Central Puget Sound Water Suppliers' Forum

Independent Review of Water Demand Forecast Model

Task 1 Technical Memorandum

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Table of Contents

INTRODUCTION

As a part of its Municipal Water Demand Forecast and Water Supply Assessment, the Central Puget Sound Water Suppliers' Forum is utilizing the services of CDM to perform supply and demand forecasts for the region. The demand forecast is being performed under the direction of the Water Demand Forecast Advisory Committee. In order to facilitate its review of CDM's work on the demand forecast, interested members of the Advisory Committee formed a Subcommittee to initiate and oversee an independent technical review of the water demand forecast. This memorandum comprises the first product of that review, reporting the results of Task 1. The full scope of work for the review is provided as an Appendix to this report.

Task 1 is a review of CDM's approach, including examination of the water use model, data requirements, and data collection protocols. Task 1 will also consider the suitability of the model for preparing water use forecasts for the Central Puget Sound region. The Scope of Work for the independent review suggests that Task 1 can be limited to review of those CDM technical reports, presentations, and other materials available by mid-November 2007. However, because of their importance to certain themes of this report, the review will cover materials received up to December 7, 2007. Because of delays in starting this review, Task 1 comes at a later time and covers considerable more of CDM's work than had been originally contemplated.

Following CDM's completion of the water demand forecast and production of the final report, the review team (under Task 2) will prepare an evaluation of the final forecast, revisiting topics discussed in the Task 1 report and covering additional topics as needed. This final evaluation will be presented to the Subcommittee and interested Forum members at a meeting expected to be held in February or March, 2008. After receipt of comments from the Subcommittee and the full Committee, a final evaluation report will be prepared and submitted.

THE PROCESS OF WATER USE FORECASTING

Water use forecasting consists of two discrete steps: **explanation** and **prediction**. In the first step, analysts collect data on past water use and on selected determinants of demand, then specify and estimate a mathematical model which explains water use in terms of the chosen determinants (explanatory variables). The form of the mathematical model defines the data requirements, which in turn determine the cost and complexity of the approach. The planned use of the water use model for forecasting purposes imposes further requirements on the data, since the model should not utilize variables that cannot be reasonably forecast for future years. As a general rule, more complex models are expected to have more explanatory power, while simpler models involve lower costs. The requirements of each individual application determine the choice of the water use model.

Obtaining a reliable water use model may involve some amount of verification and calibration. In many applications, the reliability of the model is demonstrated by backcasting historical water use. Once the water use model is complete and deemed acceptable, it can be used to forecast future water use. This is done by first forecasting the values of the explanatory variables then, using those values, computing the forecast future value of water use. Obviously, there is a great deal of judgment involved in this exercise, beginning with the judgment that the derived water use model is an appropriate basis for computing water use 25 or 50 years in the future. Beyond that major decision, each explanatory variable requires a further exercise of judgment as to its likely future value. It is worth noting that, while the explanation step is a largely objective, quantitative process, the use of the explanatory various to forecast water use is an entirely subjective step, relying on consensus views and the experience and judgment of the analyst to obtain a reasonable result.

This report attempts to summarize both the requirements for a regional water use forecast for the Central Puget Sound area and the approach taken by CDM. Since this is a preliminary review, undertaken prior to the completion of CDM's work, it is based on documents available as of December 7, 2007. Accordingly, some parts of the narrative may be incomplete or inaccurate. The report concludes with a summary of the issues, observations, and questions that have arisen in the first phase of this independent review.

CDM'S FORECASTING MODEL

The following discussion pertains to the water use model which CDM plans to use in the development of the forecast (described in CDM documents as the "forecasting model"). The quality and utility of the resulting forecasts depend critically on the explanatory power of this model.

SCOPE OF FORECAST

Because the water use model will be used for forecasting, it must be selected with required scope of that forecasting application in mind.

Geographical Scope

The Forum has requested a regional water use forecast, covering those portions of Snohomish, King, and Pierce Counties served by public water systems. The geographical scope, therefore, consists of the service areas of at least 118 water purveyors. It is important to note here that this is a regional forecast; it is not intended to be an aggregation of utility-level forecasts.

Included Water Users

The forecast is expected to address water use by those entities that are now, or are expected to become connected to one of the public water systems in the forecast area. This requires that forecasts consider not only growth in the number of residential and non-residential users, but also growth in the fraction of all properties served by public utilities. Base year data, then, includes both served and unserved (self-supplied) users.

Temporal Scope

Available documents do not provide a clear identification of the forecast base year. Some base data are provided for 2006, although many data items were available only for 2000, 2001, 2005, or other dates.

The forecast will extend to 2060, with intermediate forecasts at ten-year intervals.

LEVEL OF DISAGGREGATION

Because water is used for many purposes, by many kinds of users, and in response to many different factors, the explanatory power of any model is strongly related to the degree of disaggregation of water use, and on the way in which that disaggregation has been accomplished.

Use Sector

CDM proposes disaggregating water use into four sectors:

- Residential – single-family
- Residential – multi-family[1]
- Non-residential
- Non-revenue water (unmetered service, meter misregistration, leakage)

The goal of disaggregation is to segregate users whose water use has similar structure and explanation, such that differences are larger between sectors than within them. Certainly that is true for the residential vs. non-residential sectors. The degree to which the single-family sector differs from the multi-family sector depends on what kinds of water users are placed in each of these categories. Most water utilities utilize a multi-family category, but the definition of this category may vary widely from one utility to another.

The principal sources of CDM's water use data are the responses to the Water Utility Survey questionnaire. That survey asks that each utility identify the number of single-family accounts, billed water for single-family customers, billed water for multi-family customers, and whether multi-family use is included in non-residential use. This format leaves many questions unanswered:

1 The CDM documents use the term “multifamily household” which is obviously not the intended meaning.

- Are individually metered duplexes, triplexes, townhomes, condominium apartments, etc., considered single-family or multi-family customers? Or does the single-family sector consist only of detached single-family residences?

- Are all master metered residential structures placed in the multi-family category?

- If multi-family uses have been included in non-residential use, how have they been separated, if at all?

Available documentation does not provide answers to these questions. Ideally, given the constraint of no more than two residential sectors, the multi-family sector would consist only of master-metered residential structures (or groups of structures), whereas the single-family sector would include all individually metered units. It seems doubtful that CDM would have been able to accomplish this separation, given the quality of available data.

The result is that the two residential sectors, while differing with respect to average water use and average sensitivity to drivers such as price, may also have a large overlap. This reduces the explanatory power of the model and will likely result in biases in the forecast, as growth changes the mix of units in each of the two sectors.

Spatial

In any large-area forecast, spatial disaggregation is essential because of the spatial variability of many of the explanatory variables. Spatial disaggregation also provides a partial correction for some omitted variables, provided that they also vary spatially. But defining sub-regions is inevitably a challenging task.

The Puget Sound Regional Council (PSRC) has divided the planning area into 219 Forecast Analysis Zones (FAZs), providing historical and projected data for population, housing units, and employment by FAZ. But other data, such as median household income and more detailed employment data, are only available for each of the three counties. CDM identified seven weather stations, scattered throughout the study area, with suitable weather data. Finally, the water connection, water use, and price data pertain to utility service areas. Using GIS techniques, CDM has extrapolated and interpolated these data, in some cases using land use information to assign data to particular FAZs. Later CDM stated that they were using the smaller Traffic Analysis Zones (TAZs) for this purpose.[2]

After considering several schemes, CDM ultimately decided to combine the FAZ/TAZ-level data into a smaller number of sub-regions.[3] These sub-regions are defined so that utility service areas are not split,

2 Meeting notes (approved), Municipal Water Demand Forecast Advisory Committee, September 20, 2007.

3 A July 2, 2007, email from Dan Rodrigo (CDM) to members of the Demand Forecast Advisory Committee mentioned 17 sub-regions. An August report defined 14 sub-regions (CDM, "Central Puget Sound Water Supply Outlook: Task 2 – Data Collection and Processing," August 9, 2007). But a presentation given the following week listed only 13 sub-regions (CDM, "Data Collection and Water Demand Factors," a presentation given on August 16, 2007).

though many of them will include multiple utility service areas.

Note that unit use coefficients are calculated at the utility service area level and it would have been possible to estimate demographic and economic variables for those same service areas. However, CDM rejected the idea of a spatial disaggregation by utility service area. There are good reasons for this decision. CDM pointed to the complexity and added cost of dealing with 118 sub-areas. A regional forecast is not expected to have the level of detail needed for a utility-level forecast. But perhaps a more important issue is that a utility-based regional forecast would invite inappropriate comparisons between the regional forecast and independent utility-generated forecasts, potentially undermining the credibility of both. The fact that these two types of forecast are performed for different purposes, using potentially different water use models, different assumptions and different data sets, does not mean that one forecast is more credible or more reliable than the other.

Seasonal

Seasonal disaggregation reflects the fact that warm weather water use (summer water use) responds to certain weather variables that have little to no impact on non-summer water use. The preferred method of dealing with this relationship is to segregate weather-sensitive water use and place it in a separate use category, explaining it with a separate model. CDM has adopted a form of this method. Seasonal water use is defined as the excess of total annual use over annualized October-April use. Because the segregation of seasonal use relies on production data to identify seasonal variation, seasonal water use cannot be disaggregated according to user sectors.

WATER USE EXPLANATION

The quality of every forecast depends on the explanatory power of the underlying model. In this case, the water use model must match the scope and level of disaggregation chosen for the forecast, but there are a number of other characteristics and criteria which, together, determine the explanatory power of the model.

Model Specification

In developing water use models, CDM employed a modified unit use approach. Each sector model begins with a single-coefficient unit use model, which is then modified to incorporate additional explanatory variables. For the two residential sectors, the unit use coefficient is water use per household; for the non-residential sector, the unit use coefficient is water use per employee. The base (unmodified) water use in each residential sector is found by multiplying the number of households by the unit use coefficient; in the non-residential sector, the total number of employees is multiplied by the unit use coefficient. Non-revenue water is estimated as a fraction of the sum of residential and non-residential water use.

The base estimates of water use are then modified to reflect possible changes in price and income. The separate identification of seasonal use presents some complication, because it is derived from production rather than use data and cannot be disaggregated by user sector. Based on the most recent information, it appears that CDM plans to develop empirical estimates of elasticities of seasonal water use with respect to number of rain days per month, monthly average of maximum daily temperatures, and employment.[4] It is not clear how the production-based seasonal water use will be adjusted or how it will be combined with the user sector-based nonseasonal water to form forecasts. One concern with this process is how price and income elasticities will affect seasonal water use, if at all.

Based on documents reviewed to date, modifications will be made to the various water use sectors and sub-sectors as follows:

Use Sector	*Additional Explanatory Variables*
Residential – SF	Price Income
Residential - MF	Price Income
Non-residential	Price
Seasonal	Temperature Precipitation Employment

The following elasticities will be applied[5]:

Use Sector	*Price*	*Income*	*Temperature*	*Precipitation*	*Population*
Residential - SF	-0.30 to -0.20	0.20 to 0.40	n/a	n/a	n/a
Residential -MF	-0.10 to -0.05	0.10 to 0.20	n/a	n/a	n/a
Non-residential	-0.30 to -0.15	n/a	n/a	n/a	n/a
Seasonal	n/a	n/a	+5.30*	-0.01*	+0.82*

* Tentative results as of October 18, 2007[6]; note that seasonal water use can only be defined for total water production and cannot be assigned to user sectors.

4 CDM, "Water Production and Weather Model," presentation given October 18, 2007.

5 CDM's November 8 presentation indicates that further minor changes have been made to these elasticities (CDM, "Preliminary Water Demand Forecast and Forecast Scenarios," presentation given November 8, 2007). However, no meeting minutes or technical memoranda describing these changes are available at this writing.

6 CDM, "Water Production and Weather Model," presentation given October 18, 2007.

The five additional variables are specified as follows:

Price:	For each forecast subregion, water plus sewer price[7]
Income:	For each forecast subregion, median household income
Temperature:	Month average of daily maximum temperature (Sea-Tac station)
Precipitation:	Number rain days per month (Sea-Tac station)
Employment:	Total employment for forecast subregion

The general form of each modification to sectoral water use (illustrated for a residential sector) is as follows:

$$Q_F = \left[N_F * WUF\right]\left[\left(\frac{MP_F}{MP_B}\right)^{\beta_{price}}\right]\left[\left(\frac{Inc_F}{Inc_B}\right)^{\beta_{inc}}\right]$$

Where: Q_F = Water use for a specific sector, selected subregion, year F

N_F = Number of units for the selected sector, subregion, year F
WUF = Water use factor for selected sector and subregion (gpd/unit)
MP_F = Marginal price of water and sewer in year F
MP_B = Marginal price of water and sewer in year B
Inc_F = Median household income in year F
Inc_B = Median household income in year B
β_{price} = Price elasticity of demand
β_{income} = Income elasticity of demand

In this adjustment, year B is the base year of the forecast, the year for which the water use factor (WUF) has been calculated.

CDM plans to apply additional elasticities to aggregate seasonal water use, but the details of this procedure are not yet available.

Data Sources and Data Processing

Water use and other data were obtained for 83 providers out of 118 contacted. This response represents over 95 percent of all connections to public systems serving 500 or more customers.[8] Demographic and economic data were obtained from PSRC, Washington State Office of Financial Management (OFM), and the U.S. Bureau of Census for various years and various geographic breakdowns. Using GIS techniques and land use maps, CDM allocated these data to 219 FAZs. Subsequently, the data were reallocated to a larger number of Traffic Analysis Zones (TAZs). The data are then re-aggregated to the

7 The documents reviewed do not describe the source of the price data, how marginal price was measured, or how utility prices were aggregated to subregions.

8 CDM, "Central Puget Sound Regional Water Supply Outlook: Task 2 – Data Collection and Processing," August 9, 2007, p. 2.

subregions actually employed in the forecast. These subregions are defined so that they do not split water purveyors. Certain data, such as price and water use factors, are represented in the subregion as the weighted average of purveyor-specific data.

Documents reviewed so far do not clearly identify the base year. The most recent water use data available from the survey (and from comprehensive plans) apply to various years from 2000 to 2006, depending on the utility. Water purveyors were asked to indicate the number of single-family accounts for as many recent years as available. Data on number of households for the single-family and multi-family categories, as well as total employment, were obtained from PSRC for years including 2000 and 2010. Some U.S. Census data are available for 2005. Using these data, CDM provided a table of calculated water use factors, but with no indication of which year they apply to, or how the various data sets were reconciled to generate water use factors for a common year.[9] One discussion of passive conservation adjustments mentioned 2006 as a base year, but it is not clear that this was intended to apply to any other part of the study.[10]

Price and income elasticities were originally taken from literature surveys of demand studies performed throughout the U.S. CDM selected elasticities that seemed appropriate to the Pacific Northwest. Later, some adjustments were made to reflect Seattle's experience and other comments.[11] The elasticities, as presented, appear plausible. The only significant question arises from uncertainty regarding the definition of the multi-family sector. If this category consists of residential units in master-metered buildings, demand may be very close to zero elasticity. CDM reports no effort to standardize the sector definitions, leading them to accept as multi-family whatever the water utilities defined as multi-family. This implies that the sector consists of some mix of master-metered and individually-metered units, justifying the elasticity range proposed.

Based on CDM's draft results, elasticities for seasonal water use are to be estimated by a "Regional Production Model" for the forecast area.[12] This model represents the result of a regression of seasonal water use data on weather and employment data. Seasonal water use is computed from monthly production data for the forecast area utilities (expressed as gallons per day); weather data are taken from the Sea-Tac weather station. The regression covers 84 months, from January 2000 through December 2006. However, since seasonal water use (as defined) is only present for five months of each year, there are, in effect, 35 observations. The full regression results are not provided, so the significance of the individual coefficients (elasticities) cannot be determined. Similarly, it is not known whether CDM considered any additional explanatory variables. Further examination of this regression model seems in order.

9 CDM, "Assignment of Water Use Factors," 2-page table, November 2, 2007.

10 CDM, "Water Demand Forecast Model: Technical Memorandum," presentation of June 7, 2007.

11 CDM, "Revised Growth Rates and Elasticities for Price and Income," November 28, 2007, p. 4.

12 CDM, "Water Production and Weather Model," presentation given October 18, 2007.

Omitted Variables

In terms of explaining historic sectoral water use, CDM's model utilizes three explanatory variables for residential sectors and two for the non-residential sector. In addition, the forecast will deal separately with seasonal water use and water conservation. This level of simplification is perhaps a reasonable compromise for a large-area regional forecast, but the possible impact of omitted variables should be examined.

In the case of the residential sectors, the omitted variables include further details on housing characteristics, household size, and housing density (or irrigable area). All of these have been shown to be important explanatory variables in water use models. Housing characteristics can be better reflected through additional disaggregation into, for example, detached single-family housing, non-detached or semi-detached individually metered housing, and master-metered housing. Household size is defined by the number of persons per housing unit, although some analysts have suggested grouping household members by age. Density measurements indicate the potential for lawn and garden irrigation and are strongly correlated with seasonal water use.

The non-residential model is based on total employment, an aggregation of employment over numerous commercial, manufacturing, government, and service categories. Water use per employee differs widely from one non-residential category to another, often by one or more orders of magnitude. Even within an industry category, there are large differences from one type of firm to another, and among firms of the same type. A global water use factor for all non-residential users submerges all of these differences, providing one number that is, in effect, a weighted average of many industry-specific factors.

Moreover, non-residential water use depends on other variables, in addition to employment. For manufacturing firms, these include such things as quantity of product, type of process, degree of self-supply, recycle ratio, etc. Water use in restaurants depends on the number of meals served; water use in schools depends on the number (and age) of students; water use in office buildings depends on the presence or absence of a cafeteria/lunchroom; etc.

The consequence of not including variables such as those just mentioned is that all forecasts are based on the assumption that none of these variables change. More specifically, the residential forecasts assume that the mix of housing units remains the same as at the base year: there is no trend to denser housing, more townhouses or condominiums, etc., or the reverse. These forecasts assume that family sizes will remain the same. Non-residential forecasts assume that the entire structure of the economy within each subregion will be unchanged throughout the forecast period.

The literature demonstrates clearly that seasonal water use is much more elastic with respect to price than is nonseasonal use. But the “Regional Production Model” used to estimate the elasticities of seasonal water use with respect to weather variables does not contain a price term. The reviewed documents contain no other reference to the price elasticity of seasonal water use so it appears that no provision will be made for a seasonal component to price response. Arguably, this response may be built into the sector models, as the elasticities proposed for the various sectors can be described as weighted averages of elasticities for seasonal and nonseasonal use. But these weighted average elasticities are assumed fixed over time even as the weights may change. If there is any significant change in the fraction of seasonal water use in the future (e.g., because of climate change), the proposed elasticities may be too low.

Obviously, some of the decisions to omit variables are very strong assumptions, especially with regard to the structure of the economy. If more detailed models are not feasible, the only way to address the impact of missing variables is to repeat the forecast at regular intervals in the future, re-estimating the models with updated current data. This allows near-term forecasts to track changes in the structure of housing and of the economy, but does not improve the accuracy of the long-term forecasts.

Water Conservation

In an October presentation, CDM defined three levels of water conservation for purposes of this study[13]:

- Passive conservation.--compliance with the provisions of the National Energy Policy Act of 1972.[14]
- Provider goals.--the set of water conservation policies and practices already implemented by water utilities, or planned for implementation by the utilities.
- Beyond provider goals.--Additional water conservations measures, beyond existing utility goals, that could be implemented in the study area in the future.

The effectiveness of each of these conservation levels was estimated by CDM, using aged inventories of housing units, data collected from water utilities, as well as additional data from the literature and from CDM's experience. Passive conservation grows in effectiveness through the forecast period, as housing units are constructed or rehabilitated. Provider goals also produce increasing effectiveness over time, as some provider's initiatives are planned to extend as far as 2030.

CDM calculations of the effectiveness of passive conservation utilize two critical water use assumptions: household use without water conserving fixtures and use with conserving fixtures. Two different sets of numbers appear in the documents: In a June presentation, CDM stated that passive conservation would lower water use from 61 to 40 gpcd.[15] In October, CDM revised these numbers to 65 and 55 gpcd, respectively.[16] The later numbers are attributed to AWWA and EPA, but no specific references are

13 CDM, "Water Conservation Scenarios," a presentation on October 18, 2007.

14 This category would logically include Washington State or other water conservation mandates, if they exist. None are mentioned by CDM.

15 CDM, "Water Demand Forecast Model: Technical Memorandum," a presentation on June 7, 2007.

16 CDM, "Water Conservation Scenarios," a presentation on October 18, 2007.

provided. Note that the earlier numbers were also attributed to AWWA (AWWARF in that case) and EPA.

From some of the documents reviewed, it appears that "passive conservation" will be embedded into the baseline forecast. However, in an October presentation, CDM stated that passive conservation will be treated as a separate scenario.[17] It also appears that "beyond provider goals" will be treated as a part of a separate scenario. However, there is conflicting information about the planned treatment of "provider goals." A July presentation notes at one point that passive conservation and utility planned conservation (presumably meaning provider goals) will both be combined into the baseline forecast.[18] Two slides later, however, the presentation says that "conservation at utility goals" will be treated as a separate scenario.

CDM's various statements aside, there in no choice but to include passive conservation in the baseline forecast. It is not a policy choice or a matter of discretion. Builders and rehabbers have little choice but to install water-conserving fixtures. Therefore, the steadily increasing effectiveness of this category of conservation must be taken as a given and is not a candidate for scenario treatment.

The "provider goal" category presents a similar problem, in part. Those elements of water utility conservation programs that are already in effect as of the base year are no longer discretionary and should be built into the baseline forecast. Only those elements that are not yet implemented can be considered for inclusion in a scenario. Whether this makes sense or not depends upon the providers' degree of commitment to these plans. If they are firmly committed, then the calculated effectiveness could be reflected in the baseline forecast. If changes in plans are likely in the future, scenario treatment is more appropriate.

Reclaimed Water

The Forum's utility survey identified a number of possible users of non-potable water.[19] It is unclear whether or not reclaimed water, if provided, would displace potable water drawn from a public supply system. No information is provided as to whether this subject will be dealt with in the water supply study, or whether the water demand forecast will be adjusted to reflect a shift of use from potable to non-potable water.

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17 CDM, "Water Conservation Scenarios," a presentation on October 18, 2007.

18 CDM, "Water Demand Forecast Scenarios," a presentation on July 19, 2007.

19 CDM, "Central Puget Sound Regional Water Supply Outlook: Task 2.5 Self-Supplied and Large Water Users," July 30, 2007.

DEMONSTRATING EXPLANATORY POWER

VERIFICATION AND CALIBRATION

The suitability of a water use model for forecasting depends on a number of things, including the choice of explanatory variables, flexibility, transparency, etc. But one of the most important qualities is the explanatory power of the underlying model. A model which does not adequately explain water use in the past is not likely to produce credible estimates of water use in the future. Explanatory power is tested in two steps: verification and backcasting.

Verification tests whether the model is capable of reproducing base year water use, subregion by subregion, sector by sector, season by season. This requirement is more or less demanding, depending on the modeling approach chosen. For example, in the case of a very simple unit use model, verification is essentially redundant: it merely repeats the calculation used to derive the unit use factor. This may also be true for the type of modified unit use method employed by CDM, since the price and income adjustment factors are equal to 1.0 for the base year. However, there are at least two characteristics of CDM's study that argue for performing a formal verification: (1) the considerable spatial complexity of the study, which included computing weighted averages of water use factors and developing various aggregations of data, and (2) the potential inclusion of a provision for seasonal water use. Note that CDM has not yet indicated how the factors that drive seasonal water use will be incorporated, but it is possible that it will require moving away from a pure unit use approach. For these reasons, a verification should be performed, if only as a check on computations.

Verification is expected to reproduce base year water use very closely, in all its dimensions. In the case of a modified unit use model, it should reproduce actual water use almost exactly. In the event of a significant error, it is necessary to calibrate the model: to determine the cause of the error and to adjust the model to eliminate that problem. Calibration is an important step for some kinds of models, particularly those using econometric demand functions, but it is unlikely to lead to major changes in CDM's models.

BACKCASTING

Successful verification demonstrates that a model is capable of reproducing base year water use, but not necessarily able to reproduce water use in any other year. In the case of CDM's model, only the water use factors have been tested. In order to test other aspects of the specification, including the price and income coefficients (elasticities), it is necessary to perform backcasting over some representative period of time. In this case, observed values of the explanatory variables (number of residential accounts, total employment, water and sewer price, median household income, temperature, precipitation, etc.) are used to generate a water use estimate for one or more prior years. The resulting water use estimates are compared--subregion by subregion, sector by sector, season by season—with actual water use for the same years.

Backcast water use estimates will never match actual water use exactly. But they should be reasonably close in aggregate as well as approximating spatial, sectoral, and seasonal differences. If this is not the case, and particularly if the backcast errors appear to be growing as the time between the backcast year and the base year increases, the cause of the errors should be investigated. This process provides a final check on the reasonableness of such assumptions as price and income elasticities. If these adjustments tend to track actual water use changes in the past, they can be expected to do so in the future.

Note: if there have been abrupt changes in price or income in the past, backcast water use estimates may overstate the effect of those changes for several years. This is the result of a difference between short run and long run price and income effects. Forecasts properly assume the long run response to price and income. The short run response may be noticeably smaller, until such time as water users fully adjust to the new parameters.

FORECASTING WATER USE

FORECAST ASSUMPTIONS

After the water use model is complete, forecasts are generated by providing projected future values for each of the explanatory variables. Some of these variables are demographic (number of single-family water accounts, number of multi-family water accounts) and economic (total employment, price, income). Others are climatologic (rainfall, precipitation). Projections of demographic variables and employment are obtained from the PSRC for forecast years up to 2040, then extended at constant growth rates thereafter. Weather variables are assumed constant for the baseline forecast, then altered in some scenarios. Projected values for price and income are discussed below.

Price

CDM proposes that forecasts be based on increases in the real price of water and sewer that range from 2.0%/year (2007-2009) to 4.0%/year (2050-2060).[20] This amounts to an overall increase of 474% in real price. Assuming an average rate of price inflation of 3.5%/year, this would produce nominal prices in 2060 more than 30 times their present level. While such a projection may be plausible in some circumstances, it should be noted that seemingly small rates of change can produce dramatic effects over the life of a long-term forecast. The rates of change, therefore, should be selected with care.

CDM justifies their projection by pointing to a U.S. Department of Energy survey of 38 utilities (including Seattle) which measured an average 2.5% annual increase in the real price of water and sewer

20 CDM, "Revised Growth Rates and Elasticities for Price and Income," November 28, 2007, p. 3. Note that CDM had proposed a steeper rate of increase earlier, ending with a 5.0% annual growth rate for the 2031-2060 period.

for the 1986-1998 period.[21] Several concerns can be raised regarding reliance on this source: (1) it is a small, presumably non-random sample, (2) the time period is relatively short, and (3) the time period coincides with implementation of increased regulation and increased treatment standards for both water and wastewater. Unfortunately, however, there are few sources for historical prices of water and sewer.

One surrogate for water and sewer price is the "Water and Sewerage Maintenance" statistic collected by the U.S. Bureau of Labor Statistics (BLS).[22] This is not a price, but rather an index tracking the total cost of water and sewer service to a representative dwelling unit in an urban environment. It is, therefore, sensitive to both average price and the assumed level of water use per household. The BLS data are collected each month from 87 urban areas in the U.S., selected to provide a statistically representative sample of all urban areas. Water and sewer costs are available from 1952 to date, a 55-year period.

According to the BLS data, the real household cost of water and sewer rose at an average annual rate of 0.55% for the 1961-1980 period, and 1.95% for the 1981-2000 period. The higher rate of change after 1980 is generally believed to reflect the role of the Safe Drinking Water Act and the Clean Water Act, and their amendments, in requiring increased surveillance and higher levels of treatment. This is also the period in which some communities, in response to the requirements of EPA's Construction Grant Program, were adopting wastewater charges for the first time, having previously recovered costs from real property taxes.

By way of comparison to the 2.5%/year escalation reported in the 1986-1998 U.S. Department of Energy survey, BLS reported an average real increase in the household cost of water and sewer of 1.70%/year for the same period. The difference can be attributed, in part, to the larger BLS sample and possible divergence between growth in marginal prices measured by the Department of Energy and average prices implied by the BLS data.

Most data point to an average rate of real increase in price of less than 2.0% in recent years (BLS measured 1.90%/year for 2000-2007). It is reasonable to continue this rate of growth for the near term. But to escalate growth in water and sewer prices after that requires one to assume that (1) treatment upgrades and regulatory requirements will accelerate much faster for many years in the future than they have in the past and/or (2) demand growth will require area utilities to construct new facilities with a higher average real cost than those built in the past. The first assumption is unlikely, the second depends on the level of forecast growth and other factors.

Based on these considerations, it can be concluded that the price increases projected by CDM are excessive. A baseline projection of price growth could begin at 2.0%/year and then decline after the first decade or two. Note that the BLS measured real prices changes of only 0.55%/year during the two decades before 1980, a period of relatively static regulation. Higher growth rates can certainly be

21 U.S. Department of Energy, "Energy Efficiency and Renewable Energy," Washington, D.C., March 2002.

22 Data from U.S. Bureau of Labor Statistics, Consumer Price Index—All Urban Consumers, U.S. City Average, Series ID CUUR0000SEHG01, accessed December 14, 2007.

considered, but they should be part of alternative scenarios. For example, a high demographic growth, warmer and drier scenario would lead to a high rate of growth in water use. This might be consistent with a higher rate of growth in real price.

Income

Median household income is a highly responsive economic indicator, adjusting quickly to expansions and contractions in the economy as a whole. For example, for the U.S. this measure showed historically high real growth from 1993 to 1999 (+1.98%/year) followed by negative growth from 1999 to 2004 (-0.66%/year).[23] For this reason, it is important to base projections on long-term trends, so as to avoid the boom-and-bust cycles. For the period 1976-2006, median household income in the U.S. rose at an average annual real rate of +0.66%. This is consistent with expectations, which hold that this measure rarely exceeds 1.0% for any protracted period.

The Pacific Northwest, however, has had a slightly different experience. OFM data for the 1989-2004 period, incorporating Bureau of the Census estimates, indicates an average annual growth in median household income of +0.79% for King County, +1.17% for Pierce County, and +0.50% for Snohomish County.[24] During this same period, median household income in the U.S. increased at an average annual real rate of +0.28%.

CDM proposes increases in real median household income ranging from 1.0%/year (2007-2009) to 1.5%/year (2050-2060). These increases, seemingly small, are nevertheless large by comparison to the historical record. There may be some support for the assumption that median household income in the study area will continue to grow more rapidly than in the rest of the U.S. There is no support for a long-term projection that assumes real growth over the entire study area in excess of +1.0%.

FORECAST SCENARIOS

The proposed forecast scenarios were first described in detail in an October presentation.[25] Nine scenarios were listed: three involving weather, three involving demographic growth, and three specifically dealing with climate change. Shortly after this meeting, a somewhat different plan was set forth in a Technical Memorandum.[26] At that time, eight scenarios were mentioned: a baseline scenario (implied but not discussed in the memorandum) and seven alternative scenarios. Two of the alternatives would utilize different rates of demographic growth, two would utilize different climate assumptions, and three would address different assumptions regarding conservation. The subject was

23 U.S. Census Bureau, "Historical Income Tables—Households," accessed December 10, 2007.

24 Office of Financial Management, <http://www.ofm.wa.gov/economy/hhinc/>, accessed December 14, 2007. The corresponding real growth rate for the State of Washington was +0.73%. CDM reported a 1989-2006 rate of +0.15%, based on OFM numbers: the review team was unable to reproduce this number.

25 CDM, "Water Production Weather Model," a presentation given on October 18, 2007.

26 CDM, "Demand Forecast Scenarios," October 23, 2007.

discussed again in December.[27] At this time, forecasts were presented showing future water use under no less than nine scenarios.

Scenario Planning

The use of forecast scenarios is an excellent way to facilitate appropriate consideration of the uncertainty inherent in key forecast assumptions. Scenarios convey much more information to planners than single point forecasts, helping to identify the most likely range of possible outcomes, showing the relative importance of various assumptions, answering many kinds of "what if" questions.

There is an important difference between scenario planning and sensitivity analysis. Sensitivity analysis explores the mathematical relationship between a selected variable or assumption and a resulting single-point forecast. The results of sensitivity analysis are useful in (1) diagnosing backcasting errors, thus improving the explanatory power of the model, or in (2) forecasting for testing the reasonableness of individual assumptions. But these results, which reflect arbitrary and isolated perturbations, do not provide much assistance to planners.

Scenario forecasting, on the other hand, is specifically designed to support planning. A scenario is a complete story, a set of trends and assumptions that together describe a possible future state. To be informative, however, the scenarios must be plausible, comprehensive and internally consistent, and balanced.

Plausible

There is no purpose in posing a scenario that includes events or trends that are so unlikely that they would never be taken into consideration in a planning process. Particularly in the case of water facility planning, where assumptions pertain to long-term trends and there are opportunities for mid-course corrections, any scenario considered in planning should have a reasonable probability of occurrence.

Comprehensive and Consistent

In the course of designing a scenario, attention must be paid to interrelationships among key assumptions. For example, suppose a higher-than-baseline demographic projection is desired. It is necessary to make further assumptions as to where this increased growth would occur and within what socio-economic class. These assumptions may lead to changes in the forecasts of employment and median household income, so that future values of these variables are consistent with the larger number of households. Finally, if the higher demographic forecasts cause forecast water use to increase significantly, this may require utilities to seek higher cost sources, or to take other actions that increase the average cost of water and sewer. This may suggest modifying the projections of water and sewer price to be consistent with the demographic forecast.

27 CDM, "Water Demand Forecast Scenarios," a presentation given on December 6, 2007.

Conversely, a lower-than-baseline demographic projection could, on examination and analysis, lead to lower rates of growth in employment and in water and sewer price. Slower growth may be associated with either lower or higher rates of growth of median household income, depending on what form the demographic changes take.

Some conservation assumptions (especially those that lower seasonal demands) may imply lower rates of growth of water and sewer prices. Some weather and climate assumptions, especially to the extent that they alter seasonal demands, might also affect projections of water and sewer prices.

Scenarios that ignore the interrelationships among the assumptions and trends do not provide useful information to planners. In fact, single-issue scenarios are nothing more than sensitivity analysis by a different name.

Balance

Scenario planning typically proceeds by comparison to a baseline scenario, which is sometimes also the most likely scenario. In order to properly consider the range of uncertainties, care should be taken to balance the scenarios; that is, to provide about the same number of scenarios that result in lower-than-baseline water forecasts as those that give higher-than-baseline forecasts. The scenarios should not give the impression that most alternative projections lead to more (or less) water demand in the future. The possibilities for deviations in either direction should be articulated in the scenarios.

CDM's Scenarios

The only detailed description of CDM's scenario development process is contained in a technical memorandum.[28] This memorandum lists seven possible scenarios, with the existence of a baseline scenario implied in the text. Two weather scenarios are mentioned: dry-hot and wet-cool. There is no indication that related changes in water and sewer price trends have been considered.

The memorandum also describes two growth scenarios: high-demographic and low-demographic. It is not clear what "demography," in this case, is intended to mean. It potentially includes changes in both categories of housing units and in total employment, but this is not explicit. Deviations from the baseline scenario would not be expected to result in uniform percentage changes in SF housing units, MF housing units, or employment. CDM does not indicate how growth assumptions have been applied to these variables. Also, there is no indication that related changes in median household income or water and sewer price were considered.

Three conservation-related scenarios are listed, but not described in the memorandum.

28 CDM, "Demand Forecast Scenarios," October 23, 2007.

INTERIM FINDINGS

The following section summarizes the interim findings of the independent review. Not all of the topics listed here have been fully reported by CDM or fully examined by the reviewers. These findings must, therefore, be regarded as tentative, pending further review.

OBSERVATIONS

Water Use Model

- The model chosen appears to be appropriate for the purposes of the study, given caveats mentioned below.

- The use of a disaggregated unit use approach, modified by the inclusion of several multiplicative factors (incorporating price, income, weather, etc.) is well established.

- The strengths of this model include:

    - The level of complexity is appropriate for a regional forecast covering the service areas of many purveyors.

    - The model is relatively transparent and easily implemented in a spreadsheet format, providing good accessibility.

    - The coefficients are readily updated in the future, with only modest data collection costs.

- The weaknesses of the model include:

    - Many significant explanatory variables are omitted, resulting in limited explanatory power.

    - It may be difficult to insure appropriate treatment of seasonal water use, while maintaining the intended responses to price and income. This aspect of the model was undergoing revision at the time of this report.

    - Elasticities transferred from other studies are potentially inappropriate for the study area. However, in this case the final choices appear reasonable.

- The disaggregation of residential users (SF vs. MF) is problematic. Due to utility reporting practices, it is likely that there is significant overlap between the two residential sectors, and possibly with the non-residential sector as well. This problem reduces the explanatory power of the model and creates the potential for biased forecasts, as growth changes the mix of units in at least two sectors.

- The model implicitly assumes that the structure of residential housing (fraction SF, fraction MF, fraction master-metered, etc.) remains unchanged through the forecast period. This assumption is driven by the choice of water use model and the data available from the water utilities.

- The model implicitly assumes that the structure of the economy (as represented by fraction employment in each sector/industry) remains unchanged throughout the forecast period. This assumption could be partially avoided by disaggregating non-residential use by employment category, then providing separate water use factors for each category. These factors could be based on data from the literature, adjusted to fit the aggregate water use per employee measured for the study area. The results would not be ideal, but they would allow for some ability to consider stuctural changes.

- The documents reviewed do not describe the source of the water and sewer price data, how marginal price was estimated, or how utility-level prices were aggregated to sub-regions.

- The draft model of seasonal water use was presented without explanation or documentation. In particular, there are no details on the regression analysis used to estimate the elasticities. Also, there is no indication of how CDM will adjust seasonal water use or combine that adjusted use with the results of the sectoral models. This is an important detail because of the potential for mis-specification and/or double-counting.

- Documents reviewed so far make no mention of plans for verification or calibration of the water use model, or of using the model to backcast water use. These steps are necessary to demonstrate the ability of the model to explain water use.

Water Use Forecast

- The intention is to prepare a regional forecast as the aggregation of a small number of sub-regional forecasts. Utility-level forecasts are not prepared, nor should they be. The modified unit use model selected by CDM, while appropriate for a regional forecast, is not suitable for utility-level forecasts.

- The proposed rate of growth for real water and sewer price is excessive. In general, the rate of growth should decline over time, not increase. Increases can considered as part of scenarios.

- The proposed rate of growth for median household income is excessive. There is no reason to expect the long-term real growth rate for this variable to exceed +1.0%. Historical data suggest that a number closer to +0.7% would be more representative and still higher than U.S. experience.

- The documents reviewed do not indicate what assumptions were made about large self-supplied users, or about users identified as being able to use non-potable water.

- Scenarios have been named, but no description or documentation has been provided. On the basis of what is available, CDM appears to have defined the scenarios without consideration of interrelationships among the key variables and assumptions. This results in single-issue scenarios; that is, little more than sensitivity analysis.

QUESTIONS

The following questions address substantive issues that the review team believes have been omitted or not adequately developed in the documents examined for this interim review. It is anticipated that CDM will either answer these questions directly or resolve the questions in the course of completing the forecast.

- What is the base year for the forecast?

- How many and which subregions will be used in the forecast?

- What is the source of water and sewer price data, how was marginal price computed, and how were utility-specific price measurements aggregated to subregions?

- How will the elasticities from the regional production model of seasonal use be applied to the sectorally disaggregated modified unit use models? In particular, what effect will the separate treatment of seasonal water use have on the price and income responses within each sector?

- Will the incorporation of a seasonal water use computation allow forecasts to include separate estimates for summer and non-summer water use?

- Does CDM plan to conduct a verification of the model, by applying it to the base year?

- Does CDM plan to use the model to backcast historical water use and, if so, for what years?

- Will adjustments be made to the water demand forecast to reflect the future use of reclaimed water? If not, how will this possibility be addressed?

- Which water conservation measures will be incorporated into the baseline forecast, and which will be treated in scenarios? In particular, will the "provider goals" group measures be divided into those which have already been implemented or committed and those which require future decisions?

- The December 6 presentation shows forecasts associated with at least nine scenarios. Please provide the full definition of each of these scenarios, showing what assumptions were made with regard to SF household units, MF household units, employment, median household income, water and sewer price, and conservation status.

DOCUMENTS REVIEWED

SCOPE OF WORK

CDM Scope of Work (as conveyed via e-mail by Kyle Comanor on Nov. 19, 2007)

MEETING NOTES (APPROVED)

Jan. 11, 2007: Joint meeting-Municipal Water Demand Forecast & Municipal Water Supply Assessment Advisory Committees

Feb. 8, 2007: Joint meeting-Municipal Water Demand Forecast & Municipal Water Supply Assessment Advisory Committees

Mar. 1, 2007: Municipal Water Demand Forecast Advisory Committee

Mar. 15, 2007: Joint meeting-Municipal Water Demand Forecast & Municipal Water Supply Assessment Advisory Committees

Apr. 5, 2007: Municipal Water Demand Forecast Advisory Committee

Apr. 19, 2007: Joint meeting-Municipal Water Demand Forecast & Municipal Water Supply Assessment Advisory Committees

Jun. 7, 2007: Municipal Water Demand Forecast Advisory Committee

Jun. 21, 2007: Municipal Water Demand Forecast Advisory Committee

Jul. 19, 2007: Municipal Water Demand Forecast Advisory Committee

Aug. 16, 2007: Municipal Water Demand Forecast Advisory Committee

Sept. 20, 2007: Municipal Water Demand Forecast Advisory Committee

Oct. 18, 2007: Municipal Water Demand Forecast Advisory Committee (including two tables: (1) Central Puget Sound Percentage of Non-Revenue Water to Total Production (10-18-07), and (2) Puget Sound Draft Projections of Percent Served Using Available Data)

PRESENTATIONS

Jul. 6, 2006: Seattle Public Utilities Water Demand Forecast Model – Bruce Flory

No Date (possibly 2006?): City of Everett, Water Demand Projection Methodology – (No name)

Jun. 21, 2006: Puget Sound Regional Council (PSRC) Forecasts and Planning Data – Mike Simonson & Tim Michalowski

Mar. 1, 2007: Water Demand Forecasting Approach – Presented to the Water Demand Forecast Advisory Committee – CDM

Jun. 7, 2007: Water Demand Forecast Model: Technical Memorandum - Presented to the Water Demand Forecast Advisory Committee – CDM

Jul. 19, 2007: Water Demand Forecast Scenarios - Presented to the Water Demand Forecast Advisory Committee – CDM

Aug. 16, 2007: Data Collection and Water Demand Factors - Presented to the Water Demand Forecast Advisory Committee – CDM

Sept. 20, 2007: Re-Calculation of Unit Use Factors - Presented to the Water Demand Forecast Advisory Committee – CDM

Sept. 20, 2007: Analysis of Water Production - Presented to the Water Demand Forecast Advisory Committee – CDM

Oct. 18, 2007: Water Conservation Scenarios - Presented to the Water Demand Forecast Advisory Committee – CDM

Oct. 18, 2007: Water Production and Weather Model- Presented to the Water Demand Forecast Advisory Committee – CDM

Nov. 8, 2007: Preliminary Water Demand Forecast and Forecast Scenarios- Presented to the Water Demand Forecast Advisory Committee – CDM

Dec. 6, 2007: Water Demand Forecast Scenarios- Presented to the Water Demand Forecast Advisory Committee – CDM

Dec. 6, 2007: Comparison of Existing Water Supply and Demand Projections- Presented to the Water Supply Assessment Advisory Committee – CDM

TECHNICAL MEMORANDA AND CORRESPONDENCE

Feb. 2007: Municipal Water Demand Forecast Advisory Committee- Background for the DCM Team, Demand Forecasting Model

Feb. 2007: Municipal Water Demand Forecast and Water Supply Assessment Advisory Committees- Background for the DCM Team, the Role of Conservation

May 22, 2007: (memo header date of May 10, 2007) Technical Memorandum Task 4.1 to Don Wright. Central Puget Sound Regional Water Supply Outlook: Water Demand Forecast Model, from Dan Rodrigo and Bill Davis

May 22, 2007: Ibid. Technical Memorandum Task 4.1. Central Puget Sound Regional Water Supplier's Forum Water Demand Forecast Model – Model Scenarios, from Dan Rodrigo and Bill Davis

Jun. 28, 2007: Correspondence from Richard Reich (e-mail) to Demand Forecast Advisory Committee members and CDM, posing questions Re the demand model structure proposed for discussion at the next advisory committee meeting

Jul. 02, 2007: Correspondence from Dan Rodrigo (e-mail) to Members of the Demand Forecast Advisory Committee and Don, in response to and regarding questions concerning the demand model structure proposed for discussion at the next advisory committee meeting posed by Richard Reich (e-mail) June 28, 2007.

Jul. 30, 2007: Technical Memorandum Task 2.4 to Don Wright. Central Puget Sound Regional Water Supply Outlook: Historical Curtailment Events, from Dan Rodrigo and Bill Davis

Jul. 30, 2007: Technical Memorandum Task 2.5 to Don Wright. Central Puget Sound Regional Water Supply Outlook: Self-Supplied and Large Water Users, from Dan Rodrigo and Scott Coffey

Aug. 9, 2007: Technical Memorandum Task 2.0 to Don Wright. Central Puget Sound Regional Water Supply Outlook: Data Collection and Processing, from Dan Rodrigo, Scott Coffey and Bill Davis

Aug. 9, 2007: Ibid. Attachment 1 – 11 X 17 Plots of Surveyed Water Purveyors and Planning Sub-Regions, Attachment 2 – Demographics by County

Oct. 23, 2007: Memorandum to Don Wright. Demand Forecast Scenarios (including table of "Assignment of Water Use Factors as of 11-2-07"), from Dan Rodrigo

Nov. 28, 2007: Memorandum to Don Wright. Revised Growth Rates and Elasticities for Price and Income, from Dan Rodrigo

SURVEY FORMS

Central Puget Sound Water Suppliers' Forum, 2008 Regional Water Supply Outlook, Water Utility Survey (one example of "Long Form," one example of "Short Form")

APPENDIX

Water Demand Forecast Review: Scope of Work and Schedule

Scope of Work

Work will be conducted in three tasks.

Task 1.--A Review of the Model Development Approach

This task will include examination of the forecasting model, data requirements and data collection protocols, and the suitability of the model for the Puget Sound application. Note, however, that this task will address only those questions that can be answered with the reports or other documentation available by mid-November 2007. Any of the following questions which cannot be answered in this task will be deferred to Task 2.

Among the questions to be asked about the model is whether it is sufficiently detailed but not overly complex; whether the degree of disaggregation produces reasonably homogeneous water use sectors; whether the model reflects current knowledge of the relationships between explanatory variables and water use but is still adequately transparent; and whether it imposes data requirements that can reasonably be met. The model design should reflect, as much as possible, consensus views of causal and other relationships. It should also minimize the role of judgment in producing a forecast.

Data requirements, data sources, and data specifications will also be examined in this task. Data should be fully documented and obtained from reliable sources. Where sampling or survey methods are used, the resulting estimates should be robust and statistically significant (where possible). Data gaps should be clearly identified and corrected by statistically sound and reproducible methods. Generally, the documentation of the data collection phase should be sufficient to allow another investigator to replicate the data set. In addition to a review of these issues, decisions regarding data specification (e.g., for the price variable) will be examined in this task.

A very important part of Task 1 is the determination of the suitability of the forecasting approach to the Puget Sound Region application. The model must include the relevant water use categories; incorporate variables which are capable of reflecting structural, economic, and demographic shifts; and must support the planned policy analyses. For example, the forecast should accurately reflect seasonality in water use, the effect of weather variation, the effect of climate change, future rate-making practices, and the effect of changes in water conservation policies.

The deliverable item for the first task will be a memorandum to the Independent Review Sub-Committee ("Sub-Committee") outlining the scope of the investigation, noting the limitations of the available information at this early stage, and summarizing the conclusions reached. The memorandum will also indicate which issues or questions are deferred to Task 2, due to lack of information. If weaknesses in CDM's approach have been identified, they will be described and, where possible, corrective actions proposed.

Task 2.--Review of the Final Model

This task covers the same topics addressed in Task 1, with the addition of a review of the application of the final model. The task will be based on whatever CDM reports or other materials have been completed by mid-December 2007.

To the extent that questions regarding the modeling approach, data collection, and model suitability could not be addressed in Task 1, they will be taken up again in Task 2.

Task 2 will also address some specific questions: If any changes have been made in the modeling approach, are those changes properly justified? Do any changes detract from the transparency, credibility, or other characteristic of the resulting forecast? Does the forecasting approach properly deal with sources of uncertainty or bias? Does the forecasting approach facilitate future updates? Will data collection for future updates be unnecessarily burdensome? Can the model be readily modified to reflect feedback from future forecasting applications?

If CDM has identified forecasting scenarios, this task will examine the way in which those scenarios were developed. Are the scenarios plausible? Is the set of scenarios balanced and bias-free? Are the scenario definitions appropriate to the decision/policy context?

Finally, this task will seek to determine if the final forecasts are likely to be fully supported by the methods and data and whether they are expected to be transparent, credible, persuasive, and useful.

The deliverable item for this task is a short draft report to the Subcommittee. After review by the Subcommittee and participating agencies, the report will be revised to reflect any questions or comments received. It is possible that the final, revised report will be submitted after the completion of Task 3.

Task 3.--Presentation of Review to Subcommittee

The Reviewer will provide a presentation of the results of this review to the Subcommittee, interested Forum members, and the model development team. In the course of a half-day workshop, the Reviewer's comments will be presented and questions and responses will be discussed. It is anticipated that the results of this workshop will be incorporated into the final report on Task 2.

Proposed Schedule

14 Nov 07	Notice to Proceed
16 Nov 07	Materials received from Subcommittee/CDM for review
19 Dec 07	Task 1 report submitted
30 Jan 08	Draft Task 2 report submitted*
Feb-Mar 08	Presentation of review to the Subcommittee at a time to be selected by the Subcommittee Final Task 2 report will be issued 14 days after receipt of Subcommittee comments on draft Task 2 report.

* Schedule for Task 2 assumes that complete documentation of the Final Model will be available not later than 19 Dec 07. IF documentation is not complete at this time, the completion of Task 2 may be delayed.