

2016 Sewer Share Assessment Report

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From: GLWA Sewer Charges Assessment Committee

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SUMMARY

When the Great Lakes Water Authority assumed operational responsibility of the regional sewer facilities from the City of Detroit in 2016, it inherited protocols for allocating the cost of operating the regional sewer system among its wholesale suburban customers.

- Each sewer customer is charged on a uniform and proportional basis
- Sewer charges are reviewed periodically to ensure the foregoing is achieved.
- The Authority continued its robust customer outreach and collaboration with its customers.

In 2013 the Detroit Board of Water Commissioners adopted a simplified approach to establish charges for common-to-all wastewater services. Each customer was allocated a percentage SHARE of the DWSD common-to-all wastewater budget based on its share of the budget in the prior five-year period. Each SHARE was constant for the Charge Period from FY 2015 to FY 2017. All customers except Detroit are billed in 12 equal monthly installments.

When the new sewer charge was adopted, the Board identified three study topics for the next Charge Period beginning in July 2017.

- The strength of flow allocation was not supported by sufficient data for sewage strength, and future study of the allocation was a condition established by the BOWC for implementing rate simplification.
- The indirect method used to estimate flows from “D+” customers, principally Detroit, Hamtramck and Highland Park, possibly introduced errors in estimates of D+ flows. Detroit agreed to 2013 rate simplification on the assurance that a better estimate of D+ would be developed before the next Charge Period.
- The protocol for allocating costs between flow and strength based on a 1979 study should be examined considering changing operational protocols.

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In February 2016, Suzanne Coffey, GLWA Chief Planning Officer, established a Sewer Shares Assessment team within the Authority's customer outreach process. Team membership included technical and financial representatives of GLWA, Oakland, Macomb and Wayne counties, Detroit and Dearborn.

When the team completed the significant majority of its work in mid November, a majority consensus had been reached on the following points which were provided to policymakers for consideration in setting charges for the next Charge Period. In mid-November, after consideration of concerns raised by team members from Oakland and Macomb Counties, a minority report identifying objections, challenges and recommendations for future study was suggested. Since that time, Oakland and Macomb Counties have communicated their intent to produce a written document which details their concerns.

1. Strength of Flow: The team analyzed national data on sewage strength for total phosphorous ("TP"), total suspended solids ("TSS") and biological oxygen demand ("BOD"). It directed a five-month sewage strength sampling program for TP, TSS, BOD and fats, oils and grease ("FOG") spanning the sewer service area, including City of Dearborn, City of Detroit, and Macomb, Oakland and Wayne counties. The team concurred on three alternative strength estimates for sanitary, DWII and wet weather flows and drew the following conclusions:

- The 2013 values used for strength of flow were not supported by local data and should be replaced by representative estimates based on national studies and local data.
- The 2013 values for DWII and wet weather strength should be reduced except for wet weather TSS.
- All three strength alternatives are reasonable and have a similar impact on changes in SHARES. The alternative using the most local data is preferred for SHARE calculations.
- Customers with a higher sanitary component of flow will see a relative increase in their SHARE, while customers with a higher percentage of DWII will see a relative decrease in SHARE, all other things being equal.
- System sampling data could not provide reliable estimates of strength of wet weather flow.
- Sampling of sewage strength should continue with modifications based on lessons learned to date.

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2. D+ Flow: In 2013, D+ flow was indirectly estimated as 37.8% of the total flow to the Water Resource Recovery Facility (“WRRF”). Detroit requested a direct estimate be prepared. The team developed estimates of D+ sanitary flow for the entire D+ area using retail water records. It used system meters to estimate DWII and wet weather flows for part of Detroit (“D+ Direct”). Combined, these estimates accounted for about 66% of D+ flows. The DWII and wet weather flow data was extrapolated for the rest of the D+ area (“D+ Incremental”). Results included:

- The estimate of D+ flow derived to replicate historic shares for the first Charge Period can be replaced by an actual estimate of D+ flow based principally on the procedures used to estimate flow of the M customers.
- A reasonable midrange flow estimate based on a four-year average projects D+ as 37% of flow to the WRRF and 42% from suburban customers. The remaining 21% is attributable to all customers in common, in contrast to the current allocation of 16.25% to all customers in common.
- At this midrange estimate, the balance of total flow between M and D+ changes only slightly from the current Charge Period. (Because strength influences cost allocation, relative SHARES of the Authority’s budget may shift because of the revised strength factors.)
- A metering plan within the D+ Incremental area should be developed to improve estimates of D+ flow.

3. Flow Data Review: The team successfully reviewed flow data collected during the Charge Period. During this review the team considered changes in customers’ systems that might have a material impact on a customer’s relative share of total sewerage flows, like the partial diversion of Oakland-Macomb Interceptor Drain Drainage District (“OMIDDD”) flow from the Authority system to the Pontiac Wastewater Treatment Facility Drainage District, and the planned diversion of flow from the Western Township Utility Authority (“WTUA”) to the Ypsilanti Community Utility Authority (“YCUA”). The team provided an updated flow balance by type of flow for FY 2013 to FY 2016 for use developing updated SHARES. Flows decreased significantly at the WRRF for the most recent period. Therefore, any customers whose flow decreased proportionally less during the period than the proportional flow decrease at the WRRF will see an increase in share allocation, all other things being equal.

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4. Review of Cost Allocation Factors: Strength of flow was introduced as a cost factor in FY 2012, consistent with wastewater industry practice.¹ Costs are now allocated between flow and flow strength based recommendations in Attachment 2, Camp, Dresser & McKee (“CDM”), Proposed Sewerage System Rates and Charges (1979), as implemented in Attachment 3, CDM, Detroit Sewer Rate Methodology (excerpt) (1980). In 2016 GLWA staff reviewed the CDM study in the context of current operations. GLWA staff concluded each of the bases for allocation adopted in 1979 remain a reasonable basis to allocate costs for the next Charge Period.

Detroit also requested a review of the basis for the allocation of General and Administrative costs. Since that request, several suburban customers have expressed a similar interest in reviewing the General and Administrative allocation. This review has been launched through the Customer Outreach and will continue through the GLWA Cost Allocation project scheduled to begin in July of 2017.

¹ Attachment 1, Water Environment Federation, *Manual of Practice #27, Financing and Charges for Wastewater Systems*, Ch. 6 & 7.

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DETAILED REPORT

I. ESTABLISHING REVENUE REQUIREMENTS

The Authority's budgeting process establishes the revenues required in a future year to operate the sewer system and meet its capital needs. This "revenue requirement" is divided into four broad categories: costs associated with facilities and processes treating wastewater from all customers ("common-to-all" costs), costs associated with combined sewer overflow facilities handling flows when the wastewater treatment plant is at capacity ("CSO costs"), costs associated with services to an individual customer, and costs associated with treating industrial wastes.²

Common-to-all costs are a function of the volume of flow (e.g., the cost to pump flow) and the pollutants conveyed in the flow (e.g., the cost to remove, treat and dispose of solids). Thus, costs are a function of the relative composition of wastewater flow treated at the wastewater treatment plant – sanitary flow, wet weather flow, and dry weather inflow & infiltration ("DWII"). Sanitary flow contains the most materials requiring removal, treatment and disposal while DWII contains the least. For an equal amount of flow, it will cost more to treat the flow from a customer with a high proportion of sanitary flow than a customer with a lower proportion because the sanitary flow carries more pollutants requiring treatment and/or disposal. Cost allocation based on flow strength is currently based on a simplified cost study performed in 1979 by Camp Dresser & McKee for the federal court.

The allocation of CSO costs among customers was established in 1999 after a court-ordered facilitation process (the forerunner to the present customer outreach process). The costs of the long term CSO control program were allocated 83% to Detroit and 17% to wholesale sewer customers. The wholesale customers allocated the 17% among themselves. The allocation of costs associated with the CSO program are being considered as part of the Wastewater Master Plan and will not be considered in connection with the establishment of charges for the Charge Period beginning July 1, 2017.

The Authority has an accounting process tracking capital and operating costs by categories associated with the common-to-all, CSO, customer-specific and industrial customer classes.

Until FY 2015, DWSD combined its revenue requirement, rate-setting protocols and forecast of each wholesale customer's future wastewater flows into a customer-specific volumetric rate

² Wholesale customers do not receive industrial charges. They are billed to industrial customers.

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(\$X per thousand cubic feet of flow (Mcf)). If, during the fiscal year, a customer's actual volume met its forecast volume, the rate-generated revenue would achieve the budgeted revenue requirement associated with serving that customer. In practice, actual flows did not meet forecasted flows and the sewer system did not achieve its revenue requirement, resulting in operating losses, deferral of capital projects, loss of system financial equity and bond rating downgrades. A cumbersome "Look Back" process had been implemented to true up actual costs and revenue against the budgeted and forecasted flows. In some cases the look back process led to large adjustments several years after the rate year ended, due in large part to Detroit's inability to produce timely annual audits.

II. 2013 RATE SIMPLIFICATION AND CONSOLIDATION

In the period 2010 to 2013, the Board of Water Commissioners directed DWSD to simplify the sewer charge model.

The effort was conducted by the Sewer Rate Simplification Subcommittee under the auspices of the Wholesale Customer Outreach. Members of the Subcommittee included DWSD staff and consultants and Wayne, Oakland and Macomb Counties with lesser participation by smaller wholesale customers like Center Line and Dearborn. In addition, under BOWC direction, DWSD retained a civil engineering firm to be an advocate for Detroit retail customers in the process. Recommendations were approved by the BOWC in November 2013 and implemented for a three-year Charge Period - FY 2015 to FY 2017. An outreach to all customers followed.

Four reforms were adopted. The many details associated with these reforms were presented in a Memorandum from the Sewer Rate Simplification Subcommittee to Board of Water Commissioners, "Rate Simplification Recommendations" (November 22, 2013).

First, each wholesale customer is now charged a fixed annual amount calculated as that customer's SHARE (expressed as a percentage) of the annual budgeted common-to-all revenue requirement for an agreed-upon future multi-year "Charge Period," based on its average share of common-to-all revenue requirements for an agreed-upon prior period. The first Charge Period began in FY 2015, has a three-year duration, and is based on the prior FY 2008-12 period. Annually, a customer's SHARE is applied to the common-to-all budget to yield the customer's common-to-all revenue requirement. Customer-specific and CSO charges are added to the common-to-all charge. Each wholesale customer's revenue requirement is billed in twelve equal

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monthly installments, providing a predictable and consistent income stream to the Authority. The Board determined that SHARES would be re-evaluated before the FY 2018 rate year began and revised or reaffirmed SHARES would be set for the next multi-year Charge Period.

Second, the annual Look Back process (i.e., the adjustment to the annual revenue requirement retroactively billed by DWSD to sewer customers when all costs and usage for a prior rate year were known) was discontinued for four reasons.

- It was time consuming, cumbersome and distracted attention from management of on-going revenues.
- It often resulted in significant retroactive adjustments to individual customer revenue requirements, with additional charges in one year followed by credits in the next.
- Eliminating the Look Back adjustment process increased charge predictability from year to year, something the customers strongly desired.
- The new revenue requirement approach guaranteed the overall sewer system revenue requirement would be met, providing a significant improvement to the department's financial condition.

Third, over half of the flow reaching the wastewater treatment plant was not measured through a billing meter (i.e., a sewer meter intercepting just one customer's flow) and thus was not directly attributable to any specific customer based on meter data. In 2013 simplified procedures were developed to estimate the customer-specific source and amount of these flows from the communities without billing meters, principally Detroit, Highland Park and Hamtramck as well as parts of several smaller communities (the "D+" customers).

Fourth, a process was established to permit SHARES to be adjusted if a customer's flow changes materially during the Charge Period. SHARES were adjusted prospectively in 2015 under this process and validated in late 2016 to reflect the diversion of flow in 2016 from OMIDDD to the Pontiac Wastewater Treatment Facility Drainage District and between Detroit and Hamtramck.

III. ISSUES DEFERRED TO POST 2013

The Sewer Rate Simplification Subcommittee identified several areas deserving further review and the BOWC committed to address them in time for the FY 2018 rate year.

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- Revisit strength of flow to better allocate costs among customers who have varying flow strengths, in particular to address the assertion by the Detroit Retail Advocate that the DWII strength factor was too high and was creating an inequitable allocation for D+ customers.
 - Review strength factors between sanitary, wet weather and DWII flow,
 - Improve estimates of each flow component, and
 - Review how costs are allocated based on strength of flow.
- Develop direct estimates of D+ flow to ensure that flows from Detroit and other D+ customers are not overestimated.

Later GLWA and its wholesale customers also agreed to consider two additional issues:

- Respond to a request from Dearborn to review the individual customer allocations of the 17% non-Detroit share of CSO projects³, and
- Review the allocation of General and Administrative (“G&A”) costs among sewer customers.

IV. CONTINUED REFINEMENT OF CHARGES – FY 2015 -16

In 2016, GLWA launched the Sewer Shares Assessment project to address the foregoing issues and to update SHARES for the Charge Period beginning in FY 2018. The Authority directed Project Innovations to use the customer outreach process to address these issues. Suzanne Coffey (GLWA Chief Planning Officer) established the Sewer Shares Assessment team and subsidiary subcommittees that included technical, financial and consultant representatives from customers. The Sewer Shares Assessment team established three subcommittees:

- Strength of Flow (“SOF”) to refine the estimates of the relative flow strengths of sanitary, wet weather and DWSII flows;
- Flow Analysis Approach (“FAA”) to improve estimates of flows from all customers, in particular to improve the estimates of D+ flow and common-to-all flow in the GLWA interceptors, and to estimate the DWII, sanitary and wet weather flow from each customer; and

³ This request was later withdrawn by Dearborn

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- Financial to review the impact of the technical findings and to present a cost allocation approach⁴ that allocated costs considering volume, strength of flow and the industrial program.

To support this effort, the Authority retained CDM Smith to provide technical support and funded technical support for Detroit, Wayne, Oakland and Macomb counties and Dearborn through the Customer Outreach Contract (CS-1445). Each of the foregoing was actively represented by staff and technical consultants in carrying out the subcommittees' work.

A. SOF Subcommittee Scope of Work

Capital and operating costs for interceptors and the treatment plant are a function of the volume of flow and/or the amount of pollutants in the flow. To allocate the costs to remove pollutants from wastewater, data on the volume of the three types of flow (sanitary, DWII and wet weather) are needed as well as the concentration of pollutants in each type of flow. Concentration or "strength of flow" means the amount of a pollutant in a volume of sewage flow, expressed as pounds of pollutant per unit of volume. The volume of flow (Mcf) times concentration of pollutants (lbs. per Mcf) yields the mass of pollutants in the flow that must be removed at the WRRF.

By way of background, GLWA, like DWSD before it, budgets and tracks its capital and direct operating costs by detailed line items that correspond (for the most part) either to transporting sewage flow or to treating pollutants in the flow. The cost of operating, maintaining and improving pump stations corresponds to the volume of flow that must be pumped. The cost of chemicals is associated with treating pollutants in the sewage flow. The cost of operating, maintaining and improving equipment to remove solids from flow (like the clarifiers where solids are settled out of the flow) is a pollutant-related cost as is the cost the solids dewatering equipment and ultimately the cost of disposing the solids. The costs of some activities are partly driven by the amount of flow as well as the amount of pollutants, in which case a cost allocation study is done to split costs between flow and pollutants on a reasoned basis. This was the purpose of the 1979 CDM study. The detailed logic for cost allocation is explained in Attachment 2 and corresponds well to the function-based allocation approach discussed in WEF Manual #27, Chapter 6 included in Attachment 1.

⁴ Based on Camp Dresser & McKee, "Proposed Sewerage System Rates and Charges" (1979).

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For example, two customers who send the identical flow volumes to the plant will cause substantially different costs at the plant if the first customer's flow is mostly sanitary flow, which has a relatively high concentration of pollutants, while the second sends predominantly wet weather and DWII flow, which have much lower concentrations of pollutants. The SOF subcommittee research indicated that a gallon of sanitary flow carries more than 40 times the amount of total suspended solids and BOD than a gallon of DWII⁵ and several times more than a gallon wet weather flow. The first customer will generate far more solids with the consequent higher cost for treatment chemicals, solids handling and drying and disposal. These operational principles were recognized and accepted by the technical representatives of the wholesale customers when pollutant loading became a factor in the charge for wastewater services. Their concern, now addressed by the SOF subcommittee's work, was the lack of data then available on the specific concentrations of pollutants in the flows.

If all customers' flows are generally the same mix of sanitary, wet weather and DWII flow, the relative sharing of flow and pollutant costs among customers is pretty much the same. However, that is not true of GLWA's wholesale customers. One customer's flow is nearly 75% sanitary while another customer's is only 25%. It was this large difference in the pollutant loadings between customers that prompted DWSD to factor the amount of pollutants into its wholesale charges in FY 2012.

The concentrations of pollutants in the flows throughout the WRRF are sampled and drive decision making regarding plant operations. For example, chemical dosing varies as the effluent phosphorus concentration varies. When the flow enters the WRRF it contains flow from 19 customers and is a mixture of sanitary, DWII and, on a rainy day, wet weather flows. It is not possible to measure any customer's daily contribution of pollutants to the WRRF. Instead the accepted approach is to develop estimates of the concentrations of pollutants in customers' flows by type of flow and use that with annual flow data to estimate annual pollutants.

In alignment with the current share model, the Technical Committee assumed that each wholesale customer's pollutant concentration is the same for each type of flow. That is, each customer's sanitary flow has the same concentration or strength as other customers. Likewise, for

⁵ The WEF Manual, Table 7.4 uses a 20:1 ratio.

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DWII and wet weather. The SOF subcommittee was charged with developing representative estimates for sanitary, DWII and wet weather strengths.

The pollutant allocation in the charges model is based on four pollutants: total phosphorous (“TP”), total suspended solids (“TSS”), biological oxygen demand (“BOD”), and fats, oil and grease (“FOG”). Estimates of the concentrations for each of these pollutants for sanitary, DWII and wet weather flow were developed.

Once representative strengths were established by the SOF subcommittee, the amount of pollutants each customer sends annually for treatment is calculated by multiplying its annual sanitary flow by the sanitary strength and likewise for DWII and wet weather, and then summing the three calculations.

1. Estimates of Strength of Flow by Type: Sanitary, DWII and Wet Weather

Flow strength was introduced as a cost allocation factor in FY 2012. While at that time suburban customers had agreed that flow strength was a valid cost allocation consideration, there were concerns with the lack of strength data for the sewer system. As a compromise, flow strengths for DWII and wet weather flow were set at one-third of sanitary strength with the commitment that a flow strength study would be conducted.

The SOF subcommittee concluded that a two-pronged approach to improving estimates of flow strength was desirable: a review and analysis of research on flow strength from national studies and a sample collection program within the GLWA system.

The strength research considered 15 studies of groundwater (for DWII), sewage (for sanitary) and storm water (for wet weather), some of which reported on strengths from several cities. When categorized by DWII, sanitary and wet weather, these data indicate significantly different strength by flow type but there was a wide variation of strength within each flow type. The SOF subcommittee reviewed the research data and developed a profile for a representative strength value for each type of flow based on the research.⁶ See Table 2, Strength of Flow, Research Summary.

GLWA took the lead in conducting an in-system flow strength sampling effort in Detroit and sampling occurred in suburban systems as well. Over 275 flow samples were analyzed. Twenty-

⁶ Fischbeck, Thompson, Carr & Huber, Inc. (Macomb’s consultant), “Summary,” presented to July 7, 2016 FAA/SOF subcommittee meeting.

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one locations were sampled on 50 dry days and 14 wet days. In addition, nighttime samples were collected at 14 suburban locations on four days to develop DWII strength estimates. Flow data were collected when the samples were collected.

Determining individual DWII, sanitary and strength of flow estimates was challenging because no sample collected consisted of just one type of flow. Flow on dry days includes both sanitary and DWII flow. During rain events, flow includes wet weather flow in addition to DWII and sanitary flows.

In the sampling data, the TSS concentration in wet weather flow exceeded the concentration of solids during periods of low flow, at odds with the accepted understanding that sanitary flow introduces most of the solids into a sewer. The subcommittee hypothesized high TSS concentrations during wet weather are caused by the high flows re-suspending sanitary solids settled out in the sewers during low-flow periods. Thus, the subcommittee relied on national research data that was considered extensive and scientifically valid.

The SOF subcommittee concluded strength of flow by flow type could not be estimated solely from sampling data alone and, further, there is not one unique set of strength values that, when applied to the flow estimates, can account for the mass pollutant loadings received at the wastewater treatment plant.

The strength of flow analyses carried out by the SOF subcommittee were performed on a concentration basis. However, the cost allocation model is structured to use the relative strengths of pollutants in each type of flow. Therefore, the final step in the SOF subcommittee's analyses of flow strengths was to express results in relative terms, not in terms of the absolute concentration. The sewer charge allocation model treats the relative concentrations of pollutants contributed by DWII and wet weather flow types as a percentage of the strength of sanitary flow, where sanitary strength is expressed as 100% and the other strengths are expressed as something less than 100%.

After considering a wide range of approaches to estimating flow strengths, the SOF subcommittee settled on three alternative derivations of flow strengths based on various combinations of the sampling data, research and professional judgement. They are set forth in Table 3, Summary of Strength Ratio Recommendations. In summary, strengths for all pollutants for DWII and wet weather flow should be reduced, except for TSS in wet weather flow.

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The Foster Group used the estimated strength factors to investigate their potential impact on SHARES. The sensitivity analysis revealed little difference between the SHARES calculated with any of the three alternatives.

The SOF subcommittee concluded that any of these alternatives was a reasonable basis for calculating SHARES in the next Charge Period. Most of the subcommittee preferred use of Alternative #1 which makes use of local sampling data for DWII. Summary of subcommittee conclusions and recommendations:

- The previous values used for strength of flow were not supported by any local sampling or national research data and should be replaced.
- As asserted in 2013 by the Detroit Retail Advocate, previous compromise values for strength of DWII and wet weather flows should be reduced except for wet weather TSS.
- All three strength alternatives have a similar impact on changes in SHARES. SOF Alternative #1 is preferred because it uses local sampling data for DWII strength.
- Customers with a higher sanitary component of flow will see a relative increase in their SHARE, while customers with a higher percentage of DWII will see a relative decrease in SHARE, all other things being equal.
- System sampling data was not able to provide reliable estimates of strength of wet weather flow for all four pollutant components.
- Limited sampling of sewage strength should continue to obtain more refined results, although some members challenged the assertion that more sampling would yield more reliable results and some customers have challenged the assumption that all SOF concentrations are uniform across the region.

B. FAA Subcommittee Scope of Work

The FAA subcommittee was charged with refining estimates of metered and unmetered wastewater flows by customer with emphasis on the following:

- Develop direct estimates of flows from the D+ areas;
- Improve estimates of the “Common” flow;
- Refine estimates of total wastewater (“WRRF”) flow at the wastewater treatment plant,
- Adjust historical flow data to create a consistent data set for the prior period to be used to estimate SHARES for the next Charge Period;

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- Refine estimates of flow by type of flow;
- Review, refine and correct flow data in general (i.e. quality control); and
- Recommend the prior rate years to be used to calculate SHARES for the next Charge Period.

The flow from suburban customers whose wastewater flows are metered directly through billing meters is referred to as “M;” from all other customers as “D+” (Detroit plus Highland Park, Hamtramck and all or portions of several adjacent communities); and from infiltration and inflows into GLWA interceptors, as “Common.” Common flow is chargeable to all customers, *pro rata* by flow. It should be noted that more than half of the flow from the D+ area is also directly metered.

Common flow in the GLWA interceptors is flow that comes from inflow and infiltration into GLWA sewers and interceptors. Some of this leakage is attributable infiltration of groundwater, possible inflow of river water into the GLWA interceptors closest to the Detroit River, water from leaking water mains and other sources. This DWII is a function of the diameter and length of the interceptors. The GLWA interceptors are very large and there are many miles within the D+ areas. As a result, the cumulative DWII into these interceptors results in Common flow.

The FAA subcommittee developed an aggregate flow balance between a) flows generated by customers (M plus D+) plus Common flow less any flows discharged from CSO outfalls during wet weather events, and b) flows received at the wastewater treatment plant as adjusted.

The FAA subcommittee recognized an exact estimate of total D+ and Common flow is not yet possible because of metering inaccuracies, uncertainties as to the source of and amount of DWII in GLWA interceptors, gaps in the metering network in part of the D+ area, and assumptions in the build-up of an estimate of D+ flow. However, the subcommittee developed two approaches to estimating D+ flows: Alternatives 2016A and 2016B. After much discussion, the FAA subcommittee recommended that 2016B be carried forward into the SHARES analysis.

Table 1 shows the flow balance for Alternative 2016B totaled by M and D+ in each year from FY 2012 through FY 2016. As components of flow are discussed below, references to the relevant lines of Table 1 are provided.

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1. Estimates of M, D+, Common and WRRF Flow

The flow balance between M, D+, Common and WRRF flow was developed through a series of independent flow estimates described in the following subsections that follow the format of Table 1.

a) “M” Flow, Lines A to G

Line A: Estimation of flows from metered customers is straight forward. Each of these customers' flow passes through one or more “billing” meters dedicated to its flow. GLWA has a long-practiced process to calibrate the billing meters in the M areas and system meters in D+ areas, to review the data received and to correct any metering data errors detected. (This metering management process is conducted in collaboration with wholesale customers through the Customer Outreach.) After data verification and correction, the billing meter data is used directly in the flow balance for M flows. The sanitary component was calculated as 90% of total winter water sales based on master water meters or 95% based on retail meters within the customer's service area. Sanitary flow was subtracted from total flow on “dry” days to yield an estimate of DWII flow. Wet weather flow was calculated as the difference between flow on “dry” days and flow on “wet” days.

Lines B & C: The FAA subcommittee sought to estimate and quantify the DWII in flows from the M areas due to infiltration and inflow from water leaking from GLWA water mains (“nonrevenue water”). Nonrevenue water can include persistent small leaks in water mains, large leaks from breaks, unmetered uses (like fire-fighting) and operational issues (like open drain valves). Nonrevenue water volume is estimated as part of the potable water system diagnostics. The subcommittee assumed how much of the nonrevenue water enters the GLWA or D+ sewers as I&I. The subcommittee proportioned the estimated I&I from nonrevenue water volume using the diameter and length of GLWA water mains within the combined sewer areas within M customers. Not all M customers have combined sewer areas; of those that do, not all have GLWA water mains within these combined sewer service areas. Accordingly, in this line this flow is deducted from total M total (and from flows of the affected customers for their individual charge calculations). Due to lack of data underlying the set of assumptions utilized to develop estimates of nonrevenue water, some customers disagreed with this approach and scenarios were presented that eliminated this factor.

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Lines D & E: The OMIDDD diversion occurred in FY2016. To create a consistent historic flow dataset for SHARES purposes, an OMIDDD deduction for prior years was created so that the entire four-year period (FY 2013 to FY 2016)⁷ represents flows adjusted for the diversion. The diverted OMIDDD is shown on Line D and subtracted from Line C to produce Line E, M Total (Adjusted) with OMID diversion. A corresponding deduction is made from Adjusted Total WRRF Flow at Line U.

Lines F & G: WTUA sends some of its flow to the Authority through Wayne County's Rouge Valley system and the balance to YCUA. In 2016, the townships comprising WTUA voted to send all flow to YCUA beginning at some point in 2017. This decision was formally communicated by Wayne County to GLWA on February 2, 2017. Wayne County requested that this be taken into consideration. Accordingly, this report treats the diversion as commencing on July 1, 2017. Therefore, SHARES for the next Charge Period have been calculated assuming no WTUA flow will enter the Authority's system after that date. Lines F & G deduct this flow from the historic flow data set. A corresponding deduction is made from Adjusted Total WRRF Flow at Line V. The subcommittee has requested a detailed presentation from WTUA to validate the exact extent of the diversion as there are some questions regarding the possibility of additional flow diversion.

b) Estimates of Flow from D+, Lines H to L

As noted above and discussed in more detail below at Section B.1(f), Common Flow (2013), D+ flow was not calculated directly for the FY 2015 to 2017 Charge Period. The FAA subcommittee was directed to develop a method to estimate D+ directly.

The D+ area includes all areas where sewer flow does not pass through a sewer billing meter. It includes Detroit, Highland Park and Hamtramck and very small portions of some other cities. Detroit, Highland Park and Hamtramck are considered together largely because of the degree of interconnection of their sewer systems, and they make up most of D+ flow.

Estimating sanitary flows for D+ customers was straightforward based on retail and industrial water sales, as was done in the M areas. Small adjustments for unmetered accounts and billing

⁷ The subcommittee developed flows for FY 2012 as well but decided not to use FY 2012 in setting SHARES for the next Charge Period.

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alignments were made. A 95% conversion factor was used, that is sanitary flows were assumed to 95% of total water sales. Note: a 90% conversion factor is used for M customers, because it is assumed that there is greater water loss in M customer wholesale water meters than the smaller retail D+ meters.

Estimating wet weather and DWII flow was more complicated. Although there are no sewer billing meters within Detroit, GLWA uses thirteen system meters to monitor and manage GLWA interceptor flows within the city. Although these system meters were never intended for billing, they have been maintained as if they are billing meters. They have been routinely monitored, calibrated, maintained and replaced for many years, and system meter data are regularly reviewed by suburban technical representatives in the Wastewater Analytical Task Force.

The FAA subcommittee evaluated the sewer district upstream from each system meter to determine whether the flows measured by the system meter are reasonably representative of the flows generated by residential and nonresidential sources within the sewer district. The subcommittee concluded reasonable estimates of flow could be obtained from directly metering the “D+ Direct” districts where 53% of Detroit’s sewer flow occurs. The D+ Direct districts are shown in color on Figure 1, Detroit Meter District Areas. The system meters in the D+ Direct districts provided measurement of total flows generated in these districts and DWII and wet weather flows were calculated by the subtraction of sanitary flows.

Line H: This line contains the direct estimate of sanitary, DWII and wet weather flow from D+ Direct districts. About 66% of the total D+ flow is accounted for by the sanitary flow estimate for all D+ districts plus the DWII and wet weather flows from the D+ Direct districts.

Line I: The remaining sewer districts in Detroit are termed “D+ Incremental.” GLWA system meters measuring flows in the interceptors in these sewer districts (“D+ Incremental districts”) cannot be used to estimate total D+ flows generated within these districts for two reasons. First, these interceptors also convey suburban flows. Second, by the time the flow reaches the metering points the GLWA interceptors have received a significant volume of DWII from leaks and cracks in those interceptors. This particular DWII flow is considered to be part of Common flow and is not used in establishing SHARES. Thus, these D+ Incremental system meters measure the combined total of three different flow sources. Although the suburban flow can in principle be subtracted from the measurement of combined flow, there is not a direct way to separate the remaining flow between D+ flow and GLWA DWII.

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The FAA subcommittee developed a two-step process for estimating flows from the D+ Incremental sewer districts. First, as explained above, sanitary flow was calculated based on retail water sales, just as was done for the M and D+ Direct areas. It should be noted small adjustments were made to account for unmetered accounts and to match billings. The sanitary flow in the D+ Incremental areas was estimated using the same approach used in the M and D+ areas. This flow (49 cfs) when added to D+ Direct flow accounts for about 66% of total D+ flow. Thus, 34% of total D+ flow was estimated by indirect methods.

In the second step, the FAA subcommittee started with the DWII and Wet Weather flows generated in the D+ Direct districts. The FAA subcommittee analyzed the flow generation characteristics from the D+ Direct districts on a “unitized” basis, that is, expressed as flows per land area (total, impervious and pervious), per capita, per interceptor length and diameter with the goal of identifying correlations between one or more of these characteristics and DWII and Wet Weather flows generated in the D+ Direct districts. The FAA subcommittee tried a linear correlation to impervious land area with a coefficient of determination (R^2) of 0.65 as the best correlation for Wet Weather flow. For DWII, none of the unitizations provided a strong correlation.

The FAA subcommittee continued its efforts by developing a DWII projection technique for DWII in the D+ Incremental districts with other components 1) an estimate of interceptor DWII; 2) an estimate of the portion of DWII related to nonrevenue water (note: this is not the NNNW analysis) and 3) the total remaining D+ Direct district DWII was unitized by total D+ Direct district land area applied to each D+ Incremental district’s land area. The process involved a sequence of multiple steps in which D+ Direct flows were broken down into components, unitized, and then used to build up the D+ Incremental DWII and Wet Weather flows from those components.

To evaluate the range in possible estimates of D+ Incremental DWII and Wet Weather flows, the FAA subcommittee developed two estimates of those flows by varying certain factors and assumptions used in unitizing and adjusting the flow estimates derived from the D+ Direct districts. These alternatives were referred to as 2016A and 2016B. By the nature of several of its assumptions, Alternative 2016A was felt to produce an estimate of D+ Incremental toward the lowest end of the range for D+ Incremental and consequently an estimate of Common flow toward the high end of the range for that flow. Alternative 2016B was adjusted by increasing several of the factors driving DWII flow in four of the six D+ Incremental districts by 20%. The rationale

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for increasing these factors was that D+ sewers in in D+ Incremental area were older and therefore leakier and the proximity of the Detroit river would have a tendency to increase DWII compared to D+ Direct areas. The FAA subcommittee felt that 2016B produced flow estimates for D+ and Common more toward the middle of the range for both flows. Thus, the FAA subcommittee recommended that flow estimate 2016B be carried through an initial SHARE impact analysis.

Analyses of one D+ Incremental district deserve additional comment. Field work was conducted to attempt to identify the sources for the high flows in this district. This work included an extended video inspection of the interceptor, and manned inspections of several connecting sewers. Some sources of river inflow were found but not enough to explain the unexpectedly high flow. Likewise, two water main leaks were located, accounting for some of the excess flow.

Line J: Total D+ flow is the sum of D+ Direct plus D+ Incremental flows.

Line K & L: As was the case for “M” flow, there is some leakage from GLWA water mains into D+ customers’ sewers. There is also leakage from D+ water mains into GLWA interceptors. These were estimated and netted against each other to produce the value on Line K. This was estimated and deducted from Line J to produce Line L, D+ Total (Adjusted).

c) Total Wastewater Generated, Line M

Line M: Total generated flow is the sum of M Total (Adjusted) and D+ Total (Adjusted).

d) Total Wastewater to Plant, Lines N to Q

Line N: Flows during extreme wet weather events can exceed WRRF plant capacity and the holding capacities of the CSO basins. When that occurs, some wet weather flows are discharged to the Detroit River after receiving primary treatment and chlorination. Approximately 5% of total generated flows are discharged.

Lines O & P: Because this CSO flow is discharged to the Detroit River, it does not reach the WRRF and is not treated. This flow is subtracted from M and D+ customers’ flow in proportion to their share of CSO system cost allocation. D+ customers are allocated 88.7% of CSO costs and get 88.7% of this CSO discharge credit.⁸ M customers received the balance of the credit.

Line Q: Net customer generated flow to the WRRF is equal to Total Wastewater Generated, less the CSO diversion.

⁸ This credit differs from the 83/17 CSO allocation because the flows of several of the suburban customers in the 17% are included in D+ flow, so their CSO share needs to be added to Detroit’s to develop a credit against total D+ flow.

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e) Adjusted Wastewater Flow To Plant, Lines R to V

Line R: The WRRF includes two pump stations that convey the sewerage flows from the collection system into the facility. The flows at Pump Station 1 (“PS1”) are estimated using pump curves and the flows at Pump Station 2 (“PS2”) are measured directly using magmeters. Estimating the total wastewater flow into the plant is complicated because some flows recycled within the plant are measured as part of the incoming flow of these two pump stations. GLWA took steps to improve the accuracy of the estimate of total wastewater flow entering the plant. First, GLWA calibrated the pump curves used at PS1. Pump curves relate the pumping capacity of a given pump to the height of the wastewater in the pump station wet well. Second, GLWA calibrated the flow meters at PS2. The sum of these two pump stations represents the total flows pumped at the plant, including the recycled flows. The improved and calibrated total flow results are reported on Line R.

Line S & T: As mentioned, the total WRRF flow includes recycled flows. Most recycled flows are metered by the Screen Final Effluent meters, which are calibrated similarly to the other meters in the sewer collection system. In addition, GLWA improved the estimate of the recycled flows in 2013 by evaluating the magnitude of other sources of recycled flows. These were estimated at 12 mgd and are added to the metered recycled flows to determine the total estimated recycled flow as given on Line S. This flow is deducted from the flow estimate on Line R to yield Line T, “Adjusted WRRF Total.”

Lines U & V: Two final flow adjustments are required to create Adjusted WRRF Total. The WRRF data on Lines R to T are based on the actual flow data for the fiscal year. To produce a consistent four-year flow data set, the OMIDDD diversion, Line D, and the WTUA diversion, Line F, are subtracted from Line T, just as the diversions were subtracted from M Total to produce Line G.

f) Estimates of Common Flow

In 2013, the wholesale customers agreed as part of rate simplification that Common flow could be omitted from allocation calculations because, being allocated *pro rata* on flow, it did not influence SHARES.

As noted above, Common flow in the GLWA interceptors is flow that comes from inflow and infiltration into GLWA interceptors. Given the multiple flows in the GLWA interceptors in the D+

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areas (suburban, D+ and GLWA interceptor DWII), it is difficult to accurately measure Common flow. It was not measured as part of calculating Shares for the first Charge Period.

Under time constraints in setting SHARES for the first Charge Period, estimates of D+ and Common flows were not prepared in 2013. Instead, the actual allocations of common-to-all revenue requirements for FY 2008 to FY 2012 were reviewed. A value of Common flow as a fraction of Total WRRF flow was deduced which replicated the combined share of the common-to-all budget paid by the M customers between FY 2008 and FY 2012. Because this value was developed to replicate the allocation of CTA costs in prior years and was not based on measurements of flow, this was called “Z” and its percentage of WRRF flow was called the “Z factor.” Initially the Z factor for the FY 2015 to 2017 Charge Period was 14.87% and Z was calculated as 14.87% of WRRF flow. The Z Factor for FY 2016 was revised to 16.21% to reflect the effect on the calculation of Z due to the diversion of OMID flow in FY 2016. D+ was calculated as Total WRRF flow minus M and minus Z. Note that the only real flow numbers in this computation are Total WRRF flow and M.

This calculation sequence shifts any overestimate or underestimate of WRRF, M or Z flows to D+. Detroit believed Z underestimated the actual Common flow in the GLWA interceptors, causing an overestimate of D+ flow. Detroit agreed to 2013 rate simplification on the assurance that a better estimate of D+ would be developed before the next Charge Period.

Line W: For the next Charge Period, Common flow is estimated as Adjusted WRRF Total with OMID and WTUA diversions (Line V) minus Total Wastewater Toward Treatment at WRRF (Line Q).

g) Flow Summaries, Lines X to AD

Lines X to AA: These lines express Common, M and D+ flows as a percentage of Adjusted WRRF Total minus OMID and WTUA diversions (Line V). Line X, Common Flow %, is analogous to the Z Factor used in the first Charge Period. However, there is an important difference. Now D+ is calculated directly and Common is the flow that cannot be accounted for as generated by either M or D+ customers.

Lines AB to AD: Because Common flow is excluded from SHARE allocation calculations, the relevant flows for allocation purposes are only M and D+. Lines AB and AC show the relative flow shares of M and D+ when Common flow is excluded.

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2. Splitting D+ Among Non-Metered Customers

The FAA subcommittee did not address the procedure to split D+ flows among all the D+ customers.

3. Summary Flow Balance Conclusions

The FAA subcommittee concluded:

- The estimate of D+ flow derived to replicate historic shares for the first Charge Period can be replaced by an actual estimate of D+ flow based principally on the procedures used to estimate flow of the M customers.
- Currently, Z, the surrogate for Common flow, is set at 16.25%. The best available data was tabulated into Table 1, the FAA Subgroup Results Summary. In this table, Common flow is stated as 20.5%.
- A reasonable midrange estimate based on a four-year average is: Common, 20.5%; M, 42.0%; and D+: 37.1% - all set forth in Table 1, Lines X, Y and Z.
- At this midrange estimate, the relative balance of total flow between M and D+ changes only slightly from 2013.⁹
- A metering plan within D+ areas should be developed to improve estimates of D+ flow.
- Further effort should be devoted to identifying sources of DWII in GLWA interceptors.

4. Estimates of Flow by Type: Sanitary, DWII and Wet Weather

Because flow strength has increased as a cost factor, GLWA requested that estimates of sanitary, DWII and wet weather flows be reviewed. The flow volume analyses were built up from estimates of sanitary and DWII flow. On days without rainfall, only sanitary and DWII flows occur. Building on work performed during the 2013 rate simplification effort, the subcommittee concluded a reasonable estimate of sanitary flow for master-metered wholesale water customers is 90% of metered retail water usage during winter months when landscape watering does not occur plus 100% of nonresidential water use. For areas where water use is not measured at master meters (primarily the D+ communities), sanitary flow was estimated as 95% of retail water sales. This effort included an emphasis of improving estimates of water sales in the D+ communities.

⁹ See, The Foster Group, "Preliminary Proposed FY 2018 SHARE Calculations" (November 30, 2016), Exhibit Page 2, for FY 2013 flow balance.

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The amount of DWII flow could be estimated on dry days using data on sewer flow and water sales within areas having sewers, calculated as total metered sewer flow minus estimated sanitary flow. To assist in the evaluation of DWII flow, flow data was also collected during the middle of the night when it was expected most flow would be DWII.

On days when weather events create wet weather flow into the sewer system, wet weather flow is calculated as total metered sewer flow minus sanitary and DWII flows as calculated from “dry” day data. In practice applying this simple conceptual approach is challenging and substantial effort was required to review, refine and analyze the data. In particular, the FAA subcommittee concluded there is substantial uncertainty in estimating DWII in D+ Incremental.

When reviewed on a customer-by-customer basis, estimates of flow components changed significantly for some customers. That is, some customers saw a significant increase in the estimate of their sanitary flow component and reduction in the DWII and/or wet weather component while others saw an increase in the estimate of their DWII or wet weather flow and a decrease in sanitary. Because of the higher costs to deal with sanitary flow, customers with increased estimates of sanitary flow can expect an increase in their SHARES and those with decreased sanitary flow estimates can expect a SHARE reduction, all other things being equal.

C. Financial Subcommittee

1. Review of Cost Allocation on Strength

Strength of flow was introduced as a cost factor in FY2011. Costs are now allocated between flow and flow strength based on the 1979 CDM study. GLWA staff reviewed the study in the context of current operations. GLWA staff concluded that the bases for allocation adopted in 1979 remain a reasonable basis to allocate cost for the next Charge Period.

2. Cost of Service Study

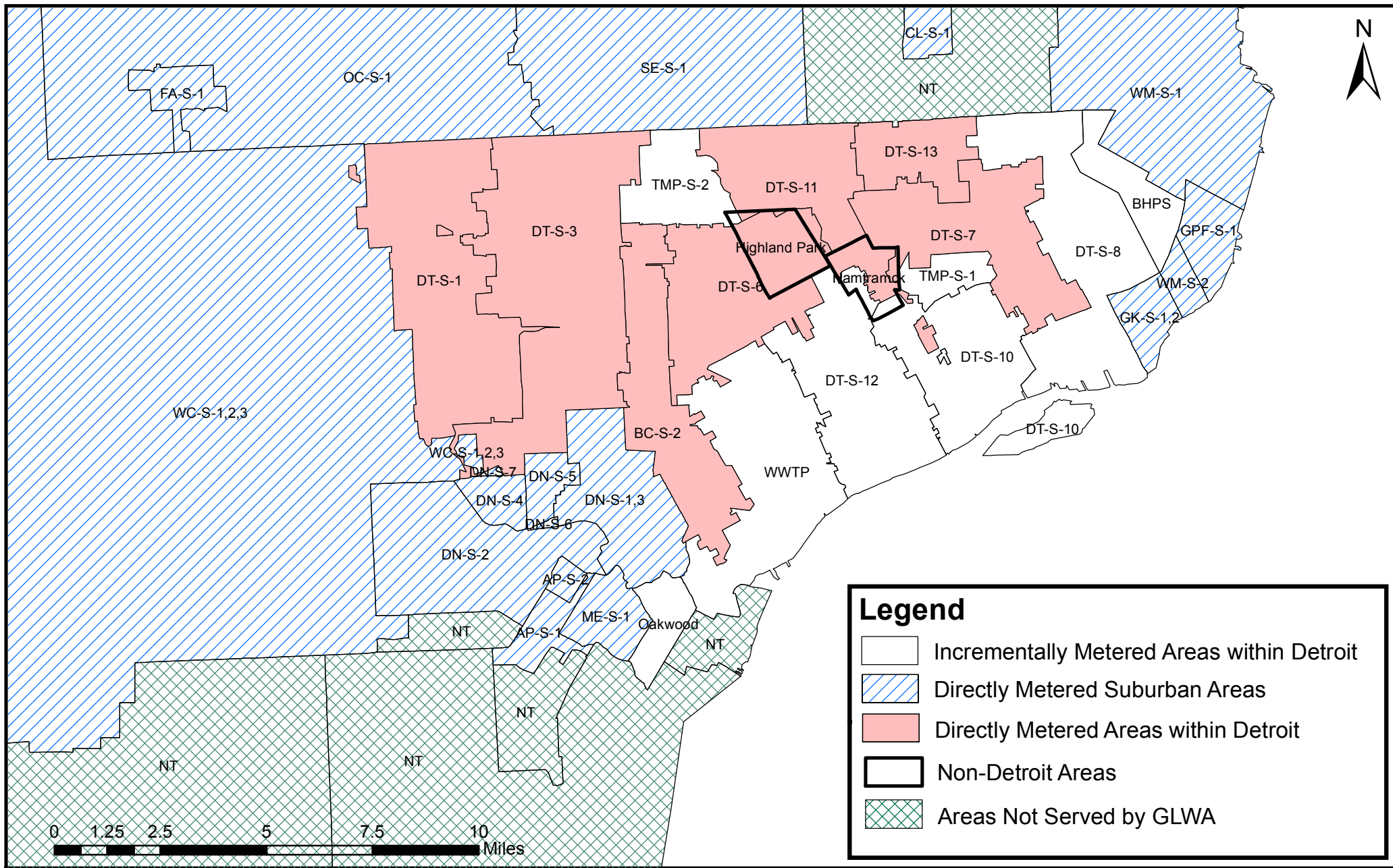
Detroit requested a Cost of Service study conducted by a nationally recognized firm (which would include customer input). Detroit believes the study should focus on cost allocation. The suburban members requested a similar study without the national firm, believing that GLWA and its customers have the resident/consulting expertise to conduct the study. In particular, the suburban customers requested consideration of using peaking factors and capacities for cost allocation.

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


3. Review of General and Administrative Cost Allocation

Detroit has requested a review of the bases for the allocation of General and Administrative costs. In response, GLWA asked the Customer Outreach to organize a workshop with broad customer participation to consider Detroit's request. The first workshop was held February 14, 2017.

Figure 1: Detroit Meter District Areas



Legend

-  Incrementally Metered Areas within Detroit
-  Directly Metered Suburban Areas
-  Directly Metered Areas within Detroit
-  Non-Detroit Areas
-  Areas Not Served by GLWA

T A B L E 1

**Sewer Shares Assessment Group
Flow Analysis Approach (FAA) Subgroup Results Summary**
with WTUA removed

| | | FY 12-13 | FY 13-14 | FY 14-15 | FY 15-16 | 4-year average |
|--|-----|----------|----------|----------|----------|----------------|
| M Total | cfs | A | 440 | 433 | 419 | 425 |
| Net Nonlocal Non Revenue Water (NNNW) in M | cfs | B | 3 | 3 | 3 | 3 |
| M Total Adjusted for NNNW in M | cfs | C | 405 | 430 | 416 | 422 |
| OMID Diversion | cfs | D | 13 | 14 | 12 | 13 |
| M Total (Adjusted for NNNW) with OMID diversion | cfs | E | 392 | 423 | 404 | 409 |
| WTUA | cfs | F | 6 | 5 | 3 | 5 |
| M Total (Adjusted for NNNW) with OMID diversion and WTUA exit | cfs | G | 386 | 412 | 401 | 404 |
| D+ Direct | cfs | H | 222 | 213 | 193 | 213 |
| D+ Incremental | cfs | I | 196 | 182 | 165 | 184 |
| D+ Total | cfs | J | 418 | 395 | 358 | 397 |
| Net Nonlocal Non Revenue Water (NNNW) in D+ | cfs | K | 8 | 7 | 6 | 7 |
| D+ Total Adjusted for NNNW in D+ | cfs | L | 410 | 388 | 352 | 389 |
| Total Wastewater Generated | cfs | M | 796 | 824 | 753 | 793 |
| CSO discharges | cfs | N | 32 | 55 | 25 | 42 |
| M Total (Adj. for NNNW) with OMID diversion, Adj. for CSO discharges | cfs | O | 382 | 409 | 398 | 399 |
| D+ Total (Adj. for NNNW), Adjusted for CSO discharges | cfs | P | 381 | 360 | 330 | 352 |
| Total Wastewater Toward Treatment at WRRF | cfs | Q | 764 | 745 | 728 | 751 |
| WRRF Total (with correction based on dye-dilution results) | cfs | R | 1,035 | 1,089 | 984 | 1,039 |
| Recycle | cfs | S | 79 | 77 | 68 | 77 |
| Adjusted WRRF Total | cfs | T | 956 | 1,012 | 916 | 963 |
| Adjusted WRRF Total with OMID diversion | cfs | U | 943 | 998 | 903 | 950 |
| Adjusted WRRF Total with OMID diversion and WTUA exit | cfs | V | 937 | 991 | 900 | 944 |
| Common Flow | cfs | W | 174 | 222 | 204 | 193 |
| Common Flow% | | X | 18.5% | 22.4% | 19.2% | 20.5% |
| M% | | Y | 40.8% | 41.3% | 44.2% | 42.0% |
| D+% | | Z | 40.7% | 36.3% | 36.6% | 37.1% |
| Total | | AA | 100.0% | 100.0% | 100.0% | 100.0% |
| M Flow Share% | | AB | 50.1% | 53.2% | 54.5% | 53.1% |
| D+ Flow Share% | | AC | 49.9% | 46.8% | 45.5% | 46.9% |
| Total | | AD | 100.0% | 100.0% | 100.0% | 100.0% |

Note: WTUA exit from RVSDES currently represented as a removal of all WTUA flows. Actual exit plan is not currently defined, therefore flow rate for WTUA exit may need to be updated.

TABLE 2
Strength of Flow Research Summary

Great Lakes Water Authority
Sewer Shares Assessment Team
Strength of Flow Subgroup

Strength of Flow - Research Summary

| PARAMETER | Strength of Flow (mg/l) | | | | | | | Median/Average Values | | |
|----------------|---------------------------|-------------------------|--|---------------------|--|---|----------------------------|-----------------------|------------------|---|
| | SANITARY (SAN) | | WET WEATHER (WW) | | | DRY WEATHER INFILTRATION/ INFLOW (DWII) | | SANITARY (SAN) | WET WEATHER (WW) | DRY WEATHER INFILTRATION/ INFLOW (DWII) |
| BOD | 300 - 350 ⁽¹⁵⁾ | 100-300 ⁽¹⁷⁾ | 11.5 (median) 14.1 (mean) ⁽³⁾ | 8.6 ⁽⁶⁾ | 9 (median) 15 (90th %) ⁽⁷⁾ | 0 ⁽¹⁸⁾ | 0.294-0.802 ⁽⁹⁾ | 262.5 | 9.7 | 0 |
| TSS | | 100-350 ⁽¹⁷⁾ | 54.5 (median) 78.4 (mean) ⁽³⁾ | 59 ⁽⁶⁾ | 100 (median) 300 (90th %) ⁽⁷⁾ | 3 ⁽¹¹⁾ | 1.78-2.09 ⁽⁹⁾ | 225 | 71.17 | 3 |
| Phosphorous, P | | 6-20 ⁽¹⁷⁾ | 0.259 (median) 0.315 (mean) ⁽³⁾ | 0.27 ⁽⁶⁾ | 0.33 (median) 0.70 (90th %) ⁽⁷⁾ | 0.05 ⁽⁸⁾ | | 13 | 0.29 | 0.05 |

^(x) = Source No. (See Bibliography)

Notes:

- SAN = Raw domestic sewage, no DWII
 WW = Stormwater runoff
 Source 3 = Table 7, median and mean event mean concentration (EMC) data (nationally pooled values from combined data sets, including NURP values and USGS data) EMCs represent the concentration of a specific pollutant contained in stormwater runoff coming from a particular land use type within a watershed. Event mean concentrations are generally used for calculating runoff pollutant loads for urban land use types.
 Source 6 = Table 1, median values from total of 3493 observations for TSS and 3105 observations for BOD₅
 Source 7 = Tables 6-17, median values and 90th percentile values
 Source 8 = Table 2
 Source 11 = Interpretation of Table 9, Median of 3mg/l
 Source 15 = Conclusion was BOD undiluted domestic sewage = 300 mg/l
 Source 15 = Reference was made to 350 mg/l as EPA design guidance for domestic sewage

Median/Average Value Justification:

In most reference sources, specific values or ranges were provided and entire data set of values were not available.

SAN

- BOD Average of [source 15 max and min averaged and source 17 max and min averaged]
 TSS Average value of max and min - entire data set not available to assess true average or true median
 P Average value of max and min - entire data set not available to assess true average or true median

WW

- BOD Average of median values from sources 3, 6 and 7 = average of 11.5, 8.6, 9
 TSS Average of median values from sources 3, 6 and 7 = average of 54.5, 59, 100
 P Average of median values from sources 3, 6 and 7 = average of 0.259, 0.27, 0.33

DWII

- BOD Source 18 stated textbook assumption/accepted BOD value in groundwater. Source 9 from Pakistan, no used.
 TSS Source 11 provided true median of data set. Source 9 from Pakistan, so not used.
 P Only value found in research.

TABLE 2 Strength of Flow Research Summary

Great Lakes Water Authority
Sewer Shares Assessment Team
Strength of Flow Subgroup

Strength of Flow - Research Bibliography

| WEB SOURCES | | | | |
|-------------|---|--|--|---------------|
| Source No. | WEBSITE TITLE | ARTICLE TITLE | AUTHOR/PUBLISHER | DATE ACCESSED |
| 1 | https://www3.epa.gov/region1/ssp/pdfs/Guide4EstimatingInfiltrationInflow.pdf | Guide for Estimating Infiltration and Inflow | United States Environmental Protection Agency | 5/16/2016 |
| 2 | https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-20.pdf | Design Flow and Loading Determination Guidelines for Wastewater Treatment Plants | Minnesota Pollution Control Agency | 5/16/2016 |
| 3 | http://el.erdc.usace.army.mil/elpubs/pdf/twrap04-3.pdf | Review of Published Export Coefficient and Event Mean Concentration (EMC) Data | Jeff P. Lin | 5/16/2016 |
| 4 | http://pubs.usgs.gov/wri/1987/4036/report.pdf | US Geological Survey Urban-Stormwater Database of Constituent Storm Loads; Characteristics of Rainfall, Runoff, and Antecedent Conditions; and Basin Characteristics | Martha Mustard, Nancy Drive, John Chyr and Brian Hansen | 5/17/2016 |
| 5 | http://stormwater.pca.state.mn.us/index.php/Total_Suspended_Solids_(TSS)_in_stormwater | Total Suspended Solids (TSS) in Stormwater | Minnesota Pollution Control Agency | 5/17/2016 |
| 6 | http://www.bmpdatabase.org/nsqd.html | National Stormwater Quality Database | Dr. Robert Pitt, P.E., University of Alabama and the Center for Watershed Protection, supported by U.S. EPA | 5/18/2016 |
| 7 | https://www3.epa.gov/nrdes/pubs/sw_nurp_vol_1_finalreport.pdf | Results of the Nationwide Urban Runoff Program Volume I - Final Report | U.S. Environmental Protection Agency - Water Planning Division | 5/18/2016 |
| 8 | http://mi.water.usgs.gov/pubs/WRIR/WRIR00-4120/pdf/wholereport.pdf | Ground Water Quality Atlas of Oakland County, Michigan | U.S. Department of the Interior, U.S. Geological Survey, prepared in cooperation with Oakland County Health Division | 5/18/2016 |
| 9 | http://www.arpnjournals.com/jabs/research_papers/jabs_0906_23.pdf | Pollution Load in Industrial Effluent and Ground Water of Gadoon Amazai Industrial Estate (GAIS) Swabi, NWFP | Journal of Agricultural and Biological Science | 5/27/2016 |
| 10 | http://water.ky.gov/groundwater/Documents/BMU2_NPS_report3.pdf | | | 5/31/2016 |
| 11 | http://kgs.uky.edu/kgsweb/olops/pub/kgs/of_04_04.pdf | Summary and Evaluation of Groundwater Quality in the Upper Cumberland, Lower Cumberland Green, Tragewater, Tennessee, and Mississippi River Basins | R. Stephen Fisher, O Barton Davidson Kentucky Geological Survey University of Kentucky | 5/31/2016 |
| 12-14 | Reserved | | | |

| NON-WEB SOURCES | | | | |
|-----------------|--|---|----------------------|----------------|
| Source No. | ARTICLE TITLE | JOURNAL/TEXTBOOK/OTHER | AUTHOR/PUBLISHER | DATE PUBLISHED |
| 15 | A Clearer View on Clear Water: How much infiltration and inflow does your system really have? | Water Environmental & Technology Magazine, Volume 28, Number 4 | George E. Kurz | Apr-16 |
| 16 | Recommended Standards for Wastewater Facilities, 2014 Edition (Ten States Standards) | | | 2014 |
| 17 | Chapter 28 | Civil Engineering Reference Manual for the PE Exam, 13th Edition | Michael R. Lindeburg | 2012 |
| 18 | Chapter 2 - Wastewater Characteristics | Biological Wastewater Treatment Volume I, Wastewater Characteristics, Treatment and Disposal | Marcos con Sperling | 2007 |

TABLE 3

Summary of Strength Ratio Recommendations

| Basis | Description |
|-------|---|
| 1 | <ul style="list-style-type: none"> - DWII Concentrations determined from sample data and research results - Wet Weather Concentrations calculated from sample data using research ratios of Wet:Sanitary concentrations - FOG concentrations undetermined by research; Wet Weather :Sanitary Ratio assumed to be 33% - Sanitary Concentrations calculated from sample data using DWII Concentrations and Wet:Sanitary ratios - Sanitary Concentrations for wet days and dry days averaged based on annual number of wet and dry days |
| 2 | <ul style="list-style-type: none"> - DWII, Sanitary and Wet Weather Concentrations determined from research results - FOG concentrations undetermined by research; DWII:Sanitary Ratio assumed to be zero, Wet Weather :Sanitary Ratio assumed to be 33% - Ratio to sanitary concentrations rounded to whole number percentage |
| 3 | <ul style="list-style-type: none"> - Research results used to input ratios of DWII:Sanitary and Wet:Sanitary into calculation - FOG concentrations undetermined by research; DWII:Sanitary Ratio assumed to be zero, Wet Weather :Sanitary Ratio assumed to be 33% - Sanitary Concentrations for wet days and dry days averaged based on annual number of wet and dry days |

| Basis | DWII Concentrations (mg/L) | | | | Sanitary Concentrations (mg/L) | | | | Wet Weather Concentrations (mg/L) | | | |
|-------|----------------------------|-------|------|------|--------------------------------|--------|--------|-------|-----------------------------------|--------|-------|-------|
| | TP | TSS | BOD | FOG | TP | TSS | BOD | FOG | TP | TSS | BOD | FOG |
| 1 | 0.20 | 10.00 | 7.00 | 0.00 | 5.00 | 471.28 | 287.19 | 38.66 | 0.13 | 183.58 | 15.23 | 15.49 |
| 2 | 0.05 | 3.00 | 0.00 | NA | 13.00 | 225.00 | 262.50 | NA | 0.29 | 71.17 | 9.70 | NA |
| 3 | 0.02 | 4.92 | 0.00 | 0.00 | 4.84 | 369.02 | 259.15 | 40.34 | 0.13 | 183.83 | 15.70 | 17.88 |

| Basis | DWII Ratios | | | | Sanitary Ratios | | | | Wet Weather Ratios | | | |
|-------|-------------|------|------|------|-----------------|------|------|------|--------------------|-------|------|-------|
| | TP | TSS | BOD | FOG | TP | TSS | BOD | FOG | TP | TSS | BOD | FOG |
| 1 | 4.0% | 2.1% | 2.4% | 0.0% | 100% | 100% | 100% | 100% | 2.5% | 39.0% | 5.3% | 40.1% |
| 2 | 1.0% | 1.0% | 0.0% | 0.0% | 100% | 100% | 100% | 100% | 2.0% | 32.0% | 4.0% | 33.0% |
| 3 | 0.4% | 1.3% | 0.0% | 0.0% | 100% | 100% | 100% | 100% | 2.7% | 49.8% | 6.1% | 44.3% |

ATTACHMENT 1

**FINANCING AND
CHARGES FOR
WASTEWATER SYSTEMS**

WEF Manual of Practice No. 27

*Prepared by
Financing and Charges for Wastewater Systems Task Force
of the Water Environment Federation*

McGraw-Hill

New York Chicago San Francisco Lisbon London Madrid
Mexico City Milan New Delhi San Juan Seoul
Singapore Sydney Toronto

Water

Practice

ATTACHMENT 1

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Chapter 6

Allocating Costs-of-Services to Cost-Causative Components

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| Cost-Causative Factors | 95 | <i>Net Capital Costs</i> | 113 |
| Fundamental Cost Allocation Approaches | 99 | <i>Payment-in-Lieu-of-Taxes</i> | 115 |
| Design-Basis Cost Allocation Methodology | 100 | <i>Operations and Maintenance Expenses</i> | 115 |
| Design-Basis Allocation of Plant Investment and Payment-in-Lieu-of-Taxes | 100 | Exceptions for Operations and Maintenance Expense Allocations | 115 |
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Contract terms may also include a contractual peak rate of flow and contractual strength parameters for the wholesale customer. The design basis of cost allocation provides a direct linkage for allocating investment and capital related costs to wholesale service customers based on the design capacity of the various facilities used by the wholesale customer and the contractual capacities set forth in the wholesale contract.

Approach Limitations. Some utilities do not maintain records of their fixed assets in sufficient detail by utility function to readily use the design-basis methodology. In such cases, an engineer's surrogate estimates of asset design and cost details based on facilities and as-built drawings inspections may be required. Some utilities without a requirement to use monitoring or pretreatment programs may not maintain sufficient records by class of service to permit differentiation by volume and strength cost-causative parameters. Some utilities' billing records are not maintained by typical utility classes of service covering residential, commercial, institutional, and industrial customers, making allocations to classes difficult, if not impossible.

FUNCTIONAL COST ALLOCATION METHODOLOGY

Another frequently used cost allocation approach is the functional cost method. Costs by cost center or activity center are allocated to cost components using purpose-based cost-causative factors, shown in Table 6.7.

The functional cost method works well with governmental and utility-based charts of accounts. When utility charts of accounts are used, total costs by utility cost or activity centers are readily identifiable. When governmental charts of accounts are used, additional effort is required to assign revenue requirements to cost or activity centers. Interviews with knowledgeable utility staff provide estimates of the percentage of annual personnel time spent in each utility cost center. Reviews of electric bills, chemical invoices, and other materials and supplies purchases with knowledgeable utility staff provide indications of which bills pertain to particular cost centers. Either approach results in cost-of-service revenue requirements by cost centers that may be readily allocated to cost components by the purpose-based cost-causative factors shown in Table 6.7.

TABLE 6.7 An factors function

Facility and function

Collection sewer

Lift and pumpin

Interceptor sewer

Treatment plant
Grit or screen

Primary settl

Trickling filter

Aeration basi

Nutrient rem

Secondary set

TABLE 6.7 An example of the representative wastewater utility cost-causative factors functional cost methodology.

| Facility and function | Predominant purpose cost-causative factors |
|--|---|
| Collection sewers | The mains' purpose is to carry wastewater at variable rates of flow, so costs are assigned to the "volume" cost component. In the case of hybrid approaches, these costs may be assigned to both a volume and capacity component. |
| Lift and pumping stations | The stations' purpose is to move wastewater at variable rates of flow, so costs are assigned to the "volume" cost component. In the case of hybrid approaches, these costs may be assigned to both a volume and capacity component. |
| Interceptor sewers | The mains' purpose is to carry wastewater at variable rates of flow, so costs are assigned to the "volume" cost component. In the case of hybrid approaches, these costs may be assigned to both a volume and capacity component. |
| Treatment plant: Grit or screen chamber | The chamber's purpose is to remove debris and larger material carried by wastewater, so costs are assigned to the "suspended solids" cost component. |
| Primary settling basin | The settling detention basins' purpose is to remove suspended solids, so costs are assigned to the "suspended solids" cost component. |
| Trickling filters basins | The basins' purpose is to remove BOD from wastewater, so costs are assigned to the "BOD" cost component. |
| Aeration basins | The basins' purpose is to remove BOD from wastewater, so costs are assigned to the "BOD" cost component. |
| Nutrient removal | If the facilities' purpose is nitrogen removal, costs are assigned to the "TKN" cost component. Phosphorus is concurrently removed by chemical treatment, so such chemical costs are assigned to the "volume" cost component. If the facilities' purpose is phosphorus removal, cost would be assigned to the "P" cost component. |
| Secondary settling basin | The basins' purpose is to remove BOD from wastewater, so costs are assigned to the "BOD" cost component. |

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TABLE 6.7 An example of the representative wastewater utility cost-causative factors functional cost methodology (continued).

| Facility and function | Predominant purpose cost-causative factors |
|------------------------------|--|
| In-plant pipes and pumping | Costs for in-plant pipes and pumping are assigned to the cost component pertaining to their purpose: "volume", "suspended solids", or "BOD". |
| Disinfection | The facilities' purpose is to reduce bacteria and other pathogens at variable rates of flow, so costs are assigned to the "volume" cost component. |
| Residuals processing | The facilities' purpose is to handle and process sludge, so costs should be assigned to "suspended solids", "BOD", and "TKN" cost components in proportion to their respective current annual loadings at the plant. |
| Residuals disposal | The facilities' purpose is to dispose of sludge, so costs should be assigned to "suspended solids" and "BOD" cost components in proportion to their respective current annual loading at the plant. |
| Odor control | Odor control's purpose is to contain objectionable smells at the wastewater treatment or specific system facilities, so costs are assigned to the cost component representative of the purpose for each facility requiring odor control items. |
| Outfall sewer | The mains' purpose is to carry wastewater at variable rates of flow, so costs are assigned to the "volume" cost component. In the case of hybrid approaches, these costs may be assigned to both a volume and capacity component. |
| Reclaimed water treatment | The plant's purpose is to further treat wastewater at variable rates of flow, so costs are assigned to the "volume" cost component of reclaimed water service. |
| Reclaimed water distribution | The mains' purpose is to carry wastewater at variable rates of flow, so costs are assigned to the "volume" cost component of reclaimed water service. |

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FUNCTIONAL-BASIS ALLOCATION OF NET PLANT INVESTMENT AND PAYMENT-IN-LIEU OF TAXES. Table 6.8 provides an example of depreciated original cost plant investment allocated to cost components that recognizes predominant operating and service cost-causative purposes by facility during annual utility operations, as shown in Table 6.7. Cost components consist of volume, suspended solids, BOD, TKN, customer billing, and customer. Capital costs in lines 19 and 20 of Table 6.8 reflect *cash basis* revenue requirements determination. Allocations unique to this example are as follows:

- Sludge processing and disposal facilities are allocated 42% to suspended solids, 45% to BOD, and 13% to TKN functional cost components representing the current levels of annual loadings for this example. However, each plant's operating records should be accessed to determine the actual loadings on which to base percentage splits.
- Collection system costs are allocated to volume and customer cost functions. The 10% of collection system costs assigned to the customer function reflects an allowance for the relative size of the system and low density of development's impact on collection system costs. Also, the utility is assumed to use a minimum collection main size for cleaning purposes. Such sizing is independent of wastewater volumes carried by the mains.
- An assumed 25% of general plant costs covers wastewater's share of customer billing equipment.
- Contributed facilities may cover federal and state grants plus developer and individual customer contributions. For this example, contributions are assumed to be limited to collection system small mains and lift stations, which are allocated solely to the volume cost component.
- The net plant value on line 18 of Table 6.8 is expressed as original cost less the accumulated depreciation reserve for all fixed assets.

Net Capital Costs. "Net capital costs", in line 19 of Table 6.8, consist of annual debt service payments, equipment purchases, and capital improvements made from user-charge revenue, as shown previously in Table 5.3. Although not identified by this example case study, miscellaneous funding by system development charges, interest earnings on invested capital funds, and other capital fees should be deducted. Net capital costs are allocated to functional cost components in the same manner as "total

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TABLE 6.8 An example of the allocation of net plant investment and capital costs to cost components functional cost methodology.

| Line No. | (1) Total \$ | (2) Volume \$ | (3) Wastewater strength | | (6) Customer billing \$ | (7) Customer \$ |
|----------------------------|-----------------|------------------|-------------------------|------------|----------------------------|--------------------|
| | | | Suspended solids \$ | BOD \$ | | |
| Treatment plant in service | | | | | | |
| 1 | 7,558,000 | 7,558,000 | | | | |
| 2 | 5,434,000 | | 5,434,000 | | | |
| 3 | 3,327,000 | | 3,327,000 | | | |
| 4 | 11,435,000 | | | 2,082,000 | | |
| 5 | 2,082,000 | | | 9,318,000 | | |
| 6 | 9,318,000 | | | | | |
| 7 | 1,690,000 | 1,690,000 | | | | |
| 8 | 19,049,000 | | 8,001,000 | 8,572,000 | 2,476,000 | |
| 9 | 28,788,000 | | 12,091,000 | 12,955,000 | 3,742,000 | |
| 10 | 1,101,000 | 1,101,000 | | | | 0 |
| 11 | 3,751,000 | 432,000 | 1,205,000 | 1,766,000 | 0 | 0 |
| 12 | 93,533,000 | 10,781,000 | 30,058,000 | 44,046,000 | 8,648,000 | 0 |
| 13 | 4,092,000 | 4,092,000 | | | | 7,972,000 |
| 14 | 79,723,000 | 71,751,000 | | | 146,000 | 134,000 |
| 15 | 3,986,000 | 1,460,000 | 507,000 | 742,000 | 997,000 | 134,000 |
| 16 | 181,334,000 | 88,084,000 | 30,565,000 | 44,788,000 | 997,000 | 8,106,000 |
| 17 | 42,630,000 | 38,542,000 | 0 | 0 | 0 | 4,088,000 |
| 18 | 138,704,000 | 49,542,000 | 30,565,000 | 44,788,000 | 997,000 | 4,018,000 |
| 19 | 9,610,000 | 3,433,000 | 2,118,000 | 3,103,000 | 69,000 | 278,000 |
| 20 | 975,000 | 121,000 | 310,000 | 455,000 | 0 | 0 |
| 21 | 10,585,000 | 3,554,000 | 2,428,000 | 3,558,000 | 69,000 | 278,000 |

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Allocating Costs-of-Services to Cost-Causative Components

| | | | | | | | | |
|----|---------------------|------------|------------|------------|------------|-----------|-----------|-----------|
| 19 | Net capital costs | 9,610,000 | 47,242,000 | 30,262,000 | 44,788,000 | 8,794,000 | 997,000 | 4,018,000 |
| 20 | PILOT | 975,000 | 3,433,000 | 2,118,000 | 3,103,000 | 609,000 | 69,000 | 278,000 |
| 21 | Total capital costs | 10,585,000 | 50,675,000 | 32,380,000 | 47,891,000 | 9,403,000 | 1,066,000 | 4,296,000 |

net investment" in utility assets, shown on Line 18 of Table 6.8. This allocation approach recognizes the following:

- The investment in system assets reasonably represents the level of investment anticipated for the planning period that new rates are intended to be in place.
- If no new debt issues are anticipated beyond those recognized by the revenue requirements development, and annual capital expenditures are reasonably uniform regardless of the varying types of expenditure needs during the rate period, cost recovery from customer classes would remain reasonably consistent for the rate period.
- If cost recovery is reasonably consistent, rates will be reasonably consistent without considerable swings in rate levels during the rate period.

Payment-in-Lieu-of-Taxes. Payment-in-lieu-of-taxes, for this example and seen in line 20 of Table 6.8, is assumed to be based on current asset value for above ground facilities and computed in the same manner as ad valorem taxes are computed for similar investor-owned utility property. The assessors office should be able to identify or estimate the current appraised value of each above-ground utility facility. Care should be taken by the assessors office to recognize differences in commercial and utility property costs when determining current value.

Operations and Maintenance Expenses. The O&M expenses, by example, are allocated to cost components in Table 6.9 similarly to plant investment in Table 6.8. The O&M covers expenses for wastewater treatment, sludge disposal, industrial waste pretreatment program, transmission, collection, and administration functional-cost centers. Cost components consist of volume, suspended solids, BOD, TKN, customer billing, customer, and industrial surcharge. Net O&M expenses exclude miscellaneous revenue from other sources. The O&M expense cost centers are allocated to cost components by recognizing the purpose-based cost-causative factors from Table 6.7, with the exceptions discussed below.

EXCEPTIONS FOR OPERATIONS AND MAINTENANCE EXPENSE ALLOCATIONS.

- Costs by wastewater treatment and sludge removal cost centers are typically allocated to flow, BOD, suspended solids, and nitrogen cost components

ATTACHMENT 1

TABLE 6.9 An example of the allocation of operations and maintenance expense to cost components functional cost methodology.

| Line No. | (1) Total \$ | (2) Volume \$ | (3) Wastewater strength | | | (5) TKN \$ | (6) Customer billing \$ | (7) Customer \$ | (8) Industrial surcharge |
|----------------------|-----------------|------------------|-------------------------|-----------|---------|---------------|----------------------------|--------------------|-----------------------------|
| | | | Suspended solids \$ | BOD \$ | | | | | |
| Wastewater treatment | | | | | | | | | |
| 1 | 1,861,000 | | 782,000 | 837,000 | 242,000 | | | | |
| 2 | 745,000 | 745,000 | | | | | | | |
| 3 | 372,000 | 372,000 | | | | | | | |
| 4 | 745,000 | | 313,000 | 335,000 | 97,000 | | | | |
| Sludge disposal | | | | | | | | | |
| 5 | 1,954,000 | | 821,000 | 879,000 | 254,000 | | | | |
| 6 | 782,000 | 782,000 | | | | | | | |
| 7 | 391,000 | 391,000 | | | | | | | |
| 8 | 782,000 | | 328,000 | 352,000 | 102,000 | | | | |
| 9 | 1,093,000 | | | | | | | | |
| 10 | 8,725,000 | 2,290,000 | 2,244,000 | 2,403,000 | 695,000 | | 0 | 547,000 | 546,000 |
| Subtotal treatment | | | | | | | | | |
| 11 | | | | | | | | | |
| 12 | 503,000 | 503,000 | | | | | | | |
| 13 | 770,000 | 770,000 | | | | | | | |
| (continues) | | | | | | | | | |

TABLE 6.9 An example of the allocation of operations and maintenance expense to cost components functional cost methodology (continued).

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|-----|-----|-----|-----|---------------------|-----|-----|-----|
| | | | | Wastewater strength | | | |

| | | | | | | | | | |
|----|-------------------------|-----------|-----------|-----------|-----------|---------|---|---------|---------|
| 10 | Subtotal treatment | 0,123,000 | 2,270,000 | 2,244,000 | 2,403,000 | 023,000 | 0 | 217,000 | 270,000 |
| 11 | Wastewater transmission | 503,000 | 503,000 | | | | | | |
| 12 | Pump & lift stations | 770,000 | 770,000 | | | | | | |
| 13 | Equipment maintenance | | | | | | | | |

(continued)

TABLE 6.9 An example of the allocation of operations and maintenance expense to cost components functional cost methodology (continued).

| Line No. | (1) Total \$ | (2) Volume \$ | (3) Wastewater strength | | (4) BOD \$ | (5) TKN \$ | (6) Customer billing \$ | | (7) Customer \$ | (8) Industrial surcharge \$ |
|----------|--------------------------------------|------------------|-------------------------|-----------|---------------|---------------|-------------------------|-----------|--------------------|--------------------------------|
| | | | Suspended solids \$ | | | | | | | |
| 14 | Supervision | 456,000 | | | | | | | | |
| 15 | Subtotal transmission | 1,729,000 | 0 | | 0 | 0 | | 0 | | 0 |
| 16 | Wastewater collection administration | 3,667,000 | 3,300,000 | | | | | 367,000 | | |
| 17 | Billing & collection | 1,142,000 | | | | | 1,142,000 | | | |
| 18 | Office of the director | 502,000 | 240,000 | 74,000 | 79,000 | 23,000 | 38,000 | 30,000 | 18,000 | |
| 19 | Engineering | 795,000 | 382,000 | 117,000 | 125,000 | 36,000 | 59,000 | 48,000 | 28,000 | |
| 20 | Planning & project management | 1,002,000 | 479,000 | 147,000 | 158,000 | 46,000 | 75,000 | 60,000 | 36,000 | |
| 21 | All other | 640,000 | 307,000 | 94,000 | 101,000 | 29,000 | 48,000 | 38,000 | 23,000 | |
| 22 | Subtotal administration | 4,081,000 | 1,408,000 | 432,000 | 463,000 | 134,000 | 1,362,000 | 176,000 | 105,000 | |
| 23 | Total operations & maintenance | 18,202,000 | 8,728,000 | 2,676,000 | 2,866,000 | 829,000 | 1,362,000 | 1,090,000 | 651,000 | |
| 24 | Operations & maintenance reserve | 66,000 | 32,000 | 10,000 | 10,000 | 3,000 | 5,000 | 4,000 | 2,000 | |
| 25 | Less revenue from other sources | 17,000 | 8,000 | 2,000 | 3,000 | 1,000 | 1,000 | 1,000 | 1,000 | |
| 26 | Net O&M expense | 18,251,000 | 8,752,000 | 2,684,000 | 2,873,000 | 831,000 | 1,366,000 | 1,093,000 | 652,000 | |

based on estimates of how personnel costs, chemicals, power, sludge removal and other budgeted line-item costs are generally used during the year. In this example, for personnel and other, the percentages used are 42% for suspended solids, 45% for BOD, and 13% for TKN, paralleling the current loadings handled by the plant. Power and chemical costs are assigned directly to the volume cost component.

- Some utility activities may benefit only specific users, such as waste pretreatment programs for industrial customers and customer billing and collection services. Such costs should be assigned directly to their corresponding cost components.
- Costs for treatment plant safety and security should be added in proportion to the total costs for the other cost parameters, much like general plant and administrative and general operating costs.
- Any costs for odor, vector, and corrosion control would be allocated to cost components using the same purpose bases as are used for the impacted treatment plant and collection system facilities.
- Administration costs for "office of director", "engineering", "planning and project management", and "all other" are assigned on the same basis as the totals of each cost components, excluding power and chemical costs so that the volume cost component will not be overstated. This allocation processes recognizes that, while the exact nature of administrative activities during any year cannot be known in advance with certainty, they will generally proportionally support the operations and services represented by the cost components over time, if not each year.

Approach Advantages. The functional-cost allocation methodology, by assigning the revenue requirements by cost or activity centers to cost components based on the function or purpose of the cost center, provides a practical means of demonstrating how a utility incurs its costs and what it costs a utility to serve each class. The allocation process is logical without requiring knowledge of specific design parameters. Furthermore,

- The approach may be used when fixed asset, treatment, and customer billing records are incomplete or when engineering design by system and plant components are not readily known.

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Allocating Costs-of-Services to Cost-Causative Components

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- The simplified cost allocation and rate development approaches are relatively easy for policymakers and the general public to understand.
- Operating expense and capital costs may be allocated to cost components using the purpose-based allocation of plant investment as a pattern to simplify the allocation process.
- For those utilities that have federal grants requiring the development of user-charge systems, the functional cost allocation methodology demonstrates how the utility fairly and equitably recovers operations, maintenance, and replacement capital costs (OM&R) from customers served.

Approach Limitations. In its basic form, the functional cost methodology for allocations of cost or activity centers to cost components is generally based on knowledgeable utility staff and rate analysts' estimates and opinions about a particular facility's purpose, rather than engineering design documentation. Though these estimates may reference information sources, such as costs recorded by utility charts of accounts, detailed plant investment records, and facility engineering design reports, these estimates and opinions are more subjective than reliance on specific engineering design information.

Another limitation of the functional-cost allocation methodology is that it may be based on current use and not recognize capacity built into the system to serve future customers or how that capacity should be recovered from the existing customers served. By default, when available or unused capacity is not separately recognized, the methodology assumes that capacity requirements are all the same for all customers and are reflected proportionately by each class's currently contributed volumes. Current-use volume proportionalities may not reflect customer class service capacity requirements used for system design. Large volume users tend to pay a greater share of total costs than they might otherwise have to bear if capacity is not recognized by the allocation methodology. To address this concern, however, hybrid approaches may be used to ensure that selected capacity-related costs may be assigned to both volume and capacity components.

As a corollary to the current use limitation described above, the functional-cost allocation methodology also does not lend itself as well as the design allocation methodology in the assignment of contract capacity-related costs for wholesale service customers. Typically, a wholesale customer's service contract specifies capacity limits for average daily flow, peak rates of flow, and strength parameters. The design

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Chapter 7

Distribution of Costs-of-Service to Customer Classes

| | | | |
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| Classification Factors | 123 | Unit Costs and Distribution of Costs to Customer Classes | 138 |
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INTRODUCTION

The costs incurred by a utility are directly related to the services it provides. Therefore, the process of identifying service characteristics of the utility's customers and distributing costs in proportion to their service demands are critical steps in the development of equitable rates and charges. If all customers had the same service characteristics, the cost of serving each customer would be equal. In this hypothetical case, a utility's costs could be distributed evenly among users, resulting in equal rates for all customers. In reality, however, this is not the case; different types of users have different service characteristics and, therefore, the costs associated with serving each customer varies. Because it is not practical or, in most cases, possible to determine the

cost of serving each customer individually, it is accepted industry practice to group customers with similar service characteristics into a limited number of classes to determine cost responsibility and, ultimately, rates applicable to each class.

Chapter 6 presented approaches and issues related to the allocation of wastewater system revenue requirements to cost-causative components. This chapter discusses the process of further distributing the system costs to customer classes based on their service demands. The assignment of cost responsibility to each customer class follows a three-step process as shown in Figure 7.1. First, customer classes are established and units of service are quantified for each class for the period that rates will be effective.

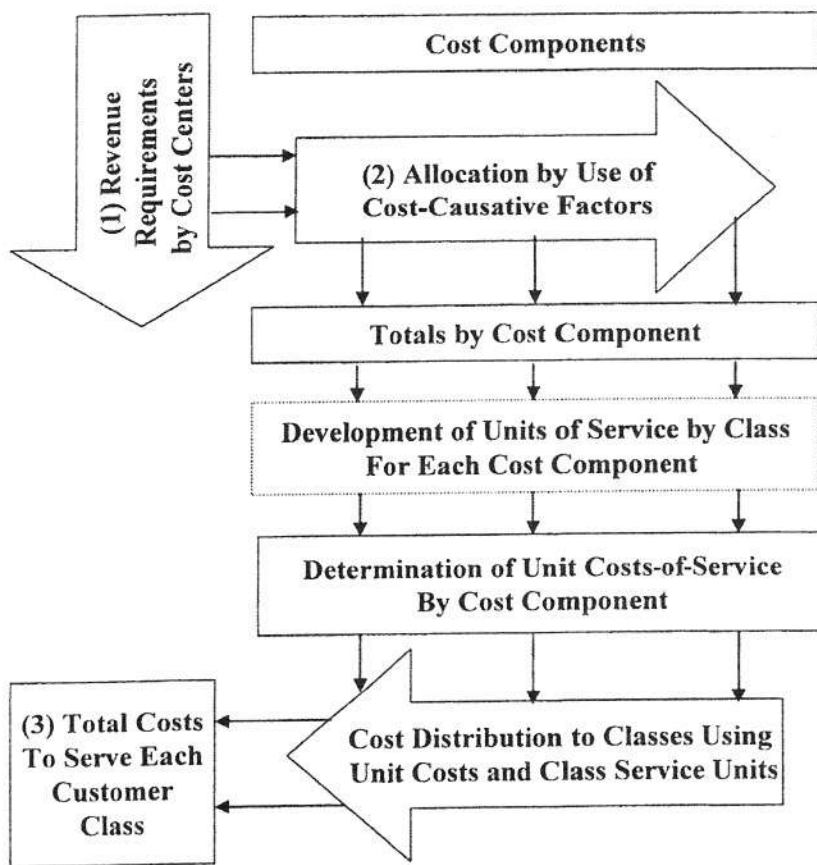


FIGURE 7.1 Cost-allocation flow chart.

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The service characteristics analyzed should parallel the cost-causative factors identified by the utility (discussed in Chapter 6). Second, unit costs are developed for each cost component or service characteristic. The third and final step is the distribution of costs to customer classes, based on individual class service units and component unit costs. Once costs have been identified for each customer class, rates may be developed to recover the assigned cost-of-service. Rate design is the subject of Chapter 8.

CUSTOMER CLASSES

CLASSIFICATION FACTORS. A careful analysis is necessary when establishing the appropriate classification of customers to ensure that the resulting customer classes consist of users with similar usage characteristics who are served at similar costs. Three factors are generally used to determine the appropriate classification of a utility system's customers: (1) general service requirements, (2) customer usage characteristics, and (3) geographic location.

Service requirements vary among customers, for instance, depending on whether they are receiving retail or wholesale service from the utility. A wholesale customer may, for example, own and maintain its own sewer collection mains and lift stations, and, therefore, in this case, its service and cost responsibility would be limited to the utility's larger interceptor, pumping, and treatment facilities. The utility's retail customers, on the other hand, may use the entire conveyance system so, in this case, separate classes are necessary to equitably assign costs to customers based on their specific service requirements. Table 7.1 lists different types of service requirements provided by utilities, along with a description of each.

As discussed in Chapter 6, wastewater quantity and strength are important cost-causative components of a wastewater system, as systems must be sized to handle both peak and average flows and to treat wastewater of varying strengths and composition. Therefore, classification of wastewater customers should also consider the volume, capacity, and strength characteristics of different types of customers' flows.

The third factor that should be considered when establishing customer classes is geographic location. One basis for differentiating customers geographically is with respect to corporate limits of the city or jurisdiction. Such a distinction may be appropriate if the utility incurs different costs when serving users located outside of the corporate limits, compared to serving similar users inside the city or jurisdiction limits. Also, differences in the owner-customer relationship between inside and outside city users may justify a different rate or rate approach between these two groups.

ATTACHMENT 1

TABLE 7.1 An example of different types of service requirements provided by utilities.

| Service type | Description |
|-----------------------|--|
| Retail | Primary users of the owning utility's collection system and backbone facilities. May reside either within corporate boundaries of the owning municipality, immediately adjacent to but outside the corporate boundaries of the owning municipality, or within the boundaries of a contract municipality being provided full retail service by the owning municipality. Investor-owned utilities typically provide retail service to their customers without regard to municipal boundaries, although they may also provide wholesale and contract service to others. |
| Wholesale | Use primarily the backbone facilities, especially if they provide retail service to customers in their own service area. Wholesale customers collect wastewater from their customers and transport it to points of connection with the owning utility treating the wastewater. These points of connection are typically to large interceptor mains of the owning utility. |
| Seasonal | Contribute wastewater during only a portion of a year, thereby affecting the owning utility with potentially annual peak volumes or high-strength loadings of wastewater during the short period that they use the system. In some cases, seasonal contributors are located adjacent to the owning utility's treatment plant and may deliver wastewater directly to the plant through a customer-owned service main, minimizing the customer's use of backbone facilities. |
| High-strength haulers | Tend to be residential customer septic tank waste haulers, although some may specialize in industrial pretreatment wastes. Such customers' service is limited to wastewater treatment and disposal. |
| Pretreatment | Typically industries which are required to treat their wastewater on-site to remove pollutants to specified levels before they may discharge the resulting lower strength wastewater to the owning utility's system. Establishing an industrial pretreatment program is a requirement for municipal utilities that received federal construction grants. The owning utility usually monitors pretreatment customers' activities and tests their discharges to the utility system at a fee paid by such customers. |

TABLE 7.1 A utilities (cont

| Service type |
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| Laboratory te |
| Combined sa stormwate |
| New custom service are. |
| Other geogra may be appr cant addition to discrete pc tion to the tr required and |

TABLE 7.1 An example of different types of service requirements provided by utilities (continued).

| Service type | Description |
|--|---|
| Laboratory testing | Provided by the owning utility to periodically monitor strengths of wastewater entering its system by its wholesale, commercial, and industrial customers. The data is used by the utility to make treatment adjustments so that its discharges to U.S. waters meet the utility's permit requirements. Some utilities provide this laboratory testing service for some customers or other municipalities for a fee. |
| Combined sanitary and stormwater service | Typically pertains to older municipal systems that have constructed combined disposal systems before changes in federal environmental law requiring either separation of the systems or treatment of all discharges. Such stormwater flows would typically affect a wastewater utility more significantly with peak volumes than would solely infiltration/inflow in a utility system. |
| New customers or service areas | Often a wastewater utility has system capacity in excess of current peak requirements to meet the needs of future customers. As a result, either the wastewater utility must construct, with its own resources, or new customers and developers must construct or pay the utility through system development charges or front foot benefit fees to construct extension sewers to serve new customers or areas. If tax revenues and front-end capital cost recovery charges are not available, costs associated with extra capacity must be collected in the owning utility's service charges or through a special or betterment assessment for capital cost recovery. |

Other geographical considerations include elevation and distance. Elevation factors may be appropriate to consider in cases where pumped wastewater requires significant additional costs relative to nonpumped service, and pumped service is provided to discrete portions of the service area (e.g., pump zones). Distance (generally, in relation to the treatment plant) may also be used as it relates to the length of pipe required and, therefore, the cost of service. (Generally, when solely dealing with inside city or inside district retail service, distance relative to the treatment plant[s] is not a consideration for cost-of-service differentiation among customers or customer classes.) Table 7.2 provides a summary of typical classification factors.

(continues)

TABLE 7.2 Summary of classification factors.

| Factor | Sample types |
|------------------------------|---|
| General service requirements | Retail Wholesale Seasonal High-strength haulers Pretreatment, laboratory testing Combined sanitary and stormwater service New customer or service areas |
| Usage characteristics | Wastewater flow <ul style="list-style-type: none"> • Customer contributed (volume and capacity) • Infiltration/inflow Wastewater strengths <ul style="list-style-type: none"> • Biochemical oxygen demand • Total suspended solids • Nitrogen • Phosphorous Customers Meter size |
| Geographic location | Inside or outside city Elevation (e.g., pump zones) Distance (e.g., from treatment plant) |

CLASSIFICATION APPROACHES. The appropriate classification system for a utility must balance equity and fairness considerations with other concerns, including administrative feasibility, revenue adequacy and stability, data availability, and public acceptance. Implementation of a highly disaggregated customer classification system may be complicated by the general problem of limited data to support customer class definitions and added administrative costs.

Historically, the typical approach to retail customer classification for wastewater utilities consisted of separate groups for residential, commercial, industrial, and, if applicable, classes for other types of services listed in Table 7.1 (i.e., wholesale customers). Residential customers typically include single-family dwellings, including mobile homes and trailers. Commercial users typically consist of business enterprises such as motels, hotels, restaurants, and general office and retail establish-

ments. Industrial establishments reflecting the... For instance, s... tomers, altho... trial classes b... tomers may b... commercial or

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ments. Industrial customers generally consist of manufacturing and processing establishments. Many exceptions to this "typical" practice are in place, often reflecting the prominence of particular types of users in a given utility service area. For instance, some communities may establish a separate class for institutional customers, although these customers tend to be included in the commercial or industrial classes based on the nature of their activities. In addition, multifamily customers may be grouped as a separate class or combined with other classes (i.e., commercial or residential).

A simplified approach—consisting of a relatively few customer classes—has been traditionally viewed as acceptable for two reasons: (1) rates were relatively low, and (2) limitations on data made it difficult to further disaggregate customer classifications by strength contributions of different types of users. Both of these conditions are changing, affording utility managers and policymakers the opportunity to advance rate equity, in some cases, through development of cost-of-service rates across a larger, better-defined set of customer classifications.

In communities where the diversity of the customer base warrants recognition of relative-strength contributions, two approaches are generally used: (1) extra-strength surcharges and (2) strength-based classifications. A hybrid approach may also be appropriate. The extra-strength approach is common among utilities that are required by law to set up pretreatment programs for specified industrial users and by some state agencies to monitor potential high-strength users such as laundries, restaurants, and car washes. Identified and monitored high-strength users pay a surcharge for strengths above domestic-strength wastewater. When determining class-service requirements, strengths related to surcharge customers are removed from the total and all customer classes receive a portion of remaining strength loading based on volume or other criteria.

Another approach is to assign commercial customers to separate classes; for example, to high, medium, and low wastewater strengths, or by particular types of businesses (i.e., restaurants, bakeries, or general office). Most utilities have relatively little site-specific data on the strength contributions of industrial and commercial customers who are not subject to industrial waste monitoring. As a result, assignment of customers to separate classes based on wastewater strengths will generally require expanded sampling efforts, supplemented with information from other communities or from standards developed by regulatory agencies or other sources. Similarly, many utilities do not have data on, or the data collection procedures necessary to monitor, the (often-changing) building uses of commercial customer accounts. As a

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result, establishment of separate classes for commercial customers requires a comprehensive review and supplementing of current customer account records and development of procedures to keep such information current.

Table 7.3 provides examples of the extra-strength, strength-based, and hybrid classification systems. Expansion of sampling programs and data collection procedures generally result in added administrative costs associated with a strength-based classification approach. In contrast, the extra-strength surcharge approach relies on readily available data from the industrial monitoring program. The hybrid approach incorporates standardized strength data for certain high-strength-type customers (i.e., laundries and restaurants) to disaggregate commercial customers beyond a single class. From an equity perspective, the strength-based and hybrid approaches may be desirable when significant diversity exists beyond those customers subject to monitoring requirements. The cost impacts need to be weighed against the community's equity and other objectives in determining the optimal classification approach.

TABLE 7.3 Sample wastewater customer classification approaches.

| Approach | Sample classes |
|--------------------------------|---|
| Extra-strength surcharge | Residential Commercial Industrial Extra-strength |
| Strength-based classifications | Residential Commercial* Low-strength (combined BOD & TSS of 400 mg/L or less) Medium-strength (combined BOD & TSS of 400 to 800 mg/L) High-strength (combined BOD & TSS of 800 to 1200 mg/L) Very high-strength (combined BOD & TSS of over 1200 mg/L) |
| Hybrid approach | Residential Commercial Industrial Standardized-strength class Extra-strength surcharge |

*Strength thresholds by subclass are for illustration only.

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UNITS OF SERVICE

Once customers have been classified into relatively homogeneous groups or classes, a common basis for identifying cost responsibility is established. Chapter 6 described the process of allocating wastewater system revenue requirements to cost components based on cost-causative factors, including wastewater flow (both contributed average and peak wastewater flow and infiltration and inflow), wastewater strengths, customer service, and other cost components (e.g., collection system acreage and density). The next step in the rate development process is to quantify the service demands associated with each cost component, for the period rates will be effective, and to identify each customer classes' respective units of service. Costs by component may then be allocated to each class in proportion to service demands.

WASTEWATER VOLUMES

Wastewater volumes consist of two components: (1) customer-contributed wastewater and (2) infiltration and inflow. Contributed wastewater volume is the quantity discharged directly from customers to the wastewater system. Depending on system characteristics and the cost allocation methodology used, contributed wastewater volume may consist of average annual volume and peak volumes. Because direct metering of wastewater volume is generally limited to large industrial or wholesale customers, it is common practice to use metered water data to estimate customer-contributed average wastewater volume units of service for the majority of customer classes.

In recognition of the often significant amount of water used by residential customers for lawn irrigation, car washing, or other purposes not discharged to the wastewater system, it is generally reasonable, for allocation purposes, to estimate contributed residential wastewater volumes based on winter water usage (where irrigation is generally limited to summer months) or as a representative percentage of total annual use (where irrigation is year-round). Contributed volumes for nonresidential customers are typically based on actual water sales. Sometimes, utilities may grant an allowance for product or process water that is not returned to the sewer, where there is a defensible rationale for doing so (for example, based on reliable documentation provided by the customer.) For large users, the utility may also install a sewer meter to measure flows returned to the sewer. Some commercial accounts (e.g., schools) may have separate water meters for outdoor use, so that the domestic water meter reflects water returned to the sewer.

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Customer classes may deliver peak wastewater volumes to the system at different times. Wastewater volume from residential customers, for example, is typically at its peak on weekday mornings, as residents prepare for the workday. Residential loads may also peak in the winter, in some parts of the country, when faucets are turned on to keep pipes from freezing. Industrial customers tend to discharge peak volumes during the shutdown and cleanup of a process run. The timing and frequency of such events vary by industry. Commercial use tends to peak seasonally or as a result of a major influx of convention visitors to the community. Individual class wastewater peaking estimates may be based on estimates of noncoincidental class maximum day water demands (excluding allowances for irrigation and other non-sewered usage). However, the lack of specific data on wastewater peak volumes by customer class tends to limit the practice of developing individualized class capacity factors.

The second element of flow that combines with contributed wastewater to make up the total volume reaching the treatment plant is infiltration and inflow (I/I). Infiltration is the flow entering the sanitary sewer resulting from high groundwater or precipitation that occurred days or weeks before the observed flow in the sanitary sewer. Inflow results from rainfall that enters the sanitary collection system through a number of direct connections such as catch basins, roof drains, foundation drains, and manhole covers. The total I/I in the system may be estimated based on available studies or comparisons of contributed wastewater and metered plant flows (see Table 7.4 and plant balance discussion below).

Infiltration and inflow costs pose a special challenge in wastewater ratemaking because these costs are not a consequence of directly measurable service demands by utility customers. Groundwater levels, age of pipe, and soil conditions may influence the amount of I/I that enters the system from different basins. Administering a system of wastewater charges that differs by drainage basin, age of pipe, or soil conditions would be difficult and costly. Therefore, cost allocation approaches must be based on factors that estimate service requirements to equitably distribute I/I cost responsibilities.

As part of the 1972 Water Pollution Control Act and subsequent amendments, the U.S. Environmental Protection Agency (U.S. EPA) issued guidelines regarding the establishment of wastewater rates. Included in these guidelines are sections related to recovery of operations and maintenance costs through user charges. The relevant portions of these guidelines discuss the allocation and recovery of I/I costs. The guidelines state that I/I costs shall be allocated and recovered using one or a combi-

TABLE 7.4 Wastewater treatment plant balance analysis.

| Category | Wastewater strength | | | |
|----------|---------------------|-------|--------------------------------|----------------|
| | Volume 1000 Ccf | Mgals | Suspended solids 1000 lb | TKN 1000 lb |
| | | | mg/L | mg/L |
| | | | 1000 lb | 1000 lb |
| | | | BOD | |
| | | | 1000 lb | |

to the system at different times, for example, is typically on a workday. Residential users, when faucets are turned on, tend to discharge peak flows at the timing and frequency of their own peak seasonally or weekly activity. Individual class users, such as coincidental class users, are more likely to discharge peak volumes by utilizing their own class capacity.

Wastewater to make up for the difference in inflow (I/I). Infiltration and groundwater flow in the sanitary sewer system through foundation drains, basement drains, and other non-sanitary sources, based on available data, are not included in flows (see Table 7.4).

Water ratemaking is based on service demands by users. Factors that may influence water rates include administering a sewer system, pipe, or soil conditions. Approaches must be taken to distribute I/I cost among users.

When making amendments, the sewer system sections related to the problem are the most relevant. The relevant I/I costs. The sewer system is one or a combination of

TABLE 7.4 Wastewater treatment plant balance analysis.

| Category | Volume 1000 Ccf | Mgals | Wastewater strength | | | |
|---|--------------------|--------|--------------------------------|----------------|----------------|------|
| | | | Suspended solids 1000 lb | BOD 1000 lb | TKN 1000 lb | mg/L |
| 1 Totals received at plant | 15 740 | 11 774 | 28 567 | 22 727 | 3112 | 32 |
| 2 Less: | | | | | | |
| 3 Total billed volume | 11 084 | 8291 | | | | |
| 4 | | | | | | |
| 5 Infiltration/Inflow ^a | 4656 | 3483 | 436 | 436 | 436 | 15 |
| 6 Surcharge strength | — | — | 5225 | 4321 | 444 | — |
| 7 Standardized strength ^b | 1653 | 1236 | 6187 | 3609 | 412 | 40 |
| 8 Balance: | — | — | — | — | — | — |
| 9 Domestic strength wastewater ^c | 9431 | 7054 | 16 719 | 14 361 | 1820 | 31 |

^a Assume I/I is the difference between plant inflow and billed volumes and has nominal strengths of 15 mg/L for SS, BOD, and TKN.

^b Assume standardized strength class represents 25% of commercial and industrial classes' volumes and customers.

^c Assume average domestic-strength wastewater volumes come from residential, surcharge, and 75% of commercial and industrial customers.

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nation of approaches that are identified. These approaches include recovery of I/I costs from customers in proportion to the following:

- Contributed wastewater volumes;
- Number of connections;
- Land area; and
- Property valuation of users, if the system has approval for user charges based on ad valorem taxes.

None of these methods fully captures the extent of I/I in the system, but each has a relationship to the quantity of I/I. The most common approaches have been to use contributed wastewater flow, the number of connections (or customers), or a combination of the two to allocate I/I related costs. Contributed flows are often used because of the correlation between flow volume and pipe size. Further, volume recognizes the potential for greater runoff from large properties than smaller properties, and it is assumed that large-volume users have larger properties than small-volume users. Runoff from properties contribute to street runoff that has the potential to enter poorly sealed manhole covers, serving large diameter mains or curb inlets directly to combined stormwater and sanitary sewers. Also, considerable inflow may enter large mains over time when they are placed in the ground water table or below waterway crossings. The number of connections in the wastewater system reflects the size of the collection system, the greater potential for infiltration through poor joints and cracked pipes, and the potential for inflow through roof, floor, and foundation drains.

The property valuation approach is seldom used because few systems have an approved user-charge structure based on ad valorem taxes. A shortfall of the property area approach is that there is not always correlation between the area of the property and the length of lines that serve the property. Both of these approaches are also complicated by additional data requirements.

For systems where there are significant costs related to I/I or stormwater for combined sewer systems, the allocation approach selected could have a significant impact on the relative utility rates of different customer classes. Allocating I/I or stormwater costs in proportion to contributed wastewater volumes will result in more costs being recovered from large users, all other things equal, than if the number of connections is used to allocate costs.

WASTEWATER

The wastewater pollutants such as suspended solids, plant influent, and The individual combination of (typically industrial and other community) also proper to prevent the sanitary

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WASTEWATER STRENGTHS

The wastewater strength component may be separated into costs that may vary with pollutants such as biochemical oxygen demand (BOD), chemical oxygen demand, suspended solids, nitrogen, and phosphorus plant loadings. Wastewater treatment plant influent records provide information on total pollutant loadings for the system. The individual service units for each customer class are typically estimated from a combination of data, including sampling data of individually monitored customers (typically industrial and some wholesale and contract customers), and industry and other communities' data on average strength concentrations by type of customer. It is also proper to provide recognition of the pollutants present in I/I or stormwater that enters the sanitary system.

CUSTOMER SERVICE

Customer-related costs generally include customer billing and service connection costs and, in some cases, meter reading and maintenance costs. Billing costs are generally distributed to the customer classes based on the number of bills. Where wastewater charges are based on quantity of water use, a portion of water-meter-related costs may be distributed to the wastewater system customers. Equivalent meter ratios are typically used to recover meter and service connection costs to reflect the increasing nature of such costs with meter and service line size, while billing costs are recovered on a per-bill basis reflecting computer billing. However, if a large retail or wholesale customer requires special billing and collection considerations, a miscellaneous fee or direct assignment of cost may be used for special services that others do not receive.

OTHER UNITS OF SERVICE

In some systems, special recognition should be given to industrial waste sampling or the recovery of costs associated with required pretreatment program monitoring. Special cost components and customer units may be required to properly establish customer class responsibility.

In addition, units of service related to acreage or density are sometimes used for allocation of collection system costs. When customers within classes are relatively close together, the investment in collection system costs are less than those customers who are relatively spread out. Thus, density, or the ability to serve more customers

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PLANT BALANCE ANALYSIS

As discussed above, the projections of customer class units of service are generally based on limited local data, supplemented with data from other communities. As a means of "testing" the assumptions and data used in the analysis, particularly related to the estimation of customer class volume and strength units of service, a plant balancing technique may be used. This technique involves comparing the total units of service estimated from customer classes to the actual flows and loads measured at the plant. Through this analysis, assumptions of strength concentrations, water-use adjustments, and I/I may be refined to improve the overall equity of the cost-allocation process, and to ensure that rates are based on a reasonable representation of actual volumes to the plant, discouraging potential claims of overcharging insofar as billed units of service could exceed actual units of service.

Table 7.4 provides an example of a plant balance analysis. In the example provided, the total plant volumes (line 1) are reduced by total billed wastewater volumes (line 3) to estimate I/I (line 5). The I/I is assumed to have a nominal strength loading of 15 mg/L for total suspended solids (TSS), BOD, and total Kjeldahl nitrogen (TKN). Total plant suspended solids, BOD, and TKN loadings are reduced further by monitored "surcharge" industrial loadings (line 6) and assumed standardized commercial and industrial strengths (line 7). (Ideally, wastewater strength assumptions would be supported by local sampling data. However, when local data is not available industry reference sources may be used, for example, the California State Water Resources Control Board's Revenue Program Guidelines [State of California, 1998].) The balance (line 9) is attributed to the remaining customers that include residential, other commercial and industrial customers not included in the standardized class, and the portion of surcharge customer load that is average strength.

SUMMARY OF CUSTOMER CLASS UNITS OF SERVICE

Table 7.5 shows units of service by customer class under the design-basis cost allocation methodologies described in Chapter 6. Service units under the design basis include volume, capacity (peak wastewater volume), strength (suspended solids, BOD, and TKN), and customer billing units. The volume units by class (line 1 in

TABLE 7.5 An example of customer classes' units of service design-basis methodology.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|--------------|-------------|------------|------------|-----------|-----------------------|-------|
| Denomination | Residential | Commercial | Industrial | Surcharge | Standardized strength | Total |

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example pro-rata volumes length loading rogen (TKN). her by monitoring commercial ons would be able industry er Resources) The balance l, other com- and the por-

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TABLE 7.5 An example of customer classes' units of service design-basis methodology.

| Description | (1) | (2) | (3) | (4) | (5) | (6) |
|--|-------------|------------|------------|-----------|-----------------------|---------|
| | Residential | Commercial | Industrial | Surcharge | Standardized strength | Total |
| Wastewater volume (1000 Ccf) | | | | | | |
| 1 Billed wastewater volume | 4473 | 2761 | 2197 | | 1653 | 11 084 |
| 2 I/I allocated 2/3 by customers | 2680 | 282 | 36 | | 106 | 3104 |
| 3 I/I allocated 1/3 by volume | 626 | 387 | 308 | | 231 | 1552 |
| 4 Total annual treated volume | 7779 | 3430 | 2541 | 0 | 1990 | 15 740 |
| Wastewater capacity flowrate (Ccf/day) | | | | | | |
| 5 Estimated wastewater peaks | 18 382 | 11 347 | 9029 | | 6793 | 45 551 |
| 6 I/I allocated 2/3 by customers ^a | 29 378 | 3087 | 391 | | 1159 | 34 015 |
| 7 I/I allocated 1/3 by volume ^a | 6864 | 4237 | 3371 | | 2537 | 17 009 |
| 8 Total | 54 624 | 18 671 | 12 791 | 0 | 10 489 | 96 575 |
| Wastewater strength (1000 pounds) | | | | | | |
| 9 Suspended solids | 7930 | 4895 | 3895 | 5225 | 6187 | 28 131 |
| 10 BOD | 6811 | 4204 | 3346 | 4321 | 3609 | 22 291 |
| 11 TKN | 863 | 533 | 424 | 444 | 412 | 2676 |
| 12 I/I allocated 2/3 by customers ^b | 753 | 79 | 10 | 0 | 30 | 872 |
| 13 I/I allocated 1/3 by volume ^b | 176 | 109 | 86 | 0 | 65 | 436 |
| Customer billing units | | | | | | |
| 14 Number of bills | 208 400 | 21 900 | 8328 | 828 | 24 672 | 264 128 |
| 15 Number of customers | 52 100 | 5475 | 694 | 69 | 2056 | 60 394 |

^a Infiltration/inflow volumes represent one-third or two-thirds of the volume, from Table 7.4 and a 4.0 peaking factor.

^b Infiltration/inflow strengths represent one-third or two-thirds of the combined total pounds for suspended solids, BOD, and TKN, shown in Table 7.4.

Financing and Charges for Wastewater Systems

Table 7.5) come from customer billing records, and I/I volume is estimated based on the plant-balance analysis (Table 7.4).

Under the design-basis approach (Table 7.5), capacity units of service (line 5) are estimated based on wastewater volumes and peak-to-average day capacity factors. Capacity factors for contributed wastewater for this illustration are estimated to be 1.5 for all classes. The capacity factor for I/I is 4.0.

Wastewater strength loadings (lines 9, 10, and 11) are based on class volumes and the following: assumed strengths for I/I and standardized strength customers, monitored strengths for surcharge customers, and estimated domestic strengths from the plant balance analysis for remaining customers.

The I/I loadings (estimated in Table 7.4) are redistributed to the customer classes; two-thirds by the number of customers, and one-third by the amount of class-contributed volume. For example, I/I volume is estimated to be 4 656 000 Ccf (100 cu ft; 1 Ccf = 2.83 m³), as indicated in Table 7.4 (line 5). Two-thirds (3 104 000 Ccf) is redistributed back to the customer classes in proportion to each classes' share of total customers' wastewater volume. Residential customers represent approximately 86.4% of total customers (net of surcharge customers) and 40.4% of wastewater volumes. The residential class is, therefore, responsible for 3 306 000 Ccf of I/I volume, as shown below and in lines 2 and 3 of Table 7.5.

In U.S. customary units (1 Ccf = 2.38 m³)

$$\begin{aligned}
 3104 \text{ (1000 Ccf)} \times .864 &= 2680 \text{ (rounded)} \\
 1552 \text{ (1000 Ccf)} \times .4035 &= 626 \\
 2680 + 626 &= 3306 \text{ (1000 Ccf)}
 \end{aligned}$$

The process illustrated above is used to allocate I/I loadings for each service parameter and customer class. The results are shown in Table 7.5 (lines 2 to 3, 6 to 7, and 12 to 13). As alluded to in footnote (b) of Table 7.5, in the interest of saving space for a nominally small portion of the overall system units of service, the combined strength of I/I for suspended solids, BOD, and TKN (each assumed to have a strength of 15 mg/L) are shown on lines 12 and 13 of Table 7.5.

Table 7.6 shows the units of service by customer class under the functional-cost allocation methodology. Under this approach and for purposes of this example, capacity is not used as a cost determinant. Volume, strength, and customer units of service are determined in the same manner as described above for the design-basis methodology.

TABLE 7.6 Unit costs-of-service and allocation to classes' design-basis methodology.

| Line no. | Category | (1) Total | (2) Volume | (3) Capacity | (4) Wastewater strength | | | (7) Customer billing | (8) Customer | (9) Industrial surcharge |
|----------|----------|-----------|------------|--------------|-------------------------|-----|-----|----------------------|--------------|--------------------------|
| | | | | | Suspended solids | BOD | TKN | | | |

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TABLE 7.6 Unit costs-of-service and allocation to classes' design-basis methodology.

| Line no. | Category | (1) Total | (2) Volume | (3) Capacity | (4) Wastewater strength | | | (6) TKN | (7) Customer billing | (8) Customer | (9) Industrial surcharge |
|--------------------------|---------------------------------|--------------|---------------|-----------------|-------------------------|------------|-----------|------------|-------------------------|-----------------|-----------------------------|
| | | | | | Suspended solids | BOD | TKN | | | | |
| Annual costs: | | | | | | | | | | | |
| 1 | Net operation and maintenance | 18,251,000 | 1,153,000 | 7,100,000 | 2,349,000 | 3,256,000 | 1,327,000 | 1,304,000 | 1,103,000 | 659,000 | |
| 2 | Total capital costs | 10,585,000 | 1,064,000 | 4,011,000 | 1,811,000 | 2,573,000 | 779,000 | 69,000 | 278,000 | 0 | |
| 3 | Totals (\$) | 28,836,000 | 2,217,000 | 11,111,000 | 4,160,000 | 5,829,000 | 2,106,000 | 1,373,000 | 1,381,000 | 659,000 | |
| Annual units of service: | | | | | | | | | | | |
| 4 | Quantity | 15,740,000 | Ccf | 96,575 | 28,567,210 | 22,727,210 | 3,112,210 | 264,128 | 60,325 | 828 | |
| 5 | Unit of measure | | | Ccf/day | lb | lb | lb | lbills | each | lbills | |
| 6 | Unit costs of service (\$/unit) | 0.141 | 0.141 | 115.050 | 0.146 | 0.256 | 0.677 | 5.198 | 22.893 | 795.894 | |
| Classes of service | | | | | | | | | | | |
| Residential | | | | | | | | | | | |
| 7 | Units of service | 7,779,000 | | 54,624 | 8,239,000 | 7,121,000 | 1,173,000 | 208,400 | 52,100 | | |
| 8 | Allocated annual costs (\$) | 13,477,000 | 1,096,000 | 6,284,000 | 1,199,000 | 1,827,000 | 794,000 | 1,084,000 | 1,193,000 | | |
| Commercial | | | | | | | | | | | |
| 9 | Units of service | 3,430,000 | | 18,671 | 4,957,000 | 4,267,000 | 595,000 | 21,900 | 5,475 | | |
| 10 | Allocated annual costs (\$) | 5,089,000 | 483,000 | 2,148,000 | 722,000 | 1,094,000 | 403,000 | 114,000 | 125,000 | | |
| Industrial | | | | | | | | | | | |
| 11 | Units of service | 2,541,000 | | 12,791 | 3,927,000 | 3,378,000 | 456,000 | 8,328 | 694 | | |
| 12 | Allocated annual costs (\$) | 3,636,000 | 358,000 | 1,472,000 | 572,000 | 866,000 | 309,000 | 43,000 | 16,000 | | |
| Surcharge | | | | | | | | | | | |
| 13 | Units of service | 0 | 0 | 0 | 5,225,000 | 4,321,000 | 444,000 | 828 | 828 | 828 | |
| 14 | Allocated annual costs (\$) | 2,832,000 | 0 | 0 | 761,000 | 1,108,000 | 300,000 | 4,000 | 47,000 | 659,000 | |
| Standardized strength | | | | | | | | | | | |
| 15 | Units of service | 1,990,000 | | 10,489 | 6,219,000 | 3,641,000 | 444,000 | 24,672 | 2,056 | | |
| 16 | Allocated annual costs (\$) | 3,802,000 | 280,000 | 1,207,000 | 906,000 | 934,000 | 300,000 | 128,000 | 47,000 | | |
| 17 | Totals | 28,836,000 | 2,217,000 | 11,111,000 | 4,160,000 | 5,829,000 | 2,106,000 | 1,373,000 | 1,381,000 | 659,000 | |

UNIT COSTS AND DISTRIBUTION OF COSTS TO CUSTOMER CLASSES

The major effort in distributing costs to customer classes is complete after customers are classified and their respective units of service determined. Determination of customer class revenue responsibility can now be established based on component unit costs and the projected units of service for each customer class. Unit costs are calculated for each component based on the allocated revenue requirements and the total number of applicable units of service for the test period. The unit costs by component are then applied to the individual class units of service to determine the cost responsibility of each class. This process is illustrated in Tables 7.7 and 7.8, with a summary of the two approaches provided in Table 7.9.

Table 7.7 illustrates calculation of unit costs of service and distribution of costs to customer classes based on the design-basis allocation methodology described in Chapter 6. Under the design basis, costs are allocated to volume, capacity (peak wastewater volume), strength (suspended solids, BOD, and TKN), customer billing, customer, and industrial monitoring categories. Based on the allocated costs by component and the total units of service (from Tables 7.4 and 7.5), unit costs-of-service are calculated for each component. These unit costs are then used to distribute costs to customer classes, based on the customer class units of service shown in Table 7.5. Surcharge customers are assumed to be allocated costs of the industrial surcharge program entirely.

Table 7.8 illustrates the development of units of service and distribution of costs to customer classes for the functional-cost allocation methodology, also described in Chapter 6. As in Table 7.7, the process relies on customer billing units developed in Table 7.6, and unit costs of service derived from the allocated costs by component divided by total billing units. Also, industrial surcharge program costs are allocated entirely to surcharge customers.

Table 7.9 summarizes costs by customer class under the alternative allocation methodologies. As Table 7.9 indicates, residential customers are responsible for a greater share of costs under the design basis relative to the functional cost basis. This is reflective of the design-basis allocation resulting in more costs allocated to volume (both average volume and capacity), relative to strength components. Commercial-, industrial-, surcharge-, and standardized-strength customers have greater cost responsibility under the functional-cost allocation basis, because a larger portion of costs are allocated based on wastewater strengths.

TABLE 7.7 Customer classes' units of service functional cost methodology.

| Description | (1) | (2) | (3) | (4) | (5) | (6) |
|-------------|-------------|------------|------------|-----------|-----------------------|-------|
| | Residential | Commercial | Industrial | Surcharge | Standardized strength | Total |

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TABLE 7.7 Customer classes' units of service functional cost methodology.

| Description | (1) Residential | (2) Commercial | (3) Industrial | (4) Surcharge | (5) Standardized strength | (6) Total |
|---|--------------------|-------------------|-------------------|------------------|---------------------------------|--------------|
| Wastewater volume (1000 Ccf) | | | | | | |
| 1 Billed wastewater volume | 4473 | 2761 | 2197 | | 1653 | 11 084 |
| 2 I/I allocated 2/3 by customers ^a | 2680 | 282 | 36 | | 106 | 3104 |
| 3 I/I allocated 1/3 by volume ^a | 626 | 387 | 308 | | 231 | 1552 |
| 4 Total annual treated volume | 7779 | 3430 | 2541 | 0 | 1990 | 15 740 |
| Wastewater strength (1000 pounds) | | | | | | |
| 5 Suspended solids | 7930 | 4895 | 3895 | 5225 | 6187 | 28 131 |
| 6 BOD | 6811 | 4204 | 3346 | 4321 | 3609 | 22 291 |
| 7 TKN | 863 | 533 | 424 | 444 | 412 | 2676 |
| 8 I/I allocated 2/3 by customers ^b | 753 | 79 | 10 | 0 | 30 | 872 |
| 9 I/I allocated 1/3 by volume ^b | 176 | 109 | 86 | 0 | 65 | 436 |
| Customer billing units | | | | | | |
| 10 Number of bills | 208 400 | 21 900 | 8328 | 828 | 24 672 | 264 128 |
| 11 Number of customers | 52 100 | 5475 | 694 | 69 | 2056 | 60 394 |

^aInfiltration/inflow volumes represent one-third or two-thirds of the volume from Table 7.4.

^bInfiltration/inflow strengths represent one-third or two-thirds of the combined total pounds for suspended solids, BOD, and TKN shown in Table 7.4.

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TABLE 7.8 Unit costs-of-service and allocation to classes' functional cost methodology.

| Line no. | Category | (1) Total \$ | (2) Volume \$ | (3) Wastewater strength | | (4) BOD \$ | (5) TKN \$ | (6) Customer billing \$ | (7) Customer \$ | (8) Industrial surcharge \$ |
|--------------------------|---------------------------------|-----------------|------------------|-------------------------|------------|---------------|---------------|----------------------------|--------------------|--------------------------------|
| | | | | Suspended solids \$ | lb | | | | | |
| Annual costs: | | | | | | | | | | |
| 1 | Net operations and maintenance | 18,251,000 | 8,752,000 | 2,684,000 | 2,873,000 | 831,000 | 1,366,000 | 1,093,000 | 652,000 | |
| 2 | Total capital costs | 10,585,000 | 3,554,000 | 2,428,000 | 3,558,000 | 698,000 | 69,000 | 278,000 | 0 | |
| 3 | Totals (\$) | 28,836,000 | 12,306,000 | 5,112,000 | 6,431,000 | 1,529,000 | 1,435,000 | 1,371,000 | 652,000 | |
| Annual units of service: | | | | | | | | | | |
| 4 | Quantity | 15,740,000 | Ccf | 28,567,000 | 22,727,000 | 3,112,000 | 264,128 | 60,394 | 828 | |
| 5 | Unit of measure | 0.782 | | 0.179 | 0.283 | 0.491 | 5.433 | 22.701 | 787.44 | |
| 6 | Unit costs of service (\$/unit) | | | | | | | | | |
| Classes of service | | | | | | | | | | |
| Residential | | | | | | | | | | |
| 7 | Units of service | 12,462,000 | 7,779,000 | 8,239,000 | 7,121,000 | 1,173,000 | 208,400 | 52,100 | | |
| 8 | Allocated annual costs | 5,311,000 | 2,682,000 | 1,474,000 | 2,015,000 | 577,000 | 1,133,000 | 1,182,000 | | |
| Commercial | | | | | | | | | | |
| 9 | Units of service | 3,430,000 | 3,430,000 | 4,957,000 | 4,267,000 | 595,000 | 21,900 | 5,475 | | |
| 10 | Allocated annual costs (\$) | 5,311,000 | 2,682,000 | 887,000 | 1,207,000 | 292,000 | 119,000 | 124,000 | | |
| Industrial | | | | | | | | | | |
| 11 | Units of service | 3,931,000 | 2,541,000 | 3,927,000 | 3,378,000 | 456,000 | 8,328 | 694 | | |
| 12 | Allocated annual costs (\$) | 3,931,000 | 1,987,000 | 703,000 | 956,000 | 224,000 | 45,000 | 16,000 | | |
| Surcharge | | | | | | | | | | |
| 13 | Units of service | 0 | 0 | 5,225,000 | 4,321,000 | 444,000 | 828 | 69 | | |
| 14 | Allocated annual costs (\$) | 3,034,000 | 0 | 935,000 | 1,223,000 | 218,000 | 4,000 | 2,000 | | |
| Standardized strength | | | | | | | | | | |
| 15 | Units of service | 1,990,000 | 1,990,000 | 6,219,000 | 3,641,000 | 444,000 | 24,672 | 2,056 | | |
| 16 | Allocated annual costs (\$) | 4,098,000 | 1,556,000 | 1,113,000 | 1,030,000 | 218,000 | 134,000 | 47,000 | | |
| 17 | Totals | 28,836,000 | 12,306,000 | 5,112,000 | 6,431,000 | 1,529,000 | 1,435,000 | 1,371,000 | 652,000 | |

TABLE 7.9 C methodology

| Line no. | Category |
|----------|-----------------------|
| 1 | Residential |
| 2 | Commercial |
| 3 | Industrial |
| 4 | Standardized strength |
| 5 | Surcharge |
| 6 | |

COMMUNITY

In establishing rates, the utility should consider different classes of service previously identified across the total customer base. A subset of commercial and industrial service shown in Table 7.8 is an example.

RETURN ON INVESTMENT

When utility service customers are properly categorized, it will be appropriate to allocate costs. In this instance, Chapter 5 analyzes the cost of service for owner customers or utility is provided to the service provider to the inducement.

Distribution of Costs-of-Service to Customer Classes

TABLE 7.9 Comparison of design-basis and functional cost-allocation methodologies results.

| Line no. | Customer classes | Design basis \$ | Functional cost \$ | Difference \$ |
|----------|-----------------------|-----------------|--------------------|---------------|
| 1 | Residential | 13,477,000 | 12,462,000 | 1,015,000 |
| 2 | Commercial | 5,089,000 | 5,311,000 | (222,000) |
| 3 | Industrial | 3,636,000 | 3,931,000 | (295,000) |
| 4 | Surcharge | 2,832,000 | 3,034,000 | (202,000) |
| 5 | Standardized strength | 3,802,000 | 4,098,000 | (296,000) |
| 6 | Total | 28,836,000 | 28,836,000 | 0 |

COMMUNAL AND SPECIFIC COSTS

In establishing unit costs and customer class costs-of-service, it may be necessary to consider differences in general service requirements among customers, as discussed previously in this chapter and in Chapter 6. Costs for a component may be spread across the total units of service in the case of "communal" costs, or only among a subset of customer service units in the case of "specific" costs. The allocation of industrial surcharge program costs directly to benefiting customers in Tables 7.7 and 7.8 is an example of a specific-cost allocation.

RETURN ON INVESTMENT

When utility service is provided to non-owner customers, such as wholesale or retail service customers located outside the jurisdiction of the owner municipality, it may be appropriate to recognize return on plant value related to providing such service. In this instance, the utility basis for determining cost of service, as discussed in Chapter 5 and more fully in Appendix A, is particularly applicable because it recognizes the costs and risks utility owners must assume. As owners, the municipality or utility is entitled to a fair return on the value of facilities devoted to serving non-owner customers. Consideration of cost of borrowed funds, business risk, level of service provided, and method used for determining plant value should be incorporated to the evaluation of an appropriate rate of return that provides adequate inducement to the utility to continue providing service to its non-owner customers.

| | | | | | | |
|----|-----------------------------|-----------|-----------|-----------|-----------|-----------|
| 15 | Units of service | 6,219,000 | 3,641,000 | 444,000 | 24,672 | 2,056 |
| 16 | Allocated annual costs (\$) | 1,113,000 | 1,030,000 | 218,000 | 134,000 | 47,000 |
| 17 | Totals | 5,112,000 | 6,431,000 | 1,529,000 | 1,435,000 | 1,371,000 |
| | | | | | | 652,000 |

SUMMARY

An equitable allocation of revenue requirements to wastewater system users begins with an analysis of customer service demands. Because it is not practical to charge each customer individually, customers must be classified into relatively homogeneous groups with similar usage characteristics. Costs are then allocated to the customer classes in proportion to each classes' service demands. For the wastewater system, costs are allocated to customers based on their general service requirements, wastewater discharge characteristics, number of customers, and other factors.

As wastewater rates continue to increase and as utilities strive to meet the challenges of the 21st century, greater recognition of differences in customer service demands through the implementation of more disaggregated customer classifications may be desirable in many communities. However, such classifications may be complicated by the general problem of limited data to support customer class definitions and the ongoing administrative requirements related to tracking changing customer uses. Therefore, the appropriate classification of customers must balance equity considerations with other concerns including administrative feasibility, revenue adequacy and stability, data availability, and public acceptance.

Cost-of-service studies are important as guides for determining the necessity for and level of rate adjustments to be considered in recovering costs equitably from wastewater system customers. The importance of such studies is that they make policymakers aware of all factors contributing to the costs incurred in providing service to various system customers. When practical or policy matters dictate deviation from cost of service, decision-makers can be apprised of the dollar effects of deviation.

REFERENCE

State of California (1998) Revenue Program Guidelines (Appendix G); Water Resource Control Board; March 1998.

SUGGESTED READING

Rothstein, E.; Galardi, D. (2000) *Analysis of Strength Loading Characteristics for Wastewater Classification*. Presented at the Water Environment Federation's 73rd Annual Technical Exposition and Conference, Anaheim, California, October 14-18.

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**City of Detroit
Water and Sewerage Department**

Proposed Sewerage System Rates and Charges

MAY 1979

CAMP DRESSER & McKEE INC.



ATTACHMENT 2

Figure II-E, on the following page, presents the process flow diagram for the plant. All influent flow is lifted at the main pumping station and flows through the bar racks and grit chambers. Phosphorus removal occurs in the primary and secondary sedimentation tanks and is enhanced by the prior addition of polymer and ferrous chloride. Floatables are skimmed from the primary sedimentation tanks and pumped to the scum incinerator for disposal.

Currently, a portion of the primary effluent is biologically treated, and the remainder is chlorinated and discharged. However, the plant is scheduled to increase to full secondary treatment of 1,050 MGD by September 1, 1980.

Both oxygen and air facilities are utilized in the activated sludge process. Following aeration, settling of biological solids occurs in the secondary clarifiers. Most of the secondary effluent is chlorinated and discharged, although a portion of the flow is recovered and recirculated throughout the plant to processes where it can be utilized. The outfall, which extends into the Detroit River, serves as the chlorination chamber.

Waste sludge is mixed, gravity thickened and stored. Dewatering is accomplished by vacuum filtration, and the sludge cake from the filters is incinerated. Recently, a portion of the filter cake has also been landfilled as an interim measure while a major sludge handling and disposal study is underway.

Component Processes

The facilities and operations at the wastewater treatment plant can be described by functional component processes. In general, these component processes match those currently used by the DWSD accounting system and are:

Primary Pumping

Rack and Grit

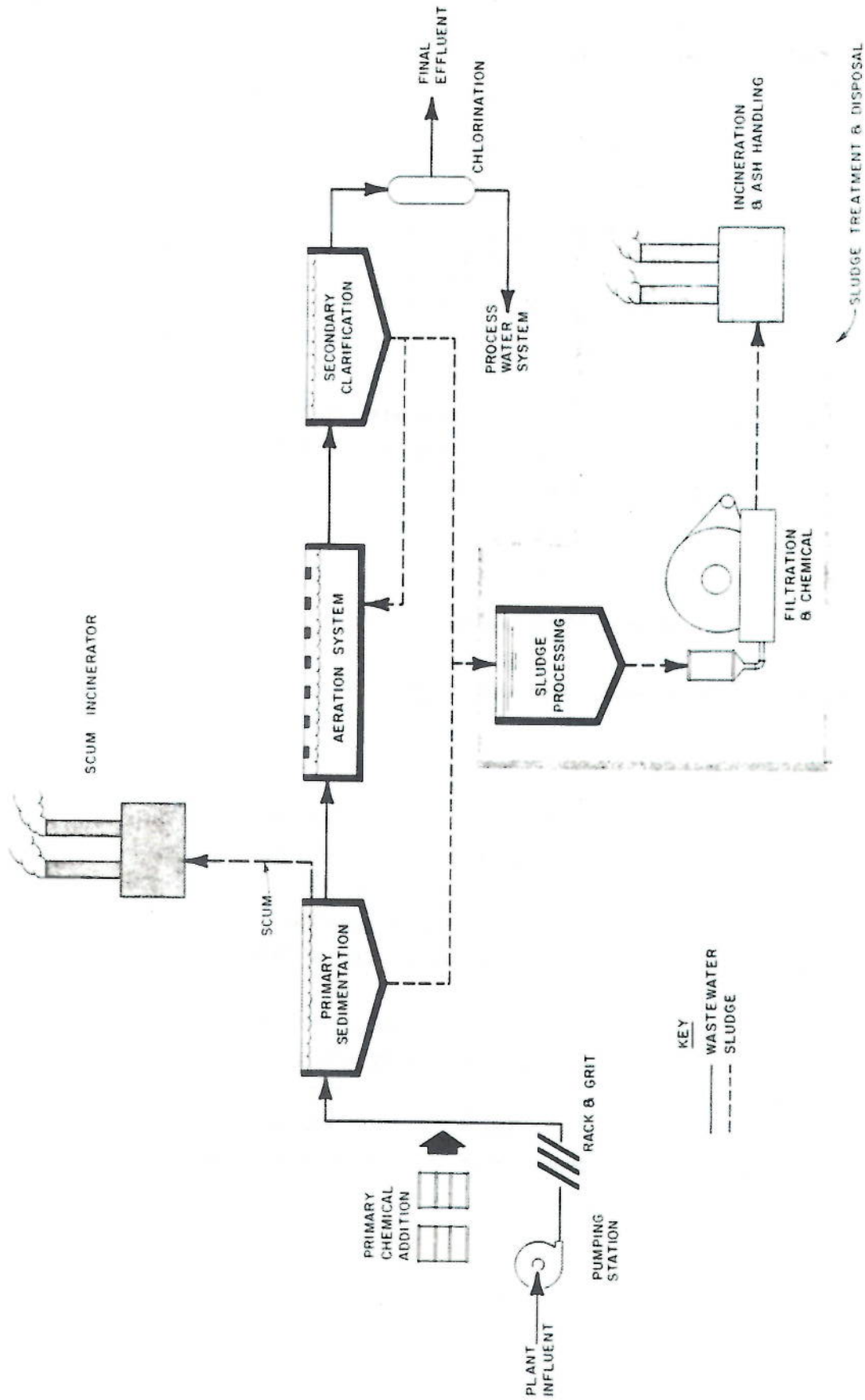


FIGURE II-E
SEWAGE TREATMENT PLANT PROCESS FLOW DIAGRAM

ATTACHMENT 2

Primary Chemical Addition
Primary Sedimentation
Aeration System
Secondary Clarifiers
Process Water & Outfall Facilities
Chlorination
Sludge Treatment & Disposal
 Sludge Processing
 Filtration and Chemicals
 Incineration and Ash Handling
Scum Incinerator.

There are also three additional component processes which are not related to any specific treatment process, but are general to all. These include:

Laboratory Services
Heating Plant
General Plant Expense.

Each of these processes is described below:

Primary Pumping

Wastewater collected in the Detroit River and Oakwood Interceptors enters the plant through the main pump station, put in service in 1940. The pump station contains eight vertical mixed-flow centrifugal pumps, six of which were added in 1956.

Flows from each of the eight pumps are discharged to one of eight corresponding screening and grit removal channels. If a pump, bar rack, or grit channel is taken out of operation for any reason, the remaining two components of the preliminary system must also be shut down.

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Rack and Grit

Bar racks with 3/4" openings are situated before each of the eight grit chambers.

The screenings are removed by a series of conveyor belts to a truckloading station for hauling to a landfill. Larger objects are removed and disposed of separately.

The current grit removal facility consists of eight mechanically cleaned grit channels. Approximately 3,120 tons of screenings and 18,780 dry tons of grit were removed from the plant in fiscal year (FY) 1977.*

Primary Chemical Addition

The existing phosphorus removal system consists of pickle liquor (ferrous chloride) and polymer feeding and storage facilities. Ferrous chloride is added to react with phosphorus to form an insoluble iron compound which may be removed with settled primary sludge. Anionic polymer is used to aid in the coagulation of the iron-phosphorus floc. Approximately 1,696 tons of phosphorus were removed in FY 1977.

Primary Sedimentation

Removal of suspended and floating material is accomplished in twelve rectangular and two circular primary clarifiers of below-ground reinforced concrete construction. Two additional circular clarifiers will be added in the near future, bringing total primary capacity to 1200 MGD.

Aeration

There are four aeration basins currently existing.
* Note: The DWSD fiscal year runs from July 1 to June 30.

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One of the existing basins is an air activated sludge process and is designed for a flow of 150 MGD while each of the remaining three is covered and utilizes a pure oxygen system with a design average flow of 300 MGD.

In FY 1977 approximately 332 MGD was treated in the secondary facilities.

Secondary Clarifiers

Presently, there are twenty-one operating secondary clarifiers. Four more are under construction, which, when completed, will provide a total secondary clarifier capacity of 1050 MGD.

Process Water

The process water system, comprised of screened final effluent, is designed to supply the water requirements of portions of the sewage treatment plant where the water required could be of less than potable quality.

The process water system is supplied from the secondary effluent chlorination contact channel.

Chlorination

The existing disinfection system is a conventional gaseous chlorine system. Four railroad sidings are used to park tank cars from which liquid chlorine is fed to eleven evaporators (one steam and ten hot water), where the liquid is converted to gas. The chlorine gas is mixed with water and fed to the plant effluent as an aqueous solution.

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Sludge Treatment and Disposal

Sludge treatment and disposal consists of a series of processes which collect, dewater and incinerate or otherwise dispose of solids generated during primary and secondary treatment. There are three subcomponents to sludge handling and disposal:

- (a) Sludge Processing: gravity thickening, blending and storage
- (b) Filtration: dewatering by vacuum filtration
- (c) Incineration

Each subcomponent is described in detail as follows:

(a) Sludge Processing

Sludge processing consists of gravity thickening, blending and storage. Sufficient operational flexibility has been built in to allow the process flow through the unit processes to be changed, and to allow a variety of sludge mixtures (primary, air- and oxygen-activated) to be processed.

Gravity thickening is accomplished by admitting sludge into a tank which has suitable quiescent conditions so that the solids settle out by gravity. A continuous flow of liquid flows over the weirs in the tank and is returned to the Oakwood Interceptor. The thickened sludge that collects at the bottom of the tanks is drawn off and pumped to either the sludge blending or storage tanks.

There are two sludge blending tanks presently in operation. Four circular and two rectangular tanks are used for sludge storage.

Overflows from the storage tanks flow by gravity to the Oakwood Interceptor. Sludge from the circular storage tanks normally flows by gravity to the Sludge Complex II vacuum filters. Sludge from the rectangular storage tanks is transferred to the Sludge Complex I vacuum filters.

(b) Filtration

Filtration refers to the method by which sludge is mechanically dewatered. There are a

total of 28 vacuum filters in two areas (known as Complex I and Complex II) which receive sludge, after it has been processed, at a solids content of less than 5 percent and produce a sludge cake with an estimated solids content of approximately 20 percent.

(c) Incineration

The sludge cake generated by dewatering in Complexes I and II is transported via a conveyor system to Incineration Complexes I and II for burning. There are currently six sludge incinerators in Complex I and eight in Complex II, all capable of operating with natural gas or No. 2 fuel oil.

Scum Incineration

At the scum incinerator building, the scum is dewatered in a grease separator. The scum is skimmed into a hopper and then pumped to the incinerator.

The water hearth incinerator consists of a vertical, cylindrical unit, lined with high temperature brick and steel "pot" with a flotation tank mounted in the bottom of the unit.

Primary scum and grease can also be sent to the sludge incinerators in Complex I.

Sewage Treatment Plant
Influent Characteristics

This section describes the treatment plant influent characteristics of pollutant parameters used for waste surcharge purposes. The pollutants are 5-day biochemical oxygen demand (BOD), total suspended solids (TSS), and total phosphorus (P). Concentrations of these pollutants are expressed in milligrams per liter (mg/l).

Daily records of wastewater loading to the sewage treatment plant were obtained and analyzed for FY 78. The parameters specifically reviewed were flow, BOD, TSS, and P. The results of the analysis are shown on Table II-E, below, which also shows additional recent historic data.

BOD, TSS and P daily loadings obtained from the plant were adjusted for 1978, substituting monthly average values for reported values greater than two standard deviations above the mean. In this way, random errors caused by variations in sampling and laboratory analysis techniques were taken into account. It should be noted that there is no influent flow meter at the plant, and flow is calculated using main pump station wet well elevations and pumping times. The relationship between these variables is empirical, and some error in the reported flows may result.

TABLE II-E

AVERAGE SEWAGE TREATMENT
PLANT INFLUENT CHARACTERISTICS

| <u>PERIOD</u> | <u>FLOW</u> ³ <u>(mgd)</u> | <u>BOD</u> ⁴ <u>(mg/l)</u> | <u>TSS</u> ⁴ <u>(mg/l)</u> | <u>P</u> ⁴ <u>(mg/l)</u> |
|-------------------------------|--|--|--|--|
| FISCAL YR 1978 ¹ | 661 | 124 | 207 | 5.52 |
| CALENDAR YR 1976 ² | 698 | 111 | 241 | 4.7 |
| CALENDAR YR 1975 ² | 722 | 99 | 203 | 5.0 |
| CALENDAR YR 1974 ² | 659 | | | |

Notes: ¹1978 data from analysis of daily plant records.

²1974, 75, 76 data as reported in the Segmented Facilities Plan, Book VII, WCT-112 Wastewater Characteristics.

³Million gallons per day

⁴Milligrams per liter

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Allocation of System Components to Sewage Parameters

As noted in the following chapter, Public Law 92-500, the Water Pollution Control Act Amendments, and subsequent amendments thereto, require that the recipients of EPA construction grants establish:

- A user charge system which distributes the cost of operation and maintenance of the sewerage system to each user (or user class) in proportion to the user's contribution to the total sewage loading of the system - with factors such as strength, volume and delivery flow characteristics being considered.

- An industrial cost recovery system which provides that each industrial user shall pay an amount equal to its share of the Federal grants divided by the expected life of the grant-funded works, or 30 years, whichever is the lesser. Factors such as volume, strength and delivery flow characteristics are to be considered in the determination of the industrial user's share.

Thus, in order to meet Federal proportionality requirements it is necessary that the costs of operation and maintenance be distributed to sewage parameters. In the case of the Detroit treatment facility and its tributary lines and pumping stations, these parameters are:

- Volume (Q)
- Biochemical Oxygen Demand (BOD)
- Total Suspended Solids (TSS)
- Phosphorus (P).

The first step in this process is to allocate the capital construction and operation and maintenance costs, by system component.

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The approach used in this report to allocate component costs to sewage parameters was to maintain a consistent, logical methodology which, when used to calculate rates and charges, will result in equitable and reasonable distributions to system customers according to their usage of the system.

Allocation of Capital Construction Costs

Capital construction costs are allocated according to the criteria used for the design of the system component. For example, pumping station facilities are designed (and pumps are sized) primarily on the basis of flow; therefore, the associated capital costs would be allocated to the flow parameter (Q).

The concept of allocating capital construction costs to design criteria is based on the following:

- Design criteria may, or may not, be related directly to the function performed
- However, size and configuration are set by these criteria and, therefore, they become the basic determinants of cost.

Design assumptions are based on compliance with the Consent Judgment which sets December 31, 1979 effluent limitations (30-day average), treating up to 1000 MGD, of:

| | |
|----------------------------|---|
| BOD | 30 mg/l |
| TSS | 30 mg/l |
| Total Phosphorus (as P) | 2.5 mg/l (1.0 mg/l beginning 12/31/81) |

By implication, "30/30" limitations require full secondary treatment. By September 1, 1980 the plant must provide secondary treatment for 1050 MGD.

Table II-F, on the following page, presents the capital cost allocations to the sewage parameters for which the system is designed.

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TABLE II-F
ALLOCATION OF CAPITAL CONSTRUCTION COSTS
TO SEWAGE PARAMETERS

| <u>System Component</u> | <u>Q</u> | <u>Sewage Parameters</u> | | |
|--|----------|--------------------------|------------|----------|
| | | <u>BOD</u> | <u>TSS</u> | <u>P</u> |
| Pumping Station | 100% | | | |
| Interceptors and Sewers | 100% | | | |
| Sewage Treatment Plant | | | | |
| Pumping Station | 100% | | | |
| Rack and Grit | 100% | | | |
| Primary Chemical | | | | 100% |
| Primary Sedimentation | 90% | | 10% | |
| Aeration System | 20% | 80% | | |
| Secondary Clarification | 65% | 35% | | |
| Process Water and Outfall | 85% (1) | | | |
| Chlorination | 100% | | | |
| Sludge Treatment and Disposal | | 15% | 70% | 15% |
| Scum Incineration | 100% | | | |
| Average for Sewage Treatment Plant (2) | 56% | 16% | 21% | 7% |

Notes:

- (1) Remainder (15 percent) is not directly allocable.
- (2) Based upon the weighted average debt payments during the rate period of all the directly allocable treatment plant components.

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A number of components, being of a general nature, are not directly allocable. Accordingly, their costs are to be distributed to the parameters in accordance with the ratio of each parameter's allocable treatment plant capital costs to the total allocable treatment plant costs. These components are:

- Process Water (15 percent)
- Laboratory Services
- Heating Plant
- Plant Administration Facilities.

The derivation of the percentages is described below:

1. Pumping Stations: Pumps are sized according to flow considerations. Auxiliary equipment and housing are keyed to pump size.
2. Interceptors and Sewers: Volume requirements set size.
3. Rack and Grit: These facilities are sized primarily by flow considerations. The fact that large objects and grit are removed is irrelevant for allocation purposes because the material removed is not a component of TSS.
4. Primary Chemical Addition: As a direct result of P removal, TSS is also reduced; however, feed pumps, chemical storage tanks, solution mixing tanks and auxiliary equipment and buildings have all been sized according to the rate and concentration of P to be removed.
5. Primary Sedimentation: 87 percent of the capital costs have been for structures, and 13 percent for equipment. Primary sedimentation tank structures are designed primarily according to hydraulic loading parameters, and the equipment is chosen and

ATTACHMENT 2

sized by both flow and solids considerations. Therefore, allocation on the basis of 90 percent of the capital costs being attributed to flow and 10 percent to TSS is believed reasonable.

6. Aeration System: The aeration basins and supporting structures account for 64 percent of the capital costs of this component, with equipment, such as pumps, blowers and oxygen generators, comprising the rest. BOD is the primary design parameter for the structures (mixed liquor suspended solids concentration being the major factor), and equipment design is determined by both BOD and flow considerations. An approximate 50/50 split of the equipment design to BOD and Q yields the final allocation of 80 percent BOD and 20 percent flow.
7. Secondary Clarifier: The secondary clarifier structures, which account for 65 percent of the capital costs of this component, are designed according to flow considerations. The equipment, 35 percent of capital costs, is designed to handle secondary return and waste activated sludges, which are primarily BOD-related. Therefore, 65 percent of the costs are allocated to Q and 35 percent to BOD.
8. Process Water & Outfall: An analysis of these components has shown that 85 percent of the total capital costs are attributable to the outfall and 15 percent to process water facilities. The design of the outfall was based on flow (Q) considerations. However, the process water system contributes to many unit processes and to general plant cleanup, thereby making its portion (15 percent of capital costs) non-directly allocable.
10. Sludge Treatment & Disposal: The facilities contained in this component are designed and sized according to the type and amount of sludge to be processed. Since

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the plant began operations as a primary facility in 1940, secondary treatment and phosphorus removal have been added, thereby altering the characteristics of the sludge.

The sizing of facilities is a function of the rate of solids loading. However, relating solids loading to the plant input parameters of BOD, TSS and P is difficult because the parameters are not mutually exclusive, i.e., TSS has a BOD component, and soluble BOD may become a suspended solid during the activated sludge process. Phosphorus occurs in soluble and insoluble forms, the latter contributing to TSS.

Therefore, operational values over a period from December 1977 to September 1978 have been analyzed to link the makeup of sludge solids to the input parameters. The following presents the results of the analysis based upon average FY 78 input values and assuming January 1, 1980 operational conditions.

TSS = 70%

BOD = 15%

P = 15%

The way these results should be interpreted is:

The sludge solids upon which the component designs are based, are, by weight, 70 percent input TSS, 15 percent input BOD and 15 percent input P.

11. Scum Incinerator: This component is designed to incinerate the floatables skimmed off the clarifiers. The concentration of floatables is generally related to flow.

Allocation of Operation and Maintenance (O&M) Cost

Operation and Maintenance (O&M) costs are allocated to the sewage parameters on the basis of function and utilization.

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This functional method contrasts with the design-based method used to allocate capital costs to the sewage parameters. Table II-G, on the following page, presents the O&M cost allocations to the sewage parameters for which the system is utilized.

A number of accounts are general in nature and thus not directly allocable. Their costs are distributed to the parameters in accordance with the ratio of each parameter's directly allocable O&M costs to the total directly allocable Sewage Treatment Plant O&M costs. These accounts are:

- Process Water and Outfall
- Laboratory Services
- Heating Plant
- Plant Administrative Facilities.

The derivation of the percentages is described below:

1. Pumping Stations: Pumps function to convey flow against the forces caused by gravity and friction. Pumps and appurtenances are entirely flow related functionally.
2. Interceptors and Sewers: Facilities function to convey flow.
3. Rack and Grit: Facilities function to remove particles and material of sizes larger than suspended solids. Because the large objects and grit removed in this component primarily originate outside of industrial, commercial and residential sources (i.e., urban runoff, street cleaning), allocation to flow is the most equitable alternative.
4. Primary Chemical Addition: Although primary chemicals indirectly aid in primary TSS reduction, the overwhelming reason for introduction of this component is phosphorus removal.

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TABLE II-G
ALLOCATION OF O&M COSTS TO
SEWAGE PARAMETERS

| <u>System Component</u> | <u>Q</u> | <u>BOD</u> | <u>TSS</u> | <u>P</u> |
|--|----------|------------|------------|----------|
| Pumping Stations | 100% | | | |
| Interceptors and Sewers | 100% | | | |
| Sewage Treatment Plant | | | | |
| Pumping Station | 100% | | | |
| Rack and Grit | 100% | | | |
| Primary Chemical | | | | 100% |
| Primary Sedimentation | | | 80% | 20% |
| Aeration System | | 100% | | |
| Secondary Clarification | | 25% | 65% | 10% |
| Process Water and Outfall (1) | | | | |
| Chlorination | 100% | | | |
| Sludge Treatment and Disposal | | 15% | 70% | 15% |
| Scum Incineration | 100% | | | |
| Average for Sewage Treatment Plant (2) | 17% | 30% | 39% | 14% |

Notes:

- (1) Not directly allocable
- (2) Based upon the weighted average O&M costs of all directly allocable treatment plant components

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5. Primary Sedimentation: Analysis of primary sludge has shown that of the estimated 375 tons per day (T/D) produced using FY 78 average input values, an estimated 298 T/D is attributable to the TSS input parameter and 77 T/D to P. These figures yield the approximate percentage values of 80 percent TSS and 20 percent P.
6. Aeration System: This component, which primarily includes blowers, oxygen generating equipment and aeration tanks, functions solely to facilitate microbial digestion of organic pollutants. Aeration system O&M costs are thus allocated to BOD.
7. Secondary Clarification: This component, along with the aeration system, serves as the heart of the activated sludge process utilized for secondary treatment. The secondary clarifiers remove suspended solids, much of which are biomass floc generated in the aeration system. However, other solids are removed as well and analysis has shown that of the 395 T/D of secondary sludge (generated assuming FY 78 average input values and January 1, 1980 operating conditions), 104 T/D is attributable to the BOD input parameter, 258 T/D to TSS and 33 T/D to P. After taking into account variations in input parameters, the following allocations are recommended: 25 percent to BOD, 65 percent to TSS and 10 percent to P.
8. Process Water and Outfall: O&M costs in this process include water purchased and electric power. In recent years, these expenses, attributable to the process water system, have accounted for approximately 98 percent of the total O&M costs of this component. Because the process water system contributes to functions throughout the plant, it is a non-directly allocable expense. The remaining 2 percent of this component's O&M costs, which

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cover labor and supplies, are assumed to be attributable to the process water system as well. It is assumed that the outfall O&M expense is negligible.

9. Chlorination: This component functions to disinfect treated wastewater. O&M costs for chlorination are related in total to flow.

10. Sludge Treatment & Disposal: The function performed by the components in this unit process is sludge handling and removal. Specific processes include mixing, dewatering, storage, conditioning, incineration and ash removal. The proper allocation of these process costs is to the plant input parameters as they ultimately contribute to the makeup of the sludge which is processed. Following this methodology, the parameter allocations, using FY 78 average plant input values and assuming January 1, 1980 operating conditions, are the same as used for the capital allocations: 70 percent to TSS, 15 percent to BOD, and 15 percent to P.

11. Scum Incinerator: This component is utilized for disposal of floatables removed in the treatment process. The O&M cost of this component is allocated to flow.



MEMORANDUM

TO COOPERS & LYBRAND - STEVE HOUGHAM
FROM CDM - LES CURTIS
SUBJECT DETROIT SEWER RATE METHODOLOGY
DATE SEPTEMBER 3, 1980

Attached is one copy of the 38-page report incorporating what are believed to be the final corrections based on the Settlement Agreement. This document will serve as the basis for the testing of the system.

Please note that the resulting rates do not necessarily match those now in effect. This is largely due to rounding errors and adjustments made during the settlement negotiations.

The attached document replaces the prior Methodology that had been given to you as a "preliminary" report.

Please let me know if you have any questions regarding the method or content.

cc: William Carney - DWSD ✓
William Krause - DWSD

Page 14 - 15 inlets - Hayes Street
allocated to common flow
in debt service

DETROIT SEWER RATE
METHODOLOGY

I Bases for Allocations
A. Capital Costs

ALLOCATION OF CAPITAL CONSTRUCTION COSTS
TO SEWAGE PARAMETERS

Direct

| System Component | Q | Sewage Parameters | | | FOG |
|--|-----------------|-------------------|-----|------|-----|
| | | BOD | TSS | P | |
| Pumping Station | 100% | | | | |
| Interceptors and Sewers | 100% | | | | |
| Sewage Treatment Plant | | | | | |
| Pumping Station | 100% | | | | |
| Rack and Grit | 100% | | | | |
| Primary Chemical | | | | 100% | |
| Primary Sedimentation | 85% | | 10% | | 5% |
| Aeration System | 20% | 80% | | | |
| Secondary Clarification | 65% | 35% | | | |
| Process Water and Outfall | 85% (1) | | | | |
| Chlorination | 100% (2) | | | | |
| Sludge Treatment and Disposal | | 15% | 70% | 15% | |
| Scum Incineration | 100% | | | | 100 |
| Average for Sewage Treatment Plant (2) | 53% | 16% | 21% | 7% | 3 |

Notes:

- (1) Remainder (15 percent) is not directly allocable, and is allocated per note (2) below
- (2) Based upon the weighted average debt payments during the rate period of all the directly allocable treatment plant components. Will vary year to year.
- (3) Percentages can change based on sludge make-up

*Bomb
R/C*

B. Operation & Maintenance Costs

ALLOCATION OF O&M COSTS TO
SEWAGE PARAMETERS

| <u>System Component</u> | <u>Q</u> | <u>BOD</u> | <u>TSS</u> | <u>P</u> | <u>FC</u> |
|--|-----------------|------------|------------|----------|-----------|
| Pumping Stations | 100% | | | | |
| Interceptors and Sewers | 100% | | | | |
| Sewage Treatment Plant | | | | | |
| Pumping Station | 100% | | | | |
| Rack and Grit | 100% | | | | |
| Primary Chemical | | | | 100% | |
| Primary Sedimentation | | | 70% | 20% | 10 |
| Aeration System | | 100% | | | |
| Secondary Clarification | | 25% | 65% | 10% | |
| Process Water and Outfall (1) | | | | | |
| Chlorination | 100% | | | | |
| Sludge Treatment and Disposal | | 15% | 70% | 15% | |
| Scum Incineration | 100% | | | | 10 |
| Average for Sewage Treatment Plant (2) | 16% | 30% | 39% | 14% | 10 |

Notes:

- (1) Not directly allocable
- (2) Based upon the weighted average O&M costs ^{in the rate year} of all directly allocable treatment plant components