Long-Term Vulnerability Assessment and Adaptation Planning for the San Francisco Public Utilities Commission Water Enterprise

Technical Report 6: Finance Module

Prepared for:
San Francisco Public Utilities Commission

Prepared by:
University of Massachusetts Amherst, Hydrosystems Research Group

November, 2019

1 Summary

This report describes the methods used to develop a financial module built for the Long-Term Vulnerability Assessment and Adaptation Planning for the San Francisco Public Utilities Commission (SFPUC) Water Enterprise (Vulnerability Assessment). The module is designed to simulate the potential impact of changing environmental and socioeconomic conditions on the health of SFPUC's fund balance, on the price of water, and on the affordability of water bills for customers. This report describes modelling goals, scope and framework. It also identifies limitations as needed.

2 Introduction and context

Climate change and other changing conditions may jeopardize the future ability of the Hetch Hetchy Regional Water System (RWS) ability to meet SFPUC's desired level of service. To help address this concern, SFPUC partnered with the University of Massachusetts Amherst to help identify key vulnerabilities of the RWS to long term change in climate and other conditions, under a project called the "Long-Term Vulnerability Assessment and Adaptation Planning for the SFPUC Water Enterprise" (LTVA or Vulnerability Assessment). The objective of the LVTA is to design and execute an exhaustive vulnerability assessment that provides a comprehensive understanding of the expected water system performance relative to goals and expectations of the system. The general approach to achieve this objective is to develop a suite of interconnected computer models and supporting analytical modules representing important processes involved in the long-term planning of RWS and to then use them along with a scenario discovery approach to quantitatively assess system vulnerability.

.

In a workshop conducted at the outset of the project, key decision makers within SFPUC were asked to identify key sources of vulnerability that they consider could put the organization at risk of not achieving its level of service goals and rank them in terms of importance and degree of uncertainty. The results of this engagement are displayed in Figure 1. Along with natural hazards, financial risk was identified as the most important source of vulnerability and a key uncertainty affecting future performance of the system. The SFPUC finance team maintain detailed long-term financial planning models that forecast operational costs (OPEX), capital costs (CAPEX), revenues and water prices forward 20 years into the future. In the context of the LTVA the key interest is incorporating the influence of climate on this fund balance. The overall modelling framework for the LTVA is provided in Figure 1.

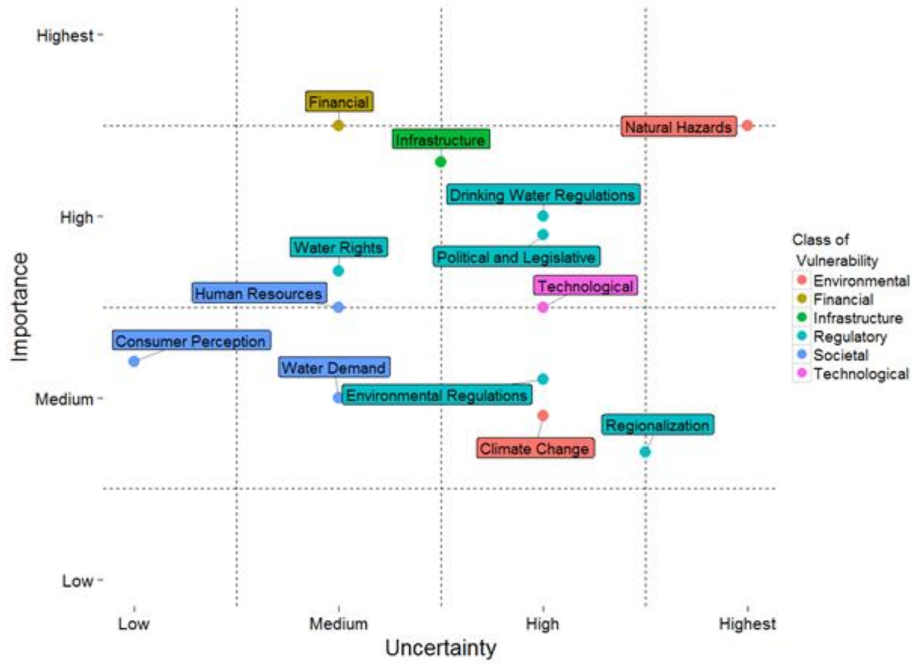

Figure 1: importance and uncertainty associated with the identified sources of vulnerability (Brown and Dufour, 2017).

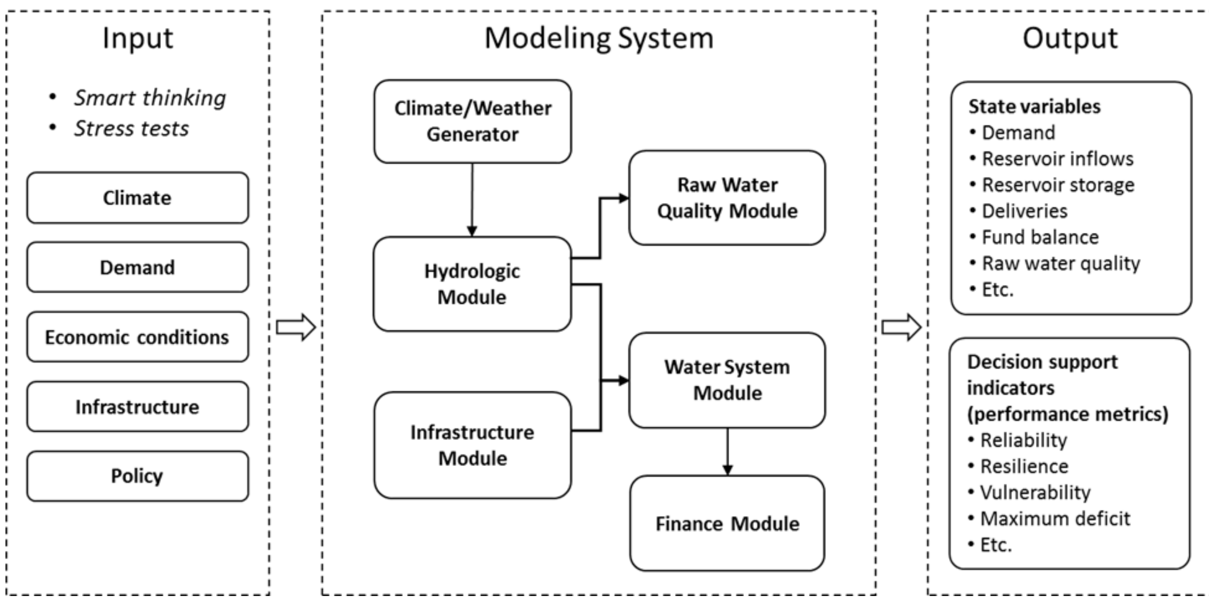

Figure 2: Conceptual diagram of the of LTVA modelling framework (including summary of inputs and outputs

3 Modelling goals and scope

The general goals of the finance module are:

- Simulate the potential impact of a changing climate, demand and regulations on SFPUC's fund balance and the price of water for customers.
- Allow the user to adjust key parameters driving uncertainty in the model, i.e. interest rate, debt repayment period, CAPEX and OPEX.
- Have a transparent, readable code base to facilitate transfer to SFPUC personnel who for further improvements/modifications

SFPUC's finance department currently maintains a long-term finance planning model that extends to 2100, however detailed capital planning only exists for 10 years into the future (and thus the overall model is referred to as the 10-year Financial Plan). This model incorporates the organisation's Capital Improvement Programme, tracks in detail forecasted spend on operations and debt service, and estimates the price of water and affordability of water bills for customers. The model assumes a static system wide demand of approximately 196 mgd annual average demand, updated regularly based on current water usage[1]. The objective of the finance module presented here is not to supersede or duplicate this model but to compliment it by allowing SFPUC to explore how uncertain future conditions might impact the financial health of the organisation. The San Francisco Water System Model (SFWSM), developed as part of the LTVA will evaluate how variations in hydrologic conditions, level of water demand, system configuration (shutdowns, outages, new projects, etc.) and various management policies impact water delivery reliability (HRG TR4, 2021). The intention of the finance module is to take the output of the system model (deliveries) and combine this with a high-level summary of SFPUC's financial planning model to evaluate the impact of these changing conditions on the health of SFPUC's finances. Inputs and outputs to the finance model are summarized in Figure 3**Error! Reference source not found.**. SFPUC 10-year Financial Plan model is used to provide inputs including average annual CAPEX, OPEX, and average annual revenues from sources other than water sales (such as rental income, interest etc.). Input from the system model comes in the form of annual deliveries. The finance model will run at the annual timestep, which is in line with key financial planning processes such as rate setting and submission of annual financial accounts.

4 Modelling Framework

The finance module is built in Python, an open source modelling language, and houses two primary functions: 1) evaluating expenditure for a given year based on expected CAPEX, OPEX and on the volume of water delivered, and 2) setting retail and wholesale customer water rates to ensure revenues are sufficient to cover costs.

Assumptions stated here were established in collaboration with the finance team at SFPUC and represent reasonable estimations of how SFPUC finances are currently managed.

[1] WSIP 2018 HHLSM model uses a value of 265 mgd.

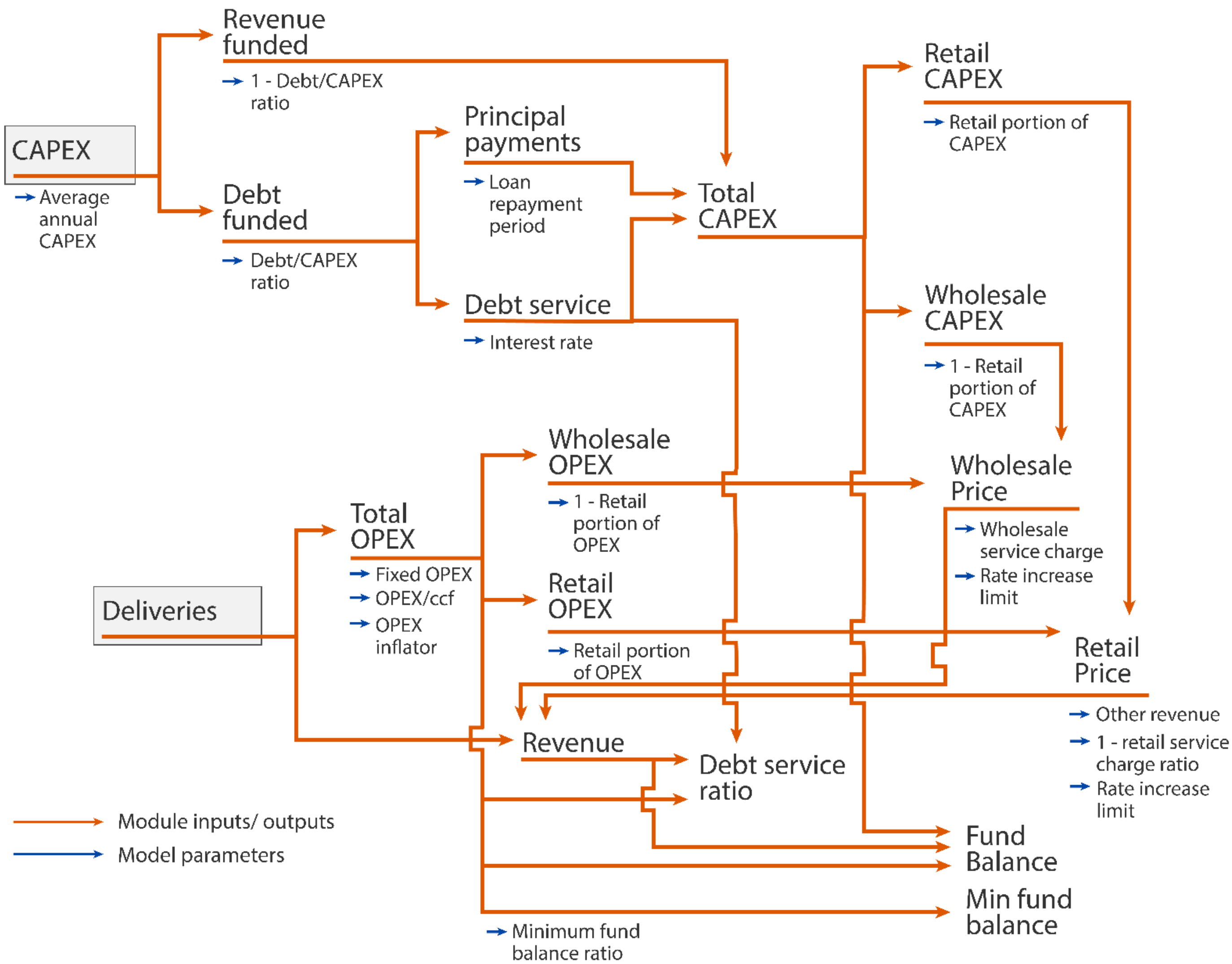

Figure 3: Schematic of finance module developed as part of LTVA. Orange arrows indicate model inputs/outputs and blue arrows indicate model parameters.

4.1 Expenditure

The finance module presented here does not itemize costs but will instead draw on the detailed breakdown provided by the SFPUC 10-year plan. High level aggregate costs are drawn from the model to provide figures for OPEX, CAPEX, and debt as a proportion of CAPEX. Figure 4 provides a breakdown CAPEX, OPEX and debt service in the 10-year plan vs that assumed in the LTVA Finance Model.

This phase of work seeks to characterize vulnerability of the system in its current form and as such, we will assume that no additional investment will be made in the system across the time horizon considered, beyond that required to maintain the existing system. This assumption can be revisited in subsequent phases of work, where adaptations to address identified vulnerabilities will be assessed.

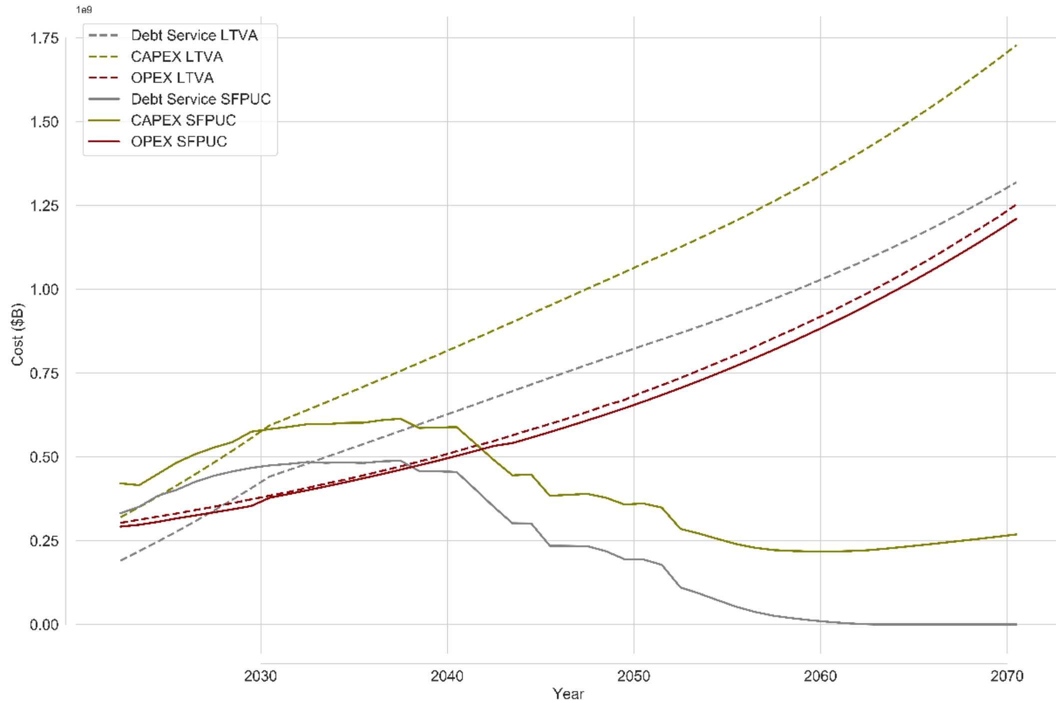

Figure 4: comparison of CAPEX (green), debt service (grey) and OPEX (red) between SFPUC 20-year plan (solid lines) and LTVA (dashed)

4.1.1 Capital Expenditure

Figure 4 shows the variation in SFPUC's forecast CAPEX spend from 2020-2070. One can observe a significant drop in CAPEX from 2040. This is because plans for "new" capital expenditure (as opposed to ongoing capital repair and replacement (R&R) of the existing system) only exist for 10-15 years into the future. As a result, the SFPUC's forecast shows the gradual reduction in CAPEX as the 30-year bonds issued to fund the existing $5B Water System Improvement Program and the planned projects in the 10-15 CIP horizon are paid off, with increases in the outer years covering only ongoing R&R. In order to establish a consistent forecast of CAPEX across the 50-year time horizon utilized in the LTVA, the finance model generates a timeseries of CAPEX spend from 2000 through to 2070. This timeseries initializes in 2000 in order to incorporate legacy debt that SFPUC holds in 2020, the LTVA's initial timestep.

In order to avoid tracking individual CAPEX expenditures and loans (which is beyond the scope of this work and duplicative to SFPUC's existing 10-year plan), the Finance model considers CAPEX spend as an aggregate value for each year and is made up of two components:

- Fixed – representing the expected new capital investment in each year and makes up 45% of total CAPEX spend.

- Variable – representing ongoing repair and replacement (including significant modification) of existing infrastructure that is inflated by 3% year on year. Variable CAPEX makes up 55% of total CAPEX.

CAPEX spend is assumed to be 75% debt funded and 25% revenue funded, where the debt funded portion is assumed to be a new loan taken out each year. Total CAPEX in each timestep is thus:

$$Total\ CAPEX_t = Debt\ Service_t + (CAPEX_t \times 0.25) \tag{3}$$

Table 1

(values given in this table are purely illustrative to demonstrate the debt service logic), which shows the first four years of the timeseries. In this example, a new loan (debt drawdown) is taken out each year to cover 75% of CAPEX spend. Assuming a debt repayment period of 30 years, each subsequent year in the time series for 30 years will require a principal payment and an interest payment against this loan. Further drawdown in each subsequent year adds additional principle and interest payment obligations for a 30-year window into the future. Debt at the end of each timestep, shown in Equation (1), is the balance of debt at the beginning of the period, additional drawdown in the current period and the sum of principal payments made in the current period. Total interest payment in a given year is the sum of all interest payment obligations due for that year. Debt service, provided in Equation (2), for each year is then the sum of principle and interest payment obligations for that year.

$$Debt\ End\ Period_t = Debt\ Start\ Period_t + Drawdown_t - Principle\ Debt\ Repayment_t \tag{1}$$

$$Debt\ service_t = Interest_t + \sum Principle\ debt\ repayment\ obligations_t \tag{2}$$

Total CAPEX in each timestep is thus:

$$Total\ CAPEX_t = Debt\ Service_t + (CAPEX_t \times 0.25) \tag{3}$$

Table 1: table illustrating the approach taken in establishing debt service in the finance module

Debt repayment period (years)	30					
Interest rate	3%					
% of capex from debt	75%					
RR CAPEX Ratio	55%					
RR CAPEX inflator	3%					
		2020	**2021**	**2022**	**2023**	**2024**
New CAPEX spend		50,000,000	50,825,000	51,650,000	52,475,000	53,300,000
Debt schedule						

Debt Beginning of Period		-	36,935,571	73,887,929	110,827,441	147,732,588
Drawdown		37,500,000	38,118,750	38,737,500	39,356,250	39,975,000
Principal Repayment		(564,429)	(1,166,392)	(1,797,988)	(2,451,103)	(3,116,568)
Debt End of Period		36,935,571	73,887,929	110,827,441	147,732,588	184,591,021
Interest payment		(1,875,000)	(3,752,716)	(5,600,800)	(7,507,865)	(9,442,831)
Debt Service		(2,439,429)	(4,919,108)	(7,398,788)	(9,958,968)	(12,559,399)

Debt Amortization Schedule

2020	Principal	($564,429)	($592,650)	($622,283)	($653,397)	($686,067)
37,500,000	Interest	($1,875,000)	($1,846,779)	($1,817,146)	($1,786,032)	($1,753,362)
2021	Principal		($573,742)	($592,650)	($622,283)	($653,397)
38,118,750	Interest		($1,905,938)	($1,846,779)	($1,817,146)	($1,786,032)
2022	Principal			($583,055)	($583,055)	($583,055)
39,737,500	Interest			($1,936,875)	($1,936,875)	($1,936,875)
2023	Principal				($592,368)	($592,368)
39,356,250	Interest				($1,967,813)	($1,967,813)
2024	Principal					($601,681)
39,975,000	Interest					($1,998,750)

4.1.2 Operational Expenditure

Figure 5 provides an overview of the logic utilized in establishing OPEX. OPEX spend is made up of two components:

- Volumetric: this OPEX is a function of the amount of water delivered and is inflated at a rate of 3% per year (from a base value of \$0.11 /ccf) and makes up 4% of total OPEX.
- Fixed: OPEX represents operational costs that do not depend of the volume of water delivered and makes up 96% of total OPEX.

Total OPEX in each year is thus:

$$Total\ OPEX_t = OPEX\ fixed_t + (Deliveries[ccf]_t \times OPEX/ccf_t) \tag{4}$$

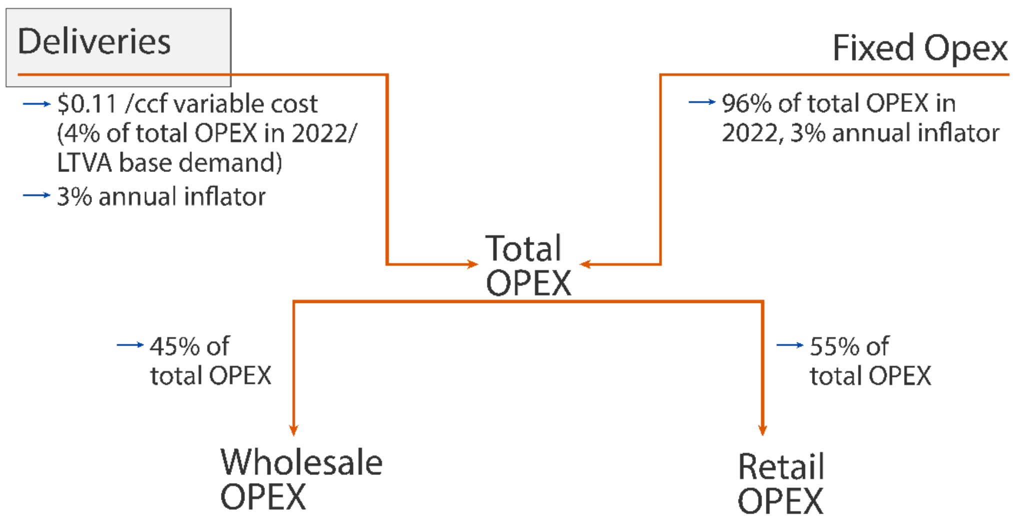

Figure 5: schematic of OPEX logic in LTVA Finance Module. Orange arrows indicate model inputs/outputs and blue arrows indicate model parameters.

4.2 Rate solver

SFPUC provides water to both retail and wholesale customers. Over 2.6 million people within the counties of San Francisco, San Mateo, Santa Clara, Alameda, San Joaquin, and Tuolumne rely entirely or in part on the water supplied by the SFPUC (Figure 6). Approximately two thirds of the SFPUC's water supply is delivered to wholesale customers, and the remaining one third is delivered to retail customers.

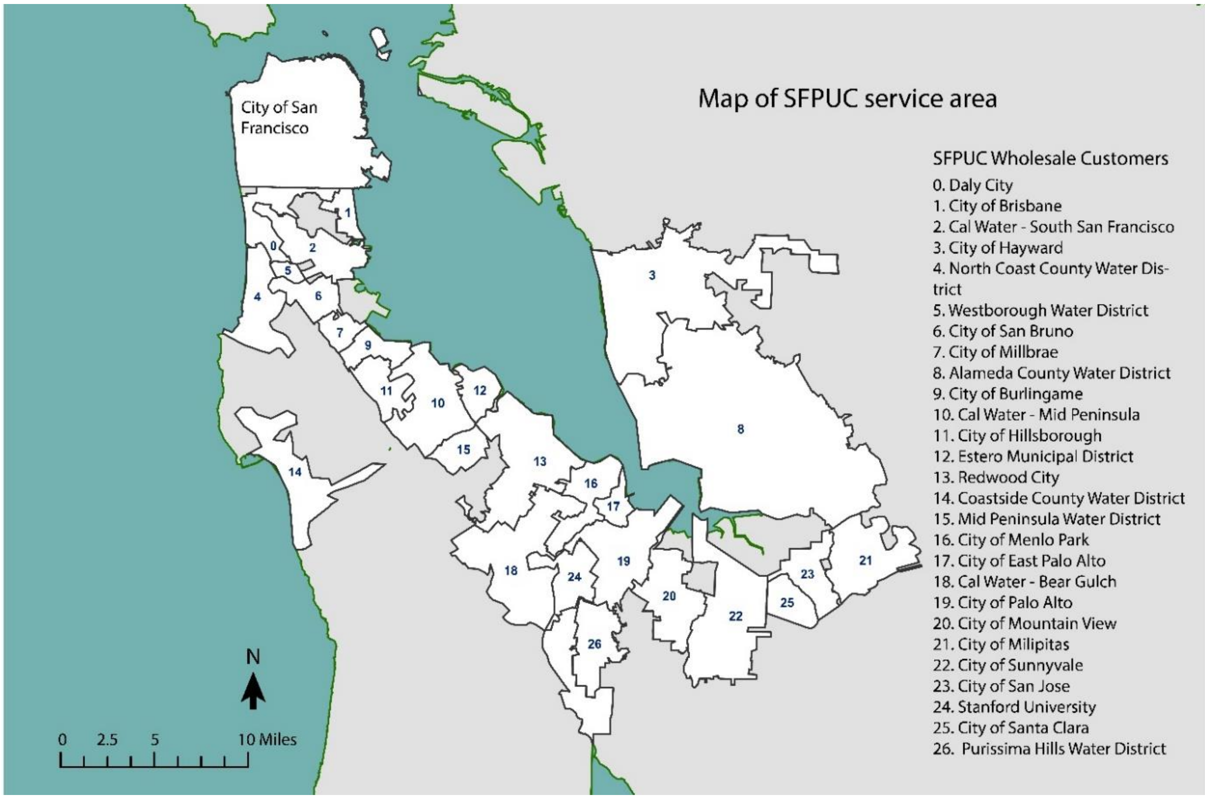

Figure 6: Map of the SFPUC service area.

Retail customers include the residents, businesses, and industries located within San Francisco city limits, referred to as the in-city retail service area, as well as a patchwork of smaller non-contiguous customers located outside the City collectively referred to as the suburban retail service area.

The RWS also delivers water to 28 wholesale customers in Alameda, Santa Clara, and San Mateo Counties, including the Groveland Community Services District (Groveland CSD) in Tuolumne County. The Bay Area Water Supply and Conservation Agency (BAWSCA) represents the interests of 27 of the wholesale customers and coordinates their water supply planning.

The logic for setting water rates is based simply on cost recovery. Each year rates are set by dividing the total expenditure for that year by the volume of water delivered. Whilst the general logic for setting wholesale and retail rates is the same, the following describes how costs are apportioned to wholesale and retail customers and the specific logic for each.

1. CAPEX: 25% to wholesale customers, 75% to retail customers
2. OPEX: 45% to wholesale customers, 55% to retail customers
3. When setting retail water rates, revenue from sources other than water sales (rental income, interest, etc.) contribute positively to the balance in the numerator of equation (5) and is multiplied by a factor of 0.85. The remaining 0.15 is split amongst all retail customer accounts to make up the service charge portion of their water bill.

$$price_R = \frac{[(Q_{Rtot} \times OPEX_R) + CAPEX_R - other\ revenue] \times 0.85}{Q_{Rtot}} \quad (5)$$

4. A service charge of $4,277,000 contributes negatively to the numerator in equation (6) when setting wholesale customer water rates.

$$price_W = \frac{(Q_{Wtot} \times OPEX_W) + CAPEX_W - service\ charge}{Q_{Wtot}} \quad (6)$$

4.3 Fund Balance

SFPUC's fund balance represents the balance of available cash, costs and revenues in a given year (equation (7)) and provides the organization with a buffer that hedges against the risk of unexpected reductions in revenue or spikes in cost. Fund balance must not fall below 25% of total OPEX for a given year and prices are adjusted year on year to ensure the fund balance meets this target.

$$Fund\ Balance\ End\ Period_t = Fund\ Balance\ Beginning\ Period_t + total\ revenues_t - total\ costs_t \quad (7)$$

4.4 Results

Results of the finance module will be presented in the forthcoming Vulnerability Assessment Report. It is expected that the health of SFPUC finances will tightly correlated to conditions that compromise the performance of the system from an operational perspective. It is likely that extended periods of low water delivery will cause prices to rise as CAPEX and OPEX costs continue to inflate in combination with reduced revenues. This is likely to impact performance against all three metrics of performance specified here.

Figure 7, provides an indication of how the model behaves using one weather realization under a no climate change scenario and base demand. As expected, revenues match costs and the fund balance remains stable across the time horizon.

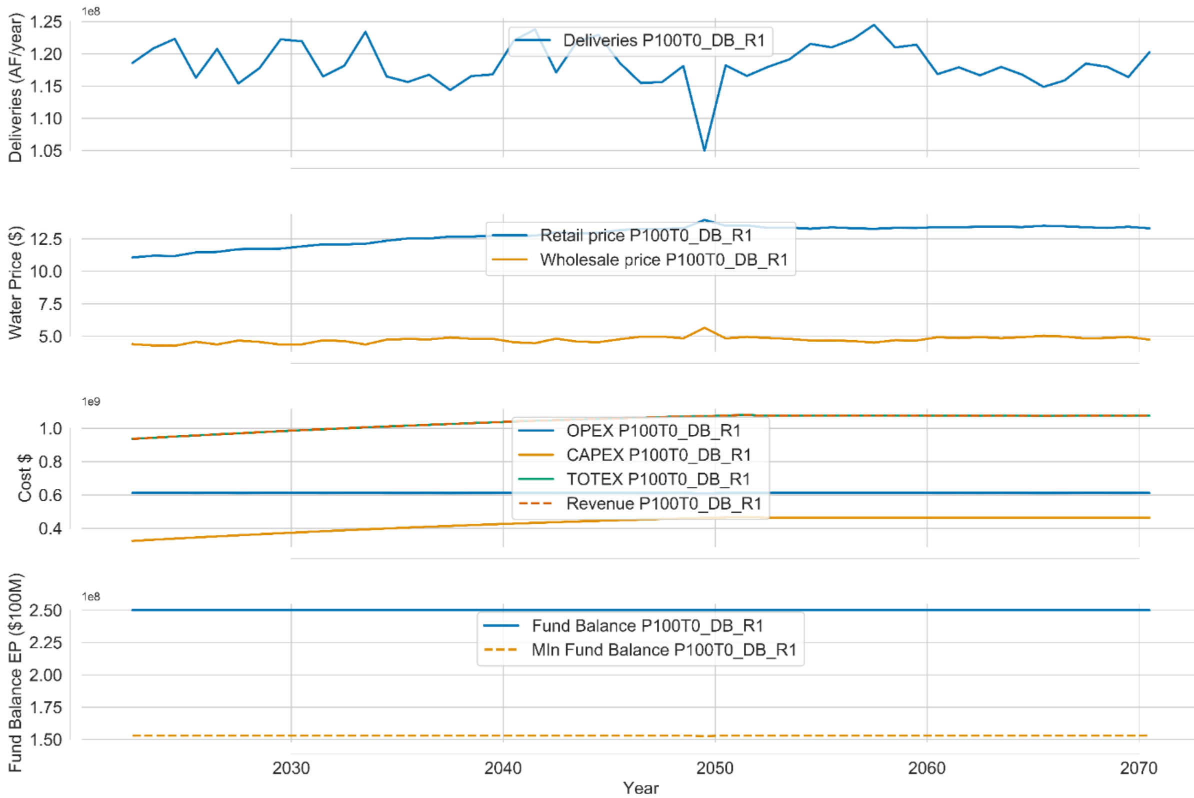

Figure 7: results of key components of Finance Model for one weather realization under no climate change and base demand. Top to bottom: fund balance, water price, costs & revenue and fund balance.

For this phase of work, the finance module will not be tightly coupled to the wider system model, but will instead take its output as direct input in a loosely coupled approach. As such, feedback loops that take account of consumer response to price change are not taken into account. In subsequent phases of work, this can be revisited to explore the role of price in driving demand of consumers, both as an adaptation strategy, and as a risk associated with drought periods.

5 Measuring Performance

The finance model will process 7648 outputs of the system model to produce key state variables of interest. These state variables characterize the performance of the system against key financial management policies current in place at SFPUC. Should these state variables pass a certain threshold at any point across the time horizon then the system is determined to have failed.

5.1 Water Rate Increase

This metric is used to evaluate the rate at which water prices are required to increase from one year to the next in order to cover costs. Failure is defined here as an increase in price of more than 10% from one year to the next for either Wholesale or Retail customers. This metric is particularly useful when considering results of trend model runs and the impact of increasing capital and operational expenditure over time.

5.2 The Price of Water

The absolute price of water is a useful indicator when considering the results of the financial stress test under step change model runs in which capital and operational expenditure are constant over time.

6 References

Brown, C., Dufour, A., 2017. Long-Term Vulnerability Assessment and Adaptation Planning for the SFPUC Water Enterprise: Technical Memorandum #1 - Identification of Long Term Sources of Vulnerability. University of Massachusetts Amherst.

HRG TR4 (2021). Technical Report 4: San Francisco Water System Model. Hydrosystems Research Group, University of Massachusetts, Amherst, Amherst, Massachusetts.