-day management of construction work to contractors, requiring, however, that WGL supervise work closely to ensure quality installation and cost and schedule effectiveness.

With schedule recovery or advancement options constrained (as discussed earlier in this report) by a limit on annual program spending, and with engineering providing an ample backlog of work ready for construction, overseeing quality and cost effectiveness became the primary focus under WGL's approach to construction.

Management has made long-term use of continuing relationships (or "partnerships") with contractors a foundation of its construction strategy, while promoting competition as contract terms approach and as increased work have allowed for it. WGL has also assigned two of its contractors strictly to District work and one to do so predominantly , producing a familiarity that promotes effective and economical performance - - factors that tend to moderate pricing changes as contracts come up for renewal and that lead to performance in accord with local management and community expectations.

Equally central has been, again as described earlier in this report, the creation of an unusually long and detailed list of pay items whose verified accomplishment entitled contractors to agreement-defined amounts of payment. This approach led to a sound system of defined payments for work accomplished without causing contractors to build in the kinds of contingencies or the right to make claims for "extras" that one often finds in other forms of contracting.

2. Construction Management Organization

Construction at the WGL-wide level operates under an Assistant Vice President for Construction Operations. Also operating in WGL's Maryland and District of Columbia service areas, a Director of Construction manages accelerated pipe replacement construction work. His resources for District of Columbia replacement work include two Managers of Construction under whom are split 11 team members:

- Senior Construction Plan Management Specialist
- Lead Construction
- Construction Project Supervisor (8)
- External Construction Support.

3. Construction Management Resource Additions

WGL has added three positions in construction management:

- Senior Manager of Construction Management
- Manager of Contractor Performance
- Construction Lead.

The two manager positions provide for centralization and management of WGL construction activities across the company's three jurisdictions. They manage and produce budgets, forecasts, and analyses of variances and crew resource plans on a consolidated, WGL basis. They also manage relationships with vendors, and address contractual issues involving them. They also address customer issues arising from construction issues. Note, however, that CPSM addresses PROJECT*pipes*-specific reporting, however. CPSM's manager reports directly to the WGL Vice President of Construction, Compliance and Safety. It is at this vice president that all functions,

including CPSM, responsible for PROJECT*pipes* work come together, making this person accountable for program success.

As we finished our 2018 audit field work, WGL was in the process of adding a manager of Construction Management and a project manager support resource for PROJECT*pipes*. These added personnel will support the activities of the functions engaged in program activities by providing dedicated resource to managing projects from planning through execution and completion. First work efforts are expected to focus on process documentation and effectiveness assessment, and creation of reporting and analysis templates. Their ongoing responsibilities will include monthly internal reviews and forecasts of spending, required and available crew numbers, and work levels. They will prepare annual and quarterly budgets and forecasts, conduct monthly vendor meetings, and perform long-term resource planning

WGL added in Year 3 the Lead Construction, assigned to the District of Columbia office to work with WGL's construction supervisors. The new lead provides oversight of District activities generally, but primarily focused on replacement work. He provides support for a variety of field-related activities, including project status, field conditions, permits, customer issues, and coordination with others working in the streets. He oversees tie-in operations on projects as assigned. The Construction Lead's work responsibilities also include oversight of contractor crew field work to ensure compliance with regulations. He works with DDOT and Urban Forestry Inspectors to keep project work progressing and in compliance with permit requirements.

4. Controlling Contractor Work and Payment

However strong WGL's pay item system may be, it cannot be considered self-executing. It depends on a carefully constructed, and a timely and diligently executed system of listing, validating, and controlling payment for work items claimed to be performed.

During Years 1 and 2, WGL required the submission of paper lists of work (pay items) performed. The forms required signatures first from contractor management, second from a WGL construction supervisor, and third by a data specialist, after which contractors could invoice WGL for payment. Our sampling of them found them to be generally complete, with required signatures missing on a relatively few occasions, and with somewhat greater frequency, but still uncommonly, construction supervision signatures provided days or in some cases a week or more after work performance.

WGL began a new, spreadsheet-based system in March 2018. Management adopted a spreadsheet-based log system to provide for easy and timely verification of work performed by contractors. Two major log components drive the system. First, a "Daily Pay Item" log imposes a consistent process for logging all items for which contractors may be paid under the Pay Item Definitions of their contracts with WGL. The Company's construction supervisors must pre-approve logged pay items before contractors can submit them for payment. Second, it is not uncommon for work during the day to identify additional, unexpected pay items.

Contractors must secure pre-approval of them from WGL construction supervision, then document the approval using a Changes Log.

A tool called Safety Net logs all approved pay items. WGL construction management personnel compare contractor billing paperwork to a summary report generated from Safety Net, endorsing it if the work units match. Mismatches go to the Construction Manager for review.

Following a trial period of operation under the log system, WGL, in November 2018 began to require that pay items be included on the logs, or no approval for them would be forthcoming.

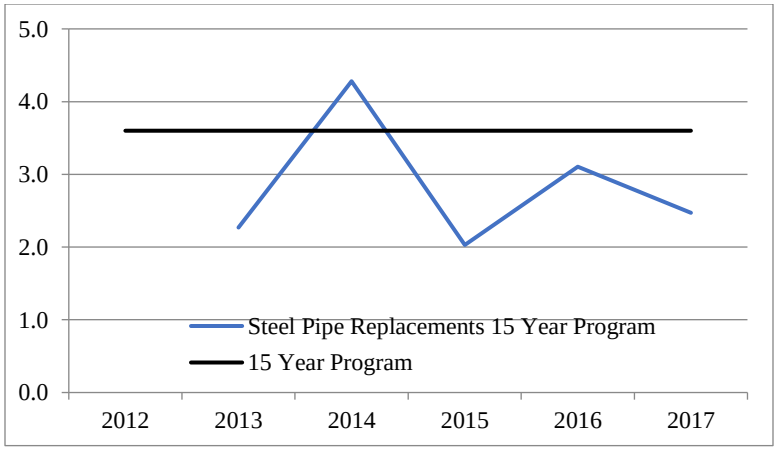
We reviewed a sample of the pre-2018 log system paperwork used by contractors and WGL construction supervisors to list and approve pay items for invoicing. At program outset, with work efforts smaller, the WGL sign-offs came closer to the date of work performance indicated in contractor paper records. As time went on, however, the duration to WGL supervisor sign-offs generally extended. Durations at or just above a week appeared reasonably common, with several extending to a month. We also noted some delays between sign-off of the contractor's crew leader and contractor management. We generally found that required WGL sign-offs did occur, with extremely rare exceptions. A significant number of pass-through payments (services that others provided to contractors). These "voucher requests" were invariably accompanied by the third parties' invoices, detailing what was provided and the costs.

The change to this log system provides substantially greater assurance of current contractor listing and WGL construction supervision review and approval of pay items. Using an electronic (spreadsheet) system in lieu of the prior, paper-based system, also substantially enhances management's ability to use the information for analyzing work performance and verifying proper and effective work listing and approval by contractors and construction supervisors.

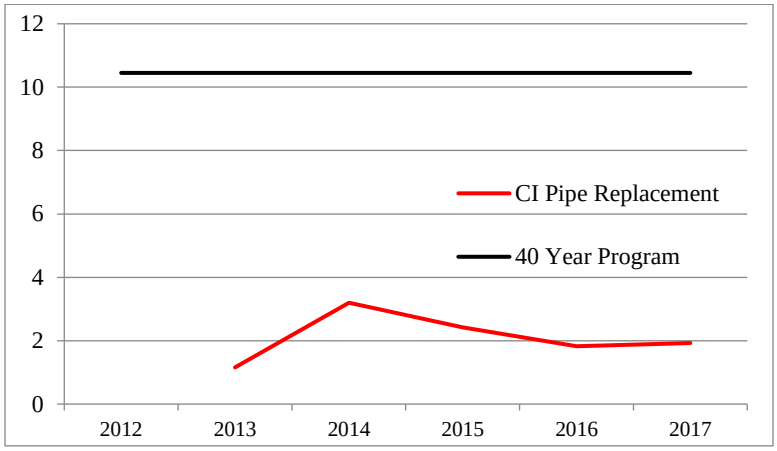
5. Replacement Work Accomplished

The next charts show current versus required rates of replacement, using data from annual WGL submissions to the U.S. Department of Transportation. The latest information available from these reports is December 2017 (submitted in March of 2018). The graphs show the large gap between expected and actual replacements. In addition to the loss of progress against targets established at program start, the additions that management has made to its numbers of at-risk services through data correction add to the large gap that already exists, just a few short years into the program.

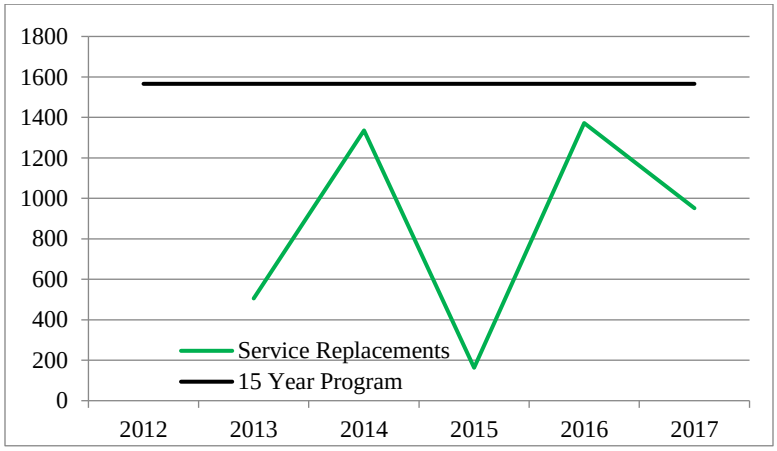
Miles of Steel Main Replaced



Miles of Cast-Iron Main Replaced



Numbers of Services Replaced



6. DDOT and Urban Forestry Permits and Requirements

As is common, particularly in dense urban areas, main and service replacement productivity experiences substantial impacts from government requirements and expectations. DDOT and Urban Forestry inspection have had such effects on WGL's replacement work. Early program permits allowed work between 7am and 7pm, conforming to the city utilities work schedule. A subsequent government change cut WGL's allowed time of occupancy of all streets in half. The current allowed six hours between 9:30am and 3:30pm comprises less than a normal day's work shift.

Direct work is constrained even further. At the front end, traffic control crews can only begin setup activities at 9:30. Moreover, their required activities include temporary passageways for bicycles and pedestrians. Our observations showed this work typically to require at least 30 minutes in the morning for set-up. At the back end, all spoils, traffic signs, equipment, and all else must be off the street by 3.30. These efforts require another 30 minutes or more. Any plating in place can add to unproductive time, if equipment to move it is not on-site. It cannot be removed until all traffic control is in place.

Therefore, a day offers only five hours of productive work generally. Contractors have to build into their prices worker expectations for full-time work. They also cannot use overtime to wrap up a job, thereby allowing efficient re-mobilization at the next work site - - no work can take place after 3:30pm. Continuing work at the same site suffers as well. Consider, for example, a service replacement, which has to finish once begun. Contractors cannot continue for the short time it might take to finish a service replacement. They cannot take the chance that they might not be able to get the customer back in service before the 3:30 deadline (or 3:00 if a half hour of shut-down work remains).

Other changes not anticipated at program initiation followed. WGL began to have to provide temporary bike lanes and pedestrian walkways. Other changes include the requirement to use chain-link fencing in lieu of plastic construction fencing around all trees and tree-root preservation.

7. Directional Drilling

Management has eliminated the use of directional drilling (HDD), because of past instances of cross boring through sewer laterals. HDD can be very cost effective for replacing mains and services. Management says that its use of video cameras failed to prevent these instances. WGL limits HDD on replacement work to services it cannot direct bury without considerable problems, such as on steep hills. Many other gas distribution companies have had similar issues but were able to overcome them.

8. Materials Availability and Quality

Management reported no Year 1 or 2 cost or schedule consequences arising from material availability or quality issues. We were able to perform real-time inspection of field work in 2018. Direct observations and discussions with field personnel disclosed no materials-related issues. WGL controls all materials, and uses its specifications and purchasing department to make the necessary purchases. The construction contracts do not provide for payments for mobilization. Contractors can and do shift to other projects when long-lead-time items prove unavailable. Thus, no short-term impact to WGL can result from availability issues, but ensuing bids, as contracts come up for renewal, would presumably include these, as any other necessary costs of serving WGL.

9. Accounting for Service-Replacement Work

Our sampling of Years 1 and 2 work took place well after the end of that period. We could not do, as we did in 2018, any inspection of ongoing work. Our Year 1 and 2 work sampling tested the prohibition against including the costs of new services for accelerated rate recovery. We randomly chose five quads including Program 1 service replacements. Cross referencing listings of service replacements versus new customers in each of the selected quads found none of the new services listed as part of the replacement program. We thus found no reason to determine that WGL has charged new service to service replacement Program 1.

C. Conclusions

1. The Year 4 change to a log system for managing contractor pay items has substantially improved control over payments.

The pay item system employed by WGL since the start of PROJECT*pipes* has been a sound one. Management generally implemented it acceptably during Years 1 and 2, but expanding work led to sometimes material delays in approval of pay items for invoicing. In all cases we tested, controls to limit invoicing to approved items did in fact occur. But we found a material number of instances where week or longer delays occurred between contractor approval of pay item lists and WGL construction supervisor validation and sign-off of those lists. The required sign-offs routinely occurred, but supervisor review needs to occur as close as possible to work that is overseen by busy company employees.

The electronically-enabled log system begun in 2018 provided a timely method for listing, reviewing, and approving pay items. Enforcing timely adherence to its sign-off requirements in November 2018 (after using it on a trial basis earlier) provides strong assurances that contractors and WGL construction supervisors deal with pay items daily, while maintaining the pre-invoicing role of WGL personnel in ensuring all entries are in order prior to payment processing.

2. Construction and program management leadership recognize the valuable role that the new log system has for program management, but developing its capabilities to do remains for the future.

The log system's spreadsheet foundation allows for easy data entry by contractors and WGL construction supervisors and, just as importantly, for consolidation in ways that will promote the effectiveness of controls and the identification of work performance factors. The addition of data fields to do so, while straightforward, remains a work in process.

For controls purposes, consolidation of data will permit management to assess a number of factors not necessarily conclusive on, but relevant in evaluating the diligence, consistency, and integrity of system entries:

- Contractors whose pre-work day lists of expected items are most subject to claims for unexpected items arising during the day
- Contractors with outlying numbers of rejected claims for pay items
- Supervisors with outlying rates of acceptance/rejection of claimed pay items
- Contractors or supervisors with outlying numbers of delays in providing required sign-offs
- Types of jobs producing largest numbers of each type of pay item.

For program management purposes, consolidating the data from the logs can assist in addressing factors like:

- Unexpected pay items having the largest impact on project cost growth
- Neighborhood, street, permit, conflict with other facilities, and other factors producing the most significant numbers of and costs for unexpected pay activities
- Similar neighborhoods, streets, or other project-defining parameters that produce anomalously high or low pay items, thus suggesting areas to investigate as sources of improved methods or practices
- Contractors requesting outlying numbers of pay items of varying types
- Unexpected pay items that may have gaps in engineering or permitting as a root cause.

3. Field Management additions after Year 2 improved management of contractor pay items, and expedited field decision making.

Changes in construction supervisor assignments and locations have provided more effort dedicated to managing and overseeing contractor replacement work in the District of Columbia. The addition of a separate manager for District of Columbia work, and a construction director responsible for the District and Maryland helped. To improve oversight and timeliness in making necessary field decision, increasing the availability of company personnel on site and with each contractor most of the time. WGL bases these added personnel in the District, rather than at its headquarters.

For example, during our field examinations of work we observed a recurring need for "offsets" to turn street corners - - offsets sometimes not accounted for in original engineering packages. Such offsets get identified in the field for a number of reasons, including obstructions from corner congestion due to others' underground facilities or abandoned infrastructure, for example. WGL's on-site presence with the construction crews supported prompt engineering involvement in securing change approvals with minimal delay.

4. WGL has generally employed effective work methods and practices, but remains in the process of creating and using effective performance reporting and analysis methods for optimizing performance.

Our examination of Year 1 and 2 work occurred well after its actual performance, making direct observation of work methods and practices impossible. The descriptions given of them, however, generally accorded with what we would expect of replacement work in dense urban areas. Our direct observations of work methods and practices during Year 4 found them in accord with descriptions we had received during our work addressing Years 1 and 2. We also found them in accord with good utility practice.

Reliance on contractors to perform the work reflected a sound approach, which WGL supported with competitive bidding, a long-term view of contractor relationships, and a well-designed pay item system. WGL provided appropriate controls over that pay item system, but we found delays in its sign-offs on contractor pay item requests as work on PROJECT*pipes* ramped up. Although delayed, review and sign-off did occur routinely. Management changed from a paper-based to a spreadsheet-supported log system in 2018. When it made timely log entries a condition of qualification for contractor payment in November 2018, it fully addressed the time-lag issue that had affected its prior sign-off process.

Management recognizes, but has yet to tap the potential its new log system has for performance analysis. As earlier chapters of this report have described, we found a lack of sufficient attention to performance reporting, analysis, and corrective action, particularly in Years 1 and 2. That condition, like the yet-to-be-tapped use of pay item analysis impaired management's ability to optimize productivity and to manage unit rates as thoroughly as it could have. As this and preceding chapters observe, enhancing program management has been underway since Year 2 and remains, as management concedes a "work in progress."

Thus, it is fair to conclude that continuing maturation of WGL's program management approaches, methods, and practices, enhanced, we hope, by the recommendations of this report will produce

some improvement in the unit rates that have, as compared with early expectations, proven a very substantial disappointment.

Without a fundamental criticism of work methods and practices, despite a belief that they can improve and would have improved under a different, earlier program management approach, we remain left with explaining the source of that disappointment about performance. We find two related causes:

- A reliance in Years 1 and 2 on historical unit rates that proved far too optimistic
- A failure to incorporate very substantial impacts on productivity from government requirements.

The two causes are clearly related, in that the first (use of historical unit rates) did not include already existing public requirements. The second, however, reflects continuing changes as public authorities responded to their stakeholders and to their experiences with work by WGL (and perhaps others as well, given, for example, major undergrounding and other work by the District's electricity distributor). We have observed other instances where permit and other requirements have continued to evolve as representatives of public agencies learned more about the burdens and in some cases the opportunities created by major utility work in their public ways.

Externally imposed productivity reducers here include strict limits on hours available for work, the need for removal of all work support items, creating temporary bicycle and pedestrian pathways, protecting trees with chain-link (versus more normal plastic, temporary) fencing, and prohibiting temporary storage of materials, spoils, and equipment in some areas). Contractors face the need (and therefore price their work) to include well less than a full-day's work for resources they need to maintain permanently and to preclude overtime as a means for maximizing efficiency of work performance.

A number of these requirements apply in other places on a somewhat more limited basis; *e.g.*, main streets into major centers. They are less common for residential areas and side streets with more limited traffic (vehicle, bicycle and pedestrian). Even heavily traveled streets can present options for accommodating directional traffic flows. On some streets, the company has been "given" the parking lane to store equipment, or install mains without impeding traffic flow.

5. Unmarked and abandoned underground facilities of others have required careful efforts, which WGL has performed appropriately.

During our field work we observed the need for unplanned offsets required by abandoned underground utilities neither marked nor identified on maps provided to the contractors and WGL's construction supervisors. Both must treat these "unknown" facilities as potential hazards before verifying otherwise. WGL has made its contractors aware of its policy requiring them to report and hand dig around unmarked, mismarked, or unmapped underground facilities encountered. WGL typically investigates such conditions, responding to the field within an hour. During this time, the contractor can continue working in the area (but not over the facility), or they can start to expose it via hand excavation. While time consuming and expensive, this WGL-required practice conforms to good safety practice.

6. WGL's past experience with directional drilling has led to a too-restrictive limitation on its current use

WGL's past use of HDD has caused it to contact or pass through sewer laterals and mains (an adverse consequence termed "cross boring"). WGL now therefore will not employ HDD where it has any other reasonable option. Many other utilities have had similar past experiences, but have found ways to continue using HDD effectively and economically. They have instituted additional safeguards to prevent cross boring or to repair the damage when it happens.

In certain situations, such as on side streets and areas without congested underground utilities, careful use of HDD can prove a cost effective method of installing new or replacement mains and services. Properly performing HDD requires location of all underground active utilities on maps and, where warranted, physically via small excavations along the HDD route. In addition, using a video camera along the bore verifies that no other utilities have been contacted or cross-bored. Where questionable situations arise, video inspection of the sewer line or lateral may also have to occur. Physically locating the sewer laterals (by digging a small hole above it - - called a "pot hole") permits the line to be viewed as the bore passes under or over it. If the bore were to contact the lateral, it could be repaired immediately. HDD can also work for some service lines, after similar precautions.

7. WGL's use of paper maps for construction work does not reflect best practice.

Management continues to use paper maps for construction work and notes via "red lines" any deviation from the original plan or scope of each project. Many projects use plastic pipe, which includes tracer wires for future locating. At each change in direction or at service tees or other fittings, WGL's specifications require burial of marker balls.

When a utility changes a main or service location, it must also change the original drawings accordingly, and submitting them for "as built" mapping. Many gas utilities, particularly in dense areas, have switched to digital mapping, using GPS to locate all service tees, elbows, and other items, eliminating paper maps and "red line" drawings. Typically the GPS provides sub-meter accuracy and the device automatically updates the map after the day's construction takes place. This feature allows for accurate maps almost instantaneously and it reduces the likelihood of misplaced paper updates. Tying this feature to the DIMP inventory of materials assists in performing risk analysis on the system. After the initial expense of digitalizing existing maps, large cost savings generally result, along with the ease produced in locating new mains and services in the future. We consider this approach a best practice.

8. WGL employed a sound approach and methods execution to Operator Qualification, and has executed them well.

U.S. Department of Transportation rules require those performing covered tasks on gas facilities to be qualified by knowledge and experience to protect life and property. Covered tasks on pipeline facilities include maintenance or operations tasks: (a) required by: (a) DOT 49 CFR 192 or 195, or (b) affecting pipeline operations or integrity. These rules require that WGL maintain a qualification program that:

- Documents program plan, procedures and qualification criteria
- Identifies covered tasks and evaluation methods
- Identifies the individuals performing covered tasks
- Qualifies them to perform covered tasks

- Periodically evaluates qualified individuals
- Monitors performance and seeks improvement
- Maintains appropriate program records
- Manages change
- Includes field verification

WGL requires its contractors to provide operator qualification (OQ) training for their resources. An electronic database records the OQ status of all contractor employees. WGL personnel, such as construction supervisors and auditors, have access to it. Thus during any inspection there should be easy access to OQ records. WGL compliance group personnel may attend some contractor-run OQ training programs to validate their effectiveness and conformity to regulatory requirements. WGL auditors encountering an OQ lapse (such as a worker not having the correct or up to date qualification) can remove the work from the job immediately, and require reperformance of all work the individual performed. WGL has found the most common OQ issue to arise from lapses in updating the electronic data base to include recently-hired or placed laborers on these programs. A review of auditor inspections of contractor crews and an auditor interview disclosed that the major safety issue encountered involves the failure to wear personal protection equipment, such as safety glasses or hard hats, for example. WGL auditors also observed OSHA violation of shoring violation - - corrected on the spot. WGL auditors do not wait until the reports are filed to inform contractors of safety violations and they have the authority to shut down jobs on finding unsafe conditions.

D. Recommendations

21. Work with public authorities to secure as flexible a set of working conditions as conforms to government's requirements and expectations.

District of Columbia requirements for the conduct of replacement work have changed significantly. In particular, many of them apply to all thoroughfares, despite differences the disruption that WGL's replacement work causes to those having differing characteristics.

Traffic and congestion typify urban areas generally, making it appropriate for limits on work like that WGL performs in replacing pipe. Those requirements frequently vary, however, based on the type of street, neighborhood, and traffic flow. The District of Columbia, however, generally treats all streets and locations the same. Work restrictions on residential streets with no bicycle lanes or sidewalks can follow the same rules as downtown main streets with regard to work hours, pedestrian and bicycle lanes, and tree protection. There is a balance between the level of inconvenience replacement work produces and the length of time that inconvenience exists. Unilateral imposition of requirements despite differences in inconvenience experienced can extend its length without producing commensurate benefits. The longer construction takes the longer the inconvenience to residents, drivers, and others.

WGL and its customers bear very significant costs in meeting the requirements at issue here. While it is for public policy makers to determine where the balance lies, it is incumbent on WGL to ensure that government makes its decisions on the basis of a full knowledge of the costs involved. We are familiar with other urban areas where transportation authorities imposed restrictions based on traffic flows, rather than employing a universal set of limits. Management has reported

numerous meetings with permitting authorities, but outreach should continue, particularly with knowledge of customer cost impacts and the potential for delays in elimination of high-risk pipe as utility regulatory process stakeholders struggle with maintaining affordability.

22. Work with other underground utilities to update construction maps to contain all existing and abandoned facilities along planned main and service replacement routes

WGL applies appropriate safeguards to ensure that unanticipated underground facilities encountered get treated carefully and thoroughly. Its practices ensure safety. Management should ensure that the maps provided to contractors have as much information as possible, including abandoned facilities where applicable. If necessary the contractor should be allowed to do test holes to find and locate active and abandoned underground facilities. These facilities should be mapped for the use of the field construction team so that a minimum of hand digging and delays due to finding unmapped underground facilities occurs.

Locating all active and abandoned underground facilities up front, will allow design of gas replacement mains and services to avoid unplanned offsets. Unexpected field conditions will still require changes. Underground facilities with poor mapping may still present problems for the final design but may present a situation warranting test holes. If the route can be fully designed, there should be an increase in productivity of the field construction crews.

23. Develop and execute a directional drilling pilot program for residential or side streets.

It should include appropriate safe guards to prevent cross boring and it should carefully measure costs involved. The results should be used to determine whether HDD should become a long-term tool in management's efforts to optimize replacement costs.

Directional drilling, also termed HDD, can in some circumstances offer significant cost savings in installing mains and services. Like others, WGL has had issues in the past with HDD. The typical problem arises from putting the gas main or a service through an existing sewer main or lateral. Doing so risks a future safety incident; *e.g.*, when later cleaning the sewer or lateral using a cutting device that pierce the plastic gas pipe, releasing gas into the sewer.

Proven safe guards can sufficiently mitigate the risk of cross bores, while leaving HDD a cost effective alternative in many instances. Using this method of replacement in residential and suburban settings warrants consideration. It can save paving, restoration, and property damage costs, while also considerably shortening installation times. Drilling mains a block at a time would limit excavations (apart from test holes) to connect services. In addition, proximity to a regulator station supplying medium pressure several blocks away, could provide an economical opportunity to connect it via HDD, allowing new main and services conversions to medium pressure.

24. Conduct a structured, quantitative evaluation of converting to digital GPS mapping.

Many other urban and suburban gas distribution companies (and other utilities) have converted maps and construction drawings to digital GPS systems. WGL still uses paper maps and analog reference drawings. Others now use GPS to map and track actual locations of each main, fitting, service line, and valves. They do so during construction, after main or service installation, but before covering.

Using GPS can prove more cost effective in the long run, after conversion has been performed on existing maps and data. It also eliminates sources of errors, allows for rapid retrieval of data, and provides a basis for developing a more robust and accurate database. Some other gas distribution utilities have made using GPS a requirement of their contractors, thus minimizing their upfront costs. Contractor crews, already in the field, do the locating of replaced main and services at the end of every day before backfilling.