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MEMORANDUM

Methodologies for Base Demand Adjustment Ratios, Nodal Demand Distributions and Detroit & Dearborn Diurnal Curves

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COPIES:
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1. Base Demand Adjustment Ratios

For each planning year, average day base demand for each wholesale community and Detroit and Dearborn can be calculated from per capita demand, projected population and ICI (Industrial, commercial and institutional) water use. In order to develop maximum day and minimum day base demands, base demand adjustment ratios are required. Base demand adjustment ratio is the flow ratio of maximum day to average day or minimum day to average day.

a) Existing Wholesale Customer Communities

Based on the available information, the base demand adjustment ratio for each existing wholesale customer community is developed as follows:

Maximum Day: Fiscal year 1989 data is used since the record high maximum day flow rate and maximum day to average day ratio occurred on July 7, 1988. The following method is employed for the calculation of maximum day base demand adjustment ratio:

Max Day Base Demand Adjustment Ratio for a Wholesale Community =
(Avg Flow Rate of Max Day Period / Avg Flow Rate of the Year) * TAR

Where Max Day Period is one week or two week period coincides with maximum day of the year. TAR is the Totalizer Adjustment Ratio. It was developed to further adjust the average flow rate of the maximum day period to the actual maximum day flow. The actual maximum day flow is read from the chart recorders attached to the master meters. Since there are only about 1/3 master meters have chart recorders, TAR is not available for each community, thus Community Group Approach was used to develop TAR. The communities were divided into 15 community groups, each community group has several communities which have similar water consumption characteristics. TAR was calculated for each master meter which has a chart recorder, then community group TAR was developed by using the weighted average of TARs within the community group based on the flow rate of each meter.

TAR =
Max Day Flow Rate from Chart Recorders / Avg Flow Rate of Max Day Period

Minimum Day: Follow the same approach as maximum day, and fiscal year 1994 data is used. Fiscal year 1994 has almost the lowest minimum day to average day ratio in the last decade.

b) Future Wholesale Customer Communities

Base demand adjustment ratios are assigned for future wholesale customer communities from similar existing wholesale customer communities based on land use, location and population.

c) Retail Customers: Detroit and Dearborn

Since no master meter is used in Detroit and Dearborn area, system pumping records and mass balance approach are used to develop Detroit and Dearborn base demand adjustment ratios. Low pressure zone is an isolated area in Detroit, a separate base demand adjustment ratio is calculated. Another base demand adjustment ratio is developed for the rest of Detroit and Dearborn area: intermediate and high pressure zones.

Low Pressure Zone: Fiscal years 1989 and 1994 pumping records for low pressure system of Water Works Park Water Treatment Plant are used for max day and min day, respectively. The data is obtained from DWSD's Summary of Operating Statistics.

Max Day Low Pressure Zone Base Demand Adjustment Ratio =
Max Day Flow Rate of Fiscal Year 1989 / Avg Flow Rate of Fiscal Year 1989

For example, from Operating Statistics, fiscal year 1989 maximum day low pressure zone flow is 46.91 MGD, average day flow is 28.45 MGD, so the maximum day low pressure zone base demand adjustment ratio is 46.91/28.45 = 1.65.

Min Day Low Pressure Zone Base Demand Adjustment Ratio =
Min Day Flow Rate of Fiscal Year 1994 / Avg Flow Rate of Fiscal Year 1994

Intermediate and High Pressure Zones: Fiscal years 1989 and 1994 data is used for max day and min day, respectively. System mass balance approach is employed to calculate the base demand adjustment ratios. Maximum day calculation is shown as follows, the same approach is used for minimum day.

Max Day Base Demand Adjustment Ratio for High and Intermediate Pressure Zones =
Max Day Flow Rate of Fiscal Year 1989 / Avg Flow Rate of Fiscal Year 1989

Where
Max Day Flow Rate of Fiscal Year 1989 =
Max Day Total System Pumpage – Max Day Metered Wholesale Community Flow Rate – Max Day Wholesale Community Unaccounted-for Water - Max Day Low Pressure Zone Flow Rate

Avg Flow Rate of Fiscal Year 1989 =

Avg Metered Detroit & Dearborn Flow Rate + Avg Detroit and Dearborn Unaccounted-for Water – Avg Low Pressure Zone Flow Rate

All the terms in above equations are discussed as follows:

In the calculation, the unaccounted-for water is considered. The percentage of unaccounted-for water for each fiscal year is obtained from DWSD's Summary of Operating Statistics. In fiscal year 1989, the unaccounted-for water is 6.39% of total system pumpage. In fiscal year 1994, it is 18.28%. Based on the discussion in project report of DWSD CS-1171 "Water Quality Model of the DWSD Transmission System", the further breakdown for the percentage of the unaccounted-for water that occurs within Detroit and Dearborn and wholesale portion of the system is at 75% and 25%, respectively.

Maximum Day Total System Pumpage, Maximum Day Low Pressure Zone Flow Rate, Average Detroit & Dearborn Flow Rate and Average Low Pressure Zone Flow Rate are all available in the DWSD's Summary of Operating Statistics for fiscal year 1989.

For each wholesale community, maximum day flow rate is equal to average day base demand times maximum day base demand adjustment ratio. Maximum Day Metered Wholesale Community Flow Rate is the sum of maximum day flow rates for all suburban communities.

For example, from Operating Statistics, average day total system pumpage in fiscal year 1989 is 630.91 MGD, the system unaccounted-for water is 6.39% of total system flow, 630.91 x 6.39% = 40.32 MGD. Assign 25% of unaccounted-for water to wholesale customer communities, which is 10.08 MGD. Assign 75% of unaccounted-for water to the City of Detroit , which is 30.24 MGD. Metered Detroit flow is 172.29 MGD, metered Dearborn flow is 27.07 MGD, Detroit low pressure zone flow is 28.45 MGD. So average day Detroit and Dearborn intermediate and high pressure zone flow is 172.29 + 27.07 + 30.24 – 28.45 = **201.15** MGD.

The maximum day occurred on July 7, 1988. The total system pumpage is 1341.5 MGD. The maximum day metered flow is 902.84 MGD. With considering the unaccounted-for water, the total is 902.84 + 10.08 = 912.92 MGD. Total Maximum Day Detroit & Dearborn flow is the difference between total system flow and total wholesale customer communities flow 1341.5 – 912.92 = 428.58 MGD. Maximum Day low pressure zone flow is 46.91 MGD. So the maximum day intermediate and high pressure zone flow is 428.58 – 46.91 = **381.67** MGD.

Maximum Day Intermediate and High Pressure Zones Base Demand Adjustment Ratio for Detroit and Dearborn is 381.67/201.15 = **1.90**.

2. Nodal Demand Distributions

a) Existing Wholesale Customer Communities

Most wholesale customer communities have more than one master meter, and normally each meter is represented as a demand node in planning models, thus base demand of each community calculated from Task B needs to be distributed to different demand nodes. The

distribution is based on the average flow (two weeks) of a meter divided by the average flow of all of the meters supplying a community. The average flows of meters are from DWSD totalizer books. The two-week period selected coincides with maximum, average or minimum day. The nodal demand distributions were developed for 59 wholesale customer communities for three demand days.

Maximum Day: 1995 and 1999 data is used (drought and most recent years).
Average Day and Minimum Day: 1997 and 1999 data is used (most recent years).

The procedures used to develop nodal demand distributions are as follows:

1) For each demand day, calculate the percentage volume through each meter within the community using two years' data.
2) Compare percentage distribution of each meter in two years. If the difference of all the meters within a community is below 20 percentage points, use two-year's average.
3) If the difference of at least one meter is higher than 20 percentage points, check the data quality, i.e. if the meter reading was estimated (not the actual reading) for one year, that year's data will be dropped. Use another year's data if available and repeat step 1).
4) If no additional data is available, or there is a trend of distribution change with time for that community, i.e. a meter was newly installed or the population served was increased dramatically in the last a few years, the most current data is used.

For example, Table 1 shows the nodal demand distributions of Allen Park for three demand days. In Allen Park, there are 7 active master meters, the distributions of different years all agree with each other very well, so the average is used.

Table 1. Nodal Demand Distribution of Allen Park

Community & Meter Location	Meter	Maximum Day (%)			Average Day (%)			Minimum Day (%)		
		1995	1999	Final	1997	1999	Final	1997	1999	Final
Allen Park										
Park & Moore	AP-4	21	23	**22**	22	26	**24**	30	31	**31**
Philomene & Arno	AP-6	52	48	**50**	46	41	**44**	37	28	**33**
Outer Drive & Gas Hwy	AP-7	5	4	**4**	4	5	**4**	7	8	**8**
Gas Hwy & Enterprise Dr.	AP-8	11	14	**13**	18	17	**18**	14	20	**17**
Gas Hwy & S. of Outer Dr.	AP-9	6	6	**6**	8	7	**7**	10	10	**10**
Oakwood & Southfield	AP-11	2	2	**2**	2	2	**2**	1	2	**1**
Fairlane Blbd & Oakwood	AP-12	2	2	**2**	1	2	**2**	1	1	**1**
	Total			**100**			**100**			**100**

Table 2 shows another example of Southeast Oakland County Water Authority (SOCWA). There used to be three active meters in SOCWA, SE-5, SE-6 and SE-8. In August 1997, meter SE-9 was installed and the distributions were changed significantly at SE-6 and SE-9 after then. So the most current information – 1999 data is used.

Table 2. Nodal Demand Distribution of Southeast Oakland County Water Authority

Community & Meter Location	Meter	Maximum Day (%)			Average Day (%)			Minimum Day (%)		
		1995	1999	Final	1997	1999	Final	1997	1999	Final
SOCWA										
Northland & Greenfield	SE-5	41	36	**36**	26	36	**36**	32	28	**28**
Livernois & 8 Mile	SE-6	36	10	**10**	30	5	**5**	24	1	**1**
12 Mile & Inkster	SE-8	24	29	**29**	28	29	**29**	28	35	**35**
14 Mile & Lahser	SE-9	0	25	**25**	15	30	**30**	16	37	**37**
	Total			**100**			**100**			**100**

b) Future Wholesale Customer Communities

Assign one node for each community, or if it is necessary to put more than one node, the nodal demand distribution will be based on the population distribution of TAZs.

c) Detroit and Dearborn

City of Detroit and Dearborn have 306 and 28 demand nodes, respectively. The base demands for Detroit and Dearborn in planning models need to be distributed to each node. Three nodal demand distributions are developed for Maximum Day, Average Day and Minimum Day, they will be used for all planning years.

City of Detroit

1) There are 49 Geographical Billing Districts, they are billed quarterly. Water consumption is evenly distributed to the demand nodes within each district. The water consumption is from 1993 & 1995 Water Quality Model data.

2) There are 7 Special Billing Districts (public schools, public housing, parks and recreation, etc.), they are billed quarterly. 1993 and 1995 Water Quality Model water consumption data is used. The demands for Central Schools, Western Schools and Eastern Schools is evenly distributed to demand nodes within Central, Western and Eastern Zones, respectively. The demand for Wayne State University is evenly distributed to three demand nodes near the university. The demands for Suburban Water Usage, Parks and Recreation and Public Housing is evenly distributed throughout the demand nodes within the City of Detroit.

3) There are more than 3800 Large Water User accounts, they are billed monthly. The top 76 users which have average daily demand 0.1 MGD or larger are identified using 1999 water consumption data. The demands of these 76 large water users are distributed to demand nodes nearest to them. The remaining large water users are divided into the Central, Western and Eastern billing zones, and the demands are evenly distributed to the demand nodes within Central, Western and Eastern Zones, respectively.

4) The percentage of Large Water User demand in the total Detroit demand in 1999 is calculated. This percentage is used for all planning years. Two nodal demand distributions are developed: Large Water Users based on 1999 data and the rest of Detroit (Geographical Billing District, Special Billing District) based on 1993 and 1995 data.

City of Dearborn

1) There are 23 geographical billing zones, the demands for these zones are distributed evenly to the demand nodes within each zone. If no demand node can be located within its zone, the zone's demand is placed at the nearest Dearborn demand nodes.

2) The demand for public schools and the Board of Education is distributed evenly between the 28 Dearborn demand nodes.

3) The demand for Ford Motor Company is placed at the demand node nearest to its billing address.

4) 1993 and 1995 Water Quality Model demand data is used.

3. Diurnal Curves for Detroit and Dearborn

Water Works Park pumping records is used to develop the diurnal curves for low pressure zone. Since no diurnal water use information is available for Detroit and Dearborn high and intermediate pressure zone, system mass balance approach is employed to calculate the hourly demand. 1993 data is used for maximum day and minimum day, 1995 data is used for average day. The procedures of mass balance approach are described as follows:

a. All demand nodes in the DWSD water transmission system are categorized as high and intermediate or low pressure zone nodes.

b. System mass balance approach: Detroit & Dearborn hourly demand = Hourly system pumpage + Hourly reservoir drain – Hourly reservoir fill – Hourly wholesale community demand.

c. System pumpage and Reservoir fill & drain rates are from DWSD Systems Control Center. Maximum Day occurred on July 23, 1993. Average Day occurred on May 25, 1995. Minimum Day occurred on October 17, 1993.

d. Use nodal base demand of wholesale communities developed from Water Quality Models (CS-1171). Perform QA/QC on diurnal curves of wholesale communities developed from Water Quality Models, apply the modified curves to base demand and calculate hourly demand for wholesale communities.

e. Percentage of UFW for 1993 and 1995 is obtained from DWSD's Annual Summary of Operating Statistics. UFW of the total system is distributed to wholesale communities (25%) and Detroit (75%). The reason of this distribution is discussed in Water Quality Model report.

f. Calculate the total water demand of high and intermediate pressure zones for Detroit & Dearborn from the mass balance for each hour, and then normalize hourly demand factors (Q_i/Q_{avg}, where Q_i is flow rate at hour i, Q_{avg} is 24 hour average flow rate), this procedure gives the diurnal curves.

The data used for this process has some uncertainties, such as the inaccuracies of the flow rates at water treatment plants, the estimated distributions of unaccounted-for water to wholesale communities and Detroit, diurnal curves applied to the master meters without charts based on the community group approach. The project team decide to combine the low pressure zone together with intermediate and high pressure zones to create one diurnal curve

for the whole area of Detroit and Dearborn. The curves are also smoothed out in order to keep their shapes more reasonable.