Detroit Water and Sewerage Department

Wastewater Master Plan

DWSD Project No. CS-1314

Flow Projections from Significant Industrial Users

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Flow Projections from Significant Industrial Users

1. Background

This memorandum summarizes both the current (2000) and future (2010–2050) flow and loading projections for significant industrial users (SIUs) in the service area of the Detroit Water and Sewerage Department (DWSD). Current flows and loadings were based on DWSD SIU monitoring data. Future flows and loadings were estimated using employment projections developed by the Southeast Michigan Council of Governments (SEMCOG).

The scope of this evaluation was limited to SIUs. During the past 10 years, SIUs have been numbered between 400 and 500. There are currently 12,042 non-SIU dischargers; but SIUs discharge the pollutant types and loadings of most concern to the DWSD. In addition, information and monitoring data are readily available only for SIUs. Steve Kuplicki (manager of DWSD IWC) estimates that SIUs discharge about half the total industrial flow.

The DWSD's definition of SIUs is, for the most part, consistent with the federal definition (40 CFR 403.3 (t)). Per Sec. 56-3-58.1. (a) (48) of Ordinance 39-99 of the Detroit Municipal Code:

> Significant industrial users means any user of the POTW who:
>
> (i) Has an average discharge flow of 25,000 gallons per day or more of process wastewater excluding sanitary, boiler blowdown, and noncontact cooling water; or
>
> (ii) Has discharges subject to the national categorical pretreatment standards; or
>
> (iii) Requires pretreatment to comply with the specific pollutant limitations of this division; or
>
> (iv) Has in its discharge toxic pollutants as defined pursuant to 33 U.S.C. § 1317, or other applicable federal and state laws or regulations, that are in concentrations and volumes which are subject to regulation under this division as determined by the department; or
>
> (v) Is required to obtain a permit for the treatment, storage or disposal of hazardous waste pursuant to regulations adopted by this state or adopted under the Federal Solid Waste Disposal Act, as amended by the Federal Resource Conservation and Recovery Act, as amended, and may or does contribute or allow waste or wastewater into the POTW including, but not limited to, leachate or runoff; or
>
> (vi) Is found by the City of Detroit to have a reasonable potential for adverse effect, either singly or in combination with other contributing industries, on the POTW operation, the quality of sludge, the POTW's effluent quality, or air emissions generated by the POTW.

2. Description of Data Sources

The key information needed for conducting the analysis included:

- List of SIUs for the past 10 years with facility name, and complete address (for regional analysis and GIS geocoding)
- SIC code for each SIU (for industry group analysis)
- Daily average SIU discharge flows (current year was minimum; past 10 years was preferred)
- Employment numbers for each SIU (current year was minimum; historical data were desired)
- SIU discharge monitoring results (current year and historical)
- Regional economic trend, industry trend, and employment trend forecasts
- Wastewater flow and quality development trends for each SIU industry group
- DWSD wastewater treatment plant average dry weather influent flow during the past 5 years (for an alternative method analysis)
- DWSD wastewater treatment plant average dry weather pollutant influent concentrations
- Dry weather inflow/infiltration estimates
- Domestic background flow (including non-SIUs and institutional flow) and pollutant concentrations

No single source or database had all the above information. The DWSD industrial waste control (IWC) section probably has the largest amount of records and information regarding historical SIU information and monitoring data. CDM has some recent data about the dry and wet weather flow estimates and inflow/infiltration flow estimates through its GDRSS CS-1249 (Great Detroit Region Sewer System) project for DWSD. The DWSD monitoring database is comprehensive in many areas; however, only limited data can be retrieved. DWSD is addressing the computer system as a whole. The database should be fully online by the summer of 2003 and will eventually permit better data retrieval.

Seven different data sets, which ranged in content from SIU facility names and addresses to actual monitoring data, were obtained from different sources. In addition, CH2M HILL staff manually collected monitoring data from the DWSD comprehensive inspection reports for 2000 and constructed an eighth data set. The eighth data set was necessary because of inconsistencies between the seven other data sets and lack of current and reliable SIU flow and monitoring data. The goal was to assemble a master database for current conditions that is as accurate and complete as possible. The master database also was used to evaluate historical trends. The eight data set provided facility and/or monitoring data from the years 1993 (one data set provided by DWSD IWC), 1994 (one data set from the DWSD local limits study report by McNamee, Porter and Seeley), 1995 (one data set from CDM), 1998 (one data set from CDM), 2000 (three data sets from DWSD IWC), and 2001 (one data set from DWSD IWC). The data sets contained the information in Table 1.

Table 1. List of Data Sources

Data Year	Data Included in Data Set	How Data Incorporated into Current Flows and Loadings
1993	SIU facility names, account numbers, permit numbers, 1993 SIU flows, metals concentrations	Metals data used for calculating SIU metals loadings
1994	SIU facility names, addresses, permit numbers, 1994 SIU flows	Checkup and historical information
1995	SIU facility names, permit numbers, 1995 SIU flows, metals, BOD, TSS, and oil and grease concentrations	Metals, BOD, TSS, oil and grease data not used as data qualifiers undefined and data incomplete
1998	SIU facility names, addresses, business descriptions, phone numbers, contact names, 1998 SIU flows and metals concentrations	Metals concentrations data not used as all facilities had same metals concentrations; used for historical trend evaluation
2000	SIU and non-SIU facility names, addresses, SIC codes, 2000 SIU and non-SIU flows	Used for check up and historical trend
2000*	SIU facility names, addresses, SIC codes, number of employees, 2000 SIU flow rates, BOD, TSS, oil and grease, phosphorus, and nitrogen concentrations	Data set compiled manually by CH2M HILL, SIU flow rates, BOD, TSS, oil and grease and phosphorus concentrations used, secondary source of SIC codes
2000	SIU facility names, addresses, permit numbers, SIC codes, number of employees, 2000 SIU flows	SIU list compiled from facility names, primary source of facility SIC codes, number of employees
2001	SIU facility names, addresses account numbers, permit numbers, phone numbers, contacts	SIU list compiled from the facility names

*Data set compiled manually by CH2M HILL after reviewing the 2000 DWSD comprehensive inspection reports.

The most recent SIU list was obtained from the DWSD IWC division. The current daily flows for the SIUs were obtained primarily from the year 2000 data set constructed by CH2M HILL. If a daily flow was unavailable for a particular SIU from the data set, the flow data were obtained from one of the DWSD provided 2000 data sets. Metals concentrations for some SIUs were obtained from the 1993 data set, as the SIU list changed between 1993 and 2000. More recent metals concentration data were available in various files and in the electronic database but were not retrievable. BOD, TSS, oil and grease, and phosphorus concentration data were available in IWC SIU files only. The data were obtained by manually reviewing comprehensive inspection reports at the IWC (the 2000 data set constructed by CH2M HILL). Nitrogen loadings were not calculated since only one SIU was monitored for nitrogen in 2000.

SEMCOG prepared population projections till 2050 for the DWSD comprehensive water master plan project. Employment numbers till 2025 by transportation zone (TAZ) and community were also from the SEMCOG study report on regional economic and employment forecast. The trend (typically a first order or second order regression curve) was developed for each industrial group within each sewer district, and the same trend was used for projection till 2050.

Manual review and override may be applied if any unreasonable future forecast resulted (sharp increased or reduced future employment number changes), mostly due to the second-order regression curves.

3. Methodology Selection (Current Conditions and Future Projections)

3.1 Survey of Methodologies

A survey was conducted of the methods employed to forecast future industrial and commercial wastewater flows and loadings in various master/facilities plans. The survey focused primarily on plans for cities similar in size to Detroit. All the surveyed plans were conducted or led by CH2M HILL except for the Milwaukee Facilities Plan. The plans included in the survey were for Boston, Clayton County (GA), Cleveland, Dallas, Gwinnett County (GA), Los Angeles, Milwaukee, Minneapolis, Pittsburgh, Seattle, Singapore, Stamford (CT), Unified Sewerage Authority (OR), and two smaller Canadian cities. The methods varied greatly and ranged from ignoring industrial and commercial flows and loadings altogether to obtaining detailed forecasted discharge data from each industry.

In general, the larger the municipality and the longer the master plan period, the less detailed the industrial and commercial forecasting data used. Large municipalities tend to have more industry than smaller municipalities but also serve a much larger domestic population. Population growth and the impact of such growth on sewer overflows were generally the focus for large municipal master plans. The longer the master planning period (e.g., > 50 years), the more difficult it is to forecast future industrial flows accurately.

Unlike population growth, industrial growth is more difficult to forecast. Existing industries are constantly changing manufacturing processes, and often such changes result in less wastewater discharged or lower strength wastewater. Industries are realizing significant cost savings by reducing the volume of wastewater generated by manufacturing processes and by better pretreatment of wastewater streams. Finally, new industrial facilities are generating less wastewater than older facilities in the same industry as improved manufacturing processes that generate less wastewater are found in the new facilities.

The following plans included no forecasts for industrial and commercial flows and loadings: Boston, Cleveland, Pittsburgh, and Gwinnett County. Some municipalities like Pittsburgh chose not to focus on industrial and commercial wastewater, whereas Gwinnett County receives no industrial wastewater. Although none of the other plans shared completely identical approaches, no plan was unique, as each plan shared some common steps with other plans to forecast industrial and commercial flows and loadings.

3.2 Current Flows and Loadings

The cities of Los Angeles, Minneapolis, Stamford, and Guelph and St. Catherines (Ontario) used existing industrial flow and monitoring data to calculate current flows and loadings. That is, the municipalities had good and available industrial monitoring data.

The Dallas plan calculated industrial and commercial wastewater flows based on water usage (from meters) by assuming 90 percent of water used was discharged as wastewater.

The city of Dallas was most concerned on flows into its interceptors so loadings were not calculated. Flow information was not available for all sub-basins in the Dallas area, so gallons of water consumed per employee per day (gped) were calculated for industry and commercial establishments. Before performing this calculation, major dischargers of wastewater were subtracted out so as not to skew the gped rate. The gped rate was then applied to all subbasins based on available employment population data, and then the major dischargers were reintroduced into the calculation.

The industrial flow for the Milwaukee plan was calculated by first obtaining total flow monitoring data from the two treatment plants. The residential and commercial flows were then calculated by multiplying the population by a gpcd estimate (obtained from Milwaukee's *Cost Recovery Procedures Manual*). The industrial flow was calculated by subtracting the calculated residential and commercial flows from the total flow. Similarly, current industrial loadings (BOD and TSS) were calculated by first obtaining total BOD and TSS monitoring data from the two treatment plants. The residential and commercial loadings were then calculated by multiplying the population by lb BOD/cap/day and lb TSS/cap/day estimates (obtained from Milwaukee's *Cost Recovery Procedures Manual*). The industrial BOD and TSS loadings were calculated by subtracting the calculated residential and commercial BOD and TSS loadings from the total BOD and TSS loadings.

3.3 Future Flows and Loadings

The Dallas plans forecast future flows by using rates from past reports for the Dallas area. These reports estimated a rate of increase of gallons per capita per day per year that included all classes of customers (i.e., residential, commercial, industrial, and government). Previous reports established a rate of gallons of wastewater generated for every gallon of water used. Using population growth forecasts and the above rates, future flow was calculated for residents, commercial, industry, and government. Again, the city of Dallas was more concerned with future wastewater flow than with flow from each class of customer.

The Los Angeles plan converted current industrial flows and loadings (included SIC codes, industry names, and monitoring data) to a per-capita basis using existing population data. The data showed that about 80 percent of the industrial wastewater was discharged by about 20 percent of the industries. Future industrial flows and loadings were forecast using the future population growth rates. That is, industrial growth was assumed to be identical to population growth. The Los Angeles plan was for 100 years. Due to the period of the plan, the team took a broader look at population growth and asked the question, "What will truly control population growth?" The banking community felt that jobs and economics would drive population growth (hence the link between population and industrial growth). It also felt that other issues that could limit population growth, such as air pollution, land availability, and water shortages, would be solved. The time span of the report and the team's approach forced the city of Los Angeles to get away from looking at forecasts from planning agencies and to focus on the true cause of population growth in Los Angeles.

The Milwaukee plan converted industrial flows and loadings (BOD, TSS) to per-acre rates based on industrial acres. Future industrial flows and loadings were calculated by multiplying baseline industrial flow and loading per-acre rates by forecast industrial land use growth in acres. The land use growth information was obtained from the Southeastern Wisconsin Regional Planning Commission.

Future nitrogen loading was calculated using a typical nitrogen concentration for wastewater and multiplying it by future total wastewater flow. Future phosphorus loading was calculated using current average phosphorus concentration at both treatment plants and multiplying it by future total wastewater flow.

The Minneapolis plan converted industrial flows and loadings (BOD, SS) to a per-employee basis (gped). The future flows and loadings were calculated by multiplying current flows and loadings by the projected employment for commercial and industrial companies. There was no reference given in the plan as to the source of the projected employment numbers.

St. Catherines, Ontario, distributed questionnaires to industrial users regarding pretreatment, expansion plans, closure plans, etc. Future flow and loadings estimates were based on responses to the questionnaires. St. Catherines is a smaller city, and the plan was completed many years ago.

The Seattle plan forecast future industrial and commercial flows and loadings by using population growth estimates obtained from government agencies. The industrial and commercial growth rates were assumed identical to the population growth rate.

The Stamford plan identified current flows and loadings and divided the flows into residential, commercial (estimated), and industrial (reported, only four major industries). Loadings were not broken down by category. CH2M HILL staff met with the Stamford Planning Department to discuss potential residential, commercial, and industrial development. Planned and potential development projects were identified and tabulated along with estimated land area for commercial projects. Future flows were estimated using the gathered information.

3.4 Methodology Applied

The methodology for projecting future flows and loadings for SIUs was selected based on the survey of methodologies, available flow and concentrations data, and available employment forecasting data. Since monitoring data were available for the SIUs, estimating current SIUs' flows and loadings was unnecessary. Although some of the data were dated, SIU monitoring data included flows and metals, BOD, TSS, oil and grease, and phosphorus concentration data. Metals concentration data included silver, cadmium, chromium, copper, mercury, lead, nickel, and zinc. The following steps were followed in projecting future flows and loadings.

1. Identify SIUs
2. Group SIUs based on type of business
3. Group SIUs based on geographical location
4. Identify current SIU employment numbers
5. Identify current SIU flows
6. Identify current SIU loadings
7. Project future SIU employment numbers
8. Project future SIU flows
9. Project future SIU loadings

Table 2 summarizes the initial proposed methodologies for estimating current and future SIU flows and loadings.

Table 2. Summary Of Applied Methodologies: For Estimating/Projecting Current And Future SIU Flows And Loadings

	Current	Future
Flow	**Typical steps:** 1. Obtain the current list of SIUs from DWSD Industrial Waste Control division 2. Calculate the total SIU flows by totaling all individual Y2000 SIU flows. If a particular SIU flow is missing from the Y2000 data, use the maximum of the available previous recorded flows (Y93, Y94, Y95, and Y98) 3. Additional analysis: • Calculate gped (gallon per employee per day) for all SIUs or per sub-groups (per SEMCOG category), compared to the gped calculated for industrial & commercial flows in GDRSS and national SIU average if the latter is available • Compare the total SIU numbers and SIU flows from Y93 to Y2000 (4 to 5 years data available) • Compare the total SIU flow estimates against previous estimates (such as Y94 local limits study, and GDRSS study) • Check water consumption for major SIUs (may be top 5% dischargers, or > 0.5 mgd), using a discharge factor of 0.95, to verify the discharge flow • GIS. SIU location and flow range will be displayed on a GIS map • Regional analysis based on sewer district division	**Typical steps:** 1. Calculate current gped, as described under current flow section 2. Calculate future flows using the employment growth rate till 2020 • If SIU fits one of the SEMCOG industrial group, estimate the future SIU (till 2020) flow by SIU flow x SEMCOG group employment growth rate • If SIU doesn't fit into any of the SEMCOG group, estimate the future SIU flow by SIU flow x overall SEMCOG employment growth rate • Then sum all future SIU flows to have the total future SIU flow 3. Calculate the future flow till 2050 using the employment growth rate (correlate to population growth rate) Note: the SEMCOG employment growth (overall and group) rate is for all industrial, commercial, and institutional growth, and up to 2020 only • Calculate 2050 employment growth rate by correlating it to the population growth rate which has till 2050 projection data • Repeat the above steps to obtain the 2050 SIU flow projections 4. Sensitivity analysis Note: The overall employment growth rate (as done by SEMCOG) may not be related to the SIU growth rate. There are also industry and SIU specific issues, and automation and conservation programs to be implemented by SIUs • Project the future flow based on gped change rate, assuming average, upper and lower rates using available information and best judgement • Project the future flow based on SIU discharge change rate, assuming average, upper and lower rates using available information and best judgement 5. Additional analysis • Major SIUs (5% of list, or >0.5 mgd) trend analysis. All available information will be reviewed to project the future major SIU flows, and the adequacy of group employment growth rate for flow increase projection will be assessed • GIS. Future SIU flow range can be displayed on a GIS map • Radius. Regional future SIU discharges can be displayed on a GIS map

Table 2. Summary Of Applied Methodologies: For Estimating/Projecting Current And Future SIU Flows And Loadings

	Current	Future
Loading (BOD/TSS/P)	**Typical steps:** 1. Obtain the current SIU list and flow information as described in the current flow section 2. Calculate the BOD/TSS/P loadings using the two methodologies below 3. Using SIU monitoring data • Obtain BOD/TSS/P average concentration data from IWC records (manually go through the IWC files) • Calculate the loadings of BOD/TSS/P for each SIU • Sum the loadings for all SIUs 4. Using plant monitoring data and domestic loading estimates • Identify Y2000 plant influent loadings of BOD/TSS/P • Estimate the domestic flow loadings of BOD/TSS/P by both ⇒ national average domestic conc. X gpcd x population ⇒ local limits 94 report domestic conc. X estimated domestic flow 5. Compare the BOD/TSS/P loading calculations from the above methods 6. Additional Analysis • Calculate pped (pounds per employee per day) for all sub-groups (per SEMCOG category and region) • Calculate equivalent SIU BOD/TSS/P concentration in Method 2.2 • GIS. SIU location and loading range can be displayed on GIS maps if using Method 2.1 • Regional analysis	**Typical steps:** 1. Project the future SIU flow as described in the future SIU flow section, then multiply with three sources of BOD/TSS/P concentrations 2. Using IWC monitoring data • Future loading = future flow x IWC monitoring concentration 3. Using pped method • Future loading = future employee number x pped for each industrial group within each district • Total future loading = sum of all industrial groups or district SIU sub-group loadings 4. Using the equivalent SIU concentrations from Method 2 described in current BOD loading section • Future loading = future flow x equivalent SIU concentration 5. Sensitivity analysis • Assume an upper and a lower future concentrations (or percent changes) of BOD/TSS/P, using available information and best judgement 6. Additional analysis • GIS. Future loading range can be displayed on GIS maps if using Method 1.1 • Radius. Radius analysis can be performed for future regional SIU loading contributions and be displayed on GIS maps if using Method 1.1

Table 2. Summary Of Applied Methodologies: For Estimating/Projecting Current And Future SIU Flows And Loadings

	Current	Future
Loading (Metals)	Same as current BOD/TSS/P loading calculations, except: • The 1993 IWC monitoring concentrations will be used because this is the only available database containing the metal concentrations • There may not be national average metal concentrations available	Same as BOD/TSS/P
Loading (N)	Same as current BOD/TSS/P loading calculations, except: • There is no IWC monitoring data on N, it is not monitored. Therefore, Method 2.1. is not applicable • Because a uniform equivalent N concentration will be applied to all SIUs, the radius analysis of current regional N loading distribution will be similar to the current flow radius analysis	Same as future BOD/TSS/P loading calculations, except: • There is no IWC monitoring data for N; therefore, Method 1.1. is not applicable • Because a uniform equivalent N concentration will be applied to all SIUs, the radius analysis of future regional N loading distribution will be similar to the future flow radius analysis

The following sections present the steps in detail that were followed to project future SIU flows and loadings

4. Existing SIU Flows and Loadings

4.1 Identify SIUs

The list of SIUs constantly changed and evolved throughout the project as data sets and new information became available. The SIU list was constructed by combining one of the DWSD provided 2000 data sets and the DWSD provided 2001 data set. These two data sets were for the most part similar, but some SIUs were not shared by both data sets. These SIUs were incorporated into the current SIU list. The number of SIUs in the DWSD service area was 403 as of April 2001.

4.2 Group SIUs Based on Type of Business

SIUs were grouped based on type of business to better observe trends in projected flows and loadings. To group the SIUs, an SIC code was first assigned to each SIU. One of the DWSD data sets for 2000 was the primary source of SIC codes; the 2000 data set constructed by CH2M HILL was the secondary source. If neither data set contained an SIC code for a facility, the SIC code was obtained from other resources.

Once an SIC code was assigned to each SIU, the facilities were sorted by SIC codes and then grouped together using SEMCOG industrial classes. The SIC codes correlate directly with the SEMCOG industrial classes.

The industrial classes describe the predominant purpose and major product or service of the SIUs. The four SEMCOG industrial classes for the SIUs were Manufacturing (SIC code 20 - 39), TCU (Transportation, Communications, Utilities) (SIC code 40 - 49), Wholesale/Trade (SIC code 50-51), and Service (SIC code 70 - 89).

4.3 Group SIUs Based on DWSD Sewer Service Districts

SIUs were then further grouped by DWSD sewer service districts, using facility addresses. The eight sewer districts were Clinton-Oakland, Dearborn, Detroit, Evergreen-Farmington, Macomb, NE Wayne, SE Oakland, and Western Wayne. Each SIU now had a SEMCOG industrial class and sewer district.

4.4 Identify Current SIU Employment Number

SIU employment numbers were obtained from one of the DWSD provided 2000 data sets (the same data set that was used to generate the SIU list). If the employment population was not available for a particular SIU, the employment numbers were obtained from either the IWC file record or from INFOUSA data source.

4.5 Identify Current SIU Flows

The daily flows for SIUs were primarily obtained from the 2000 data set constructed by CH2M HILL. If a daily flow was not available for a particular SIU from the data set, the flow datum was obtained from one of the DWSD provided 2000 data sets (the same data set that was used to generate the SIU list). If flows were available from both data sets, the flow from the 2000 data set constructed by CH2M HILL was selected. Two methods were used to calculate current SIU flows.

The first method involved summing total SIU flows. Flows summed by industrial groups and sewer districts were also conducted for detailed analysis. That is, total flows from Manufacturing, TCU, Wholesale/Trade, and Service were calculated and total flows from Clinton-Oakland, Dearborn, Detroit, Evergreen-Farmington, Macomb, NE Wayne, SE Oakland, and Western Wayne were calculated. For example, the total flow for all Manufacturing SIUs was 35.6 mgd, and the total flow for all SIUs in the Clinton-Oakland area was 3.02 mgd. Total SIU flows were also calculated for each industrial group in each sewer district. For example, the total SIU flow for Manufacturing SIUs in the Clinton-Oakland area was 2.65 mgd.

A second method (subtracting domestic flow from WWTP dry flow) to identify current flows was used for comparison purposes. This method involved estimation of the WWTP average influent dry flow, average dry weather I/I flow, and domestic (including non-SIUs and institutional) flow. Because many more variables were involved and used a larger component of the total WWTP influent flow to estimate the smaller portion of the flow (in this case, SIU flow), a larger error resulted. This calculation was conducted only for comparison purposes, but the results were not used for projection purposes because it was deemed inferior to method one in this case (where individual SIU flow information is quite complete).

4.6 Identify Current SIU Loadings

Current SIU loadings were calculated for metals, BOD, TSS, oil and grease, and phosphorus. The 1993 data set contained metals concentrations for some of the SIUs as a number of the current SIUs were not in the 1993 data set and vice versa. Not every 1993 SIU was sampled for all eight metals. The number of sampling events per facility ranged from one event to over 100 events in 1993. The maximum, average and minimum metals concentrations were calculated for each facility. The average concentration was used for calculating current loadings and for future loading projections.

The BOD, TSS, oil and grease, and phosphorus concentrations were obtained by manually reviewing the DWSD comprehensive inspection reports for the SIUs at the IWC (the year 2000 data set constructed by CH2M HILL). Most, but not every SIU was sampled for all four parameters. The average, minimum and maximum concentrations for each facility's parameters were listed in the reports and the average concentration was used for calculating current loading and future loading projections. The lack of loading concentration data for all the SIUs led to two different methods for calculating loading data.

Both methods began with the calculation of the individual SIU loadings for all pollutants by multiplying each SIU's daily flow by its corresponding metals, BOD, TSS, oil and grease, and phosphorus concentration data. The SIU loadings were then summed for each subgroup by both the industrial groups and sewer districts resulting in 32 subgroups (4 industrial groups by 8 sewer districts). This sum, however, is incomplete because SIUs that do not have flow and concentration data for the pollutant of interest were not included in the total SIU loading calculations. The two estimation methods built upon the above summation of SIU loadings that have both flow and concentration data, by inclusion of additional SIUs that do not meet the same criteria.

The first method (volume adjusted method) was designed to include those SIUs that have flow but not monitoring data into the summation of the SIU loadings. This adjustment was done for each subgroup by industry group and by sewer district. The total SIU loadings summed for each industrial group in each sewer district were volume adjusted by multiplying the total SIU loadings for each subgroup times the ratio of total flow for all SIUs in the same subgroup (including those that have flow only but no concentration data) to total flow for all SIUs (with both flow and concentration data). For example, the total loading for SIUs with both flow and silver monitoring data in the Manufacturing industrial group in the Clinton-Oakland area was 0.115 lb/day. The corresponding total flow for this SIU subgroup was 1,821,378 gal/day. The total flow for all SIUs in the Manufacturing industrial group in the Clinton-Oakland area was 2,651,298 gal/day. The volume adjusted loading calculates as shown below.

$$0.115 \text{ lb silver/day} \times (2{,}651{,}298 \text{ gal/day} / 1{,}821{,}378 \text{ gal/day}) = 0.167 \text{ lb silver/day}$$

The volume-adjusted calculation assumes the same volume weight concentration for those SIUs without concentration data as those with concentration data. However, since this adjustment was done for each individual subgroup, the error of estimation was minimized.

The second method (constant pped assumption) for calculating total loadings was also developed to improve the coverage of SIUs to be included in the loading summation and for comparison purposes.

The "pped" (pounds-per day-per-employee) value for each pollutant was calculated from the SIUs that have both flow and concentration data within each of the 32 subgroups. Because the employment number was the most complete information available (almost 100 percent for the SIUs), this approach covered nearly 100 percent of the SIUs for loading estimates. The total SIU loadings in each subgroup were then calculated by multiplying "pped" (from above) times the total employment number in each subgroup (which included those SIUs that have no monitoring data and/or flow data). For example, the total loading for SIUs (with both flow silver monitoring data) in the manufacturing industrial group in the Clinton-Oakland district was 0.115 lb/day. Dividing this sum by the number of employees (16,693) in SIUs with flow and monitoring data resulted in a "pped" of 6.89×10^{-6} pped. The total employment population for all SIUs in this subgroup was 19,306 employees. The adjusted loading calculates as shown below.

$$6.89 \times 10^{-6} \text{ pped} \times (19{,}306 \text{ employees}) = 0.133 \text{ lb silver/day}$$

The approach assumes the "pped" of the two groups (SIUs that have both flow and concentration data and those SIUs that do not) to be the same within each subgroup. Again, since each subgroup had this adjustment, the potential error was minimized.

5. Future SIU Flows and Loadings

5.1 Project Future SIU Employment Populations

SEMCOG provided employment number projections by industrial groups and sewer districts from the base 2000 year to 2025 in 5-year increments. For example, SEMCOG provided manufacturing employment projections for the Clinton-Oakland area for 2000, 2005, 2010, 2015, 2020, and 2025. Linear and polynomial regression (if necessary) analyses were performed on the SEMCOG projection data. The best-fit equation from the regression analysis was used to project employment populations for 2030, 2040 and 2050. The projection numbers were then checked for obvious unrealistic situations. Several second order regression curves yielded 2050 employment projections that deviated 50 to 100% from the 2025 data. In such cases, the deviated number was discarded and changed to keep a more realistic flat or linear change curves. Employment growth rates were calculated by dividing the projected employment number for the future year of choice by its corresponding year 2000 employment number. For example, the projected 2010 employment number for manufacturing SIUs in the Clinton-Oakland area was 23,501 and the corresponding 2000 employment number was 19,306. The employment growth rate during the period for this subgroup was 23,501/19,306 = 1.217.

5.2 Project Future SIU Flows

Future SIU flows were calculated for each subgroup by industry and sewer district. Either the total future employment number or projected employment growth rate for the subgroups was used to project future SIU flows. The current SIU flows for each subgroup calculated using the first method in the **Identify Current SIU Flows** section were multiplied by the appropriate growth rate. For example, the total 2000 flow for manufacturing SIUs in the Clinton-Oakland area was 2.65 mgd. The corresponding employment growth rate for 2010 was 1.217. The projected 2010 total flow for manufacturing SIUs in the Clinton-Oakland area is shown below.

$$2.65 \text{ mgd} \times 1.217 = 3.23 \text{ mgd}$$

An alternative calculation method was to multiply the "gped" value for each subgroup by the future employment number of the same subgroup. The projected total SIU flows for each industrial group in each sewer district were summed to calculate the projected total SIU flows for each industrial group and the projected total SIU flows for each sewer district.

5.3 Project Future SIU Loadings

Future SIU loadings were calculated for industrial groups and sewer districts. The projected employment growth rate for each industrial group in each sewer district was used to project future SIU loadings. The current SIU loadings calculated using the constant pped adjusted method in the **Identify Current SIU Loadings** section were multiplied by the appropriate growth rate. For example, the total 2000 silver (with pped adjusted method) loading for manufacturing SIUs in the Clinton-Oakland area was 0.133 lb/day. The corresponding employment population growth rate for 2010 was 1.217. The projected total 2010 silver loading for manufacturing SIUs in the Clinton-Oakland area is shown below.

$$0.133 \text{ lb/day} \times 1.217 = 0.162 \text{ lb/day}$$

An equivalent way of calculating was to multiply the "pped" value of each subgroup by the future employment number of the same subgroup. The projected total SIU loadings for each industrial group in each sewer district were summed to calculate the projected total SIU loadings for each SEMCOG industrial class and the projected total SIU loadings for each sewer district.

6. Necessary Assumptions

The key factor in performing the future SIU flow and loading projections is the employment number forecast. Assumptions made during the projections include the constant pollutant concentration levels from 1993 to 2050; "gped" (gallons-per-employee-per-day) or "pped" (pounds-per-employee-per-day) remain constant from 2000 to 2050 regardless of the industrial process change or efficiency improvement, or water conservation efforts; the SIU employment trend is the same as the overall regional employment trend; and there are no specific considerations for technology or process improvements or changes.

Making these assumptions was necessary because in almost all cases, detailed information was unavailable. However, the simplified approach may not be accurate due to the omission of many other important factors.

7. Results and Findings

7.1 Current Flow and Loading Estimation

Characteristics of Current SIUs. As of April 2001, there were 403 SIUs in the DWSD sewer service area. Almost all SIUs can be categorized into four groups per SIC code division:

- Manufacturing (SIC code 20-39)
- Services (SIC code 70-89)
- Transportation, communication, and utilities, or TCU (SIC code 40-49)

- Wholesale trade (SIC code 50-51)

These 403 SIUs discharge about 45 mgd. Steve Kuplicki of the DWSD's industrial waste control division (IWC) estimated that the remaining 12,042 non-SIUs discharge another 50 mgd (Meeting minutes 2001).

Current SIU Flow Characteristics. Table 3 summarizes the make-up of the current SIUs and flows by industry group.

Figure 1 illustrates the SIUs and flow discharge distributions among the four industry groups. The manufacturing sector is the largest source of SIUs and SIU flows. About 72 percent (289 out of 403) of the current SIUs are manufacturers; these SIUs discharge about 80 percent (35.6 mgd) of the total SIU flow (44.9 mgd). The services sector is the second largest, accounting for about 17 percent of the total SIUs (70 among 403 SIUs), and discharges close to 14 percent (6.0 mgd) of the total SIU flow. TCU and wholesale sectors account for about 7 percent (28 out of 403) and 4 percent (16 out of 403) of the total SIUs, and 6 percent (2.6 mgd) and 1 percent (0.6 mgd) of the total SIU flow, respectively. Figure 1 also suggests that the manufacturing sector has a larger average discharge flow than the other three industry sectors.

The current SIUs and their discharge flows also have clear regional characteristics. Figure 2 shows the number and composition of the SIUs in each of eight DWSD sewer service districts: Clinton-Oakland, Dearborn, Detroit, Evergreen, Macomb, Northeast Wayne, Southeast Oakland, and Western Wayne. The definition and division of the sewer district was provided by CDM, and is consistent with the CDM GDRSS (Great Detroit Regional Sewer System) model project. The City of Detroit has the largest number of SIUs (153 out of 403 SIUs, or 38 percent), followed by Western Wayne (with 81 SIUs, or 20 percent), Southeast Oakland (66 SIUs, or 16.5 percent), and Macomb (45 SIUs, or 11.2 percent), etc. The City of Detroit also has the highest concentration of manufacturing and services SIUs.

Table 3. SIU Number and Flow Among Different Industry Groups

	Manufacturing	TCU	Wholesale	Services	Total
SIUs	289	28	16	70	403
Flow, mgd	35.6	2.6	0.6	6.0	44.9

Figure 3 shows the current year (2000) SIU flow distribution among the eight sewer districts.

SIUs in the City of Detroit discharge about 23.6 mgd, or 53 percent of the total SIU flows. The Clinton-Oakland, Dearborn, Southeast Oakland, Western Wayne, and Macomb districts discharge from 3 to 5.2 mgd of SIU flows, with each district contributing about 6.8 to 11.8 percent of the total SIU flow. SIUs in Evergreen-Farmington and Northeast Wayne discharge the smallest amount, with 0.54 and 0.41 mgd, or 1.2 and 0.9 percent, of the total SIU flows, respectively.

Table 4 summarizes the "gped" values for all thirty-two subgroups (by district and industry group), all industry groups, all districts, and overall "gped" for total SIUs. The City of Detroit has the highest "gped" among eight districts at 355 "gped".

The TCU sector has the highest "gped" among four industry groups, with 1,240 "gped". The overall "gped for" all SIUs is 243 "gped", which is significantly higher than the non-SIU commercial/industrial "gped" of around 80 gallons/employee/day per CDM's GDRSS study.

TABLE 4. Summary of SIU "gped" Values

	MFG	TCU	WHL	SER	OVERALL GPED BY DISTRICT
Clinton-Oakland	137	4,540	0	145	148
Dearborn	213	314	289	93	194
Detroit	537	4,920	271	106	355
Evergreen-Farmington	122	0	4,640	142	190
Macomb	195	250	111	159	197
NE Wayne	374	0	0	100	163
SE Oakland	600	1,210	914	69.5	168
Western Wayne	171	2,440	1,733	149	186
Overall gped by Industry group	294	1,240	732	99	243

Current SIU Loading Characteristics. Loading estimates for 2000 were performed for the following metals: silver, cadmium, chromium, copper, mercury, nickel, lead, and zinc. Compatible pollutants: 5-day biological oxygen demand (BOD), total suspended solids (TSS), total phosphorus, and fat, oil and grease (FOG). Only partial phenolic data was available. Ammonia nitrogen data was scarce, and therefore was not analyzed.

Table 5 and Table 6 summarize the flow and loading of each pollutant by industry group and sewer district, respectively. Note the sum of metal loading in two tables may not equate perfectly due to the different approximation and estimation routes taken in generating the results.

When comparing the flow and loading distributions patterns among different industrial groups, three pattern types become apparent.

Type 1. The distribution patterns among industry groups between flow and loadings for zinc, TSS, BOD, total phosphorus, lead, and copper are very similar, which indicates the average pollutant concentration for these pollutants is similar in the different industry groups. For example, the total flow from manufacturing is about 78 percent of the total flow from all the industry groups, and the total lead loading from manufacturing is about 80 percent of the total lead loading from all the industry groups. The total flow from services is about 13 percent of the total flow from all the industry groups, and the total lead loading from services is about 14 percent of the total lead loading from all the industry groups. Figure 4 illustrates this pattern for lead.

Type 2. The loading distributions for fats, oils, and grease, Phenol (loading is not listed in the table because the data is incomplete, however, the trend is still useful) and silver among different industry groups is lower in manufacturing and higher in services, compared to the flow distribution - which indicates these pollutants are more concentrated in the discharges from services, but not manufacturing. For example, the total flow from manufacturing is about 78 percent of the total flow from all the industry groups and the total fats, oils, and grease loading from manufacturing is about 50 percent of the total fats, oils, and grease loading from all the industry groups. The total flow from services is about 13 percent of the total flow from all the industry groups, and the total fats, oils, and grease loading from services is about 27 percent of the total fats, oils, and grease loading from all the industry groups. Figure 5 illustrates this pattern for fats, oils, and grease.

Type 3. The loading distributions for cadmium, chromium, and nickel are dominated by the manufacturing sector and low in the service. For example, the total cadmium loading from manufacturing is about 94 percent of the total cadmium loading from all the industry groups, and the total cadmium loading from services is about 2.6 percent of the total cadmium loading from all the industry groups. Figure 6 illustrates this pattern for cadmium.

Table 5. Current SIU Loadings by Industry Group

	Manufacturing	TCU	Wholesale Trade	Services	Total
Flow	35	2.6	0.6	5.9	45
Silver	2.6	0.18	0.05	2.06	4.9
Cadmium	17	0.59	0.07	0.47	18
Chromium	43	1.93	1.01	2.60	48
Copper	38	2.86	0.94	9.98	52
Mercury	0.079	0.005	0.002	0.055	0.140
Nickel	52	1.3	2.7	1.3	57
Lead	32	1.4	1.3	5.5	40
Zinc	180	15	16	25	236
BOD	68,100	9,900	4,100	13,100	95,200
TSS	56,000	3,500	2,900	9,400	71,700
Total phosphorus	2,300	89	155	340	2,900
Fat, oil, and grease	8,900	880	3,300	4,800	17,900

Table 6. Current SIU Loadings by Sewer District

	Clinton-Oakland	Dearborn	Detroit	Evergreen-Farmington	Macomb	NE Wayne	SE Oakland	Western Wayne	Total
Flow	3.0	3.4	24	0.54	5.2	0.41	3.5	4.9	45
Silver	0.53	0.22	2.2	0.01	0.34	0.14	0.73	0.82	5.2
Cadmium	0.22	0.19	3.0	0.01	0.45	0.75	0.34	13	22
Chromium	0.35	5.2	29	1.4	3.7	0.58	3.5	7.2	60
Copper	2.7	9.3	25	0.11	4.2	0.43	3.6	8.3	62
Mercury	0.004	0.005	0.099	0.000	0.007	0.003	0.011	0.015	0.16
Nickel	1.7	4.6	30	0.02	10	0.60	4.2	8.7	71
Lead	1.2	4.7	15	0.09	2.94	0.43	2.2	14	48
Zinc	11	13	110	0.17	18	1.7	37	46	300
BOD	5,300	1,700	43,600	355	4,600	1,100	7,400	26,800	96,500
TSS	2,700	6,100	39,300	303	4,300	580	2,900	12,800	76,100
Total Phosphorus	150	81	990	7.5	440	52	170	830	3,000
FOG	330	360	8,400	48	1,400	93	820	7,300	18,000

The regional analysis reveals that in addition to being the largest SIU flow discharger, Detroit is also the largest loading discharge for almost all pollutants, except for cadmium. Western Wayne is the largest cadmium loading discharger, as shown in Figure 7. Western Wayne County also approaches Detroit in lead, total phosphorus, fats, oils, and grease, and BOD loading discharges. Figures 8 and 9 show the lead and fats, oils, and grease loading distributions.

Tables 7 through 9 also show the "pped" (pounds/employee/day) values for Cd, BOD, and FOG.

Table 7 shows that the service sector is not a main Cd discharger; while manufacturing, due to its large flow and employment base, will be the main Cd discharger. The manufacturers in Western Wayne and Northeast Wayne districts have the highest "pped" value for Cd.

Table 7. Summary of SIU "pped" Values for Cd

	MFG	TCU	WHL	SER	OVERALL GPED BY DISTRICT
Clinton-Oakland	1.05E-05	0.000274	0	6.99E-06	1.09E-05
Dearborn	1.34E-05	3.54E-06	7.22E-05	0	1.33E-05
Detroit	6.4E-05	1.30E-03	1.33E-04	9.21E-06	4.66E-05
Evergreen-Farmington	9.35E-06	0	1.93E-04	0	5.93E-05
Macomb	1.79E-05	0	1.46E-05	0	1.79E-05
NE Wayne	1.25E-03	0	0	1.03E-05	2.82E-04
SE Oakland	6.95E-05	1.38E-04	0	4.84E-06	1.97E-05
Western Wayne	5.37E-04	5.86E-04	2.84E-04	5.98E-06	4.85E-04
Overall pped by Industry group	1.42E-04	5.97E-04	1.9E-04	7.93E-06	1.07E-04

Table 8 shows that high "pped" values for BOD are observed in the TCU and WHL sectors only. Western Wayne and Detroit have the highest "pped" of BOD among eight districts.

Table 8. Summary of SIU "pped" Values for BOD

	MFG	TCU	WHL	SER	OVERALL GPED BY DISTRICT
Clinton-Oakland	0.23	12.8	0	0.25	0.25
Dearborn	0.084	0	0.32	0.16	0.10
Detroit	0.89	9.7	0.92	0.30	0.64
Evergreen-Farmington	0.047	0	6.6	0.052	0.13
Macomb	0.16	0.16	0.015	0.86	0.17
NE Wayne	0.99	0	0	0.26	0.42
SE Oakland	0.30	74	0.48	0.075	0.22
Western Wayne	0.92	5.4	34	0.31	0.99
Overall pped by Industry group	0.54	3.4	5.5	0.22	0.48

Table 9 shows that wholesale and services sectors have the highest "pped" for FOG.

Table 9. Summary of SIU "pped" Values for FOG

	MFG	TCU	WHL	SER	OVERALL GPED BY DISTRICT
Clinton-Oakland	0.015	0.61	0	0.020	0.016
Dearborn	0.019	0	0.070	0.029	0.022
Detroit	0.111	0.95	0.54	0.13	0.13
Evergreen-Farmington	0.0071	0	0.54	0.011	0.017
Macomb	0.054	0.041	0.038	0.14	0.054
NE Wayne	0.083	0	0	0.023	0.036
SE Oakland	0.064	3.55	0.055	0.020	0.032
Western Wayne	0.091	0.915	44	0.040	0.18
Overall pped by Industry group	0.068	0.30	4.0	0.080	0.089

Current flow and Loading Compared to WWTP Dry Flow and Loading

Figure 10 compares the SIU flow/loading to the total WWTP headwork flow/loadings. Figure 11 illustrates the percentage of the WWTP flow/loadings contributed from SIUs. In summary, SIUs contribute 7.5% of the plant dry weather flow (45 mgd vs. 605 mgd in 2001); however, they contribute a significantly higher percentage of the total WWTP headwork loadings – ranging from 8.2% to over 60%. Cd is shown to be almost exclusively discharged by SIU, which is reasonable. However, over 100% ratio of SIU Loading to WWTP loading can not be corrected – which resulted from the significant reduction of the Cd from the SIU discharges and WWTP influent from 1993 (due to the drastic diminishing of the Cd plating practice). Therefore, the Cd concentration used for SIU loading calculation (1993 data) was much higher than the actual average Cd concentration from SIU discharge flow between 1995 and 2000.

Top SIU Dischargers. The group of the largest SIUs plays a significant role in shaping up the SIU flow and loading make-ups. Table 10 lists the top 5 percent (or 20 out of 403) SIU flow dischargers. Almost all top SIUs are manufacturers, except two (one TCU and one service). Thirteen of the 20 top SIUs are auto manufacturers or suppliers. The regional distribution, however, is less concentrated. Seven top SIUs are in Detroit, with the remaining 13 top SIUs spread among 12 different communities

Table 10. List of Top Five Percent of SIU Flow Dischargers

Facility Name	No of Employees	Flow, gpd	Industry Sector	City
IPMC, Acquisition L.L.C.	180	4,475,444	Manufacturing	Detroit
Ford - Rouge Complex	10,000	2,290,000	Manufacturing	Dearborn
American Axle & Mfg., Inc.-Forge Plt	1,064	1,706,847	Manufacturing	Detroit
DaimlerChrysler-Detroit Axle Plant	1,900	1,382,374	Manufacturing	Detroit
Marathon Ashland Petroleum LLC	280	1,355,536	Manufacturing	Detroit
GMC-Detroit/Hamtramck Asbly. Center	4,500	1,066,200	Manufacturing	Detroit
GMC-Orion Assembly Plant	4,000	1,054,118	Manufacturing	Orion
DaimlerChrysler-Warren Truck Asbly.	4,000	982,000	Manufacturing	Warren
Ford - Wayne Assembly Plant	8,000	960,000	Manufacturing	Wayne
DaimlerChrysler-McGraw Glass Plant	1,200	952,082	Manufacturing	Detroit
DaimlerChrysler-Sterling Hts Asbly.	2,800	899,300	Manufacturing	Sterling Heights
Detroit Ed. Co.-Warren Plant	50	803,889	TCU	Detroit
National Steel Corp., Great Lakes	1,200	797,849	Manufacturing	River Rouge
Visteon Corporation –Sterling Plant	4,050	766,800	Manufacturing	Sterling Heights
DaimlerChrysler-Jefferson N. Asbly.	5,276	688,414	Manufacturing	Detroit
DaimlerChrysler-Technology Center	12,500	672,000	Manufacturing	Auburn Hills
William Beaumont Hospital	9,500	628,181	Services	Royal Oak
LTV Steel-Tubular Products Division	99	624,858	Manufacturing	Ferndale
Visteon Corporation –Utica Plant	2,800	620,000	Manufacturing	Shelby Township
Frito-Lay	350	617,517	Manufacturing	Allen Park
Total (Top 20 SIUs)	73,749	23.3 mgd		
Total (all 403 SIUs)	185,295	44.9 mgd		

These top 20 flow dischargers employ 40 percent of all 403 SIUs' workforce, discharge over 52 percent (23.3 mgd) of the total SIU flow (44.9 mgd). Figure 10 illustrates the percentage contribution of the top 5 percent SIUs on the total SIU flow and loadings.

Figure 12 shows that cadmium is the only pollutant that does not seem to be strongly associated with the top 20 SIUs. The contributions of silver, zinc, BOD, total phosphorus, and fats, oils, and grease loadings from the top 5 percent SIU to the total pollutant loadings are less than their flow contributions of 52 percent.

7.2 Projecting Future SIU Flows And Pollutant Loadings

SIU Trend (per discussion with Steve Kuplicki of DWSD). Over 97 percent of the SIUs have pretreatment, which is typically settling, pH neutralization, and oil/water separation.

- There are 12,042 non-SIUs, all with very limited information. Discharges may not be significant or continuous.
- The trend of industrial consolidation and reduction of manufacturing activity is also evident by the change of numbers of total SIUs and SIU flow. There were about 450 SIUs total in 1994 and today the total is about 400. The total SIU flow trend has been flat to slightly down as well.
- The industrial trend is very clear that the (unit) industrial discharge will be smaller in volume and weaker in strength. Multiple driving forces including the more stringent regulations, self-interest and better awareness of environmental issues, as well as cost cutting benefits are driving the reductions. The industrial users will reuse more process water, and improve manufacturing procuresses to reduce waste flow and load. Conservation and pollution prevention makes business sense as well. For example, from 1983 to 1987, the total metal loading to the wastewater treatment plant dropped from 4 tons/yr to 1 ton/yr.
- The industrial pretreatment program (IPP) will also initiate education for non-SIUs. As a result of this program, the DWSD may see reduction in flow and loadings from non-SIUs as well.

SEMCOG Local Economic Trend Forecast and Employment Projection. SEMCOG predicts strong, broad-based economic growth over the next several decades, but a slowdown after 2010, mainly due to the aging population by that time.

The region's economy will continue to diversify as employment in service industries grows. The manufacturing jobs in the region will shrink by 15 percent from 1990 to 2020. This represents a continuing of cost cutting and efficiency in production. Manufacturing jobs were 24 percent of all jobs in Southeast Michigan in 1990 as compared to 17 percent in the entire U.S. The biggest gains, 39 percent, are in services.

The forecast predicts a full employment economy. However, job growth will halt after 2010. Because the number of prime working adults (ages 18 to 54) will drop by 166,000 between 2010 and 2025, there will need to be a major increase in labor force participation of older workers just to maintain a workforce at 2010 levels.

Job locations will continue the historical pattern of outward growth. Oakland, Out-Wayne, Macomb, and Washtenaw counties are among the fastest growing. Job losses are most pronounced in the traditional centers of manufacturing employment, such as Detroit, Pontiac and Warren. Detroit's historically large losses are expected to continue moderating, as redevelopment accelerates during the forecast period.

Table 11 shows the employment projections by decade till 2050 among different sewer districts and industry groups.

Table 11. Projected SIU Employment Populations

	2000	2010	2020	2030	2040	2050
By Sewer District						
Clinton-Oakland	20,427	24,880	26,335	28,810	31,207	33,550
Dearborn	17,490	15,899	14,265	12,709	11,161	9,613
Detroit	66,294	65,882	62,623	60,519	58,166	55,813
Evergreen-Farmington	2,854	3,132	3,174	3,245	3,215	3,112
Macomb	26,544	27,619	25,831	25,119	24,244	23,319
NE Wayne	2,533	2,580	2,544	2,557	2,558	2,559
SE Oakland	20,888	20,752		19,546	18,839	18,016
Western Wayne	26,201	25,597	23,364	21,748	20,069	18,386
Total	183,231	186,342	178,163	174,254	169,458	164,368
By Industry Group						
Manufacturing	120,617	121,161	112,664	107,479	102,143	96,808
TCU	2,128	2,138	2,208	2,307	2,337	2,327
Wholesale/trade	757	756	719	690	652	613
Services	59,729	62,288	62,572	63,778	64,327	64,621
Total	183,231	186,342	178,163	174,254	169,458	164,368

Projected Future SIU Flows. Table 12 presents the Projected SIU flows among different industry groups by decade. The current (2000) total SIU flow is 45 mgd, it will stay at this level till 2010; then the total SIU flow will decrease gradually to 35 mgd by 2050. The manufacturing sector will see the largest flow decrease, from 35.6 mgd in 2000 to 25 mgd in 2050. The services sector will see the largest flow increase, from 5.9 mgd in 2000 to 7.1 mgd by 2050.

Table 12. Projected Future SIU Flows by Industry Group

Flow	Manufacturing	TCU	Wholesale Trade	Services	Total
2000	35.6	2.6	0.55	6.0	**44.9**
2010	34.7	2.8	0.61	6.4	**44.6**
2020	31.5	2.8	0.60	6.6	**41.5**
2030	29.2	2.8	0.60	6.8	**39.5**
2040	26.9	2.8	0.59	7.0	**37.3**
2050	24.6	2.7	0.58	7.1	**34.9**

Table 13 shows the flow projection results by sewer district and by decade. The City of Detroit is the region that will see the largest net flow reduction, from 23.6 mgd in 2000 to 17 mgd in 2050; while Clinton-Oakland district will see largest net flow increase, from 3.0 mgd in 2000 to 4.8 mgd in 2050.

Table 13. Projected Future SIU Flows by Sewer Districts

Flow	Clinton-Oakland	Dearborn	Detroit	Evergreen-Farmington	Macomb	NE Wayne	SE Oakland	Western Wayne	Total
2000	3.0	3.4	23.6	0.54	5.2	0.41	3.5	4.9	**45**
2010	3.6	3.0	22.7	0.59	5.4	0.41	3.2	4.9	**45**
2020	3.8	2.7	21	0.59	5.1	0.39	2.8	4.6	**42**
2030	4.2	2.35	19.6	0.60	5.0	0.37	2.4	4.3	**39**
2040	4.5	2.0	18.2	0.59	4.8	0.36	2.0	4.0	**37**
2050	4.8	1.7	17	0.57	4.6	0.35	1.6	3.7	**35**

Figure 13 and Figure 14 show the projected future total SIU flow by decade compared with the trends of the manufacturing and service sectors, respectively. The projected total SIU flow shows that it will stay relatively constant until 2010, then it starts decreasing at roughly a rate of 3.5 mgd per decade – starting with 44.9 mgd in 2000, ending with 34.9 mgd in 2050.

Because the manufacturing sector accounts 78 percent of the current flow, its trend will determine the total SIU flow trend, as evident in Figure 13. The service sector, however, will actually increase its flow discharge from 5.9 mgd in 2000 to 7.1 mgd in 2050 as shown in Figure 14.

Figure 15 compares the projected 2050 SIU flow with the current SIU flow by different industrial groups. Again, it shows that TCU and wholesale trade sectors will have similar flow discharges between 2000 and 2050. Manufacturing SIUs will discharge less than 25 mgd by 2050, compared to over 35 mgd in 2000. Services SIUs will see flows slightly increase from 5.9 mgd in 2000 to 7.1 mgd in 2050.

Figure 16 compares the current (2000) and future (2050) SIU flows by sewer service districts. The City of Detroit – due to its large manufacturing component – will see the largest net flow reduction, from 23.6 mgd to 17 mgd. The Southeast Oakland district will see the largest percentage SIU flow decrease, over 50 percent (from 3.5 mgd to 1.6 mgd). Clinton-Oakland district will see the largest percentage increase of SIU flow of nearly 60 percent (from 3.0 to 4.8 mgd).

Figure 17 and Figure 18 show the projections for the Clinton-Oakland and the City of Detroit sewer districts in more detail: by decade and by industrial groups. Figure 17 shows that the only reason for the future SIU flow increase in the Clinton-Oakland district is due to the increase of the manufacturing SIU discharges, a result of the projected future employment growth of the manufacturing sector in this district. Conversely, Figure 18 shows that the decrease of manufacturing SIU flow is the main cause of the future SIU flow reduction for the City of Detroit.

Projected Future SIU Loadings. Table 14 and Table 15 summarize the loading projections for 2050 by industry group and by sewer district, respectively.

Table 14. Projected 2050 SIU Loadings by Industry Group

	Manufacturing	TCU	Wholesale Trade	Services	Total
Flow	25	2.7	0.6	7.1	34.9
Silver	1.8	0.18	0.05	2.5	4.5
Cadmium	12	0.60	0.07	0.57	12.8
Chromium	30	2.0	1.1	3.1	35.7
Copper	27	2.9	0.98	12	42
Mercury	0.055	0.005	0.002	0.065	0.13
Nickel	36	1.4	2.8	1.6	41.5
Lead	22	1.4	1.3	6.6	31.4
Zinc	125	15	17	30	187
BOD	47,200	10,100	4,300	15,700	77,300
TSS	38,800	3,500	3,000	11,300	56,600
Total Phosphorus	1,600	90	160	410	2,200
FOG	6,200	890	3,500	5,700	16,300

Table 15. Projected 2050 SIU Loadings by Sewer Districts

	Clinton-Oakland	Dearborn	Detroit	Evergreen-Farmington	Macomb	NE Wayne	SE Oakland	Western Wayne	Total
Flow	4.8	1.7	17	0.57	4.6	0.35	1.6	3.7	35
Silver	0.85	0.09	1.7	0.01	0.29	0.15	0.49	0.91	4.8
Cadmium	0.36	0.08	2.1	0.01	0.38	0.44	0.12	7.8	16
Chromium	0.55	2.2	19	1.3	3.2	0.34	0.6	5.3	45
Copper	4.4	4.0	19	0.10	3.6	0.30	1.9	6.3	51
Mercury	0.006	0.002	0.080	0.000	0.006	0.003	0.006	0.014	0.15
Nickel	2.6	2.0	20	0.02	8.6	0.37	0.8	7.9	53
Lead	1.9	2.0	11	0.08	2.5	0.32	1.0	10	38
Zinc	17	5.6	80	0.16	15	1.1	8.4	40	240
BOD	8,300	1,100	32,400	350	4,200	898	5,500	20,500	77,200
TSS	4,000	2,800	28,200	300	4,000	524	1,900	10,600	59,200
Total Phosphorus	230	40	735	7.2	381	37	86	622	2,300
FOG	520	210	7,150	49	1,300	78	577	8,400	16,200

Table 16 presents the total loading for each pollutant by decade. Because the pollutant concentrations are assumed to remain constant during the projection period, the loadings

change trend for all pollutant is similar to the overall SIU flow change trend – that is decreasing over the next 50 years. However, pollutants that are strongly associated with the services sector (silver, mercury, and fats, oils, and grease) will result in the smallest reduction; while the pollutants that are strongly associated with manufacturing (such as cadmium, chromium, nickel) will result in the largest percentage loading reduction.

Table 16. Projected Future SIU Loadings by Decade

	2000	2010	2020	2030	2040	2050
Silver	4.9	5.0	4.8	4.8	4.6	4.5
Cadmium	18	18	16	15	14	13
Chromium	48	48	44	41	39	36
Copper	52	53	49	47	45	42
Mercury	0.14	0.14	0.14	0.14	0.13	0.13
Nickel	57	56	52	48	45	42
Lead	40	40	37	35	33	31
Zinc	236	237	221	211	199	187
BOD	95,200	96,000	90,100	86,400	81,900	77,300
TSS	71,700	71,900	67,000	63,900	60,3	56,600
Total Phosphorus	2,870	2,880	2,680	2,550	2,400	2,250
FOG	17,900	18,500	17,800	17,400	16,900	16,300

Figure 19 and Figure 20 show that copper has a similar relationship between flow and loading distributions, in both 2000 and 2050. This relationship holds true for all other pollutants, so that the total SIU flow and specific pollutant-loading pattern will be the same during the projection period.

Figure 21 and Figure 22 show the loading comparisons between 2000 and 2050 for fats, oils, and grease and nickel, respectively. Again, these loading distributions are pollutant specific (due to different concentration distributions among industry groups for different pollutants), but the patterns between 2000 and 2050 are similar because they are only determined by the SIU flow distribution. Generally, the manufacturing sector loading in 2050 will be lower than in 2000, and services sector will see a slight increase of the pollutant loading.

Figure 23 and Figure 24 show the total SIU, manufacturing sector, and services sector BOD loadings by decade. The "volume adjusted" and "constant pounds-per-employee-per-day (pped)" methods used for projection are explained in the methodology section.

The total SIU BOD loading remains constant until 2010, when it steadily decreases. The manufacturing sector BOD loading follows almost the same pattern as the total SIU loading because manufacturing is the largest component of the SIUs. The services sector BOD loading will increase steadily from 2000 to 2050.

Figure 25 explores the loading distribution for fats, oils, and grease between different sewer districts for both the 2000 and 2050 scenarios.

Clinton-Oakland and Western Wayne will see the fats, oils, and grease loading increase between 2000 and 2050; while most other districts, especially the City of Detroit, will see the fats, oils, and grease loading decrease during the same period.

Figure 26 and Figure 27 further examine the fats, oils, and grease loading in the Clinton-Oakland and City of Detroit sewer districts by decade. Figure 26 shows that the manufacturing sector loading increase is the primary cause of the fats, oils, and grease loading increase for the Clinton-Oakland district from 2000 to 2050. The services sector fats, oils, and grease loading for the Clinton-Oakland district will also increase during the same period, but to a lesser degree. The manufacturing fats, oils, and grease loading decrease far outweighs the services fats, oils, and grease loading increase in the City of Detroit, resulting in the net fats, oils, and grease loading decrease from 2000 to 2050 in the City of Detroit.

7.3 Sensitivity Analysis

The key factor in performing the future SIU flow and loading projections is the employment population forecast. Assumptions made during the projections include the constant pollutant concentration levels from 1993 to 2050, the "gped" (gallons-per-employee-per-day) or "pped" (pounds-per-employee-per-day) remain constant from 2000 to 2050 regardless of the industrial process change or efficiency improvement, or water conservation efforts, the SIU employment trend is the same as the overall employment trend, and there are no technology or process improvements or changes.

Making these assumptions was necessary because in almost all cases, detailed information was not available. However, the simplified approach may not be accurate due to the omission of many other important factors.

From general knowledge of the past and previous forecasts by groups such as SEMCOG, some qualitative information at least points to the future direction of SIU flow and loading changes.

For example, it is generally believed that the future SIU flow and loading will decrease, because:

- Manufacturing will become less weighted in the future local economy;
- Industry will continue waste reduction, process optimization, pollution prevention, water conservation efforts because of more restrictive regulations and economic sense, as well as general improved environmental awareness;

Based on the above analysis, it can be assumed that the upper limit of the future SIU flow and loading trend is to maintain a flat growth. The low limit would be continued reduction at a certain annual average percentage. A "-10 percent" was used in this sensitivity analysis, and a "-5 percent" rate was also evaluated.

Figure 28 shows the sensitivity analysis results for SIU flow by decade, and Figure 29 through Figure 31 present the typical loading sensitivity analysis results.

The projected SIU flow through 2050 is similar to the "-5 percent" annual SIU flow change rate scenario. With the 0 percent change rate, the SIU flow would stay at 45 mgd until 2050.

The current estimate and the "-5 percent" annual change rate sensitivity analysis results will result in 35 mgd by 2050. If the actual annual change rate is "-10 percent", the SIU flow will decrease to about 27 mgd by 2050.

The loading trends for all pollutants evaluated can be categorized into three general types.

Because of the assumption of constant pollutant concentrations during the whole projection period (2000 to 2050), the loadings will be determined only by the flow volume that contains such pollutants.

For pollutants that are mainly contributed by manufacturing, the loading is projected to drop faster than the SIU flow volume decrease as well due to the significant drop of the projected manufacturing flow. These pollutants include cadmium, chromium, and nickel.

Figure 29 shows results of the cadmium sensitivity analysis. The projected cadmium loading decrease will be more than the "-5 percent" rate. The "-10 percent" annual decrease rate will lower the 2050 cadmium loading projection to less than 11 lb/day from the 13 lb/day estimated using the current projection method.

For pollutants that are mainly from the services sector, the situation is opposite of the manufacturing dominated pollutants because the services sector SIU flow volume is projected to increase during the 50-yr projection period. Therefore, the loading rate of these pollutants is slower than the overall SIU flow volume's decreasing rate. The pollutants in this group include silver, mercury, and fats, oils, and grease.

Figure 30 shows that the fats, oils, and grease loading trend, using the current projection method, will decrease much slower than the "-5 percent" annual rate. The "-10 percent" actual decrease rate will put the fats, oils, and grease loading at 11,000 pounds per day versus the 17,000 lb/day projected using current projection method.

For the pollutants that have similar concentrations across industry groups, such as BOD, TSS, total phosphorus, lead, zinc, and copper, their loading projections follow the same trend as the total SIU flow.

Figure 31 compares the BOD loading forecast using the current projection method and the sensitivity analysis. It shows the current projected loading change is similar to the flow pattern, which is at about a "-5 percent" annual change rate. The "-10 percent" decrease rate will result in a 2050 BOD loading of 56,000 lb/day, compared with over 73,000 lb/day using the current estimate.

7.4 Conclusions

- The current (2000) SIU list consists of 403 SIUs. Over 70 percent (or 289) of the SIUs are in the manufacturing sector. The services, TCU, and wholesale sectors make up the remaining 30 percent (or 114) SIUs.
- The current (2000) SIU flow in DWSD service area is about 45 mgd. About 72 percent of which (36 mgd) is from the manufacturing sector. The remaining 28 percent SIU flows are from the services, TCU, and wholesale sectors.

- Among the eight DWSD sewer districts, the City of Detroit is home to the largest number of SIUs (153 or 38 percent), followed by Western Wayne (with 81 SIUs, or 20 percent), Southeast Oakland (66 SIUs, 16.5 percent), and Macomb (45 SIUs, 11.2 percent), etc.
- SIUs in the City of Detroit discharge about 23.6 mgd, or 53 percent of the total SIU flows. The Clinton-Oakland, Dearborn, Southeast Oakland, Western Wayne, and Macomb districts discharge 3 to 5.2 mgd of SIU flows, with each district contributing about 6.8 to 11.8 percent of the total SIU flow. SIUs in Evergreen-Farmington, and NE Wayne discharge the smallest volume of flows at 0.41 and 0.54 mgd, or 0.9 and 1.2 percent of the total SIU flows, respectively.
- The total SIU loadings for the current year are: silver – 5.2 lb/day, cadmium – 22 lb/day, chromium – 60 lb/day, copper – 62 lb/day, mercury – 0.163 lb/day, nickel – 71 lb/day, lead – 48 lb/day, zinc – 300 lb/day, BOD – 96,500 lb/day, TSS 76,000 lb/day, total phosphorus – 3,000 lb/day, fats, oils, and grease – 18,000 lb/day.
- The "gped" values of MFG, TCU, WHL, and SER SIUs are 294, 1,240, 732, and 99 gallons/employee/day, respectively. The "gped" for all SIUs is 243 gallons/employee/day. These values are significantly higher than the non-SIUs commercial/industrial "gped" value (around 80) estimated by the GDRSS.
- The current SIU flow accounts for about 7.7% of the WWTP dry flow, however, it accounts for 21%, 17%, 13%, 33%, 24%, 61%, 20%, 18%, 8.2%, 16%, and 17% of the WWTP headwork loadings for Ag, Cr, Cu, Hg, Ni, Pb, Zn, BOD, TSS, P, and FOG, respectively. SIUs also are almost the exclusive sources of Cd to the WWTP headwork.
- The top 5 percent (20) SIUs employ 40 percent of all 403 SIUs' workforce, discharge about 52 percent (23.3 mgd) of the total SIU flow (45 mgd), and up to 40 percent of the total SIU pollutant loadings.
- The future SIU flow is projected to decrease, from 45 mgd in 2000 to 35 mgd in 2050 on average. The decrease of manufacturing SIU flows is the most significant factor. The service sector, however, is expected to see a small increase of total flows, from 5.9 mgd in 2000 to 7.1 mgd in 2050.
- The City of Detroit will see the largest net SIU flow reduction between 2000 and 2050, from 24 mgd to 17 mgd. The Southeast Oakland district will see the largest percentage SIU flow decrease of over 50 percent (from 3.5 mgd to 1.6 mgd). The Clinton-Oakland district will see the largest percentage increase of SIU flow at nearly 60 percent (from 3.0 to 4.8 mgd).
- The projected loadings for all pollutants will decrease between 2000 and 2050, roughly at an annual average rate of -5 percent.
- Some metals will see loading reduction at an annual rate faster than -5 percent. These include cadmium, chromium, and nickel. Other pollutants may see a loading reduction an annual rate slower than -5 percent, such as silver, mercury, and fats, oils, and grease.

Pollutants that are mainly discharged by manufacturing SIUs will see the fastest loading reduction in general, and pollutants that are generated more from the services sector will see the slowest loading reduction overall.

- The total SIU flow and loading change rate is expected to decrease between the 0 percent to –10 percent annual rate. The flow and loading projections using the method stated in this report yield results within this range.

7.5 Potential Future Improvement of the Projections

- The availability of more current and complete pollutant monitoring concentration information will improve projections. This may be possible after DWSD completes upgrading its IWC database system, which will enable the retrieving and processing of the complete monitoring database.
- Historical pollutant monitoring concentration analysis may reveal trend or technology improvements within industry. For example, it is known that cadmium has dropped significantly since 1993. The above projection used 1993 cadmium concentration data which may result in an overestimate.
- Mercury data used are not very accurate because of the accuracy using of the conventional analytical technique near the mercury detection limit. More information may come from the DWSD Air Deposition project (Phase I and II) in the future. Other programs such as mercury/PCB minimization will likely result in a much faster mercury loading reduction from SIU discharges than what is projected here.
- Facility specific analysis of the top SIUs, or regularly updates with their operations and waste characteristics, will increase the forecast accuracy. Because the enormous weight the top SIUs place on the overall SIU flows and loadings, any dramatic change of one or several of the top SIUs may affect the total SIU flow and loadings greatly.

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