Brown AND Caldwell

FINAL TECHNICAL MEMORANDUM |
Prepared for **County of Maui**

Phase 1: Central and Upcountry Demand and Capacity Analysis

13 July 2023

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Technical Memorandum

Prepared for: County of Maui, Department of Water Supply, Water Resources & Planning Division

Project Title: Feasibility Study for East Maui Source Development

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Subject: Phase 1: Central and Upcountry Demand and Capacity Analysis

Date: July 13, 2023

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List of Abbreviations

2018 D&O	2018 Decision & Order
ADD	average day demand
AM	average month demand
ASEA(s)	aquifer sector area(s)
BC	Brown and Caldwell
BLNR	Board (of) Land (and) Natural Resources
CCR	California Code (of) Regulations
COVID-19	Coronavirus Disease 2019
CPI	Consumer Price Index
CWRM	(State of Hawaii) Commission on Water Resource Management
DHHL	Department of Hawaiian Homelands
DOH	Department of Health
EMFS	Feasibility Study for East Maui Source Development
EMI	East Maui Irrigation Company
ft	foot/feet
ft^3/s	cubic feet per second
GAC	granular activated carbon
gal/cap-day	per capita consumption (in gallons)
gpd	gallons per day
GIS	geographic information system
GWUP(s)	Ground Water Use Permit(s)
IIFS(s)	interim instream flow standard(s)
KAP	Kula Agricultural Park
LOS	Level of Service
MAR	Maui Administrative Rules
MCC	Maui County Code
MDD	maximum day demand
MDWS	(County of) Maui Department of Water Supply
mgal	million gallon(s)
mgd	million gallons per day
MIP	Maui Island Plan
MM	maximum month demand
Priority List	Upcountry Meter Priority List
SWMA	Surface Water Management Area
SWUP(s)	surface water use permit(s)
SY	sustainable yield
TM	technical memorandum
TMK	tax map key
USGS	United States Geological Survey
WRPP	(2019) Water Resources Protection Plan
WSS	(State of Hawaii) Water Systems Standards
WTF(s)	Water Treatment Facility(ies)
WUDP	(2019) Water Use and Development Plan
WUP(s)	Water Use Permit(s)

Executive Summary

This technical memorandum (TM) describes an analysis of the demand and capacity for the water distribution systems operated by the County of Maui Department of Water Supply (MDWS) for the Central and Upcountry Districts and is part of a feasibility study to evaluate water source alternatives that will ensure sufficient potable water supply to accommodate growth associated with the Central and Upcountry Maui water systems. The goals and focus of this TM, with respect to the Central and Upcountry Districts, are:

- Evaluate the previous production demand projection methodology presented in the Water Use and Development Plan (WUDP) adopted by Ordinance in 2022.
- Refine the production demand projections based upon more recent water system data while extending the projection horizon to the year 2040.
- Review the existing system capacity, constraints, and reliability.
- Quantify the amount of new source water required to meet the future production demand requirements.

Brown and Caldwell (BC) performed an analysis of recent billed consumption and production data. Figures 1 and 2 display the trend in average annual billed consumption and production between calendar years 2015 and 2020. Production, consumption, and system losses are all increasing over time for both the Central and Upcountry systems.

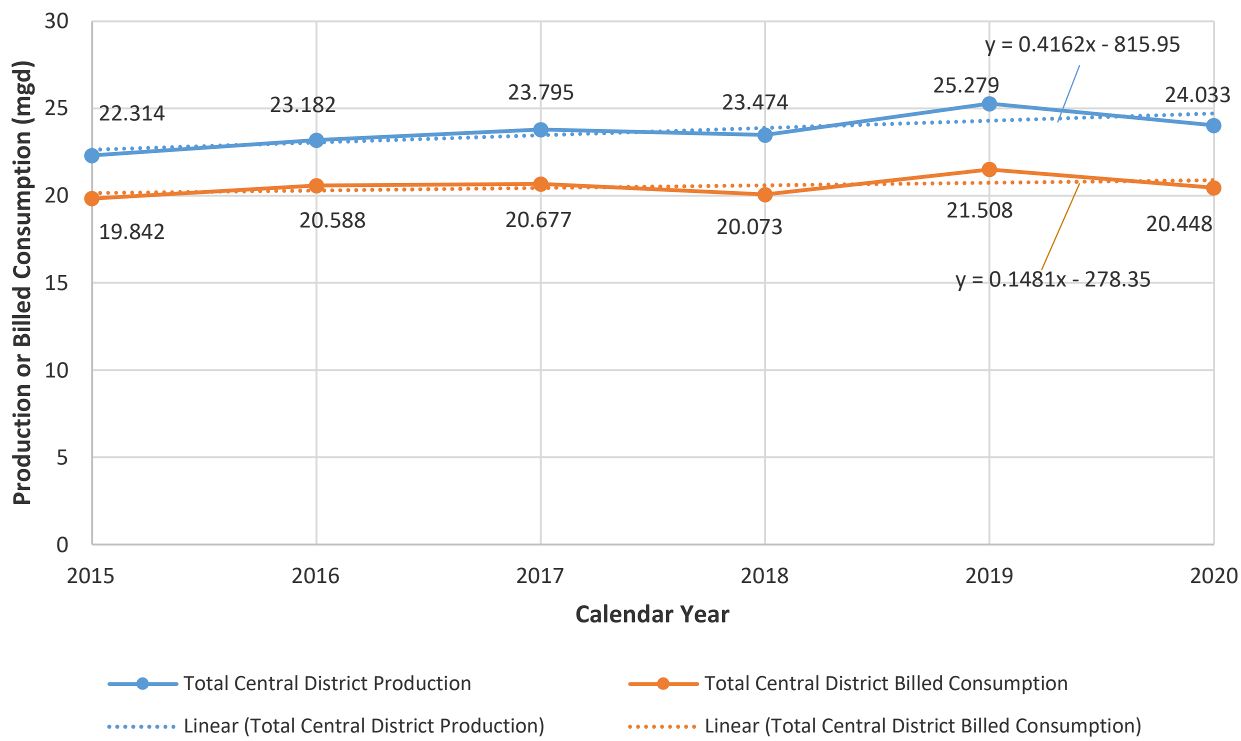


Figure 1. Central District – Total Production vs. Total Billed Consumption

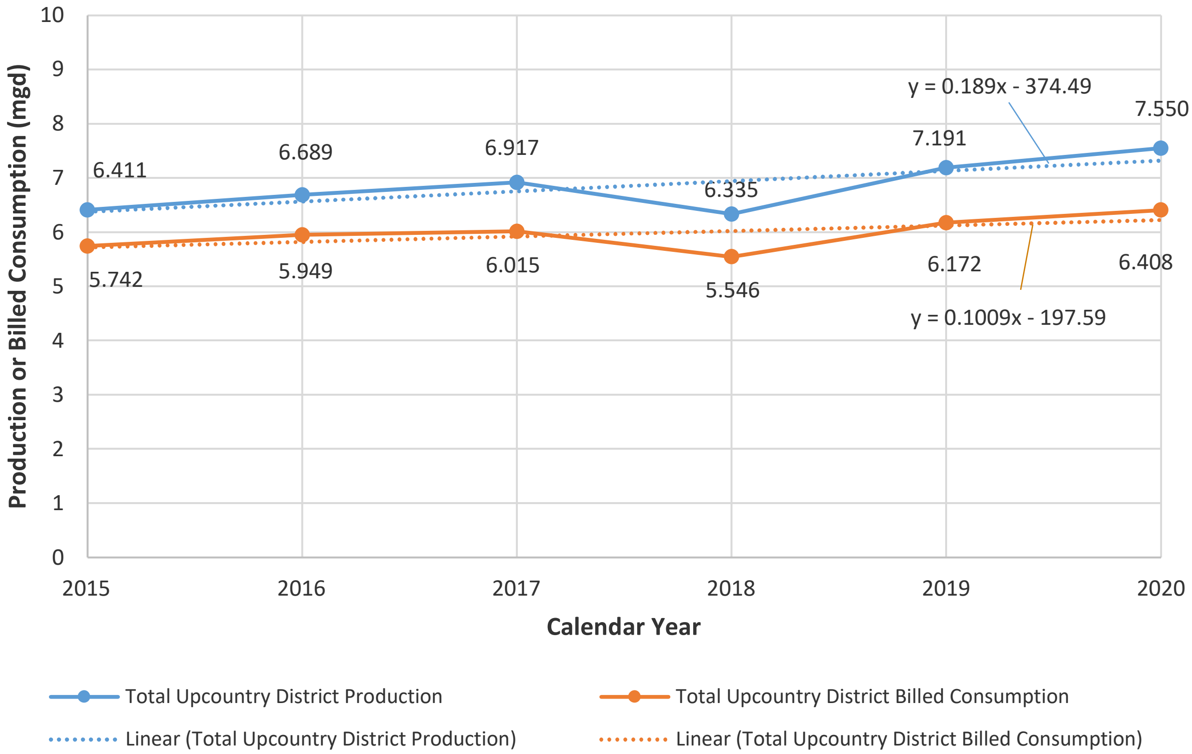


Figure 2. Upcountry District – Total Production vs. Total Billed Consumption

The population and demand projections established in the 2019 WUDP were updated using population data from Census 2020 and the most recent Socio-Economic Forecast projections. Application of the Socio-Economic Forecast projections resulted in an over-estimation in the average annual population change and the 2019 projection methodology correspondingly overestimated the growth in production demand for 2014 to 2020. The Central District 2020 data was approximately 1.4 mgd, or 5.8 percent, below the projected value, while the Upcountry District observed data is approximately 0.6 mgd, or 8.0 percent below the projected value.

To refine and extend the production demand projections from now through 2040, three separate projection methodologies were evaluated. Ultimately, the recommended projection approach incorporates all three methodologies to establish a range of "most likely" projection values, as well as a conservative upper limit for each time interval considered. The three methods include:

1. A baseline linear trend was established by projecting forward using the most recent five years of production data.
2. The WUDP method was updated and extended to 2040, using population data from Census 2020 and the most recent Socio-Economic Forecast projections.
3. As a high-end (upper threshold) conservative limit estimate production demand associated with planned future development was added to the baseline trend using consumption guidelines from the 2002 Water Systems Standards.

For the Upcountry District, existing and outstanding production demand associated with processing the Upcountry Meter Priority List and subsequently addressing potential Upcountry pent-up demand were also incorporated into the projections.

Key assumptions included:

- Remaining applications on the Priority List (approximately 1,500 applications as of 2021) would be processed at a rate of 80 applications per year, resulting in full resolution of the Priority List in year 2040.
- Approximately 50 percent of processed applications would result in an actual service connection, which is consistent with historical application processing outcomes.
- Any pent-up demand would be addressed between years 2040 and 2045.

An additional projection method, which assumes that all Upcountry demand is based solely on processing the Priority List over time was also considered.

Table 1 summarizes the recommended ranges in projected production demand through 2040, extending to 2045 only where appropriate to include addressing of the potential pent-up demand component.

Table 1. Recommended Production Demand Ranges (mgd)

Projection Scenario	Calendar Year					
	2020	2025	2030	2035	2040	2045[b]
Central District						
Most Likely Demand Range	24.033[a]	26.6 – 26.8	28.9 – 29.6	31.0 – 32.3	33.0 – 35.1	–
High-End Conservative Limit		28.4	32.5	36.6	40.7	–
Upcountry District – excluding the Priority List and potential pent-up demand						
Most Likely Demand Range	7.550[a]	7.7 – 8.3	7.8 – 9.2	7.9 – 10.2	8.0 – 11.1	–
High-End Conservative Limit		8.6	9.9	11.2	12.6	–
Upcountry District – including the Priority List and potential pent-up demand						
Most Likely Demand Range	7.550[a]	8.4 – 9.0	9.3 – 10.7	10.1 – 12.4	11.0 – 14.1	13.2 – 17.2
High-End Conservative Limit		9.3	11.4	13.5	15.6	18.6

Notes:

a. *2020 reflects actual average day production.*

b. *Extension of projections to 2045 was performed for the Upcountry District when considering the Priority List and Pent-Up Demand conditions only, as it is assumed that the Priority List will be fully resolved by 2040 (assuming 80 applications processed per year), and that the pent-up demand will be resolved between 2040 and 2045.*

Figures 3 and 4 display the recommended ranges in chart form by plotting each of the projection methods described above for the Central and Upcountry Districts. Only the range which includes Priority List and pent-up demand components is presented. The original 2019 WUDP projection is included on each of these charts also for reference.

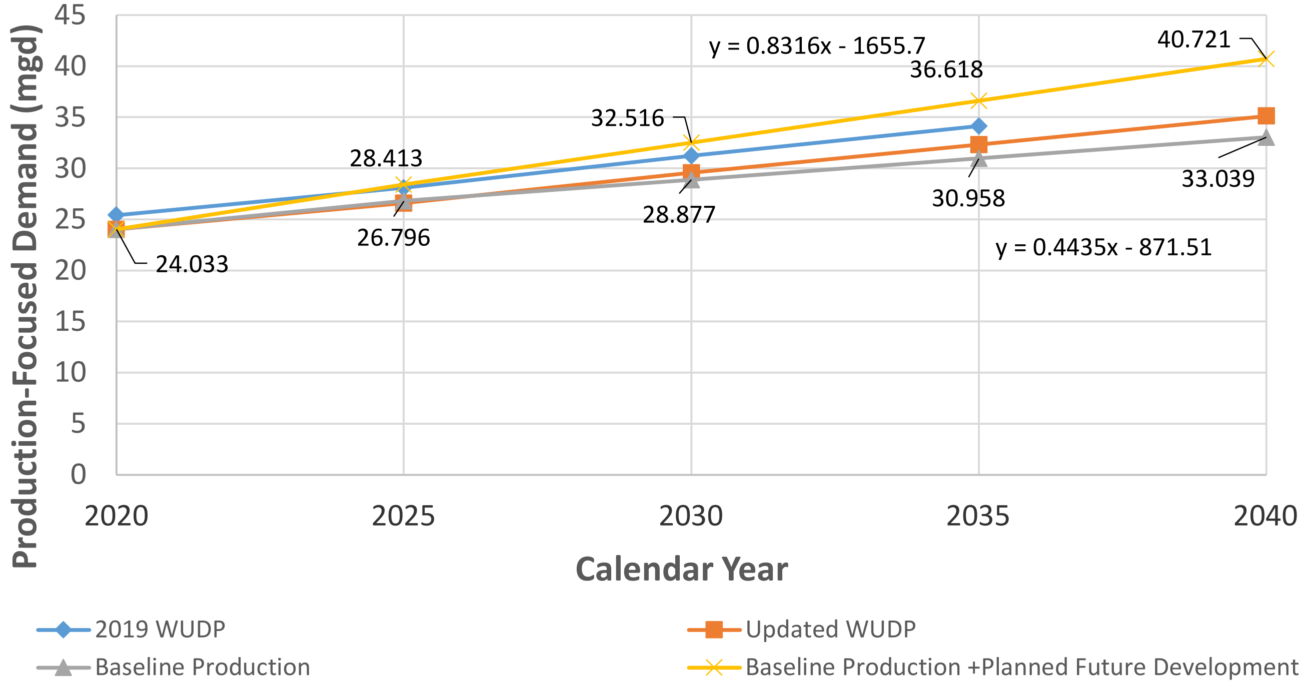


Figure 3. Projection Methodology Comparison and Recommended Production Demand Ranges - Central District

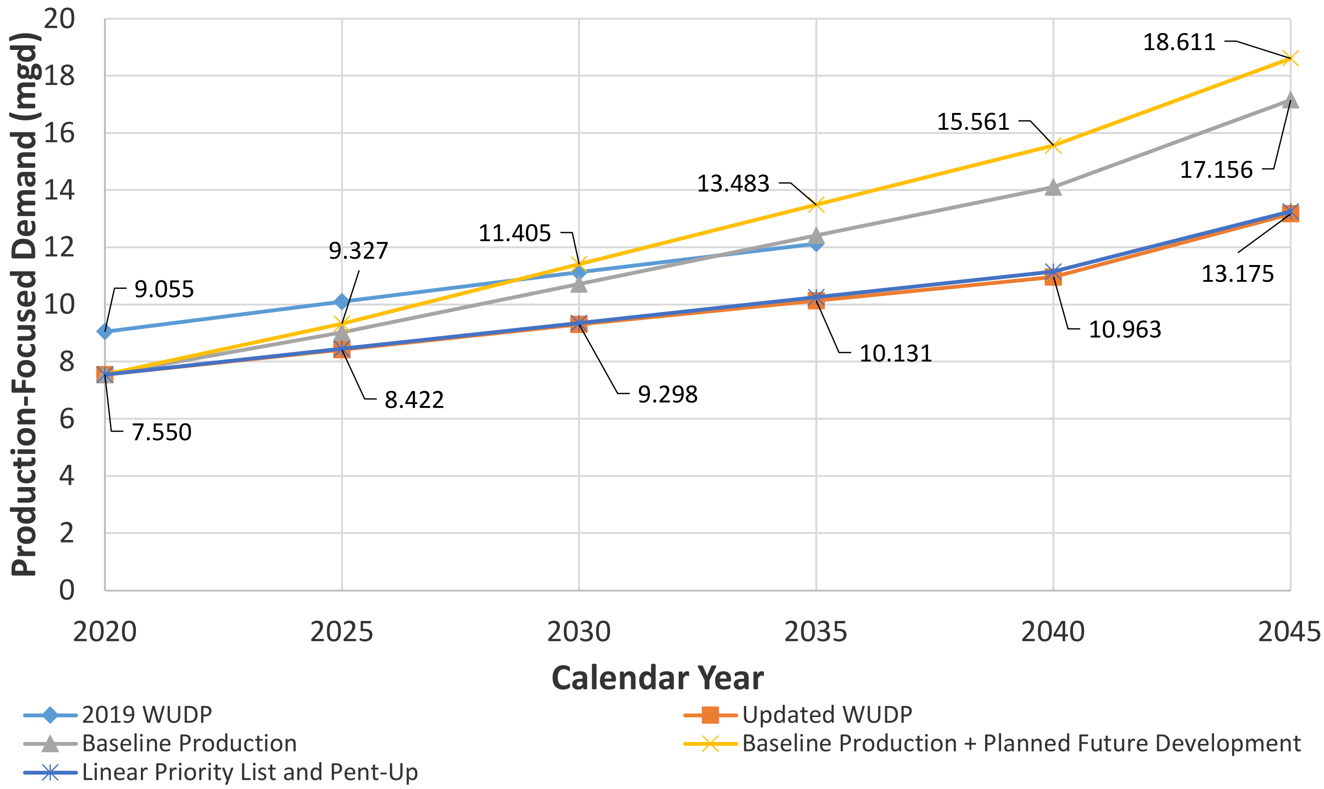


Figure 4. Projection Methodology Comparison and Recommended Production Demand Ranges - Upcountry District (Including the Priority List and Pent-Up Demand)

Constrained source production capacity was determined for the Central and Upcountry Districts, which was defined as the actual/recommended maximum amount of water that can be produced at a source on an ongoing basis, considering system, source, equipment, and operational limitations and constraints. For Central wells, the constrained source production capacity takes into account pumping capacity when equipment is run 16 hours per day and 24 hours per day. If withdrawal is limited by Ground Water Use Permits (GWUPs) or legal agreements this number is reduced to the permitted or agreed-upon amount.

For water treatment facilities (WTFs), the constrained source production capacity is the lesser of nominal capacity (sustainable treated water production level that accounts for necessary unit downtimes) and practical available raw water supply (the average daily raw water inflow available considering raw water collection, transmission, and storage limitations). Table 2 summarizes the constrained source production capacity, and the permitted capacity for the Central District.

Table 2. 2022 Constrained Production – Upcountry and Central Districts (mgd)

Source	Constrained Production		Permitted Production
Upcountry Ground Water Total	2.232		N/A
Upcountry Surface Water Total (Constrained Capacity)	8.370		N/A
Upcountry Total (Excluding Emergency)	**10.602**		**N/A**
Central Ground Water Total	25.339 (24-hr)	23.350 (16-hr)	26.664
Central Surface Water Total (Constrained Capacity)	2.5 (24-hr)	2.5 (16-hr)	3.2
Central Total	**27.839**	**25.850**	**29.864**

Historic production and capacity were analyzed, with historic multipliers identified to calculate of maximum month (MM), and maximum day demand (MDD) from average day demand (ADD). These factors were applied to future capacity projections (Figures 5 and 6). Finally, supply surplus/deficit to achieve each of MM, MDD, and ADD with current constrained production capacity was determined through 2040 for the Central District and 2045 for the Upcountry District (Table 3).

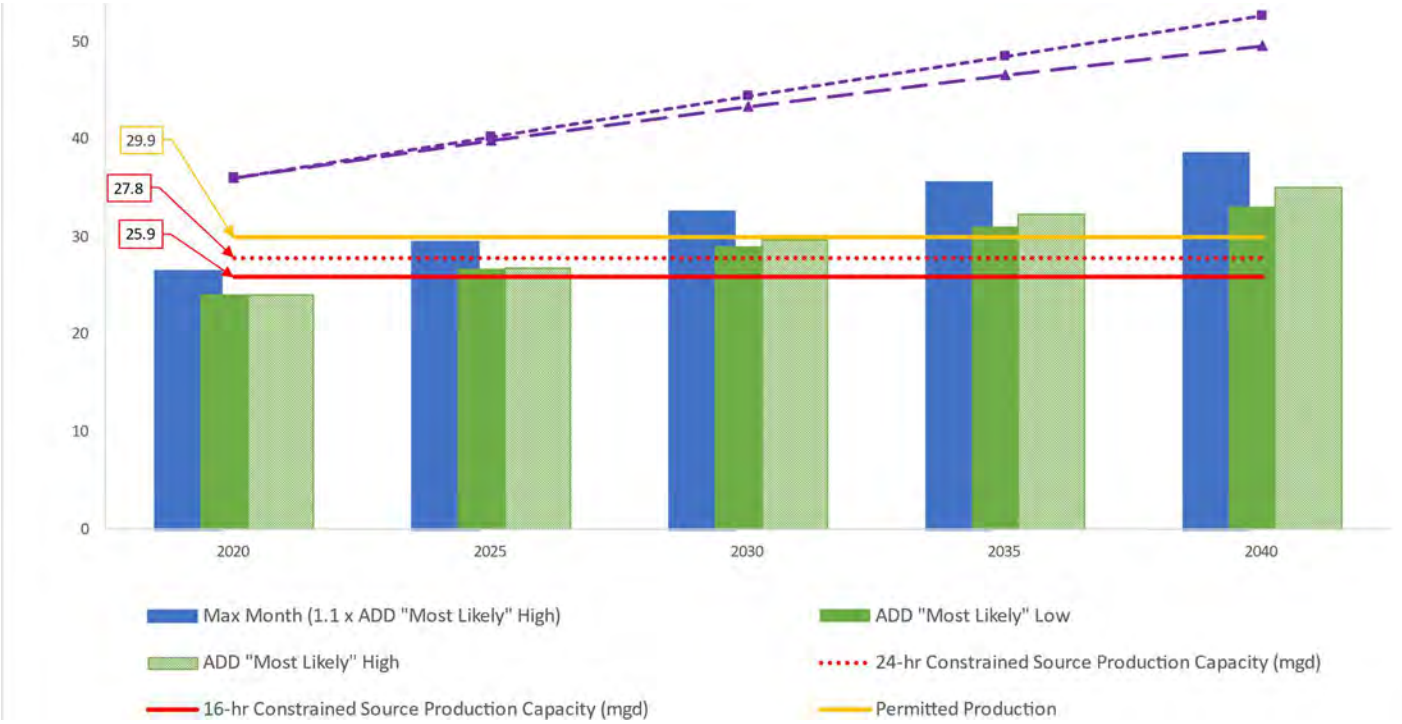


Figure 5. Future Production and Source – Central District

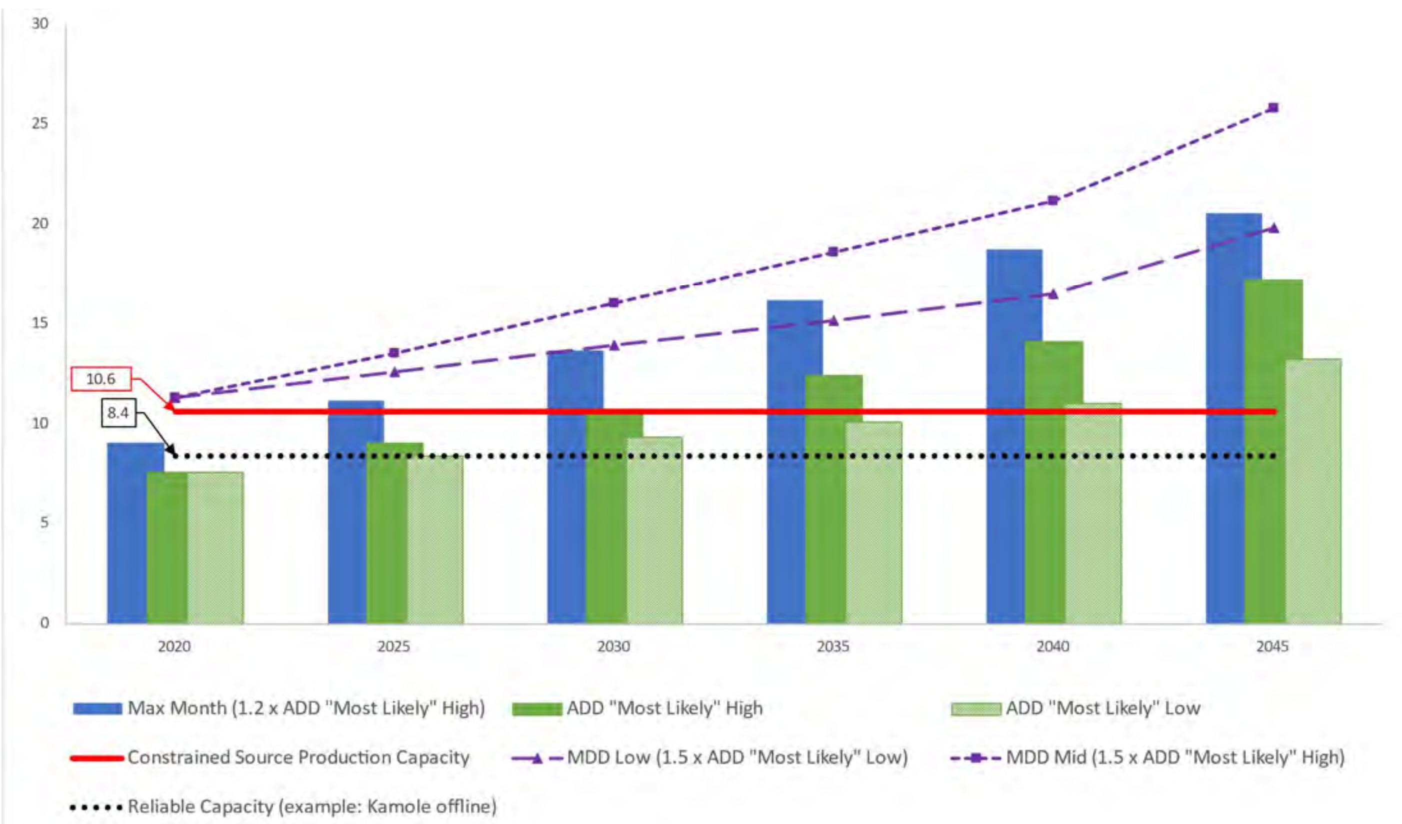


Figure 6. Future Production and Source – Upcountry District

Table 3. Source Surplus/Deficit through 2040 and 2045 (mgd)

Projection Scenario	Calendar Year					
	2020	2025	2030	2035	2040	2045 [b]
Central District						
Constrained Source Production Capacity	**25.9**	**25.9**	**25.9**	**25.9**	**25.9**	–
"Most Likely" Demand Range (ADD)	24.033[a]	26.6 to 26.8	28.9 – 29.6	31.0 – 32.3	33.0 – 35.1	–
MDD Mid (1.5 x "Most Likely" High ADD)	36.0	40.2	44.4	48.5	52.7	–
Surplus/Deficit to meet ADD	1.8	-1.0	-3.8	-6.5	-9.3	–
Surplus/Deficit to meet MM	-0.6	-3.6	-6.7	-9.7	-12.8	–
Surplus/Deficit to meet MDD	-10.2	-14.4	-18.6	-22.6	-26.8	–
Upcountry District – including the Priority List (to 2040) and potential pent-up demand (2045 only)						
Constrained Source Production Capacity	**10.6**	**10.6**	**10.6**	**10.6**	**10.6**	**10.6**
"Most Likely" Demand Range (ADD)	7.550[a]	8.4 – 9.0	9.3 – 10.7	10.1 – 12.4	11.0 – 14.1	13.2 – 17.2
MDD Mid (1.5 x "Most Likely" High ADD)	11.3	13.5	16.1	18.6	21.2	25.8
Surplus/Deficit to meet ADD	3.1	1.6	-0.1	-1.8	-3.5	-6.6
Surplus/Deficit to meet MM	1.5	-0.6	-3.1	-5.6	-8.1	-9.9
Surplus/Deficit to meet MDD	-0.7	-2.9	-5.4	-8.0	-10.5	-15.2

Notes:

a. *2020 reflects actual production.*

b. *Projection extension to 2045 was performed for the Upcountry District when considering the Priority List and Pent-Up Demand conditions only, as it is assumed that the Priority List will be fully resolved by year 2040 (at 80 applications processed per year), with subsequent resolution of pent-up demand between 2040 and 2045.*

Additional key findings and recommendations from this analysis include:

- The current constrained production capacity of the Central and Upcountry systems is insufficient to meet maximum day demand (MDD) for each District.
- By 2025, the Central and Upcountry systems will have insufficient constrained production capacity to meet the maximum month (MM) demand for each district, and the Central system will be challenged to meet the average day demand (ADD).
- Additional source development is required to meet projected demand for both the Central and Upcountry Districts.
- Piiholo and Olinda WTF production appears to be limited by availability of raw water, with Olinda impacted by raw water supply and Piiholo further limited by a transmission bottleneck from source to the Piiholo reservoir.
- Wailoa Ditch flow has been drastically reduced by the implementation of IIFS, and historic flow-duration curves for the Ditch can no longer be relied upon to predict future availability of water at the Kamole WTF. Monitoring of ditch flows and precipitation is recommended for study of the impact of IIFS on water availability for MDWS.
- Development of additional ground water source, construction of raw water reservoirs to store water and offset periods of low surface water availability, upgrading the raw water transmission systems to convey additional raw water collected upcountry are options identified to ensure consistent supply is available to serve the Upcountry District and fully utilize the surface water sources.

- This study has been performed at a District level. Specific supply availability at a system or subdivision development level will vary.

Additional findings and recommendations have also been identified through the course of the investigation:

- Operational changes such as pumping from Kamole to supplement upper elevation reservoirs levels during dry months could enhance supply.
- At the wells, investment in backup or alternate power to mitigate electric utility fluctuations, additional wellsite storage and interconnecting infrastructure could enhance system resilience. Further investigation is recommended to determine the benefits, impacts and feasibility of these strategies.
- An overall review of the 2002 WSS by MDWS is recommended – specifically the pumping and surface water demand limits (§ 100.111.08 and § 100.111.04).
- Development of a Master Plan and hydraulic model would provide opportunities to further identify levels of service, identify system deficiencies, outline a long-term Capital Improvement Program for utility-wide upgrades to develop supply to meet maximum daily demand well in advance of need, and facilitate a detailed analysis for service requests.
- While a detailed investigation of conservation trends, triggers, and efforts is beyond the scope of the EMFS, population and consumption may better correlate if conservation trends are analyzed.
- Alternate supply-related options such as recycled water, conservation, desalination, reduction in non-revenue water and other strategies outlined in the 2019 WUDP have not been considered within this TM.

Section 1: Introduction

Island-wide, new water source and infrastructure are needed to accommodate planned growth as outlined in the Maui Island Plan (MIP). To help meet this need, the MDWS is conducting a feasibility study to evaluate water source alternatives that will ensure sufficient potable water supply to accommodate growth associated with the Central and Upcountry Maui water systems.

The Feasibility Study for East Maui Source Development (EMFS) will be conducted in four phases to assess existing capacity, refine future potable water demand projections for the MDWS Central and Upcountry Maui systems, evaluate viable surface and ground water resource alternatives, and recommend a stream restoration plan in accordance with Section 4.2 of the 2003 East Maui Consent Decree (Consent Decree Order: The Coalition to Protect East Maui Water Resources, et al. v. The Board of Water Supply, et al., 2003). The study is divided into four separate phases:

- Phase 1 – MDWS Central Maui and Upcountry Systems Demand and Capacity Analysis
- Phase 2 – Availability of Surface Water and Cost/Benefit Study for Waikapu, Iao, and/or Waihee Hydrologic Units
- Phase 3 – Cost/Benefit Study for Central Maui Region, Upcountry Maui Region, and East Maui Region
- Phase 4 – Assess and Recommend a Plan for Stream Restoration in the Portion of the East Maui Region Outlined in Exhibit A of the Consent Decree

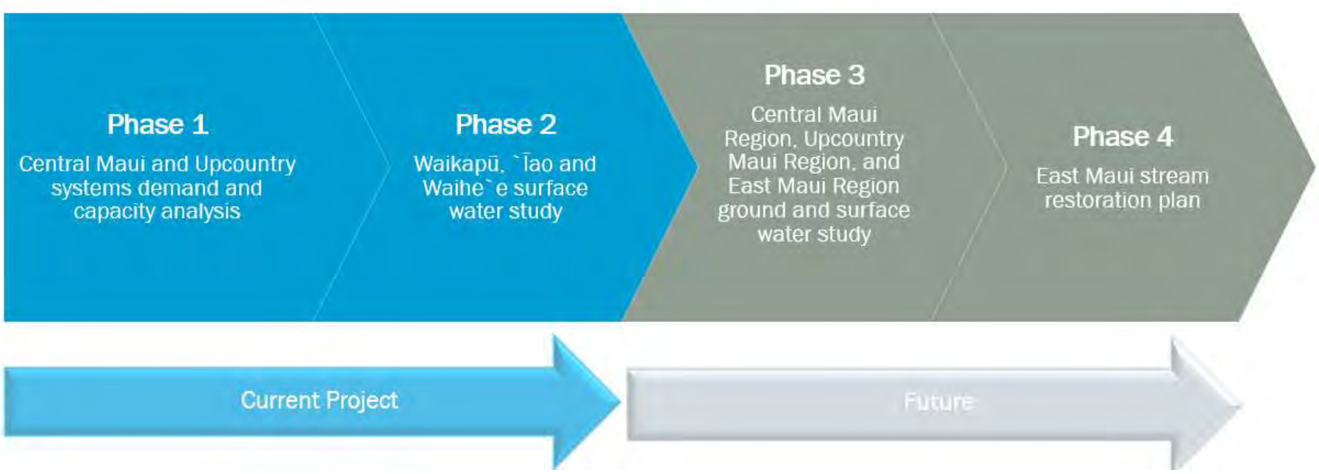
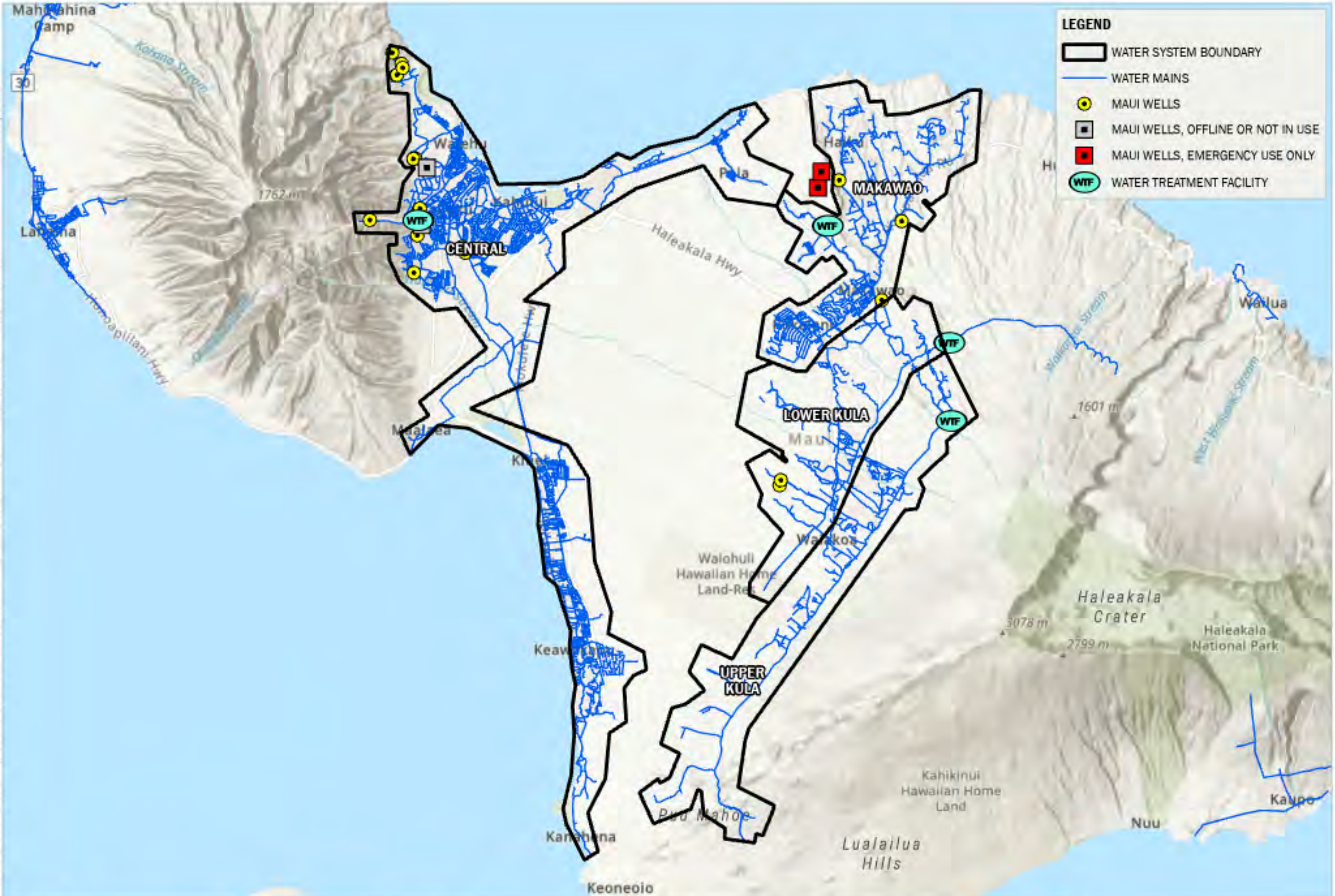


Figure 7. Feasibility Study for East Maui Source Development

1.1 Background

This TM reflects the Phase 1 study effort and describes an analysis of the demand and capacity for the water distribution systems operated by the MDWS in the Central and Upcountry Districts. The evaluated systems include the Central System within the Central District, and the Makawao, Upper Kula, and Lower Kula Systems within the Upcountry District. Figure 8 displays these four systems in terms of their distribution piping and approximate system boundaries; also shown are the MDWS surface water treatment facilities and ground water production wells.



COUNTY OF MAUI

FEASIBILITY STUDY

DATE: DECEMBER 2022
PROJECT: 159082

Sources:
Basemap: ESRI & Affiliates

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Miles

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FIGURE 8

CENTRAL AND UPCOUNTRY DISTRICT WATER SYSTEMS

1.2 Purpose

The purpose of this evaluation is to assess recent historical trends in water demand and production and provide a methodology for estimating demand and production needs into the future. In addition, source requirements to meet this need will also be identified.

The evaluation presented in this TM will serve to:

- Validate the previous projection methodology presented in the 2019 WUDP (County of Maui, Department of Water Supply, 2019).
- Refine the projections based on more recent water system and population data while extending the projection horizon to the year 2040.
- Factor in known future development and pending service request information that will entail demand requirements beyond the base trend projection.
- Inform MDWS of the future total quantity of supply needed to serve customers connected to each water system.
- Enable MDWS to identify the amount of new source needed to meet this future production requirement.

1.3 Organization

The remainder of this TM is separated into three primary sections:

- **Section 2 – Existing Demand Analysis**. This section focuses on:
  - Introducing demand-related terminology as used in this TM
  - Reviewing recent historical billing data
  - Reviewing recent historical production data from both surface and ground water sources
  - Comparing the observed production data against the observed billed consumption data
  - Providing analysis of the trends that can be identified in each, including comparison against population trends observed over the same period
- **Section 3 – Water Use Demand Projections**. This section focuses on:
  - Reviewing the water demand projection methodology utilized in the 2019 WUDP
  - Comparing the WUDP projections through 2020 against actual 2020 demand values
  - Providing an updated projection based upon the same methodology as the 2019 WUDP and extending projections through 2040
  - Considering alternative projection methodologies and extending projections through 2040
  - Providing an overall demand projection recommendation
- **Section 4 – Source and Capacity**. This section focuses on:
  - Introducing capacity-related terminology as used in this TM
  - Providing discussions on source water availability and limitations
  - Proposing a methodology for determining available production capacity
  - Summarizing the source surplus or deficit required to satisfy the projected demand through 2040, based on this methodology
  - Providing key findings and recommendations

Section 2: Existing Demand Analysis

This section introduces demand-related terminology, provides a review of recent historical billing and production data, analyzes trends in consumption and production, and provides a discussion of the correlation between population growth and observed demand.

2.1 Demand Terminology

This TM covers the topic of water use demand in depth. Key demand-related terms are defined below to clarify the distinction in the way this TM will refer to the various components of demand:

- **Demand or Water Use Demand** – These terms, used interchangeably, broadly refer to the quantity of water needed at a given time. Independently, these terms do not specify whether the demand is being discussed from a production or consumption focus. It should be noted, however, that the WUDP generally presents "water use" projections in terms of production values.
- **Consumption or Billed Consumption** – These terms, used interchangeably, refer to the quantity of water that is received by the end consumer. Consumption values are obtained from MDWS billing data and reflect the amount of water use reported from the customer's water meter. Consumption values differ from production values over the same period due to non-billed water use and losses that occur as water is treated and transported throughout the water system.
- **Production** – This term refers to the quantity of water measured at the source's point of generation, prior to transport through the water system. Production values can include both surface and ground water sources. Due to non-billed water use and system losses, production-focused demand values always exceed consumption-focused values over the same time interval.

Throughout this TM both consumption-focused and production-focused aspects of demand are discussed. To provide clarity these more specific terms will be used as appropriate.

2.2 Existing Consumption Data and Analysis

This section evaluates the existing water consumption on a per-district basis and discusses observed trends in consumption over time.

2.2.1 Billed Consumption Analysis

Brown and Caldwell (BC) performed an analysis of recent billing data, obtained from MDWS, for the Upcountry and Central Maui water districts, to update the projections established in the 2019 WUDP (County of Maui, Department of Water Supply, 2019). The billing data corresponds to water usage billed to consumers during the 2015 through 2020 calendar years; reported as the total monthly billed consumption (in thousands of gallons) throughout that duration. Table 4 summarizes the average daily billed consumption in million gallons per day (mgd) at the district level.

Table 4. Observed Annual Average Daily Billed Consumption by District, 2015 – 2020 (mgd)

MDWS District	2015	2016	2017	2018	2019	2020
Central	19.842	20.588	20.677	20.073	21.508	20.448
Upcountry	5.742	5.949	6.015	5.546	6.172	6.408

Source: MDWS Billing Data, 2015 - 2020

Table 5 and Figures 9 and 10 summarize the same demand information at a system level, also in units of mgd.

No break out of Haiku consumption? no explanation if it is part of Makawao?

Brown AND Caldwell

Table 5. Observed Annual Average Daily Billed Consumption by System, 2015 – 2020 (mgd)						
MDWS System	2015	2016	2017	2018	2019	2020
Central	19.842	20.588	20.677	20.073	21.508	20.448
Makawao	2.496	2.448	2.560	2.388	2.590	2.817
Upper Kula	1.157	1.234	1.182	1.123	1.217	1.274
Lower Kula	2.089	2.267	2.273	2.035	2.365	2.317

Source: MDWS Billing Data, 2015 - 2020

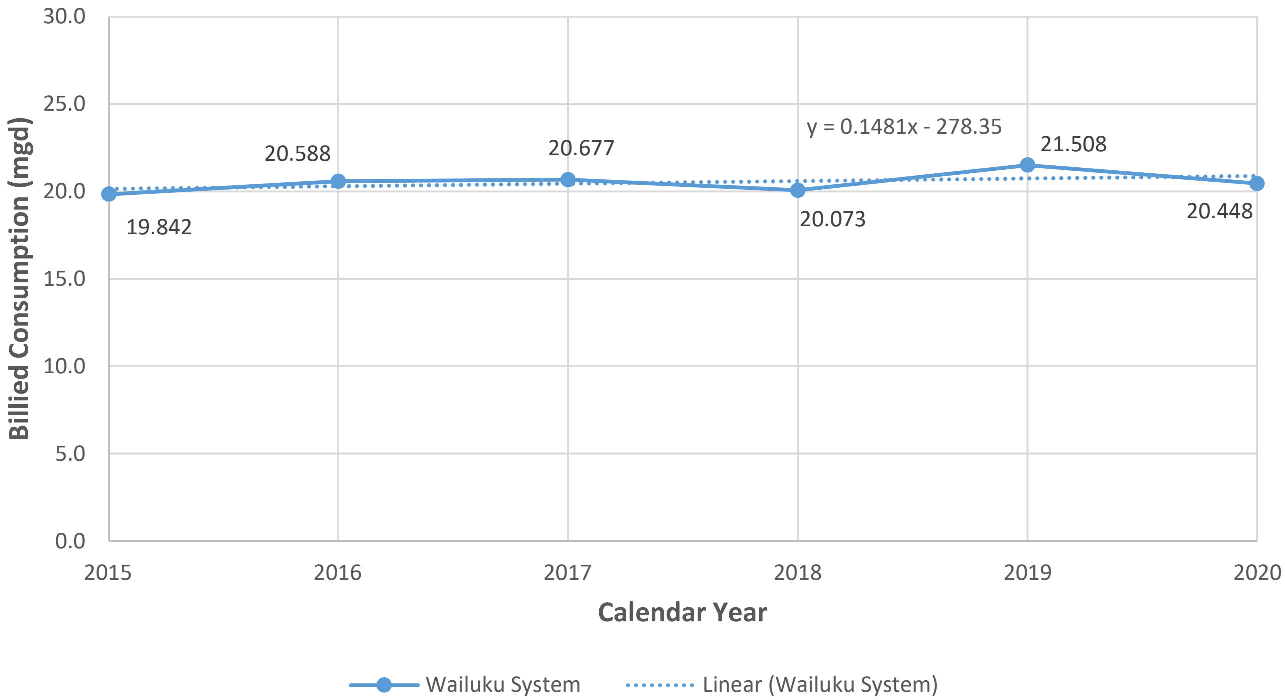


Figure 9. Central District Systems – Billed Consumption by System, 2015 through 2020

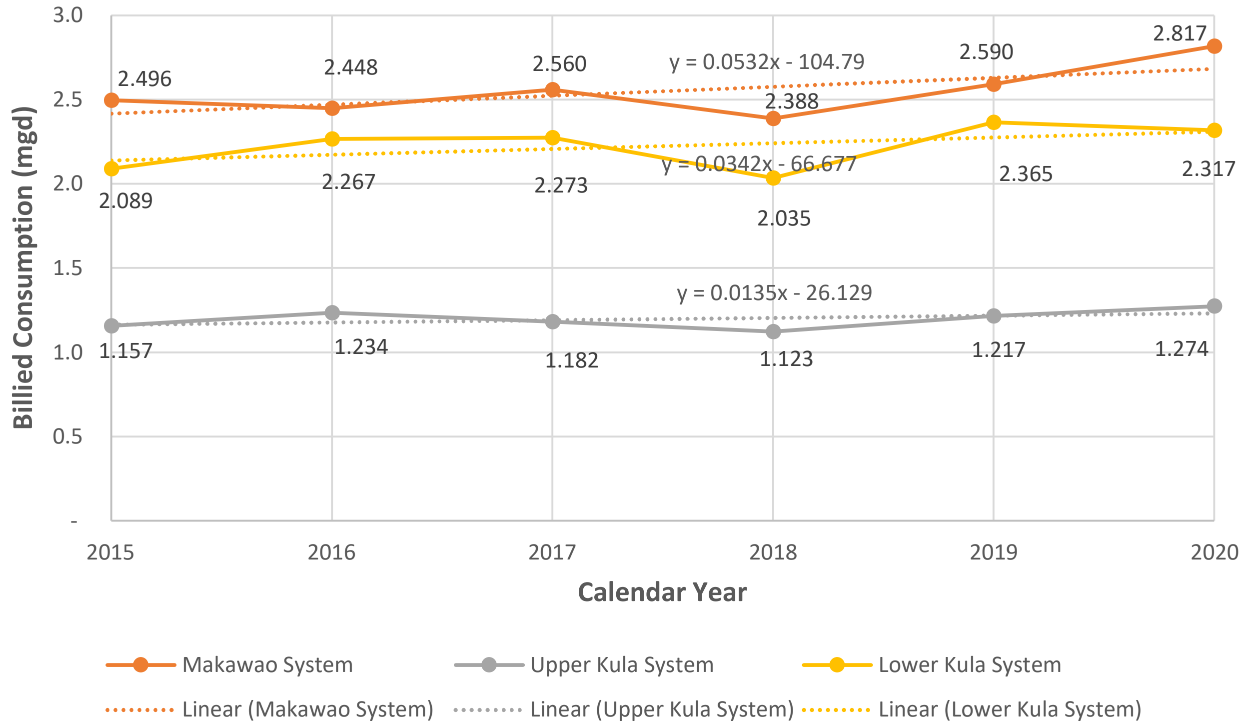


Figure 10. Upcountry District Systems – Billed Consumption by System, 2015 through 2020

2.2.2 Potential Sources of Error

The data presented here is based on billed consumption and may not absolutely reflect the actual consumption due to various potential sources of error including customer metering inaccuracies and systematic data handling errors. The MDWS approximates that customer metering inaccuracies account for roughly six percent. Unbilled (non-revenue) consumption, by definition, is not included.

2.2.3 Overall Trends in Average and Peak Year Consumption

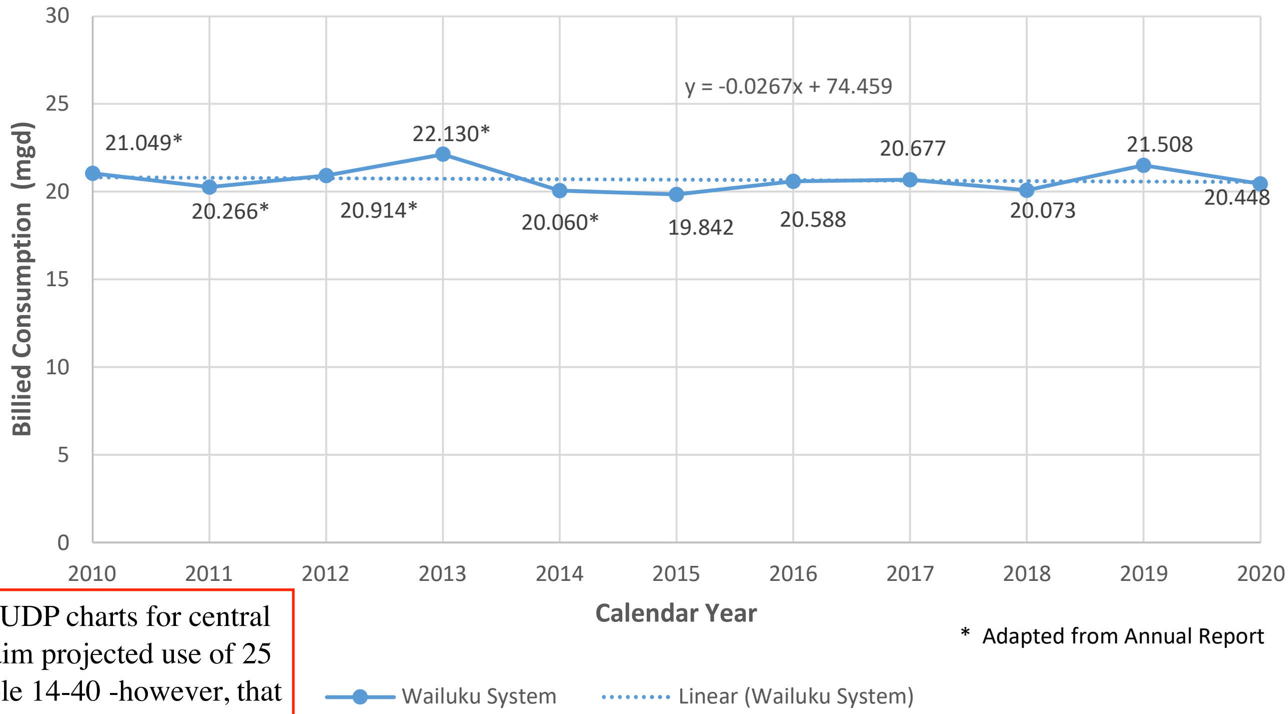
Although there are significant year-to-year fluctuations, Figures 9 and 10 indicate average consumption trends that are neutral to slightly positive, increasing over time for all systems from 2015 through 2020.

Notably, this baseline trend can be greatly influenced by extending the analysis timeframe to include years prior to 2015. In particular, the years 2010 and 2013 were significantly higher than average-consumption years, as illustrated in Figures 11 and 12, to follow. When including additional years prior to 2015 (i.e., 2010 through 2014) in the consumption evaluation, these additional data points result in an overall negative trendline across all systems for the full period, from 2010 through 2020.

Consumption data (from 2010 through 2014) reflected in these figures were obtained from the corresponding MDWS Annual Reports (County of Maui, Department of Water Supply, FY 2010 - 2021) as a supplement to the billing data for comparison only. This expanded timeframe provides insight into the significance of peak consumption years in recent historical records. Peak high and low consumption years should be considered when determining the required source and production capacity requirements.

A sensitivity analysis was performed in the WUDP, comparing the 2014 base year average consumption utilized, in that report, with three- and ten-year averages for the Central and Upcountry systems (WUDP, Appendix 4) to determine whether average consumption was representative of consumption-over-time.

The ten-year average was found to be consistent with the 2014 average daily demand, with a variation of one percent and 14 percent, for the Central and Upcountry District systems, respectively.



Note: WUDP charts for central Maui claim projected use of 25 mgd- Table 14-40 -however, that was not the metered use.

Figure 11. Central District - Billed Consumption by System, 2010 through 2020

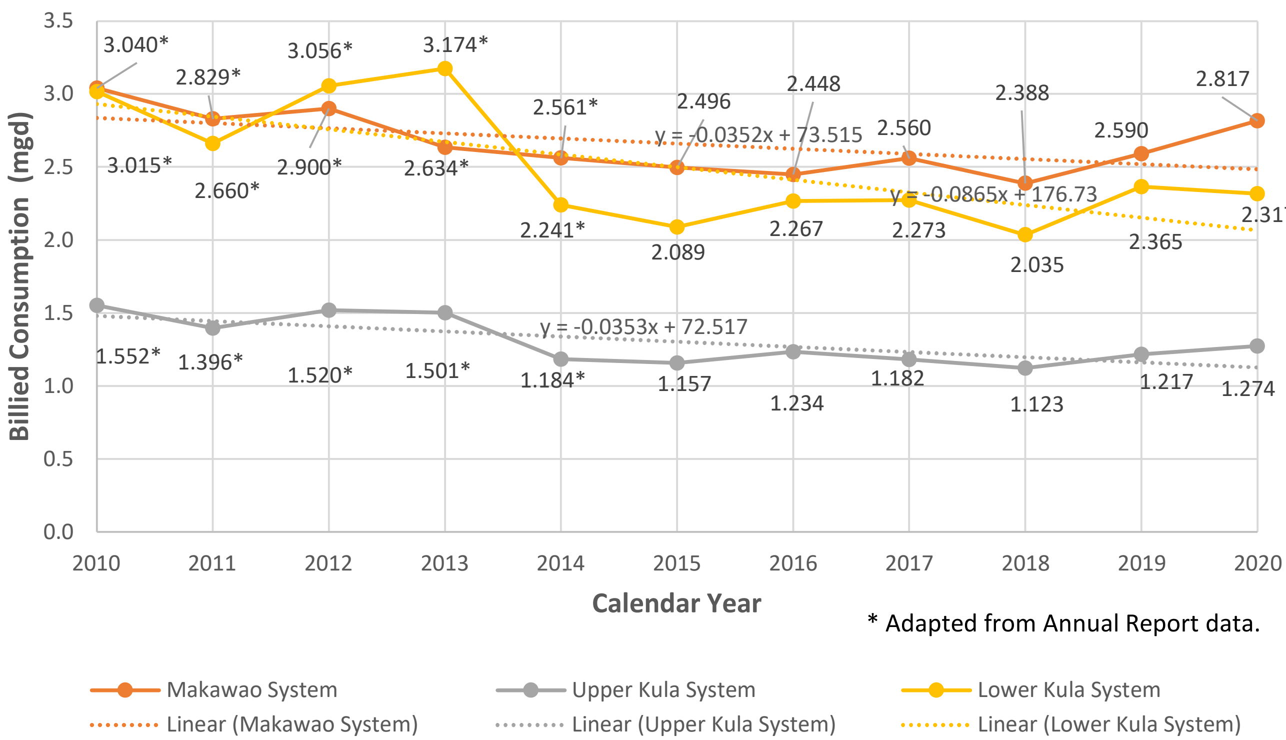


Figure 12. Upcountry District - Billed Consumption by System, 2010 through 2020

Brown AND Caldwell

2.3 Population Trends and Consumption Correlation

This section reviews recent historical trends in population change on the Island of Maui, compares actual population change with projections made in the 2014 Socio-Economic Forecast Report (County of Maui, Planning Department), and provides a discussion of the correlation between population and consumption.

2.3.1 Population Growth Projections Used in the WUDP

The 2019 WUDP used population projections set forth in the 2014 Socio-Economic Forecast Report, published by the County of Maui Department of Planning. The projections that were used focused on resident population and did not include the transient population associated with visitors and tourism. (*De Facto* population, which includes both residents and the added visitor/tourism component, is discussed in Section 2.3.3.3.).

Table 6 is a reproduction of a summary table from the Socio-Economic Forecast Report, referenced in the WUDP as Table 9-7, detailing historical and anticipated future resident population by Community Plan Area.

2020 census Data: Kihei Makena pop = 27, 646

Table 6. Population Projections by Community Plan Area

Forecast Variables	Historical			Projected				
Resident Population by Region	1990	2000	2010	2015	2020	2025	2030	2035
West Maui	14,574	17,967	22,156	24,373	27,762	32,318	36,110	39,911
Kihei-Makena	15,374	22,870	27,244	29,599	34,757	39,975	46,370	52,044
Wailuku-Kahului	32,807	41,503	54,433	60,336	62,102	64,188	65,734	67,986
Makawao-Pukalani-Kula	18,923	21,571	25,198	26,551	28,438	28,949	29,482	29,852
Paia-Haiku	7,788	11,866	13,122	13,820	13,949	14,045	14,139	14,153
Hana	1,895	1,867	2,291	2,408	2,531	2,660	2,795	2,938
Total	91,361	117,644	144,444	157,087	169,540	182,135	194,630	206,884

Source: Socio-Economic Forecast Report (Country of Maui Department of Planning, 2014)

2020 Census data- S. Maui pop of

Focusing only on the population change projected between 2010 through 2020, the relative increase predicted during that period, for each system, is summarized in Table 7.

Table 7. Predicted Relative Population Change by Community Plan Area, 2010 to 2020, Socio-Economic Forecast 2014

Community Plan Area	Historical Resident Population, 2010	Predicted Resident Population, 2020	Predicted Relative Change (Percent)
West Maui	22,156	27,762	+ 25.5%
Kihei-Makena	27,244	34,757	+ 27.5%
Wailuku-Kahului	54,433	62,102	+ 14.1%
Makawao-Pukalani-Kula	25,198	28,438	+ 12.9%
Paia-Haiku	13,122	13,949	+ 6.3%
Hāna	2,291	2,531	+10.4%
Total	144,444	169,540	+ 17.3%

Source: Socio-Economic Forecast Report (Country of Maui Department of Planning, 2014)

2.3.2 Comparison of WUDP Projections to 2020 Census Data

A comparison was made to see how the predicted change in resident population included in the 2014 Socio-Economic Forecast Report corresponds to the actual change observed between 2010 through 2020, according to the 2020 Decennial Census.

Figure 13 illustrates the rate of resident population increase based upon reported 2010 and 2020 Decennial US Census data summarized by US Census tract for Maui Island. The Community Plan area boundaries are also displayed.

To compare the observed population change, per census data, against the projected population and demand change projected in the WUDP, the US Census tract-level data was overlaid with the MDWS Central and Upcountry water system boundaries, and the population tied to each system was approximated (by utilizing a geographic information system [GIS] database). Resulting per-system populations for 2010 and 2020 are summarized in Table 8, with the relative population change illustrated in Figure 14.

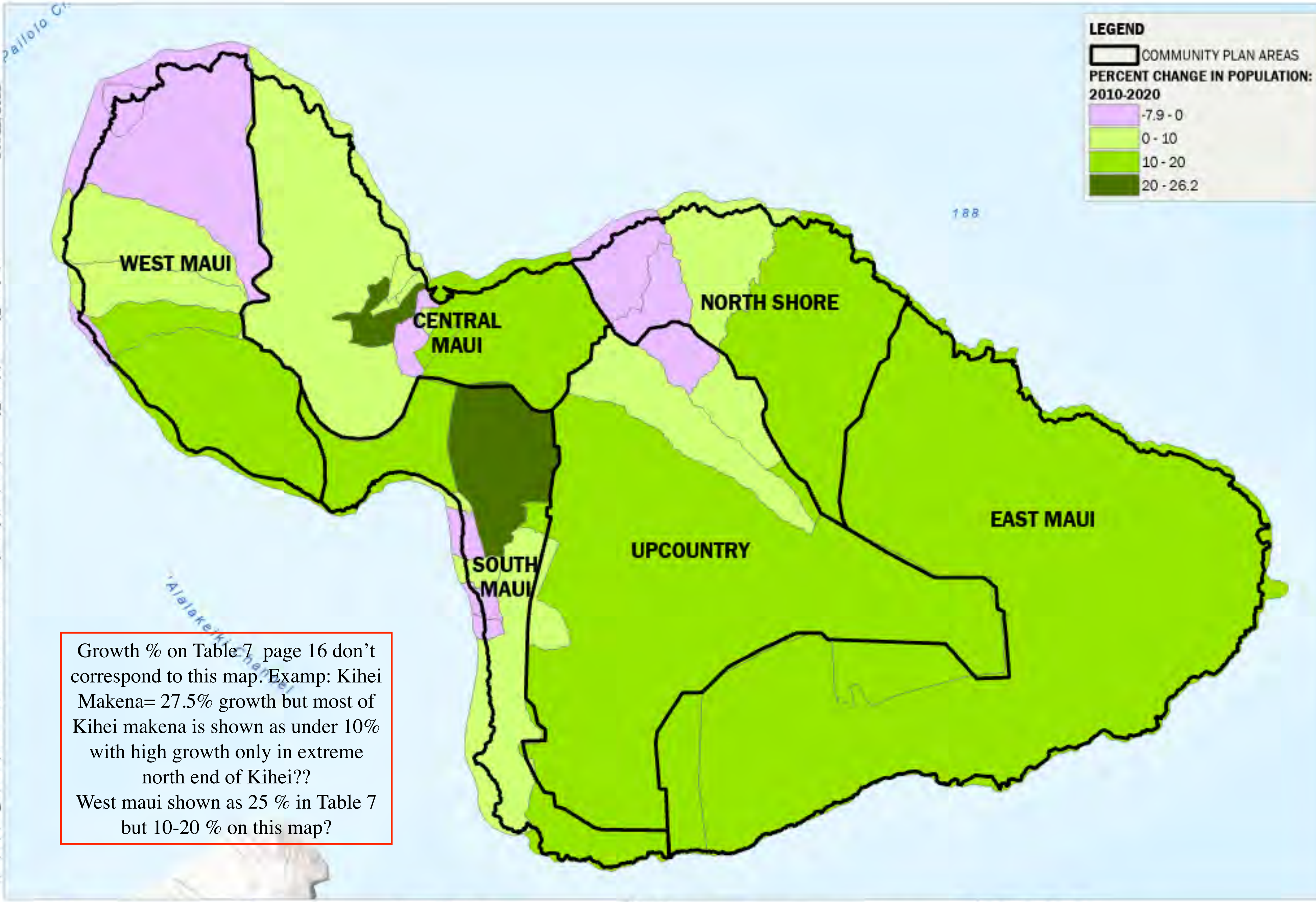
Table 8. Observed Population Change, 2010 to 2020, by System, US Census Bureau

Water System	Resident Population 2010	Resident Population, 2020	Relative Change	Avg. Annual Change
Central	82,620	88,021	6.5%	0.65%/year
Combined Upcountry Systems	32,259	34,175	5.7%	0.57%/year
Makawao	23,346	24,117	3.3%	0.33%/year
Upper Kula	5,077	5,668	11.6%	0.12%/year
Lower Kula	3,836	4,390	14.4%	0.14%/year

Source: U.S. Census Bureau, 2010 and 2020 Decennial Censuses and MDWS Water System Service Area Boundaries

The WUDP anticipated that the annual average resident population and demand increase for the period between 2015 and 2020 would be approximately 2.29 percent/year for the Central System and 1.2 percent/year for the combined Upcountry systems.

These values were extrapolated from WUDP Table 15.23 and were based on the Socio-Economic Forecast Report population projections applied to the water system areas. When compared against the observed actual annual population change, application of the Socio-Economic Forecast projections in this way resulted in an over-estimation of the average annual population change by 1.64 percent/year and 0.65 percent/year for the Central and combined Upcountry systems, respectively.



Growth % on Table 7 page 16 don't correspond to this map. Examp: Kihei Makena= 27.5% growth but most of Kihei makena is shown as under 10% with high growth only in extreme north end of Kihei??
West maui shown as 25 % in Table 7 but 10-20 % on this map?

Brown AND Caldwell

COUNTY OF MAUI

FEASIBILITY STUDY

DATE: DECEMBER 2022
PROJECT: 159082

Sources:
U.S. Census Bureau, Census 2010 & 2020 for County of Maui
Basemap: ESRI & Affiliates

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Miles
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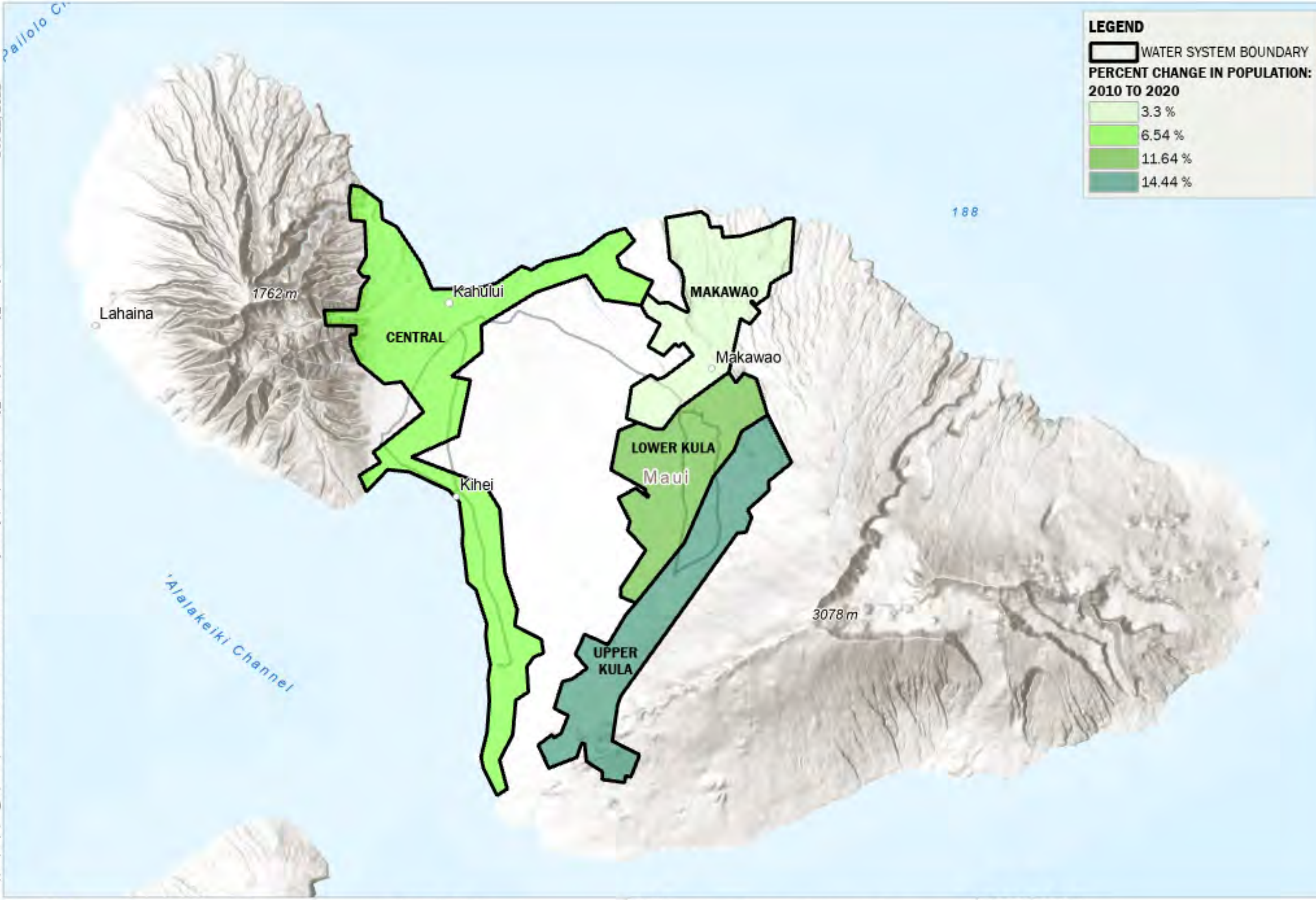
FIGURE 13

OBSERVED POPULATION CHANGE BY CENSUS TRACT (2010 TO 2020)



Brown AND Caldwell

COUNTY OF MAUI

FEASIBILITY STUDY

DATE: DECEMBER 2022
PROJECT: 159082

Sources:
U.S. Census Bureau, Census 2010 & 2020 for County of Maui
Basemap: ESRI & Affiliates

FIGURE 14

OBSERVED POPULATION CHANGE BY SYSTEM BOUNDARY, 2010 TO 2020, US CENSUS BUREAU

2.3.3 Observed Population and Consumption Trends Over Time

2.3.3.1 Per Capita Consumption

Table 9 and Figure 15 summarize the trend in per capita billed consumption over time, at a district level. In this analysis, the resident population between 2010 and 2020 was approximated by linear interpolation. The Central visitor population was estimated by assuming visitor days associated with the Central district are directly proportional to Central resident population (52-53% of total Maui County visitor days). *De facto* population is the sum of resident population and equivalent visitor population. *De facto* population was not estimated for the Upcountry district.

Overall, the per-capita consumption of water is trending downward, likely due to conservation and leak detection efforts.

Table 9. Average Per Capita Billed Consumption by District

Parameter	Calendar Year										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Central District											
Resident Population (persons) [a]	82,620	83,160	83,700	84,240	84,780	85,321	85,861	86,401	86,941	87,481	88,021
Total Consumption (mgd) [a]	21.049	20.266	20.914	22.130	20.060	19.842	20.588	20.677	20.073	21.508	20.448
Resident Per Capita Consumption (gal/cap-day)	255	244	250	263	237	233	240	239	231	246	232
De facto Population (est) [b]	107,893	109,375	111,371	112,605	113,880	115,607	117,047	118,615	121,198	122,897	99,378
De Facto Per Capita Consumption (gal/cap-day)	195	185	188	197	176	172	176	174	166	175	206
Upcountry District											
Resident Population (persons)	32,259	32,451	32,642	32,834	33,025	33,217	33,409	33,600	33,792	33,983	34,175
Total Consumption (mgd)	7.608	6.886	7.476	7.309	5.986	5.742	5.949	6.015	5.546	6.172	6.408
Per Capita Consumption (gal/cap-day)	236	212	229	223	182	173	178	179	164	182	188

Notes:

a. *Source: Population: US Census Bureau, 2010/2020, Billed Consumption: MDWS Billed Consumption, 2015 to 2020.*

b. *Central visitor population estimated by assuming visitor days are directly proportional to Central resident population (52-53% of total Maui County visitor days). De facto population is the sum of resident population and equivalent visitor population.*

County bills by meters, not population numbers. Consumption varies widely by meter by area of central Maui. Use is usually shown by "household" in county reports. Need to check out this section

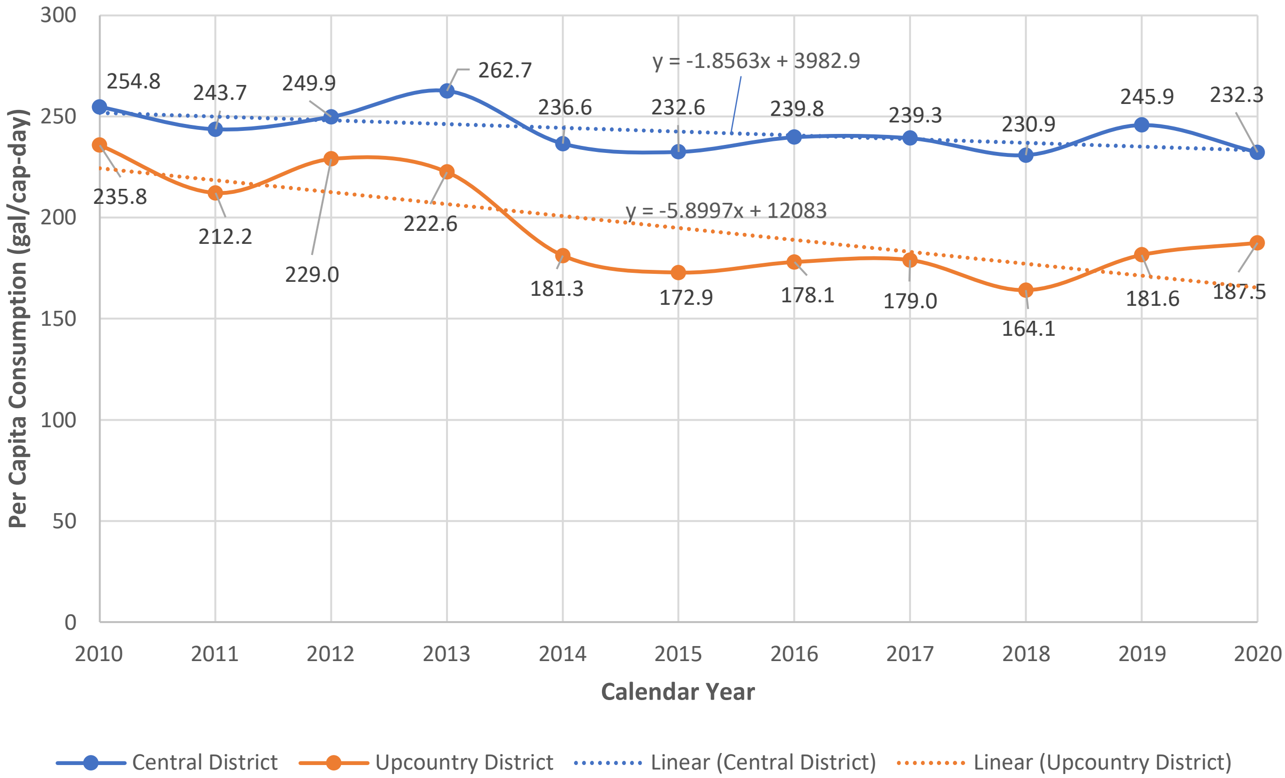


Figure 15. Per Capita Consumption Over Time, by District

2.3.3.2 Population and Consumption Correlation

Figure 16 shows the system-level resident population plotted with the observed system-level billed consumption for each of the Central, Makawao, Upper Kula, and Lower Kula systems. The period from 2010 through 2014 is also included, adapted from MDWS Annual Report data as discussed in Section 2.2.3, to represent the trend over the full ten-year period for direct comparison against the 2010 to 2020 census data.

Between 2010 and 2020, resident population for each of the Central and Upcountry systems has increased while the trendline in average annual consumption has either remained unchanged or decreased. Therefore, the assumption of a direct, linear relationship between resident population and demand is not strongly supported.

While the trend may hold for certain isolated periods, population does not appear to be a reliable sole predictor of demand over the observed timeframe, due to the variability of demand and decreasing per-capita consumption. Decreasing per-capita consumption is in part due to the success of the MDWS water conservation program, In the 2019 WUDP, conservation is considered as a supply option rather than being accounted for in demand projections. While a detailed investigation of conservation trends, triggers, and efforts is beyond the scope of the EMFS, population and consumption may better correlate if conservation trends are analyzed.

Does the text clarify that the census derived population may include people whose water needs are met by private water systems ? Or systems that are being developed privately, but later turned over to the county? Example: Ka'anapali and Kapalua- west Maui.
Does it qualify that considerable future growth will be met the same way? EXAMP: Waikapu Town

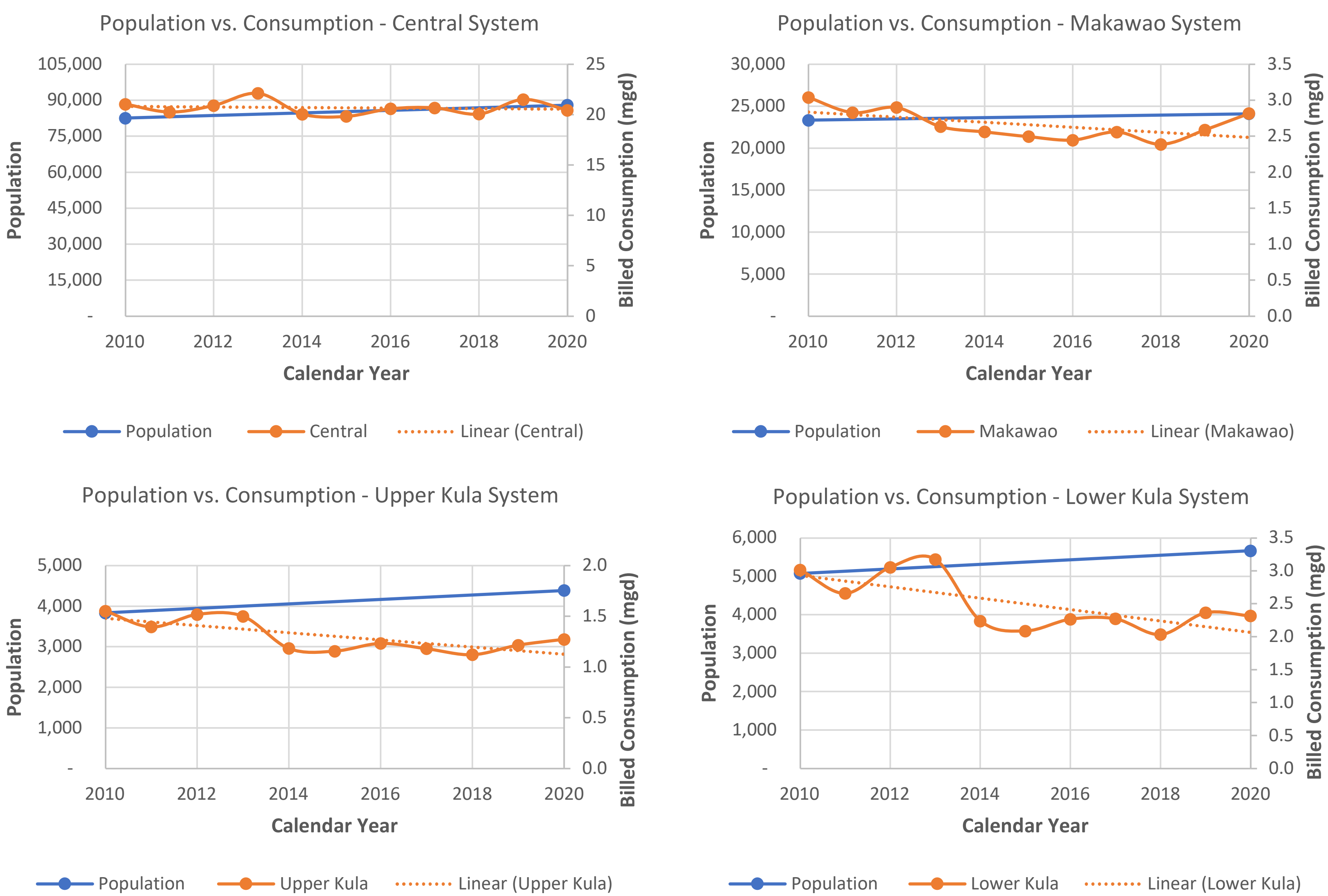


Figure 16. Population vs. Demand Comparison by System, including 2010

Source: MDWS Annual Report (adapted from data for years 2010 through 2014)

2.3.3.3 *De Facto* Population

As illustrated in Figure 17, the total visitor days (visitor arrivals multiplied by the length of stay) of those arriving by air to Maui County increased between 1990 and 2019. Subsequently, an unprecedented decrease in visitors resulted from travel restrictions implemented by the State of Hawaii during the COVID-19 pandemic in 2020 and 2021. The blue line, correlated to the left vertical axis, indicates the visitor day data.

The resident population is shown in grey in Figure 17, and the equivalent visitor population, derived from visitor days, in orange. *De facto* population reflects the total of the resident and visitor populations and is indicated by the yellow line correlated to the right vertical axis. While the overall resident population increased by 6.2 percent in Maui County between 2010 and 2020 (United States Census Bureau, 2021), the corresponding visitor numbers increased by nearly 40 percent island-wide between 2010 and 2019.

Similar to the discussion of the correlation between Census data population and water use presented in Section 2.3.3.2, Variability in consumption patterns, conservation, global events, and resident and visitor growth patterns over time indicate that a simple, linear relationship between the *de facto* population and demand is not strongly supported.

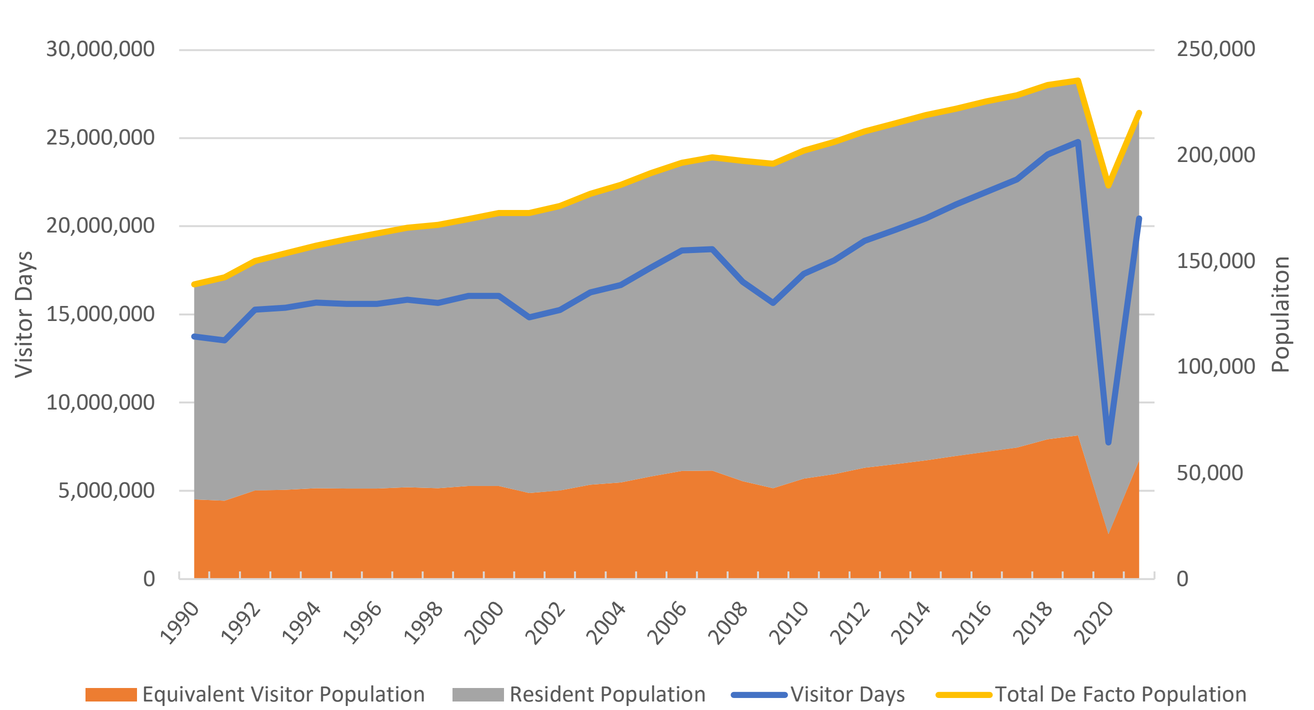


Figure 17. Maui County Visitor Days and Population 1990-2021

Source: Hawaii Tourism Authority, 2022 and US Census Bureau, 2022

2.3.4 Discussion

The results of this analysis indicate that resident population alone is not the most effective predictor of water consumption on Maui for two primary reasons:

1. Over the last ten years, resident population is not sufficiently correlated with changes to billed consumption as to be predictive on its own.
2. Estimated projections in resident population change established in the 2014 Socio-Economic Forecast report overestimate the annual average rate of population change when adapted to a water-system-level

projection, between 2015 and 2020. While resident population may hold some validity in predicting consumption trends, it is still necessary to have population projections that are sufficiently accurate to meaningfully benefit from that correlation, and to take into account decreasing per-capita consumption trends.

Additional factors further complicate water use projections on Maui, including:

- Increases in the number of visitor-days and the types of visitor accommodations
- Properties that remain unoccupied for a significant portion of the year
- Transient vacation rentals
- Climate-related variables, unrelated to population such as precipitation and drought conditions, also affect seasonal and year-to-year demand.

Even so, a population-based projection approach remains a useful single-variable methodology when population information is current and accurate. For this reason, the demand projection methodologies presented in Section 3 of this TM include both an updated population-based methodology and an empirical projection methodology utilizing historical billing and production data.

2.4 Existing Production Data and Analysis

This section evaluates the recent historical water production for the 2015 through 2020 timeframe, for both surface and ground water sources, and compares the observed production against the observed demand from Section 2.2.

2.4.1 Production Analysis

BC performed an analysis of production data for the Central and Upcountry District systems for 2015 through 2020. The analysis was completed at a district level, largely due to the interconnectedness of the three Upcountry District systems (i.e., Makawao, Upper Kula, and Lower Kula). Both surface and ground water sources were included in the analysis.

Tables 10 and 11 summarize each of the sources included in the Central and Upcountry District analyses, as well as the recorded annual production associated with each source.

Table 10. Central District Water Sources and Production, 2015 - 2020						
Source Name	Annual Source Production (mgd) by Calendar Year					
	2015	2016	2017	2018	2019	2020
Surface Water Treatment Facilities						
Iao WTF	0.877	0.526	0.439	0.336	1.480	2.413
Ground Water / Wells						
Iao Tank	0.367	1.013	0.939	0.725	1.260	0.515
Iao Tunnel	1.501	1.109	1.035	1.556	1.597	1.608
Kanoa 1	0.910	0.928	1.062	0.594	0.713	0.871
Kanoa 2	0.860	0.628	1.475	0.667	0.738	0.791
Kepaniwai	0.723	0.720	0.718	0.717	0.716	0.722
Kupaa	1.009	1.031	1.292	1.169	1.406	1.512
Maui Lani 5	0.137	0.189	0.190	0.191	0.143	0.066
Maui Lani 6	0.363	0.373	0.366	0.367	0.401	0.264
Maui Lani 7	0.523	0.538	0.533	0.540	0.524	0.492
Mokuhau 1	0.024	1.248	1.604	0.733	0.284	0.374
Mokuhau 3	2.241	1.999	2.682	2.280	2.608	2.605
North Waihee 1	0.921	1.181	0.987	0.755	0.442	0.260
North Waihee 2	0.664	0.869	0.684	0.823	0.819	0.488
Waiehu Heights 1	-	-	-	-	-	-
Waiehu Heights 2	0.968	1.002	1.098	1.091	1.211	1.241
Waihee 1	1.020	2.587	3.118	1.924	2.235	2.205
Waihee 2	0.905	1.559	1.007	1.619	1.835	1.096
Waihee 3	2.815	1.021	1.499	3.151	3.670	3.703
Waikapu	0.654	1.082	1.069	1.061	0.294	1.041
Wailuku 1	-	0.625	0.865	1.044	0.751	1.088
Wailuku 2	-	0.025	1.134	2.135	2.153	0.677
Wailuku Shaft 33	4.830	2.928	-	-	-	-
Total	**22.314**	**23.182**	**23.795**	**23.474**	**25.279**	**24.033**

Source: MDWS Monthly Source Reports and WTP Production Data, 2015 - 2020

Major increase in supply is from Iao Surface water (1.5 mgd increase) and waihee 1 well=+ 1 mgd and Waihee 3 well=+ .9 mgd

Table 11. Upcountry District Water Sources and Production, 2015 - 2020						
Source Name	Annual Source Production (mgd) by Calendar Year					
	2015	2016	2017	2018	2019	2020
Surface Water Treatment Facilities						
Kamole WTF	0.99	1.11	1.31	1.04	2.24	2.17
Olinda WTF	1.00	1.36	1.37	1.14	1.14	1.13
Piiholo WTF	3.50	3.40	3.16	3.41	2.77	2.90
Ground Water / Wells						
H' Poko #1	0.001	0.000	0.014	0.005	0.002	0.001
H' Poko #2	0.002	0.001	0.014	0.006	0.001	0.001
Haiku	0.277	0.211	0.242	0.214	0.293	0.322
Kaupakalua	0.599	0.545	0.529	0.520	0.559	0.605
Pookela	0.039	0.067	0.271	0.004	0.191	0.426
Total	**6.411**	**6.689**	**6.917**	**6.335**	**7.191**	**7.550**

Source: MDWS Monthly Source Reports and WTP Production Data, 2015 - 2020

Table 12 summarizes these same production amounts by source type in units of mgd, for both districts. Figure 18 presents this data in chart format and illustrates a gradually increasing trend in production for both districts between 2015 and 2020.

Table 12. Observed Annual Average Daily Production by District, 2015 – 2020 (mgd)						
MDWS District	2015	2016	2017	2018	2019	2020
Central	**22.314**	**23.182**	**23.795**	**23.474**	**25.279**	**24.033**
Surface Water	0.877	0.526	0.439	0.336	1.480	2.413
Ground Water	21.436	22.656	23.356	23.138	23.800	21.620
Upcountry	**6.411**	**6.689**	**6.917**	**6.335**	**7.191**	**7.550**
Surface Water	5.494	5.865	5.847	5.587	6.146	6.194
Ground Water	0.917	0.825	1.071	0.748	1.045	1.355

Source: MDWS Monthly Source Reports and WTP Production Data, 2015 - 2020

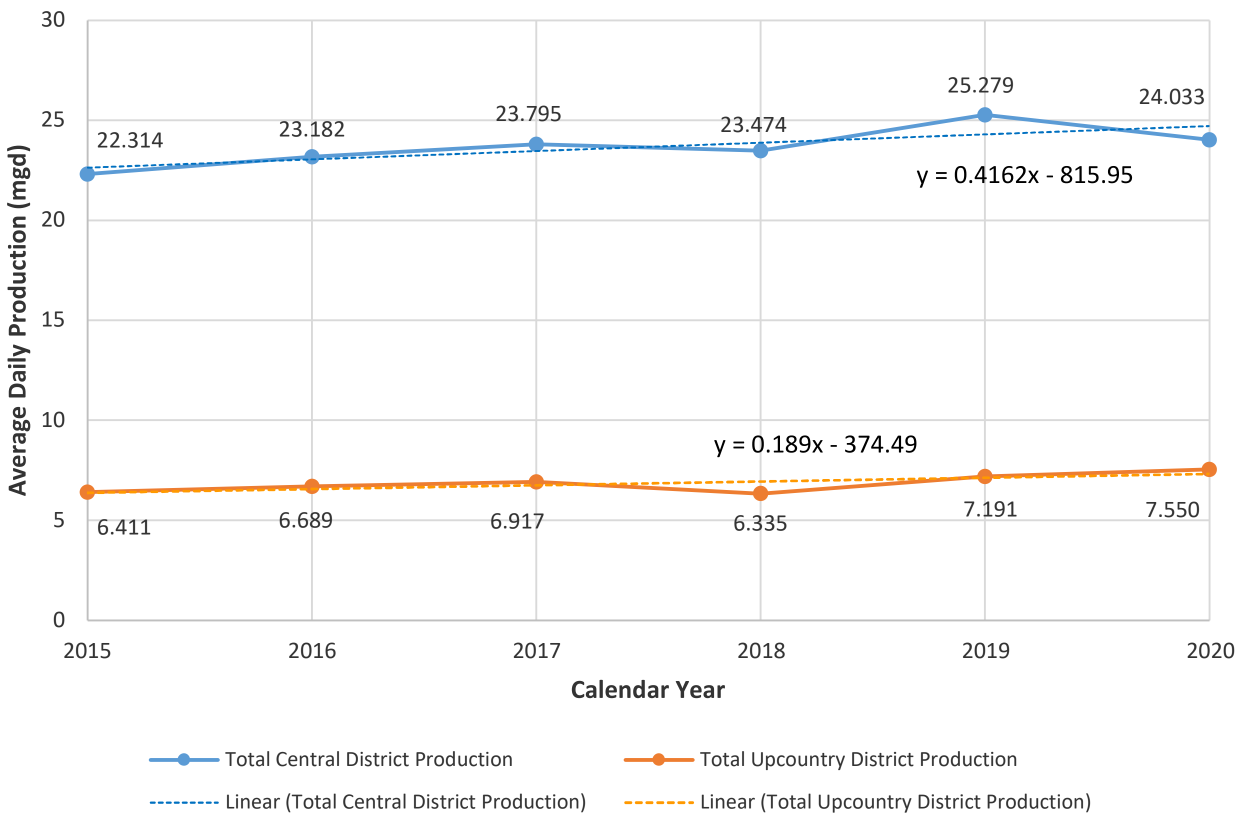


Figure 18. Annual Average Daily Production Over Time, by Water District (mgd)

2.4.2 Comparison of Billed Consumption and Production

The analyzed billed consumption and production data for the Central and Upcountry districts from 2015 through 2020, is compared in Table 13, while Figures 19 and 20 illustrate that same consumption and production comparison in chart format.

Table 13. Comparison of Annual Average Daily Production vs. Billed Consumption by District, 2015 – 2020 (mgd)

MDWS District	2015	2016	2017	2018	2019	2020
Central						
Production	22.314	23.182	23.795	23.474	25.279	24.033
Billed Consumption	19.842	20.588	20.677	20.073	21.508	20.448
Difference	2.472	2.594	3.118	3.401	3.771	3.585
Percent Difference	12.5%	12.6	15.1%	16.9%	17.5%	17.5%
Upcountry						
Production	6.411	6.689	6.917	6.335	7.191	7.550
Billed Consumption	5.742	5.949	6.015	5.546	6.172	6.408
Difference	0.669	0.740	0.903	0.789	1.019	1.141
Percent Difference	11.6%	12.4%	15.0%	14.2%	16.5%	17.8%

Source: MDWS Billing Data, 2015 – 2020, and MDWS Monthly Source Reports and WTP Production Data, 2015 - 2020

Where does this 3.5 mgd go?

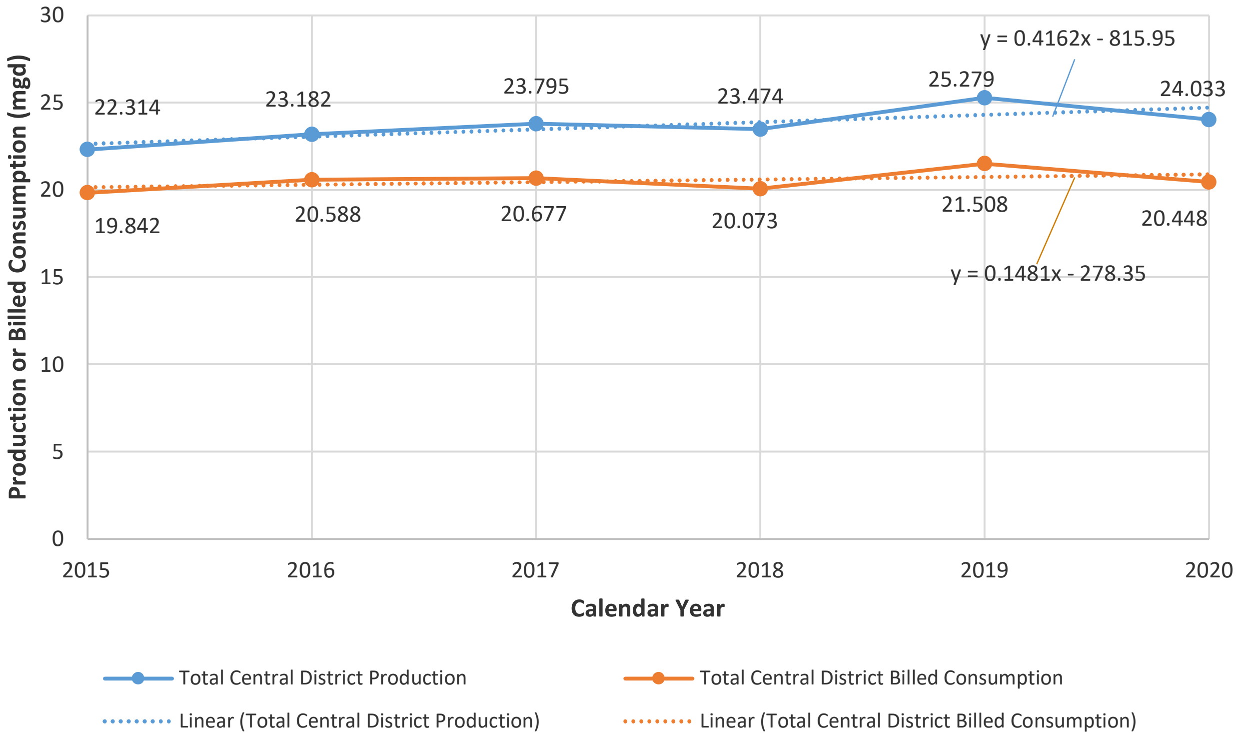


Figure 19. Central District – Total Production vs. Total Billed Consumption

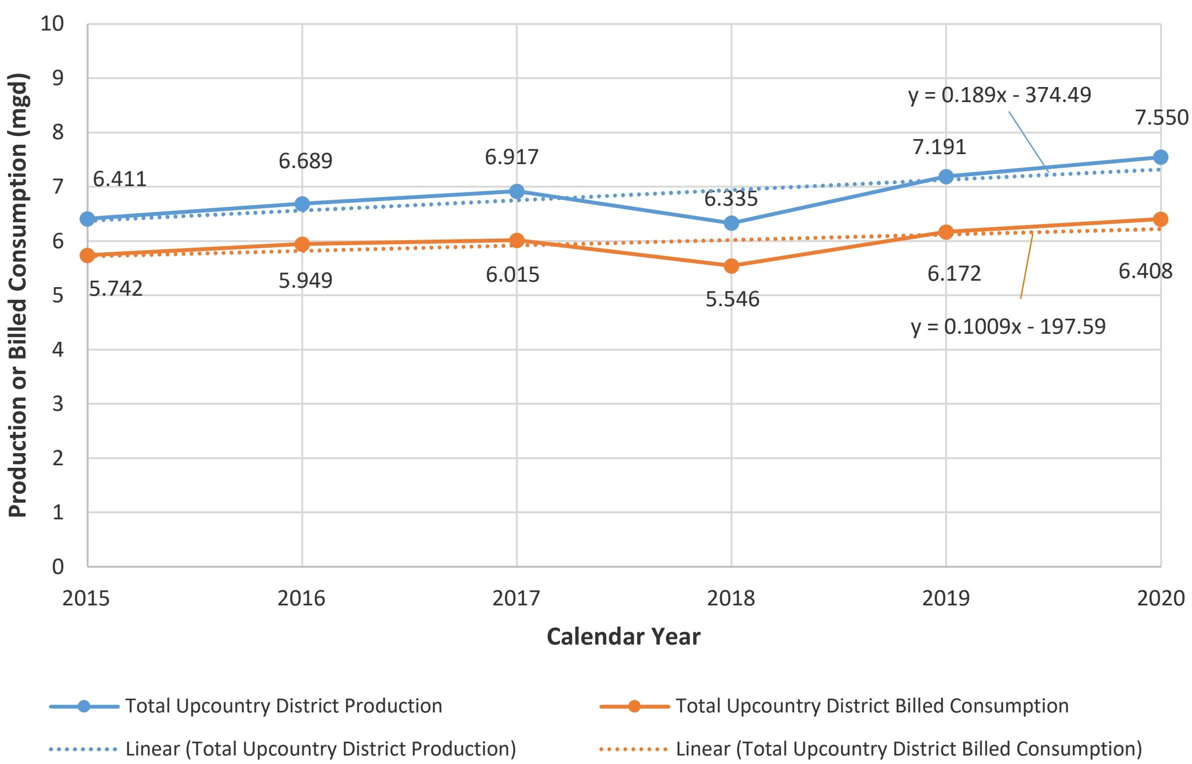


Figure 20. Upcountry District – Total Production vs. Total Billed Consumption

The difference between the observed billing and production data indicates system losses. From a production standpoint, system losses (while normal and expected) will result in the quantity of water produced always exceeding the quantity consumed, to ensure adequate water supplies are available to reach end-user customers.

While the observed production data illustrates a trend that is in alignment with the billing data, the production-versus-demand variance appears to be increasing over time. An 11.6 to 12.5 percent difference in 2015 has increased to approximately 17.5 to 17.8 percent for both districts in 2020, suggesting that the amount of non-revenue water is increasing.

This may indicate deteriorating infrastructure conditions, a change in production or metering measurement accuracy, or additional operational adjustments resulting in an increase in non-revenue consumption.

Section 3: Water Use Demand Projections

This section reviews the water use demand projection methodology utilized in the 2019 WUDP and compares the WUDP projections through 2020 against actual 2020 demand values. Subsequently, three alternative methodologies for projecting future production needs through 2040 are presented, including:

1. An updated and extended population-based approach, like that used in the WUDP.
2. An alternative empirically based approach utilizing trends in historical data.
3. An approach specific to processing of the Upcountry Meter Priority list (Priority List).

Lastly, this section concludes with an overall projection recommendation.

3.1 Existing 2019 WUDP Projections

This section reviews the methodology and results of the production-focused water use demand projections presented in the 2019 WUDP and compares the projected 2020 production demand with observed 2020 production values.

3.1.1 WUDP Methodology and Existing Projections through 2035

In the 2019 WUDP, MDWS estimated future production-focused water demand using two different approaches:

1. **By population -** As outlined in Section 2.3, assuming that the rate of increase in water demand will be directly correlated to the rate of increase in resident population over time.
2. **By ultimate land-use build out.**

However, discussion in this TM will focus solely on the population-based projection approach.

The WUDP evaluates the sources and demand for water on Maui at the aquifer sector level. The two public potable water systems that are the focus of this TM, the Central District and Upcountry District systems, do not precisely fit within the bounds of a single aquifer sector area (ASEA), as defined by the State of Hawaii Commission on Water Resource Management (CWRM).

The Central District system extends through both the Wailuku and Central ASEAs is therefore discussed in both related WUDP chapters (Chapters 14 and 15), while the Upcountry District system lies predominantly within the Central ASEA and is discussed in WUDP Chapter 15.

Central District System

The MDWS Central District is shown in Figure 21. For water use projection purposes, the WUDP uses production data from the 2014 calendar year, and projects forward, assuming water use will increase in a manner directly proportional to the population increase. The population projection data was obtained from the 2014 draft update of the Socio-Economic Forecast by the County of Maui Planning Department.

As described in Section 2.3.1, the Socio-Economic Forecast provides population projections for the major community planning areas on Maui. The WUDP then applied these projections to the Central System, proportionate to the level of water demand originating within that community planning area. For example, in 2014 the Central System served approximately 68,976 persons (per WUDP Table 15-6), of which approximately 41 and 59 percent of water use originated in the Wailuku-Kahului and Kihei-Makena Community Plan districts, respectively.

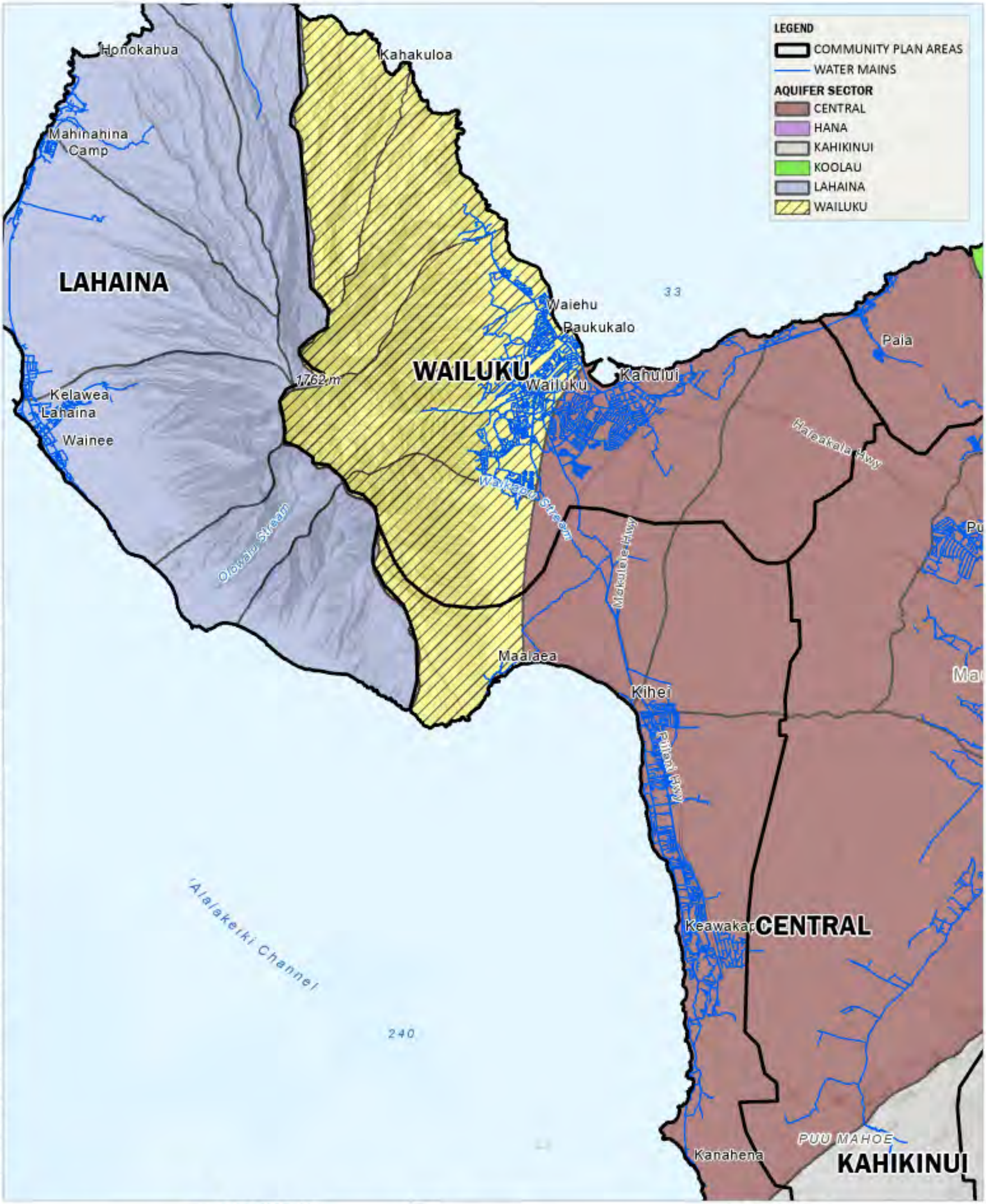


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FIGURE 21

MDWS CENTRAL SYSTEM AND THE WAILUKU AND CENTRAL ASEAS

The total population served was broken out into component parts associated with each major Community Plan District. Subsequently, the component populations were assumed to increase in a manner consistent with the Socio-Economic Forecast projections for each respective Community Plan District, through 2035. The component population projections were then totaled to determine the overall increase in population served by the Central District system and overall percentage increase in system-level population served, from one time interval to the next.

This “weighted” percentage increase in population served was then used to project the water demand forward, from 2014 through 2035. Table 14 summarizes the calculation for percentage increase in population served and the associated projected production-focused water use. The information summarized in Table 14 was compiled from WUDP Tables 14-28, 14-40, and 15-6.

Table 14. WUDP Production-Focused Water Use Projections, Central District

Parameter	2014	2015	2020	2025	2030	2035
Total Population Served (Persons)	68,976	70,293	78,353	86,650	96,335	105,350
Increase, Central District Overall (Percent)	–	1.91%	11.45%	10.58%	11.17%	9.35%
Wailuku-Kahului Fraction (41 percent in 2014) (Persons)	28,280	28,894	29,739	30,738	31,479	32,557
Increase, W-K Fraction (Percent)	–	2.17%	2.93%	3.36%	2.41%	3.43%
Kihei-Makena Fraction (59 percent in 2014) (Persons)	40,696	41,399	48,614	55,912	64,857	72,793
Increase, K-M Fraction (Percent)	–	1.73%	17.42%	15.01%	15.99%	12.24%
Water Use, Central District (Production-focused)[a] (mgd)	22.274	22.699	25.421	28.100	31.224	34.134

Note:

a. 2014 water use values are based on actual MDWS production data. Water use values for years 2015 through 2035 are estimated.

Upcountry District Systems

The combined MDWS Upcountry District systems are shown in Figure 22; they are primarily located within the Central ASEA, with some portion extending into the Koolau ASEA, near Haiku. The projection methodology used for the Upcountry District systems was the same as that described for the Central System, above.

In 2014, the three Upcountry systems served approximately 38,932 persons in total (per WUDP Table 15-6). Though the WUDP did not detail the exact percentages of existing demand originating within each related Community Plan District, as was done for the Central System, analysis of the data indicates that approximately 83 percent of the Upcountry Systems’ use originated in the Makawao-Pukalani-Kula Community Plan District, while approximately 17 percent originated in the Paia-Haiku Community Plan District.

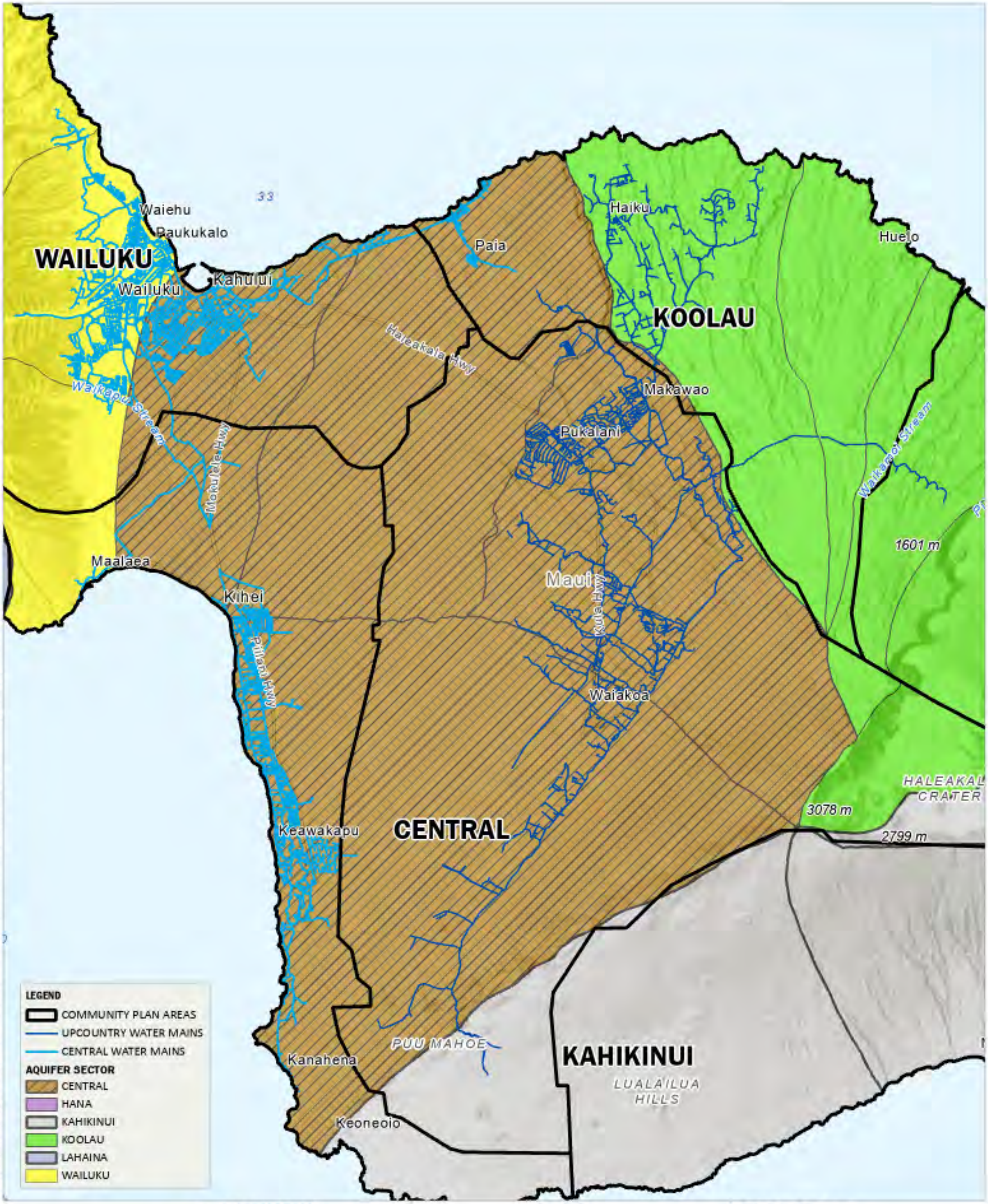

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FIGURE 22

UPCOUNTRY SYSTEM AND THE CENTRAL AND KOOLAU ASEAS

Table 15 summarizes the percentage increase in population served and the associated projected production-focused water use. The information in Table 15 was compiled from WUDP Tables 15-6, 15-23, and 15-38.

Notably, the population-based projection method does not account for the additional outstanding demand associated with processing of the Priority List.

- The 2019 WUDP estimated that the outstanding production-focused demand associated with processing the Priority List was, at that time, approximately 7.3 mgd.
- In addition, historically, the application approval rate was on the order of 50 percent. Thus, the amount of outstanding demand that would likely actually result in a service connection and need provision is on the order of approximately 3.6 mgd.

The provision for demand associated with the Priority List is also reflected in Table 15 as an additional final row.

- The demand component associated with processing the Priority List is assumed to increase at a rate corresponding to a MDWS application processing rate of 80 applications per year, such that all outstanding Priority List applications are processed by 2040.
- It is also assumed that approximately 50 percent of processed applications result in an actual service connection, which is consistent with historical application processing outcomes.

The Priority List and related considerations will be discussed in greater detail in Section 3.3.

Table 15. WUDP Production-Focused Water Use Projection, Upcountry District

Parameter	2014	2015	2020	2025	2030	2035
Total Population Served (Persons)	38,932	39,349	41,730	42,405	43,105	43,567
Increase, Upcountry District Overall (Percent)	–	1.07%	6.05%	1.62%	1.65%	1.07%
Makawao-Pukalani-Kula Fraction (~83 percent in 2014) (Persons)	32,271	32,617	34,936	35,563	36,218	36,673
Increase, M-P-K Fraction (Percent)	–	1.07%	7.11%	1.80%	1.84%	1.26%
Paia-Haiku Fraction (~17 percent in 2014) (Persons)	6,661	6,732	6,795	6,842	6,887	6,894
Increase, P-H Fraction (Percent)	–	1.06%	0.93%	0.69%	0.67%	0.10%
Water Use, Upcountry District, excluding Priority List (Production-focused)[a] (mgd)	7.610	7.693	8.155	8.292	8.432	8.530
Water Use, Priority List (Production-focused) (mgd) (Production-focused)	3.6 to 7.3[b]					
Total Water Use– MDWS Upcountry District Potable plus Priority List (Production-focused) (mgd)	7.610[c]	7.693[c]	9.055[c]	10.092[c]	11.132[c]	12.130[c]

Notes:

a. *2014 water use values are based on actual MDWS production data. Water use values for 2015 through 2035 are estimated.*

b. *The range of outstanding demand shown for the Priority List corresponds to a 50- to 100-percent application approval rate. Historically, actual approval rates are closer to the 50-percent figure.*

c. *The 50-percent application approval rate was assumed and applied to the Priority List component when performing this summation, as interviews with MDWS Planning and Engineering Division chiefs indicate that this historical trend is likely to continue. The full 3.6 mgd production demand associated with the Priority List is assumed to manifest linearly over time, such that full resolution will be achieved in 2040; consistent with an application processing rate of 80 applications per year.*

3.1.2 Comparison of WUDP Projections to Observed Demand through 2020

In comparing the 2019 WUDP production-focused water demand projections (Tables 14 and 15) against observed production data (Tables 10 and 11), the differences in the projected and actual production values for years 2015 and 2020 can be determined.

Table 16 summarizes this data comparison. The 2015 projected demand exceeded observed demand by 1.7 percent and 20.0 percent for the Central and Upcountry Districts, respectively. In 2020, the Central District observed data is approximately 1.388 mgd (5.8 percent) below the projected value, while the Upcountry District observed data is approximately 0.605 mgd (8.2 percent) below the projected value.

Table 16. Projected vs. Observed Production Demand – 2015 and 2020 (mgd)

MDWS District	2015			2020		
	Projected	Observed	Difference	Projected	Observed	Difference
Central	22.699[a]	22.314[c]	-0.385	25.421[a]	24.033[c]	-1.388
Upcountry	7.693[b]	6.411[c]	-1.282	8.155[b]	7.550[c]	-0.605

Sources:

a. *2019 WUDP, Table 14-40*

b. *2019 WUDP, Table 15-38*

c. *MDWS Production Data, 2015 to 2020*

Note, that the projected values listed in Table 16 for the Upcountry District exclude demand associated with the Priority List. Some of the increase in observed Upcountry demand from 2015 to 2020 may have been a result of processing the Priority List – meaning the projected 2020 Upcountry demand was more of an overestimation than indicated in Table 16.

3.1.2.1 Discussion

The production-focused water use demand values projected in the WUDP, from 2014 through 2020, was overestimated, in comparison to the observed actual production values. Multiple factors could contribute to this, which include (but are not limited to):

- **Limited Predictive Power of Population –** As discussed in Section 2.3, population has not been shown to be a strong single-variable predictor of billed water consumption for Maui nor, by extension, the associated production demand. This is likely due to the high degree of year-to-year demand variability having more impact than population when evaluated over short time intervals.
- **Overestimated Population Growth –** As discussed in Section 2.3, when compared to observed changes in population as measured by the U.S. Census Bureau Decennial Censuses for 2010 and 2020, the 2014 Socio-Economic Forecast Report population projections overestimated the anticipated average annual percentage increase in population, specifically in Community Plan areas that relate to the water systems being considered.
- **Tourist Populations –**The WUDP mentioned that rates of increase in visitor populations have historically been slower than rates of increase in resident populations. By basing demand projections on anticipated growth in resident population rather than the combined (or *de facto*) population, the WUDP projection methodology has been intentionally selected to be conservative with respect to tourism. While perhaps serving as a safety factor in ensuring adequate demand, this approach may also contribute toward a tendency to overestimate demand that compounds over time.

  Notably, however, this historical trend seems to have shifted in more recent years, with increases in visitor population outpacing increases in resident population for the period 2010 to 2020 (as mentioned in Section 2.3.3.3). This may mean that projections based on resident population will no longer be conservative from this point forward and may underestimate future demand.

  Impacts of the COVID-19 Pandemic – The Coronavirus Disease 2019 (COVID-19) pandemic and associated travel impacts have likely played a role in altering 2020 consumption values and, by extension, the related production demand, though the extent is difficult to quantify. A lower transient tourist population resulting from travel restrictions and atypical resident settling patterns related to the increased prevalence of work-from-home career arrangements could both be contributors. It has yet to be ascertained whether this will have a temporary or lasting impact.

3.2 Water Demand Projections to 2040

This section presents two alternative methodologies for projecting future production needs through 2040.

1. An updated and extended population-based approach, like that used in the WUDP.
2. An alternative, empirically based approach utilizing observed trends in historical data.

Provision for demand associated with the Priority List is then discussed as a separate additive component in Section 3.3. The section concludes with a discussion and summary recommendation.

3.2.1 Method A: Update and Extension of WUDP Methodology

As detailed in Section 3.1, the WUDP projection methodology, based on the assumption that changes in production-focused water use demand are linearly correlated with changes in resident population served, tends to overestimate actual production demand requirements. This is a result of:

- Resident population not being a strong sole predictor of billed consumption.
- The projected average annual percentage population increase established by the 2014 Socio-Economic Forecast Report, has thus far, overestimated population growth, as it relates to the Central and Upcountry District systems' population served.

Nonetheless, this methodology has the primary benefits of simplicity and conservatism. For this reason, an updated and extended version utilizing the same methodology was developed.

To update the WUDP projections, the observed "actual" production-focused water-use for 2020 was used as a new baseline, to calibrate the projections to current conditions. This baseline was then projected forward through 2040 using the same percentages of increase presented in the WUDP, extending an additional five-year increment to 2040.

The percentage increase between 2035 and 2040 was obtained from the 2014 draft Socio-Economic Forecast and the system-level increase was determined by a "weighted" distribution of population served by Community Plan district, in the manner described in Section 3.1.1.

3.2.1.1 Central District System

Table 17 summarizes the updated and extended production-focused water use projections for the Central District systems. The updated projection shows that, by 2035, approximately 32.3 mgd of production-side water will be required.

Table 17. WUDP Production-Focused Water Use Projection – Updated and Extended, Central District

Parameter	2020	2025	2030	2035	2040
Increase, Central District Overall (Percent)	–	10.60%	11.19%	9.37%	8.65%
MDWS Central District (mgd)	24.033[a]	26.581	29.555	32.323	35.121

Note:

a. 2020 reflects actual production.

The previous WUDP projection had predicted 34.1 mgd of production-side water use in 2035, therefore the updated projection is currently predicting that approximately 1.8 mgd less production-side water use will be required in 2035 than the previous projection.

3.2.1.2 Upcountry District Systems

Table 18 summarizes the updated and extended production-side water use projections for the Upcountry District systems. The updated projection shows that by 2035 nearly 8.0 mgd of production-side water will be required.

Table 18. WUDP Production-Focused Water Use Projection – Updated and Extended, Upcountry District

Parameter	2020	2025	2030	2035	2040
Percent Increase, Upcountry District Overall	–	1.61%	1.65%	1.06%	1.04%
MDWS Upcountry District, (mgd)[b]	7.550[a]	7.672	7.798	7.881	7.963

Notes:

a. 2020 reflects actual production.

b. Demand associated with the Upcountry Meter Priority List is not included in Table 16.

The previous WUDP projection had predicted 8.5 mgd of production-side water use in 2035, therefore the updated projection is currently predicting approximately 0.5 mgd less production-side water use requirement in 2035 than the previous projection. Note, that the updated projection in Table 18 does not include the Priority List.

Table 19 builds upon the projections from Table 18 and includes provision for demand associated with the Priority List, as well as a separate component associated with potential "pent-up" demand related to the Upcountry systems. The Priority List and additional pent-up demand components are discussed in detail in Section 3.3.

Table 19. WUDP Production-Focused Water Use Projection – Updated and Extended, Upcountry District (mgd)

Parameter	2020	2025	2030	2035	2040	2045
MDWS Upcountry District Potable, excluding Priority List	7.550[a]	7.672	7.798	7.881	7.963	8.070[b]
Priority List	3.0 to 6.0[c]					
Additional Pent-Up Demand	2.105					
Total Water Use, MDWS Upcountry District Potable + 50% Priority List + Additional Pent-Up	7.550[d]	8.422[d]	9.298[d]	10.131[d]	10.963[d]	13.175[e]

Notes:

a. 2020 reflects actual production.

b. The 2045 production demand value is not directly based on available population projections because projections are not available for that timeframe. The assumed growth from 2040 to 2045 is 1.34 percent, consistent with the average growth from among the previous four time intervals.

c. The range of outstanding demand shown for Priority List corresponds to a 50- to 100-percent application approval rate. Historically, actual approval rates are closer to the 50-percent figure.

d. The 50-percent application approval rate was assumed and applied to the Priority List component when performing this summation, as interviews with MDWS Planning and Engineering Division chiefs indicate that this historical trend in approval rate is likely to continue. The full 3.0 mgd remaining production demand associated with the Priority List is assumed to manifest linearly over time, such that the Priority List will be fully-resolved in 2040 – consistent with an application processing rate of 80 applications per year.

e. The additional pent-up demand component can only be addressed once the Priority List is fully resolved. With the Priority List resolved in 2040, it is assumed that the pent-up demand component will be fully addressed by year 2045.

The updated projection shows that by 2035 approximately 10.1 mgd of production-side water will be required, when considering the MDWS Upcountry potable systems and provision for Priority List processing, at a 50-percent application approval rate.

As summarized in Table 15, the previous WUDP projection resulted in 12.1 mgd of projected 2035 production demand when considering the MDWS Upcountry potable systems, and the Priority List, at a 50-percent application approval rate. Therefore, even when including the potential Upcountry pent-up demand component not considered in the WUDP, this updated projection yields two mgd less production-side water use requirement in 2035, than the previous projection.

3.2.2 Method B: Empirical Trendline Projection

As an alternative to the population-based production demand projection methodology, another useful projection approach is one that is based primarily upon empirical data. The approach presented here includes two primary components:

1. Empirical baseline trend analysis from the observed production data.
2. Analysis and incorporation of demand associated with planned future developments.

Note, that provision for demand associated with the Priority List is not considered as part of this main production-focused water use demand projection and will be addressed as a separate additive component, discussed in Section 3.3.

3.2.2.1 Baseline Trend Analysis and Projection to 2040

The analyzed trends in the historical production data described in Section 2.4 can be projected forward using a best-fit linear trendline equation for 2015 through 2020, for each of the Central and Upcountry Districts (see Figure 10). These trends were used to establish the baseline demand for future years through 2040.

The production-focused demand projections associated with this trendline analysis constitute a “best estimate” analysis, which assumes that future growth will remain reasonably similar to the average observed growth from this recent five-year time interval.

3.2.2.2 Provision for Planned Future Developments

<u>Rationale</u>

The initial baseline trend component of the empirical production-focused demand projection methodology reflects a continuation of the average production trend observed from 2015 and 2020. This trend is included without direct regard for population, treating production as if it varies solely with respect to time and no other variable.

The WUDP, in contrast, assumed that the change in water use varied as a function of resident population. The population projections established in the 2014 Socio-Economic Forecast already included future development projects as a key component, when analyzing growth in each of the Community Plan areas considered. Therefore, future development projects were already inherently included in the approach of the WUDP projection methodology.

By using the empirical trend in observed production, as a baseline for the production-focused water use projection methodology in this TM, population is removed from direct consideration. Future development projects, however, pose a special challenge when using this approach, for several key reasons:

1. Development projects that were completed and occupied from 2015 to 2020 are already captured in the baseline empirical trend.
2. Sufficient information is not readily available which could allow observed production associated with newly completed development projects to be separated from observed demand that corresponds with other factors.

3. The County of Maui has a known queue of future development projects. Because each development project is different and can vary substantially in its impact on demand (due to significant differences, including location, land use, size, and rate of development), it is likely insufficient to assume that the observed 2015 to 2020 trend will fully reflect new development project demand contribution into the future.
4. While residential and commercial development does occur to accommodate increases in *de facto* population (residents plus visitors), the observed increase in resident population between the 2010 and 2020 Census survey periods, combined with an increase in visitor days (visitor arrivals multiplied by length of stay) from 2010 to 2019 (excluding 2020, due to the COVID-19 pandemic) does not correspond to the observed increase in billed consumption, as discussed in Section 2.3.3.

Given these factors, the proposed empirical projection methodology will consist of two separate upper- and lower-threshold projections which will bound the range in which actual demand is most likely to occur.

- The lower-bounding projection will utilize the baseline production trend only, as previously described, intended to reflect a low-end demand estimate.
- The upper-bounding projection will reflect the same baseline trend, but also include an additional allowance for demand associated with pending future development projects.

This high-end estimate may include some "double counting" of demand due to the increase in projected resident population associated with these future development projects. However, some "double counting" has been deemed acceptable for the purpose of providing this conservative high-end estimate due to (1) the limitations of population-based projections already discussed and (2) the large potential demand associated with future development provisions in excess of resident population increase, including developments which primarily serve tourist and non-resident populations.

<u>Approach</u>

A list of future developments is produced and periodically updated by the Planning Department, detailing planned development projects, the associated number and type of units (i.e., single-family, multi-family, other, visitor), and the geospatial location associated with each project.

Figure 23 displays a GIS map overlaying all of the planned future developments in the Central and Upcountry district regions within the water system boundaries.

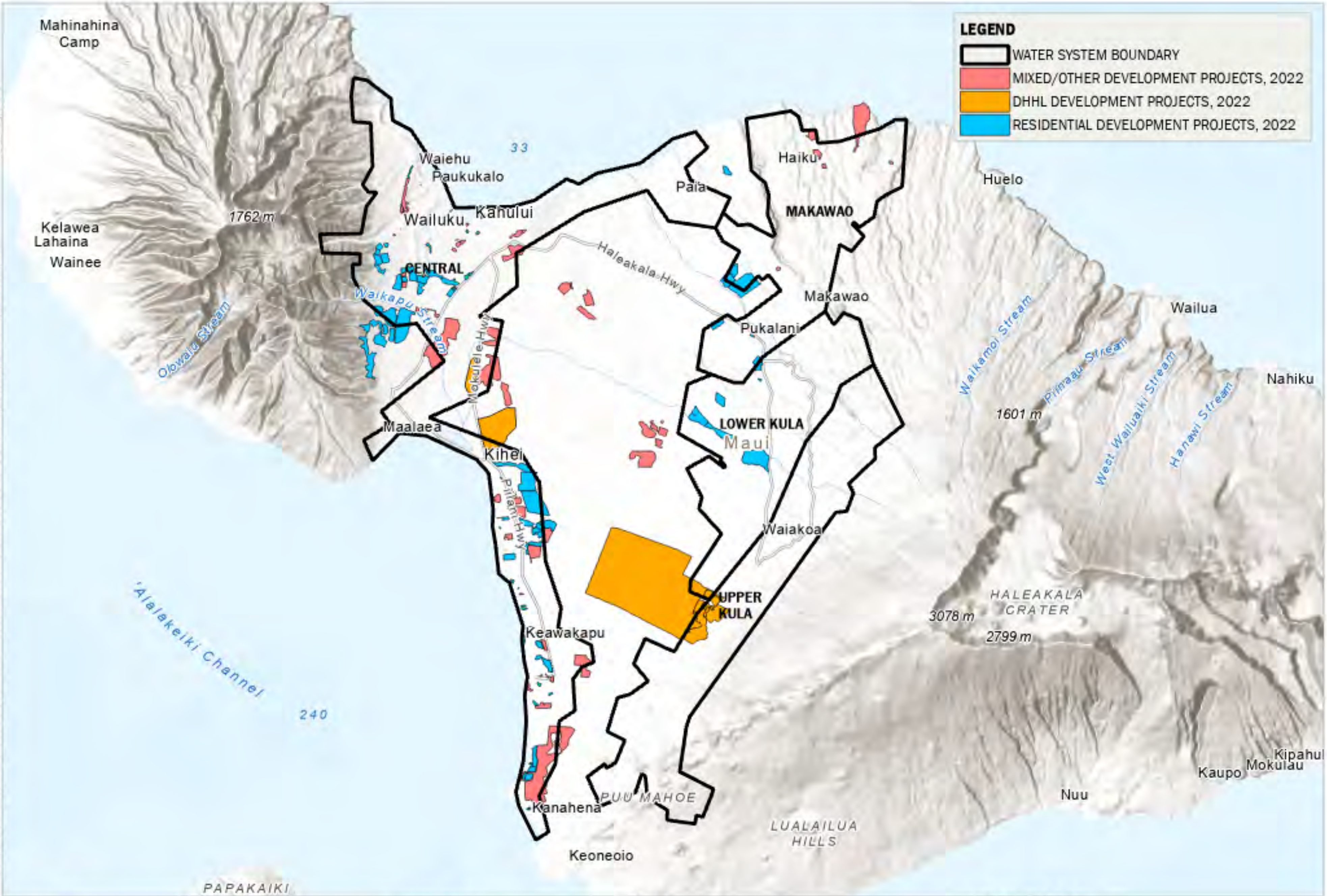

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FIGURE 23

PLANNED FUTURE DEVELOPMENTS AND WATER SYSTEM BOUNDARIES

The planned developments were associated to the nearest water system, and the planned number of units were totaled, for each of the Central and Upcountry districts. The production-focused water use demand, associated with these added units was estimated, in accordance with the Domestic Consumption Guidelines established in the 2002 Water System Standards. Table 20 summarizes this total added demand.

Since no timeframe was listed for the anticipated construction completion and inhabitation of each planned future development, the assumption was made that the additional production demand outlined in Table 20 will occur in a linear manner between 2022 and 2040.

Table 20. Estimated Production Demand Associated with Planned Future Development by System [a]

Unit Type	Water System Totals (gal/day)	
	Central District	Upcountry District
Single-Family Units	3,859,800	2,662,600
Multi-Family Units	2,229,360	34,160
"Other" Units [b]	1,123,234	-
Visitor Units [c]	470,050	-
Total Estimated Demand (gal/day)	7,682,444	3,553,956
Total Estimated Demand (mgd)	**7.682**	**3.554**

Notes:

a. *Source: County of Maui, Planning Department – Project Status Viewer GIS database, extracted on February 15, 2022, and the 2002 Water Systems Standards.*

b. *The unit type "other" assumed as zoned either commercial or light industrial, and estimated at 6000 gals/acre. Area of "other" units was calculated as a proportion of the total number of units for a development.*

c. *"Visitor" units assumed as resort zoning.*

Department of Hawaiian Homelands (DHHL) Development Projects

New Upcountry District construction that would increase required production demand is generally limited by the requirement for new development projects to have been (1) already included on the Priority List, further discussed in Section 3.3, and (2) reviewed and accepted in the order that applications were originally received.

Notably, however, the Department of Hawaiian Homelands (DHHL) has a water credit agreement, established with MDWS in 1997, which allotted a source allocation to DHHL for up to 500,000 gallons per day (gpd), to be reserved for future homesite projects (County of Maui Department of Water Supply & State of Hawaii Department of Hawaiian Homelands, 1997). As of May 2021, approximately 460,000 gpd of this reserved source amount has been utilized by constructed developments, with approximately 40,000 gpd of the original reservation left unutilized and held for additional future development.

A significant component of the planned future development for the Upcountry District, as seen in Table 20, is associated with large DHHL development projects, like the DHHL Keokea Homestead project, which alone would add 2,800 single family units. In the WUDP, both potable and non-potable DHHL demand were considered separately from the MDWS potable water system.

Overlap of Planned Future Developments with Upcountry Meter Priority List and Pent-Up Production Demand Components

Unique to the Upcountry District are two additional components of production demand, further detailed in Section 3.3: (1) provision for processing of the Priority List and (2) potential Upcountry pent-up demand. There exists the possibility, when assessing production demand associated with planned future developments located in the Upcountry District, that overlap may occur among these components.

A GIS analysis was performed to compare the parcels associated with either the Priority List or additional pent-up demand properties against the separate list of areas designated for planned future developments, to assess the degree of possible overlap and minimize potential “double counting” of production demand.

This was achieved by performing a spatial overlay of the planned future development shapefile geometries relative to the parcels that each development overlaps. All parcels that were identified as being on either the Priority List or the list of identified potential pent-up demand properties were compared against any spatially overlaying development projects. The number of planned housing units corresponding to those respective future development projects were then associated to those parcels based on the proportion of overlapping land area.

For example, if a parcel on either the Priority List or pent-up demand list overlaps with 40 percent of the land area designated as a future development project, then 40 percent of that development’s housing unit count was associated with that overlapping parcel. This analysis was performed in a manner that maintained separate accounting of the various unit types (e.g., single family, multifamily, etc.).

The resulting total housing unit count associated with any overlap was then used to determine the associated production demand, using the 2002 Water Systems Standards consumption guidelines. This production demand value represents a best approximation of demand that, if not adjusted for, would be “double counted” when considering each of these three components together.

Table 21 summarizes the results of this analysis in terms of the average daily production demand, that either overlaps or does not overlap with the Priority List and potential pent-up demand components. Based on these results:

- Only the addition of production demand associated with the “non-overlapping” future development projects will be used in projections that consider the baseline trend plus planned future development for the Upcountry District (1.455 mgd).
- The “overlapping” future development projects will not be factored in directly but will be considered as being inherently included among the Priority List and potential pent-up demand components when these properties are considered.

When the non-overlapping future development is applied in the projections, it will be applied in a linear manner, such that the full 1.455 mgd will be reached in 2040.

Table 21. Overlap of Upcountry Planned Future Development Production Demand with Priority List and Pent-Up Demand

Unit Type	Water System Totals (gal/day)			
	Upcountry District, Total	Upcountry District, Overlapping	Upcountry District, Non-overlapping	Overlapping Percent
Single-Family Units	2,662,600	2,064,926	599,674	77.5%
Multi-Family Units	34,160	34,160	-	100%
"Other" Units	855,196	-	-	0%
Visitor Units	-	-	-	N/A
Total Estimated Demand (gal/day)	3,553,956	2,099,087	1,454,869	59.1%
Total Estimated Demand (mgd)	**3.554**	**2.099**	**1.455**	**59.1%**

Notes:

a. *Source: County of Maui, Planning Department – Project Status Viewer GIS database, extracted on February 15, 2022, and the 2002 Water Systems Standards.*

b. *The unit type "other" assumed as zoned either commercial or light industrial, and estimated at 6000 gals/acre. Area of "other" units was calculated as a proportion of the total number of units for a development.*

c. *"Visitor" units assumed as resort zoning.*

3.2.2.4 Empirical Projection Methodology Results

Table 22 summarizes the overall demand projections for each district and includes both the base trendline in production-focused demand and the addition of any planned future developments. Included in Table 22 is an additional section which factors outstanding demand associated with both the Priority List and potential Upcountry pent-up demand (further discussed in Section 3.3).

Figures 24 and 25 display the empirical production-focused demand projections for the Central District system and Upcountry District system excluding the Priority List and pent-up demand components, respectively. In both figures, the initial baseline trend (reflecting the lower-bounding estimate) is shown along with an upper-bounding estimate (which includes both the baseline trend and additional demand associated with planned future development projects).

Figure 26 displays the projections for the Upcountry District when the Priority List and pent-up demand components are included in addition to both the baseline production trend and baseline production plus future development trend. It is assumed that the Priority list will be fully resolved by year 2040 (consistent with an application processing rate of 80 applications per year) and that the pent-up demand will be resolved thereafter between 2040 and 2045.

Note, the projections presented here are indicative of future average demand only. Additional peaking factors must be applied in conjunction with these estimates to ensure adequate production capacity to meet desired level of service targets during a peak, high-demand year.

Table 22. Empirical Production-Focused Water Use Demand Projections – All Central and Upcountry Systems (mgd)

Projection Scenario	Calendar Year						
	2015	2020	2025	2030	2035	2040	2045[b]
Central District							
Baseline Production Trend	22.314[a]	24.033[a]	26.796	28.877	30.958	33.039	–
Production + Planned Future Development [c]			28.413	32.516	36.618	40.721	–
Upcountry District – excluding the Priority List and potential pent-up demand							
Baseline Production Trend	6.411[a]	7.550[a]	8.271	9.216	10.161	11.106	–
Production + Planned Future Development [c]			8.577	9.905	11.233	12.561	–
Upcountry District – including the Priority List and potential pent-up demand							
Priority List	3.0 to 6.0[d]						
Additional Pent-Up Demand	2.105						
Total Water Use: Baseline Production Trend + 50% Priority List + Additional Pent-Up Demand	6.411[a]	7.550[a]	9.021[e]	10.716[e]	12.411[e]	14.106[e]	17.156[f]
Total Water Use: Baseline Production Trend + Planned Future Development + 50% Priority List + Additional Pent-Up Demand			9.327[e]	11.405[e]	13.483[e]	15.561[e]	18.611[f]

Notes:

a. *2015 and 2020 reflect actual production.*

b. *Extension of projections to 2045 was performed for the Upcountry District when considering the Priority List and Pent-Up Demand conditions only, as it is assumed that the Priority List will be fully resolved by year 2040 (assuming 80 applications processed per year) and the pent-up demand will be resolved between 2040 and 2045.*

c. *The Planned Future Development component is assumed to manifest linearly between 2022 and 2040.*

d. *The range of outstanding demand shown for the Priority List corresponds to a 50- to 100-percent application approval rate. Historically, actual approval rates are closer to the 50-percent figure.*

e. *The 50-percent application approval rate was assumed and applied to the Priority List component when performing this summation, as interviews with MDWS Planning and Engineering Division chiefs indicate that this historical trend in approval rate is likely to continue. The full 3.0 mgd production demand associated with the Priority list is assumed to manifest linearly over time, such that the Priority List will be fully resolved in 2040, consistent with an application processing rate of 80 applications per year.*

f. *The additional pent-up demand component can only be addressed once the Priority List is fully resolved. With the Priority List resolved in year 2040, it is assumed to be fully addressed by year 2045.*

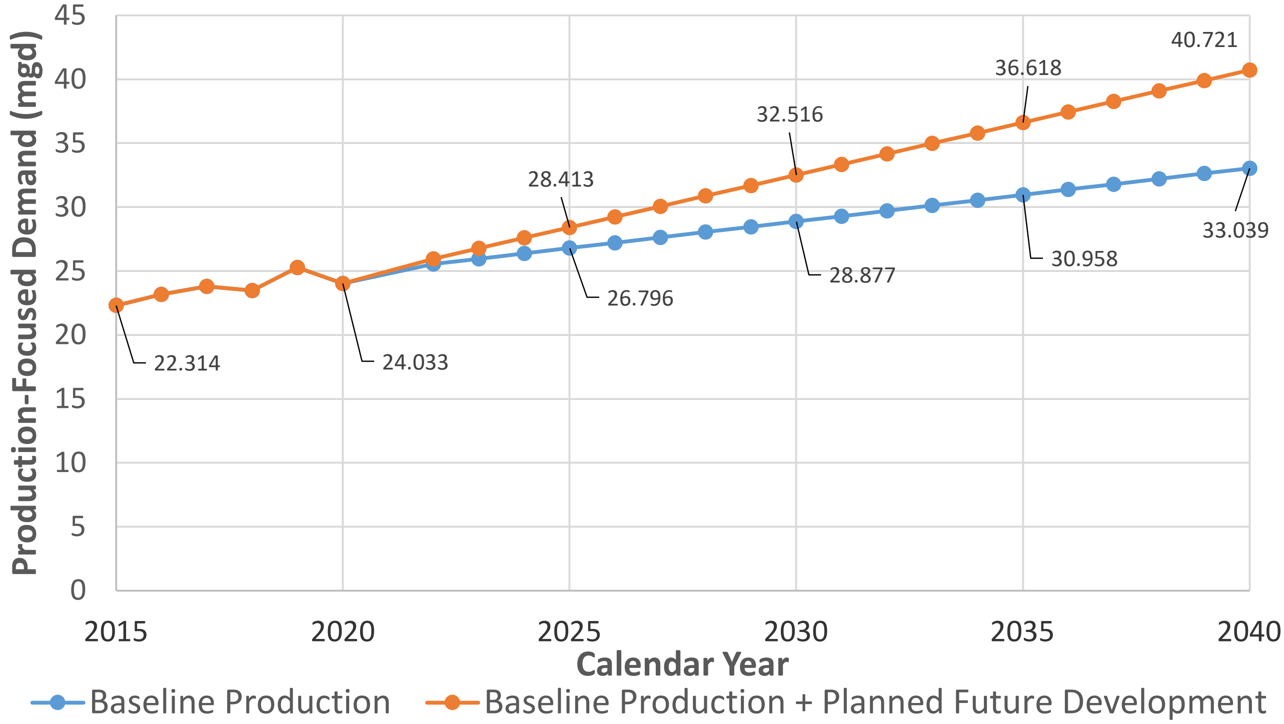

Figure 24. Projected Production Demand - Central District

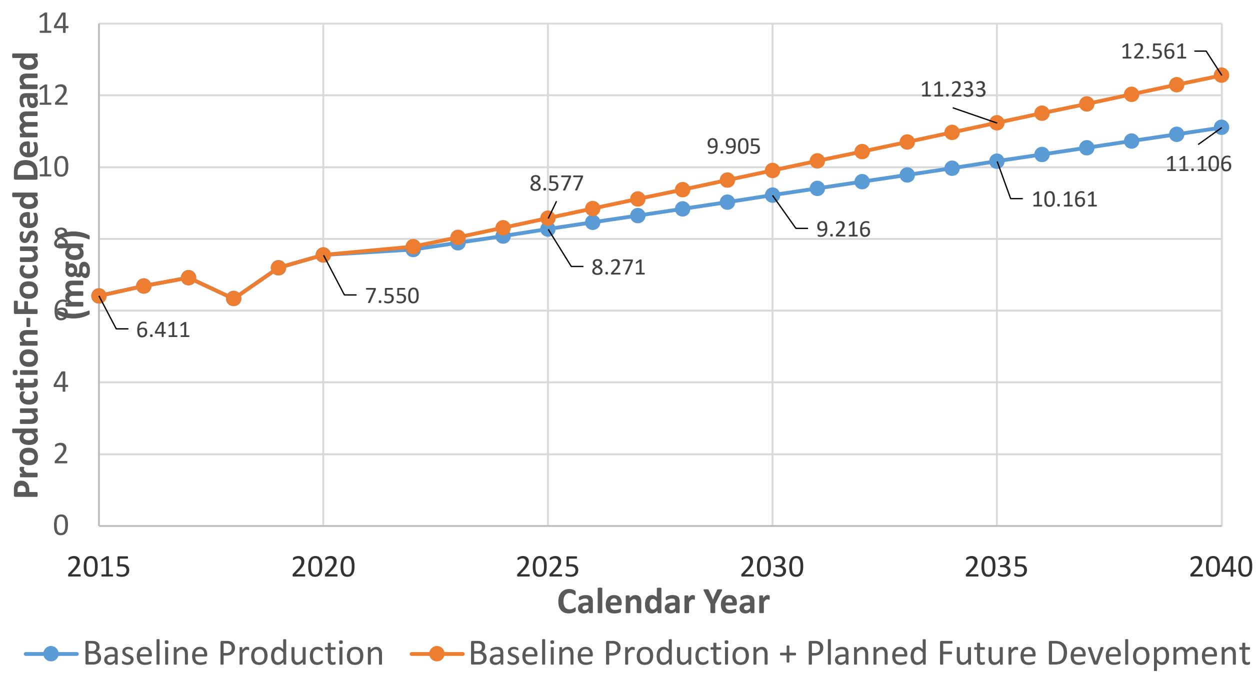

Figure 25. Projected Production Demand - Upcountry District (Excluding Priority List and Pent-Up Demand)

No attempt to determine how many multi meter subdivisions remain on list and how many have privite wells and those numbers should be subtracted

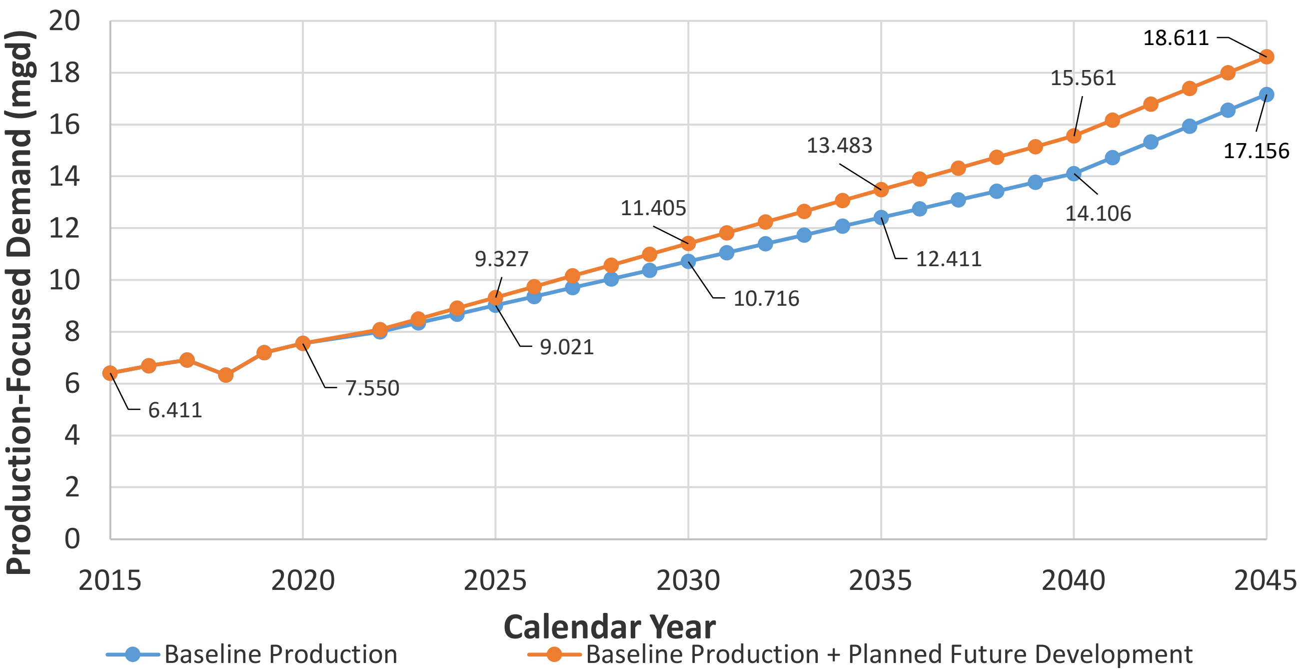

Figure 26. Projected Production Demand - Upcountry District (Including Priority List and Pent-Up Demand)

3.2.3 Method C: Upcountry District Linear Priority List Projection

An additional analysis unique to the Upcountry District was performed to evaluate another special consideration– the case where the entirety of the production demand increase for the Upcountry systems is directly- and linearly-related to processing of the Priority List (further discussed in Section 3.3), with no other factors playing a role. This projection is being evaluated to address concerns that the other methods may result in some level of "double counting," when other factors are included.

For this case, the following projection assumptions and framework were used.

- Observed upcountry average daily production was 6.777 mgd and 7.550 mgd in 2014 and 2020, respectively, for a net increase in production of 0.773 mgd, during that timeframe.
- The number of applicants remaining on the Priority List decreased from 1,822 in 2014 to approximately 1,500 in 2020, meaning that approximately 322 applications had been processed.
- Historically, approval and acceptance rates of processed applications have been approximately 50 percent. Assuming this was true during that timeframe, then approximately 161 applications that were processed resulted in new service. If the observed 0.773 mgd increase in production was entirely attributed to these 161 approved applications, then each application approval corresponds to approximately 4,800 gpd.

How much of .773 mgd is leakage?

- For the 1,500 applications that remain, approximately 750 applications are likely to result in approvals. Applying the same 4,800 gpd per approved application, the full processing of the Priority List would correspond to an additional production demand requirement of 3.6 mgd.
- For projection purposes, it is assumed that this demand will manifest linearly between 2020 and 2040, corresponding to approximately 80 applications processed (and 40 approved) per year.

Is there any proof that only 161 meters were activated from the list over 6 years? What if some of the increased demand was from meters already awarded but not used for many years?

2017 Ucounty meters + 31
2018 meter = +65
2019 meters= + 47
2020 meters = + 55
total= 198 meters
3,905 gal hookup x 750= 2.9 mgd

Table 23 summarizes the results of this projection. Also, included in Table 23 is an additional column for year 2045, which has been added to reflect the need to address the additional pent-up demand (further discussed in Section 3.3) once the Priority List has been fully processed.

Table 23. Production-Focused Water Use Demand Projections – Upcountry District Linear Priority List Projection (mgd)

Projection Scenario		Calendar Year					
	2015	2020	2025	2030	2035	2040	2045
Upcountry District							
Baseline Production Trend	6.411	7.550[a]	8.450	9.350	10.250	11.150	13.255[b]

Notes:

a. *2015 and 2020 reflect actual production.*

b. *The 2045 production demand value has been added to reflect addressing the Upcountry additional pent-up demand during the period 2040 to 2045 after the Priority List has been fully processed.*

3.3 The Upcountry Meter Priority List

According to the Maui County Code (14-01):

> *"On March 16, 1993, the upcountry water system was found to have insufficient water supply developed for fire protection, domestic, and irrigation purposes to take on new or additional water services without detriment to those already served in the regulated area. Since November 2, 1994, the department has maintained a priority list of premises, organized by the date applications for new or additional water service were received for such premises. Effective as of January 1, 2013, the department will not accept any new applications to be placed on the priority list."*

3.3.1 Provision for Production Demand Associated with the Priority List

An additional component of production demand for the Upcountry District is the manner of incorporating the outstanding demand associated with the Priority List. This component of production demand is being treated as separate from the other aspects projected and described in Section 3.2 because it is demand that technically exists but is not yet being met.

Rather than being the result of new growth, added production demand associated with the Priority List is the result of MDWS processing the long backlog of Priority List water service connection applications, with the rate of production demand increase being limited by the application processing rate.

Accounting for this outstanding demand is challenging due to a variety of factors. In the 2019 WUDP, remaining demand associated with the Priority List was estimated at 7.3 mgd, while 1,822 pending applications remained on the list. However, this estimate was based upon extrapolation of demand associated with a relatively small number of applications. MDWS does not know how much production demand is associated with an individual application until that request is processed. Furthermore, even when a meter request is approved by MDWS and an offer to connect is accepted by the applicant, this does not necessarily indicate that the meter will be installed and utilized during that same calendar year.

An updated September 2021 version of the Priority List indicated that approximately 1,500 applications remained pending. Interpolating, if the original extrapolation holds, the associated remaining 2021 production demand would be approximately 6.0 mgd.

Although there may be approximately 6.0 mgd of outstanding demand, it is unlikely that provision of this full amount will be needed, because the rate of application approval and acceptance has historically proven to be much less than 100 percent. For the production demand estimations summarized in this TM, it is assumed that processing of the Priority List will result in a 50-percent application approval and acceptance rate, on average. This assumption is consistent with the approval and acceptance rate that has been observed historically.

The approval and acceptance rate here refers to the percentage of applications that are both (1) approved by the MDWS for a new water service connection and (2) for which the resulting offer to connect is subsequently accepted by the applicant or property owner. Sometimes property owners may choose to decline to connect even after their application has been approved. One notable reason why this might occur is the potentially high cost that the property owner would incur for necessary improvements to facilitate connection, especially if they live at a significant distance from the existing water distribution system.

The amount of outstanding Upcountry production demand that will ultimately manifest and require provision is assumed to be 3.0 mgd. This will be considered as a separate demand added to the demand determined from the projection methodologies discussed in Section 3.2. The actual timeframe required to accommodate the outstanding demand associated with the Priority List will be discussed in Section 3.3.3.

3.3.2 Upcountry Additional Pent-Up Demand

Since the Priority List has been closed to new water service connection applications since January 2013, any property owners seeking water service since that time have been unable to apply for and obtain service from MDWS. For this reason, they may have chosen alternatives such as collecting water through rainwater catchment or private well, purchasing source through private allocated credits (Dowling), or deferred development altogether.

It is likely that many of these property owners would prefer to connect to the MDWS Upcountry District potable system and would choose to do so if that option were available. However, under the current regulations, the Priority List must be fully processed before any new water service applications will be accepted. Nonetheless, there is value in quantifying the potential additional “pent-up” production demand located in the Upcountry District, to help understand longer-term production needs. As a result, potential pent-up production demand was quantified and sorted by land use using the following approach:

1. A GIS shapefile layer containing the County of Maui Parcel geometry and associated data (e.g., tax map key [TMK], land value, building value, etc.) was established.
2. All parcels, except those that spatially fall within the Upcountry District water systems’ boundaries, were filtered out.
3. Parcels that are not located within a 100-foot (ft) distance from an existing MDWS water main were excluded. This step was added to narrow down the list to those properties located close enough to the existing system that would not be cost-prohibitive to connect, due to required system improvements.
4. Parcels with an existing water service connection were filtered out, including:
    a. Parcels with a TMK matching the TMK associated with an account in the MDWS billing data spreadsheet.
    b. Parcels spatially located within the 10-ft radius of a water service connection with a “200000000” TMK. This filter was applied to address a historical flaw in the MDWS billing account data where properties erroneously have a placeholder TMK value of “200000000” associated to their account, rather than the actual TMK.
5. Parcels whose TMK matches the TMK of a parcel already on the Priority List were filtered out.
6. Parcels that include a known water well within its boundaries were excluded.
7. As a final step, the remaining parcels had the applicable County of Maui zoning designation joined to them, so they could be filtered by land use.

This approach resulted in a final list of 790 unique parcels that could contribute to an existing level of pent-up demand that will go unsatisfied until the Priority List has been fully resolved. Table 24 summarizes these parcels by zoning designation, total area, and total parcel count. Also included, is a column that approximates the potential demand for each zoning classification, based on the most closely-matched zoning category listed under the domestic consumption guidelines in the 2002 Water Systems Standards. Where the 2002 Water Systems Standards' guidelines for average daily demand could be based on either a gallons-per-unit or a gallons-per-acre basis, the gallons-per-acre approach was used.

The approximate demand totals 15.157 mgd, with agriculturally zoned land comprising the vast majority at approximately 13.739 mgd (or 90.6 percent).

Does this analyses include Haiku lands as Upcountry

Table 24. Summary of Potential Upcountry Pent-Up Demand Parcels

Zoning Designation	Number of Parcels (count)	Total Area (acres)	Approximate Demand (mgd)
AG: Agriculture	421	2,747.7	13.739
B-2: Business - Community	2	1.2	0.007
B-CT: Business - Country Town	7	3.5	0.021
I: Interim	19	4,458.8	N/A
P-1: Public/Quasi-Public	4	62.9	0.378
PK: Park	1	9.2	0.016
PK(GC): Park-Golf Course	3	39.7	0.068
R: Rural	9	4.5	0.014
R-1: Residential	70	77.3	0.232
R-2: Residential	36	32.3	0.097
R-3: Residential	97	78.3	0.235
RU-0.5: Rural - 1/2 Acre	112	108.4	0.325
RU-1.0: Rural - 1 Acre	5	8.7	0.026
UR: Urban Reserve	4	4.6	N/A
Total	**790**	**7,637.3**	**15.157**
Total (excluding Agricultural)	**369**	**4,889.6**	**0.731**

It is unlikely that MDWS will desire to accommodate all of the production demand associated with agricultural-zoned properties identified in this GIS analysis. Despite properties' proximity to the system for connection, these Upcountry agricultural lands may not require irrigation to the extent assumed in these high-level calculations or may already be utilizing an alternative source to meet water demand needs. Given these considerations, only ten percent of the calculated potential demand associated with agricultural lands will be accounted for as likely pent-up demand. While ten percent, or 1.374 mgd, is a somewhat arbitrary value, it is similar in magnitude to what is currently allotted for the Kula Ag Park (1.5 mgd) and therefore seems reasonable in that it would support agricultural development to that extent.

Accounting for the 0.731 mgd of potential non-agricultural demand together with 1.374 mgd (ten percent) of potential agricultural demand, the total potential pent-up production demand considered in this TM is 2.105 mgd. Unlike the Priority List applicants, many of whom will ultimately not choose to connect (as reflected in the 50-percent approval rate), this potential demand reflects only properties within proximity of the existing system requiring minimal improvements by the property owner for connection.

For this reason, it is recommended that MDWS plans for the need to meet this additional 2.105 mgd once the Priority List has been fully processed. The actual timeframe required to meet the potential Upcountry pent-up demand is discussed in Section 3.3.3.

3.3.3 Timeline to Realizing the Priority List and Pent-Up Demand Production Demand

Provision for both the Priority List and potential Upcountry pent-up demand component is technically demand that currently exists. However, because these components are not associated to current active water service connections, it is not practical to consider that demand as having an impact at this present time.

Ultimately, the rate of increase of demand associated with these components is constrained by the rate at which MDWS can process the Priority List applications. The rate of processing applications on the Priority List has varied significantly over time, and the pent-up demand cannot be addressed until the Priority List has been fully processed.

At present, approximately 40 applications are processed annually, but the annual processing rate has been as high as 80 to 100 percent in past years. Based on this range, it could take roughly 15 to 38 years before the Priority List is fully processed, with the pent-up demand then taking additional time beyond that. Given this variability, it is difficult to confidently predict when these demand components will be fully realized.

Figure 27 illustrates the range of possible timelines for fully processing both the Priority List and pent-up demand components, depending upon application processing rate. Note that Figure 27 only includes the potential pent-up demand that may exist today and does not account for possible increases in this amount over time.

For the purposes of this TM and the 2040 projection horizon, all projections that include the Priority List will assume an annual application processing rate of 80 applications per year. This will result in the Priority List being fully resolved in year 2040. The additional pent-up is then assumed to be resolved thereafter between 2040 and 2045.

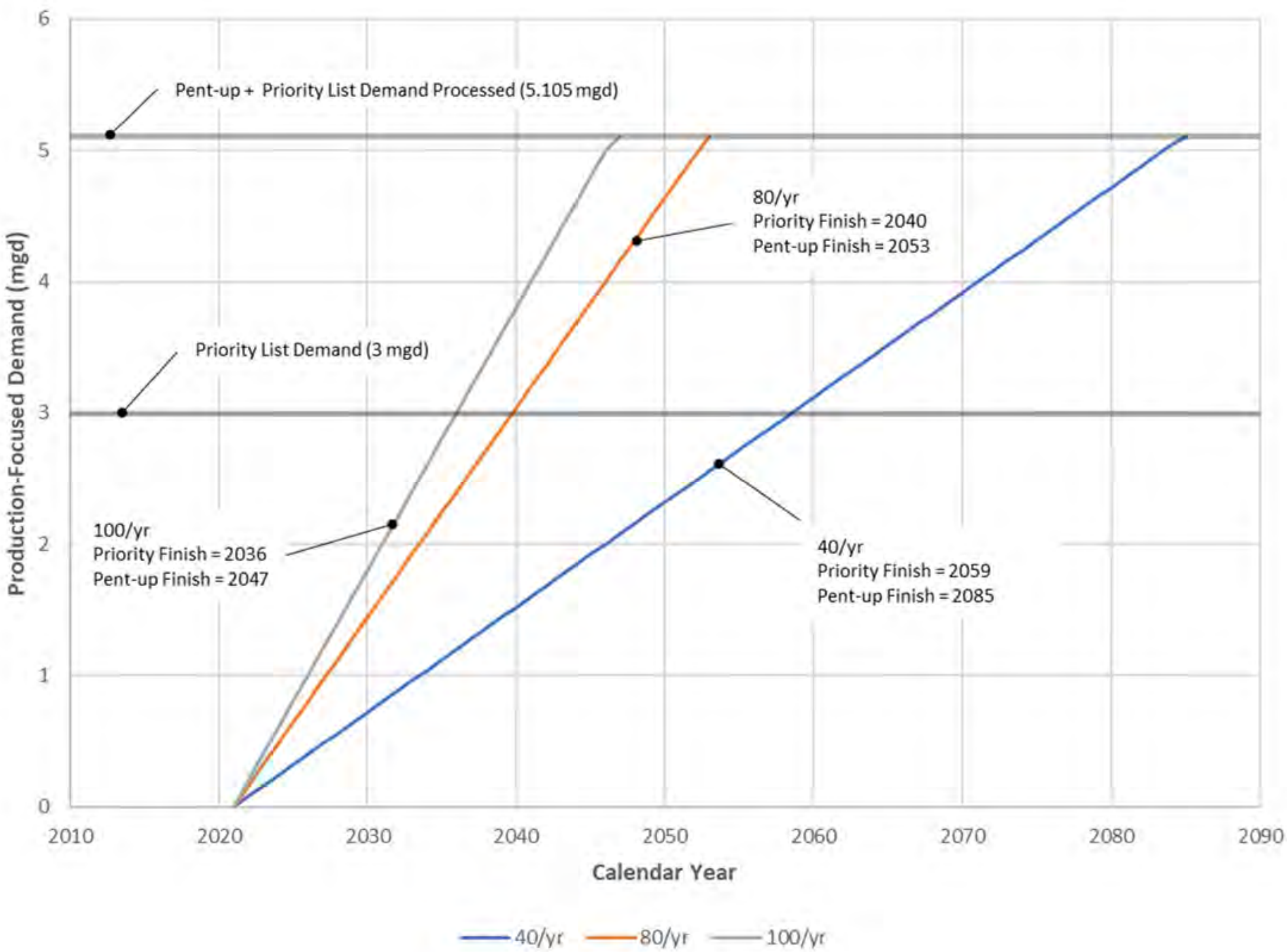

Figure 27. Priority List and Pent-Up Demand Possible Timelines

3.4 Projection Methodology Comparison and Recommendations

This section summarizes and compares each of the projection methodologies described in Sections 3.1 through 3.3 for the Central and Upcountry Districts. The methodologies are compared both quantitatively, in terms of their resulting production demand estimates, as well as qualitatively, in terms of strengths and weaknesses of each. This section concludes with a recommendation for how to best utilize these projection methodologies in projecting production demand through 2040.

3.4.1 Projection Methodology Comparison – Projection Results

Figure 28 provides a visual comparison of the projection methodologies previously discussed for the Central District system.

Figures 29 and 30 display the same information for the Upcountry District, with each figure having a slightly different focus, as follows:

- Figure 29 presents both the population-based and empirical projections but excludes demand associated with the Priority List and additional pent-up demand.

- Figure 30 presents both the population-based and empirical projections, in addition to demand associated with the Priority List and additional pent-up demand. Figure 30 also includes the "Linear Priority List Projection" (method discussed in Section 3.2.3).
  - In all cases, it is assumed that the Priority List will be fully resolved by year 2040 (consistent with an application processing rate of 80 applications per year) and that pent-up demand will be resolved thereafter, between 2040 and 2045.

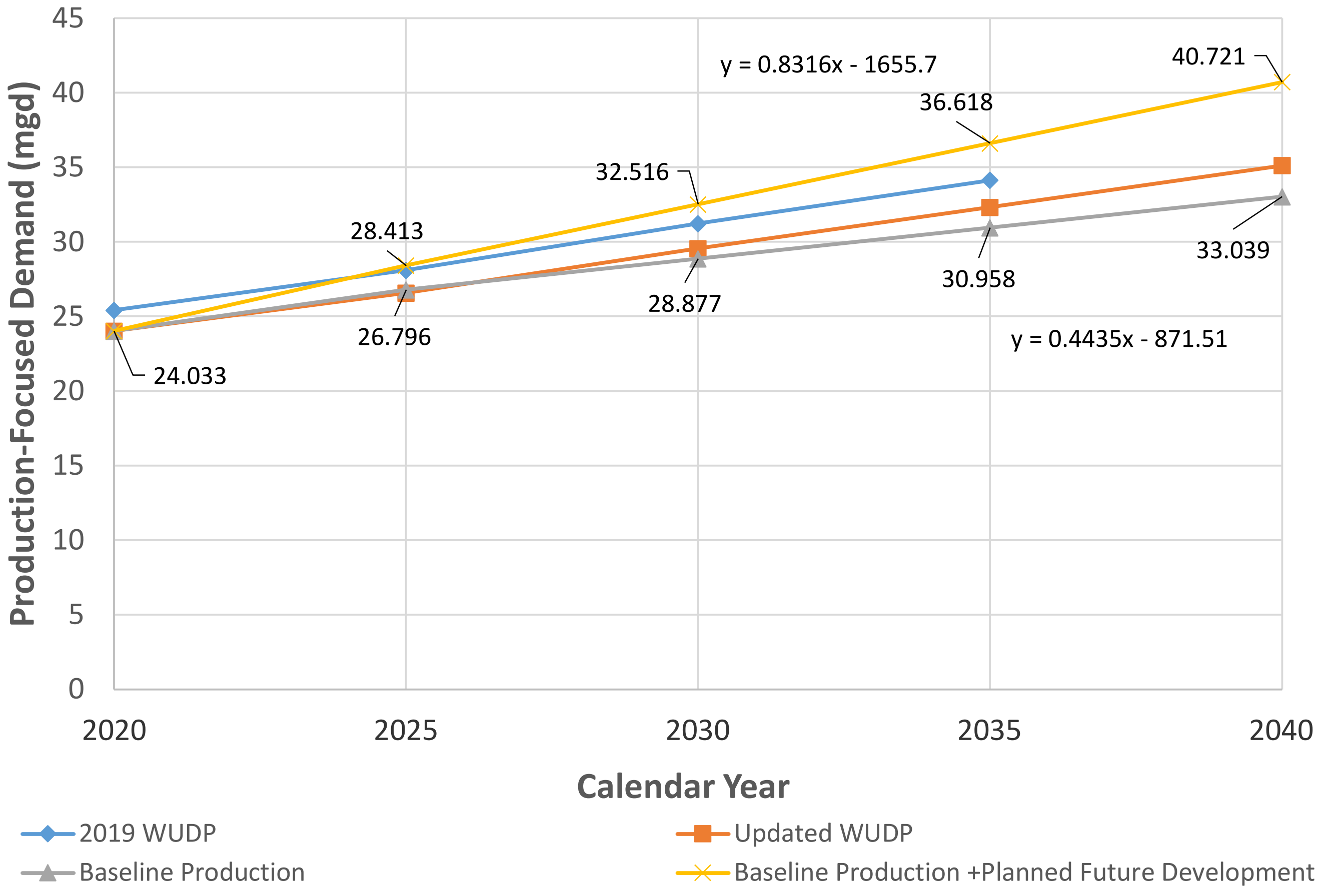

Figure 28. Projection Methodology Comparison - Central District

For the Central District, Figure 28 above, presents the empirical baseline trend projection with and without the added provision for production demand, associated with future development projects. Based on Figure 28, the 2040 production demand will likely fall within the range of 33.0 to 40.7 mgd, seen as the lower- and upper-most bounding projection, respectively. This corresponds to growth in production-focused demand ranging from approximately 0.44 to 0.83 mgd per year.

For the Upcountry District, when excluding the Priority List and pent-up demand components (Figure 29), the lower-bounding projection is the updated and extended WUDP methodology. The upper-bounding projection is the empirical baseline trend projection with added provision for production demand associated with future development projects. When excluding the Priority List and focusing purely on growth-related changes in production demand, the Upcountry District will likely experience growth within approximately 0.02 to 0.25 mgd per year.

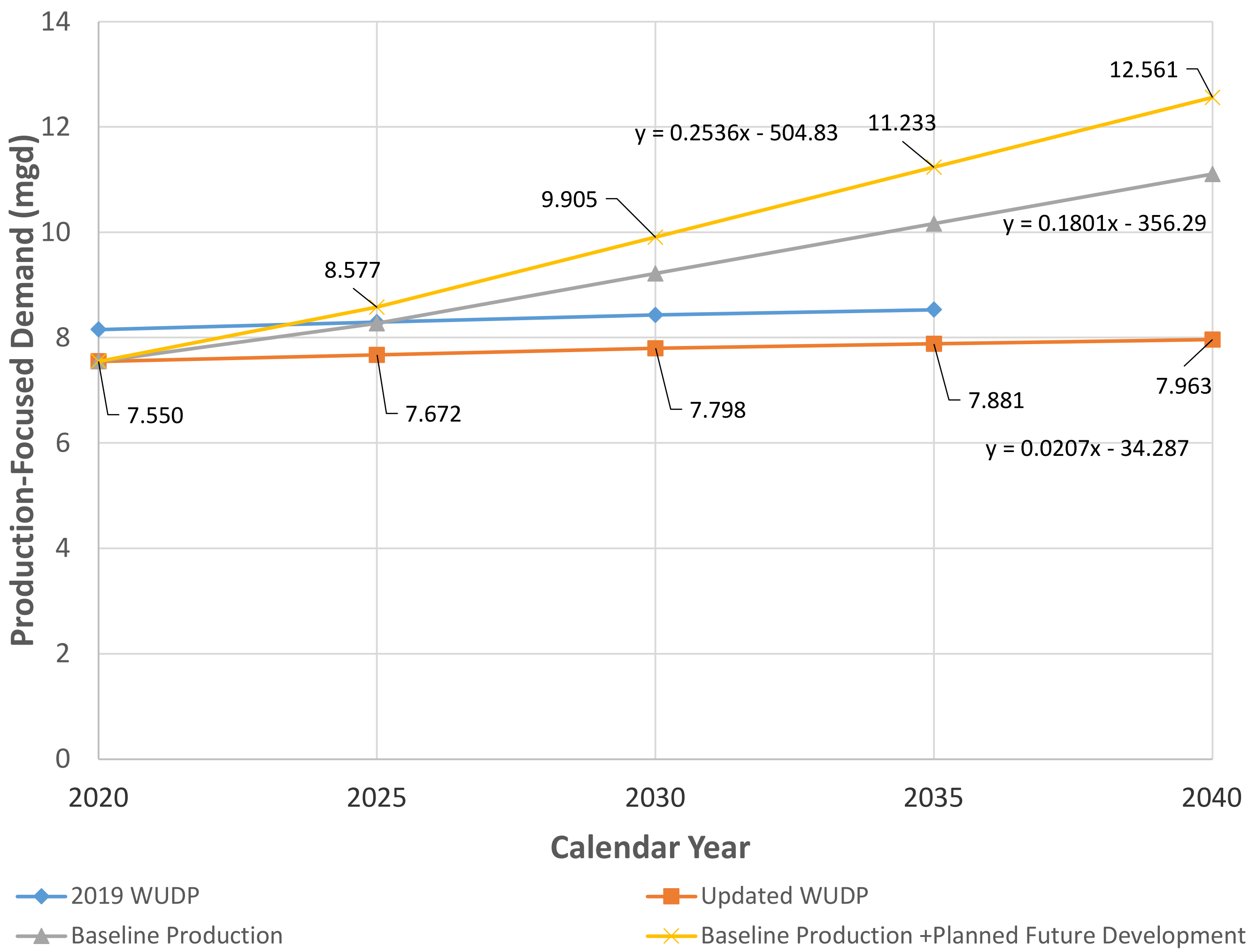

Figure 29. Projection Methodology Comparison - Upcountry District (Excluding the Priority List and Pent-Up Demand)

When the Priority List and additional pent-up demand are included in the Upcountry District production demand projections (illustrated in Figure 30), the projected 2040 demand will likely fall within approximately 11.0 mgd to 15.6 mgd. When including the Priority List and pent-up demand, the Upcountry District will likely experience growth within approximately 0.17 to 0.39 mgd per year, through 2040.

In addition, Figure 30 extends beyond the 2040 projection horizon, to 2045, to include time required to address the additional pent-up demand (discussed in Section 3.3.2), which cannot be addressed until after the Priority List has been completely resolved.

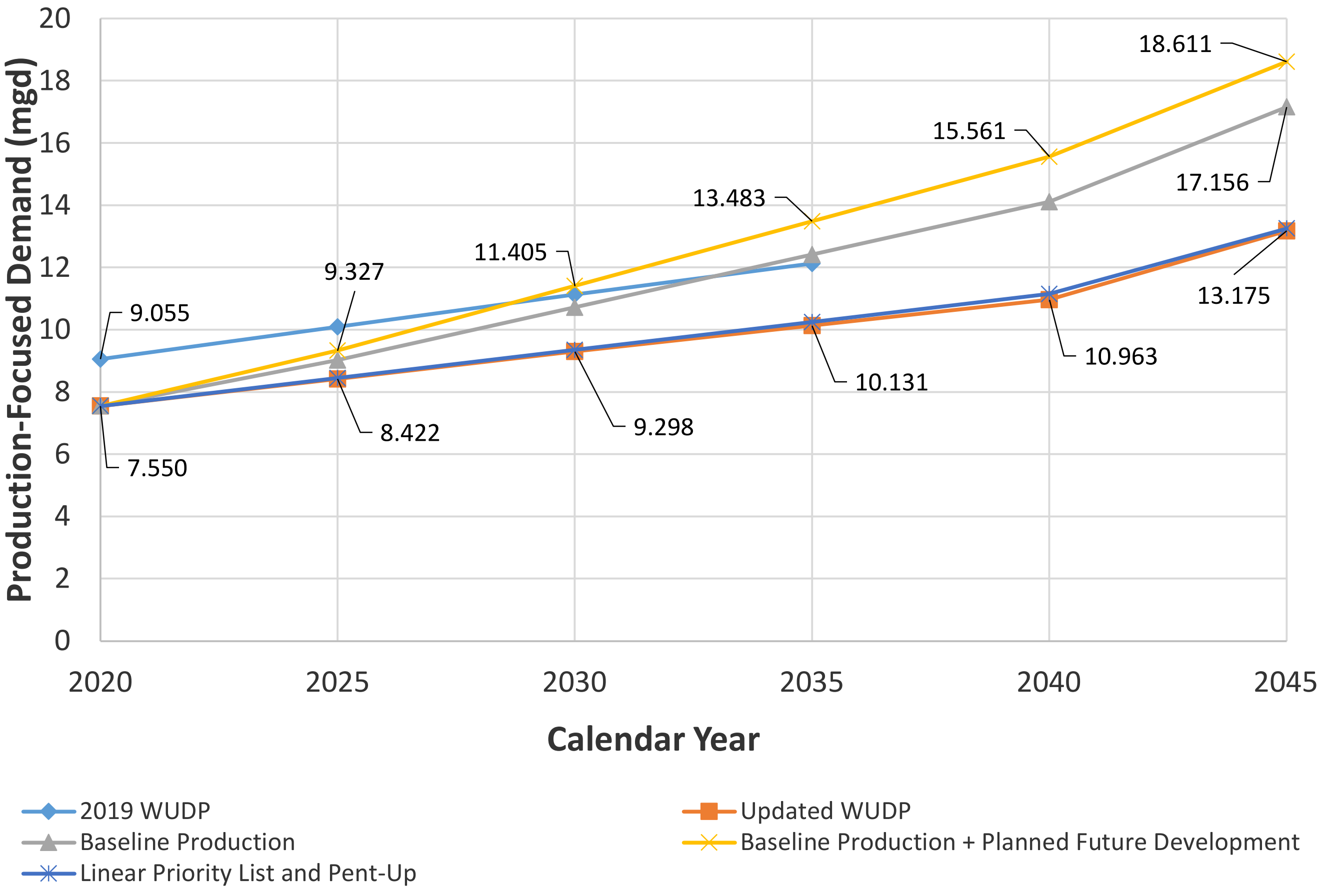

Figure 30. Projection Methodology Comparison - Upcountry District (Including the Priority List and Pent-Up Demand)

3.4.2 Projection Methodology Comparison – Assumptions, Advantages, and Disadvantages

Table 25 summarizes each of the projection methodologies in terms of their respective assumptions and relative advantages and disadvantages.

Table 25. Projection Methodology Comparison – Assumptions, Advantages, Disadvantages					
	Original 2019 WUDP Projection	Updated/Extended WUDP Projection	Baseline Production Trend	Baseline Production Trend + Planned Future Development	Linear Priority List Projection
Assumptions	Change in production demand is directly proportional to change in resident population. Based on population projections from the 2014 Socio-Economic Forecast Report.	The same assumptions as for the original 2019 WUDP projection method.	The future trend in production demand will largely remain consistent with the average trend in production demand observed in the MDWS production data from 2015 to 2020.	The same assumption as for the baseline production trend projection method. Additionally, the baseline-production trend may not be capturing the full extent of planned future development since each development project can vary significantly in terms of size and timing. This accounts for future development as an added component.	All observed increases in production demand are attributed to processing of the Priority List, occurring at a similar application approval rate until the Priority List is fully resolved. The Priority List is processed at a rate of 80 applications per year with a 50-percent approval rate (i.e., 40 approved per year). The additional pent-up demand is considered only after the Priority List has been resolved.
Advantages	Socio-Economic Forecast Report included planned future development as an inherent component of population projections.	The same advantages as for the original 2019 WUDP projection method. Additionally, Updates the base year production data to 2020, reconciling any deviations in the projection thus far and extends the projection to year 2040.	Production demand projections are based directly on actual production data, rather than a secondary indicator variable.	The same advantages as for the baseline production trend projection method. Additionally, Provides a very conservative estimate that accounts for continuation of both the average production trend and all planned future developments.	Minimizes potential “double counting” by limiting Upcountry Demand to be based on only one factor.
Disadvantages	The Socio-Economic Forecast population projections, although carefully established, are but an educated guess. The relationship between population and billed consumption (and by extension, production demand) are not strongly correlated for the analyzed period. The future trend in production demand is not based on observed historical trends.	The same disadvantages as for the original 2019 WUDP projection method. Additionally, As of 2022, the 2014 Socio-Economic Forecast report is eight years old. Updating the base year to 2020 values may have corrected any deviations to date, however, it may be impractical to assume future growth percentages, from 2020 and onward, will be congruent with previous predictions, without a more recent Socio-Economic Forecast update. Additionally, Uncertainty of unknown impact from COVID-19 on 2020 Census totals with respect to water use demand.	Using the overall production trend makes it difficult to tease out the specific subcomponents contributing to that trend. Particularly, it is not possible to accurately differentiate between changes in production demand associated with growth of the existing population from those associated with planned development projects as they are constructed.	This projection method knowingly accepts some level of “double counting” of planned future development projects, and as a result, may be overly conservative.	This methodology can only be applied with the current Priority List backlog. Once current Priority List is fully resolved, a new methodology will be required.

3.4.3 Discussion and Recommendation

Although, all the projection methodologies considered have merit in predicting future production demand trends, each on its own has its limitations, including:

- Projections which are empirically based on past production data cannot predict significant deviations from past trends resulting from future planned development, changes in growth patterns, or changes in per capita water consumption.
- Projection methodology aligned with local community growth plans and planned future development may not prove accurate, especially if planned growth reflects a marked intentional deviation from past trends.

These tradeoffs indicate that a range of potential future demand values would be most useful, rather than a single number. Instead of basing the range of potential future production values on variance in population projections (as reflected in the 2019 WUDP), it is recommended to use an approach that combines the empirical production trend and planned growth (or community planning) production trend methodologies to account for uncertainly.

The following steps, illustrated in Figures 28 through 30, outline the full process for determining the range of likely production demand values over time for a given water system when using the multiple projection methodologies discussed in this TM:

1. Determine the average annual trend in production demand based on the most recent five years of production data (combining both surface and ground water sources). Project the linear trendline forward, to determine the predicted production demand through to an approximate 20-year analysis horizon. This first estimate establishes the projection with the most “momentum,” which will likely continue unless conditions change.
2. Determine the projected trend in production demand in a manner similar to the WUDP method, by using the most recent Socio-Economic Forecast projections and the simplifying assumption that resident population growth is linearly predictive of production demand growth. Apply these planned population growth rates (adjusted to reflect system-level population growth) to the most recent years’ worth of production demand data.
   - Notably, to be most effective, the resident population projections should be as recent as possible. The 2014 Socio-Economic Forecast, as of the writing of this TM, is eight years old and a more recent forecast would improve accuracy. The “Updated WUDP” projection in this TM addresses observed deviations in planned versus actual production demand, from 2014 through 2020. A more recent projection forecast should be used to update these production demand projections when it becomes available.
3. The range, created by the results from steps 1 and 2, defines the most likely future production demand values.
4. As a high-end conservative estimate, this TM also considered inclusion of production demand associated with planned future development projects, in addition to the baseline trend in step 1. This demand was calculated using the number of housing units associated with known planned future development projects and a portion of per-unit demand based on the consumption guidelines from the 2002 Water Systems Standards. This conservative projection is intentional and accepts the likelihood of “double counting” for some future development projects.
5. With respect to the Upcountry District, special cases of existing and outstanding production demand associated with processing the Priority List and, subsequently, addressing the potential pent-up demand must be included. To accomplish that, these outstanding demand values should be added to each projection, resulting from steps 1 through 3, based upon the following assumptions:

- It is assumed that the Priority List will be fully resolved by 2040 (consistent with an application processing rate of 80 applications per year) and that the pent-up demand will be resolved thereafter between 2040 and 2045. This will shift the most-likely and high-end conservative ranges upward, to reflect these added demand components.

Table 26 summarizes the most-likely range and conservative high-end values for projected production demand for each system through 2040, as established by steps 1 through 5, above.

Table 26. Recommended Production Demand Ranges (mgd)

Projection Scenario	Calendar Year					
	2020	2025	2030	2035	2040	2045 [b]
Central District						
Most Likely Demand Range	24.033[a]	26.6 – 26.8	28.9 – 29.6	31.0 – 32.3	33.0 – 35.1	–
High-End Conservative Limit		28.4	32.5	36.6	40.7	–
Upcountry District – excluding the Priority List and potential pent-up demand						
Most Likely Demand Range	7.550[a]	7.7 – 8.3	7.8 – 9.2	7.9 – 10.2	8.0 – 11.1	–
High-End Conservative Limit		8.6	9.9	11.2	12.6	–
Upcountry District – including the Priority List and potential pent-up demand						
Most Likely Demand Range	7.550[a]	8.4 – 9.0	9.3 – 10.7	10.1 – 12.4	11.0 – 14.1	13.2 – 17.2
High-End Conservative Limit		9.3	11.4	13.5	15.6	18.6

Notes:

a. 2020 reflects actual production.

b. Projection extension to 2045 was performed for the Upcountry District when considering the Priority List and Pent-Up Demand conditions only, as it is assumed that the Priority List will be fully resolved by year 2040 (at 80 applications processed per year), with subsequent resolution of pent-up demand between 2040 and 2045.

This table swaps projected 2035 demand number from WUDP (34.1 mgd) and simply bumps it forward to 2040. 2025 demand= 28.1 mgd in WUDP. 2030 demand was 31.224 Mgd so 9 to 10 mgd more by 2040. How much of that is Waikapu Town wells supplying?
How much do Makena R and W670 supply with their systems? How much does Hi Tech park supply with their systems? (likely at least 4 mgd)

Section 4: Source and Capacity

This section begins with a discussion of capacity terminology and how capacity-related information is used by MDWS. A summary of the permitted production, limitations to production, and raw source water availability for the Upcountry and Central Districts and operational limitations to production capacity is further outlined. Finally, a summary of the additional source required to satisfy the projected demand through 2040 is presented.

4.1 Capacity Terminology

The word "capacity" has multiple meanings when applied to water systems. The State of Hawaii Water Systems Standards (WSS) (Division 100, Section 106) references capacity in terms of mechanical equipment (i.e., pumps, motors, and chlorinators), system, and carrying/reservoir capacity. MDWS also describes equipment and production capacity, and the Maui Administrative Rules (MAR) (Title 16, Chapter 201) further defines the term "maximum reliable capacity".

Capacity-related terminology is detailed in Table 27 for reference in this TM.

Table 27. Capacity Definitions

Term	Reference	Definition
Capacity	HAR 11-20 Definitions	"Capacity" means the overall capability of a water system to consistently produce and deliver water meeting all national and state primary drinking water regulations in effect or likely to be in effect when new or modified operations begin. Capacity includes the technical, managerial, and financial capacities of the water system to plan for, achieve, and maintain compliance with applicable national and state primary drinking water regulations.
Technical Capacity	HAR 11-20.29.5	A public water system with adequate technical capacity has adequate water source(s) including: • Sufficient water available to serve all customers or water users based on the water system's average daily and peak water usage, and the system's treated water output. • Sufficient water resources for the future, based on the max flow or pumping capacity of each source and a five-year or more projected growth rate study. • Adequate protection of water source(s) or watershed. • Adequate infrastructure replacement plan, which estimates the useful life and plans for replacement of wells, pumping facilities, storage tanks, treatment facilities and distribution system.
Maximum Reliable Capacity (Annual)	MAR Title 16, Ch 201	"Maximum reliable capacity" means the volume of water that the department determines can be reliably produced on an ongoing basis in any given department water system. Such value shall be based on engineering principles and shall consider various uncertainties, including but not limited to, mechanical failures, human error, and weather events. Transmission and storage infrastructure are not evaluated for this determination.
System Capacity	11-2 111.04 State of Hawaii 2002 Water Systems Standards	Water Systems Standards requirements: • The capacity of the distribution system shall deliver the maximum daily demand simultaneously with the required fire flow. • The distribution system shall also deliver the peak hour flow (without fire flow). • For Maui Only: For surface water systems, the demand shall not exceed 80-percent of the average daily inflow from the source.
Pump Capacity [a]	11-2 111.04 State of Hawaii 2002 Water Systems Standards	Pump Capacity Criteria for Maui: • Meet maximum day demand with an operating time of 16 hours simultaneously with maximum fire flow required independent of the reservoir. The standby unit may be used to determine the total flow required.

Table 27. Capacity Definitions

Term	Reference	Definition
		• Maximum day demand during the duration of fire plus fire demand less 3/4 of reservoir storage. • Meet maximum day demand with an operating time of 16 hours.
Theoretical Equipment Production Capacity	MDWS Operations	In reference to MDWS production, this is the design limit, without consideration of limitations or operational constraints. • For pumps, this corresponds to the pump rating. • For WTFs, this is the absolute maximum flux rate through the membranes, set by the filter or membrane manufacturer and approved by Department of Health (DOH), and does not consider the need for backwash cycles or maintenance. • For both wells and WTF, assumes unlimited influent availability. This is not an achievable production number.
Permitted Production Capacity	This Report	For each source, this is either the permitted CWRM Water Use Permit (WUP) limit or the maximum equipment pumping capacity.
Constrained Source Production Capacity	MDWS Operations and This Report	In reference to MDWS production, this is the actual/recommended maximum amount of water that can be produced at a source on an ongoing basis, considering system, source and equipment limitations and constraints. For wells: • 16-hour constrained source production capacity reflects pumping capacity when equipment is run 16 hours per day (per WSS). If withdrawal is limited by GWUPs or legal agreements this number is reduced to the permitted or agreed-upon amount. • 24-hour constrained source production capacity reflects pumping capacity when equipment is run 24 hours per day. If withdrawal is limited by GWUPs or legal agreements this number is reduced to the permitted or agreed-upon amount. For WTFs: • The lesser of nominal capacity and practical available raw water supply.
Nominal Capacity		Corresponds to what MDWS operations refers to as "Operational Maximum Flux Rate" or "Operational Maximum Capacity" and this reflects a sustainable treated water production level that accounts for necessary unit downtimes due to the need for regular backwashing, maintenance, equipment longevity, etc.[b] This assumes unlimited raw water source with turbidity and other water quality parameters within equipment specifications and does not account for periods of total WTF shutdown.
Source Availability		The total amount of water supply available, expressed as flow, from all active sources permitted for use by the water system, including approved surface water, ground water, and purchased water.
Practical Available Raw Water Supply		For WTFs, the average daily raw water inflow available considering raw water collection, transmission, and storage limitations.
Maximum Day Demand (MDD)	11-2 111.05 State of Hawaii 2002 Water Systems Standards	1.5 x ADD

Notes:

a. *Generally, this requirement applies to distribution system pumpage. Well source pumps may be operated continuously due to factors such as pump design, variable flow conditions, or power utility constraints.*

b. *Nominal capacity reflects a operational production capacity that accounts for necessary unit downtimes for backwash, maintenance and repair, etc. Reference: Water Treatment Plants Division email 07/07/2022 and Production Data Constraints.xls worksheet 11/30/2021.*

4.2 Source Water Availability and Production Capacity

Factors to consider when evaluating source sufficiency include:

1. **Permitted production capacity**, where regulatory factors such as WUPs and withdrawal limits are considered.
2. **Constrained source production capacity**, where environmental and operational limitations applicable to each source and system are considered along with legal agreements between private entities applicable to water purchases and operation.
3. **Source availability**, where the amount of raw water available is accounted for in terms of “how much” (i.e., aquifer and stream flows) and “how often” (i.e., drought and freshet).

The MDWS relies on both surface and ground water sources for supply in the Central and Upcountry Districts. The following sections summarize source availability, production capacity, and known limitations for the sources associated with the Central and Upcountry Districts.

Level of Service (LOS) is defined as the service quality for a particular activity or service area against which performance can be measured. Service levels usually relate to quality, quantity, reliability, responsiveness, environmental acceptability, and cost. In addition to regulation-based requirements, LOS for a water utility can establish guiding principles such as “Provide 100 percent of Upcountry water needs 100 percent of the time with no water restrictions or outages” or “Maintain rate increases in line with the Consumer Price Index (CPI)” or “Develop sufficient source to provide all applicants on the Upcountry Meter Priority List with water by 2040.”

The MDWS has not yet established formal LOS to guide source development and water provision to customers. In the absence of LOS, it is challenging to establish the timing and quantity of source availability required and corresponding production capacity needed to meet the needs of MDWS customers into the future, and to define what constitutes reliability for each system.

4.2.1 Central District

When the water resources of an area are determined to be threatened by existing or proposed withdrawals of water, CWRM designates the area as a water management area. This establishes greater administrative control over the withdrawals and diversions of ground and surface waters to ensure reasonable-beneficial use of the water resources in the public interest while protecting those resources (CWRM 2019).

The MDWS Central District is located within designated surface and ground water management areas and is supplied by the Iao, Waihee, and Kahului Aquifers. Designated surface and ground water management areas on Maui are illustrated in Figure 31. The designated surface water management areas are shown as hatched, and the designated ground water management areas are shaded blue.

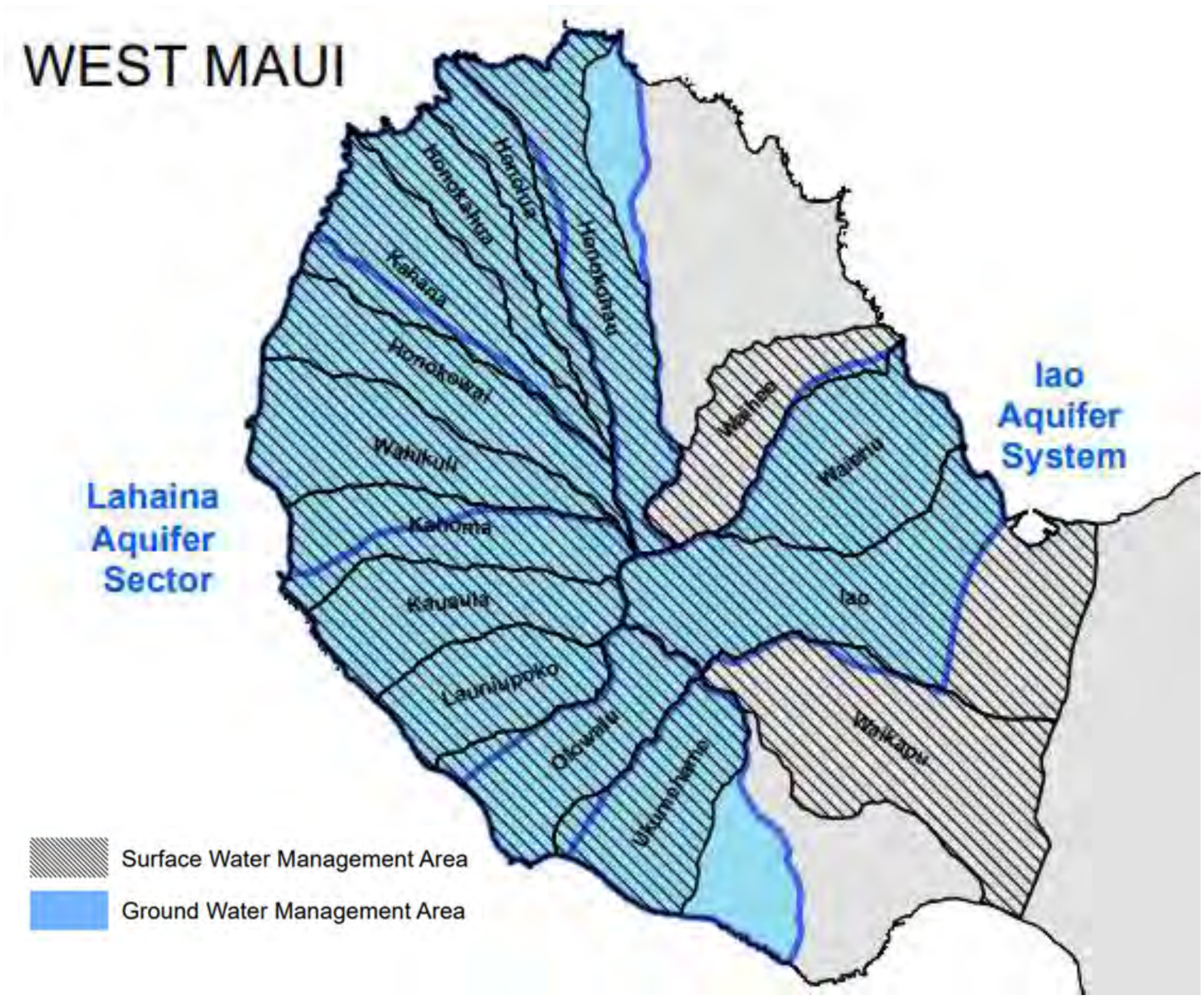

Figure 31. West Maui Designated Water Management Areas

Source: files.hawaii.gov/dlnr/cwrm/maps/wmainfo.pdf

Table 28 details production sources supplying the Central District, along with the associated aquifer system and water use permit requirements for each well and WTF. All sources located in the Iao Aquifer, designated as both a surface and ground water management area, require WUPs.

Table 28. Source, Aquifers and Water Use Permits – Central District

Source Name	Aquifer System	Designated Water Management Area		Permits/Agreements
		Ground Water	Surface Water	
Kepaniwai Well	Iao Aquifer – High Level Dike	Yes	Yes	2021 GWUP
Iao Tunnel	Iao Aquifer – High Level Dike			2021 GWUP
Iao WTF	Iao-Waikapu Ditch			CWRM SWUP
Mokuhau 1	Iao Aquifer – Basal			2021 GWUP
Mokuhau 3	Iao Aquifer – Basal			2021 GWUP
Waihee 1	Iao Aquifer – Basal			Wellfield GWUP
Waihee 2	Iao Aquifer – Basal			
Waihee 3	Iao Aquifer – Basal			
Waiehu Heights 1	Iao Aquifer – Basal			Inactive
Waiehu Heights 2	Iao Aquifer – Basal			2021 GWUP
Iao Tank Site	Iao Aquifer – Basal			2021 GWUP
Waikapu Tank Site	Iao Aquifer – Basal			2021 GWUP
Wailuku 1	Iao Aquifer – Basal			2021 GWUP
Wailuku 2	Iao Aquifer – Basal			2021 GWUP
North Waihee 1	Waihee Aquifer	No	Yes	CWRM "recommended limit" for aquifer system (no formal agreement in place).
North Waihee 2	Waihee Aquifer			
Kanoa 1	Waihee Aquifer			
Kanoa 2	Waihee Aquifer			
Kupaa 1	Waihee Aquifer			
Maui Lani 5	Kahului Aquifer	No	No	2005 operating agreement with Maui Lani Partners.
Maui Lani 6	Kahului Aquifer			
Maui Lani 7	Kahului Aquifer			

4.2.1.1 Ground Water Source

The CWRM updated statewide sustainable yields (SY) in the 2019 Water Resource Protection Plan (WRPP). Ground water wells supplying the Central District are located within the Wailuku Aquifer sector (Iao and Waihee Aquifer systems) and the Central aquifer sector (Kahului Aquifer system). The Iao Aquifer system has been designated as a ground water management area and GWUPs are required for withdrawal.

Table 29 outlines the SY for those systems, ranges identified between 2008 and 2019, and comments from the WRPP relevant to future ground water supply.

Table 29. Sustainable Yield – Central District				
Aquifer Sector	Aquifer System	SY Range	2019 SY	CWRM Comments
Wailuku	Iao	10-28	20	The SY for the Iao Aquifer system area was maintained at 20 mgd as this is believed to be the best estimate to date.
Wailuku	Waihee	6-23	8	The 1990 value is eight mgd. The correct value is six mgd. However, based on (1) current ground water demands within the system, (2) the fact that the eight mgd falls within the predicted range of SYs for the aquifer system, and (3) the presence of a deep monitor well within the system that will allow for long-term monitoring of the transition zone, CWRM elected to maintain the SY at eight mgd.
Central	Kahului	1-10	1	Represents SY under natural conditions, which ignores significant return irrigation recharge from East Maui. Kahului receives additional return irrigation recharge from Na Wai Eha diversions that is ignored. Upper range of SYs are more likely for current situation.

Source: CWRM Water Resources Protection Plan 2019 update, Table F-10.

Although not a designated ground water management area, withdrawal from the Waihee Aquifer has been voluntarily limited to four mgd by MDWS due to concerns raised by CWRM in 2004. Research has indicated that there could be a separation of ground water flows within the aquifer due to underlying geology, potentially increasing the impact of the MDWS wells concentrated within a small area of the aquifer.

The 2019 SY for the Kahului system is notable because it is so low, with total pumpage by all users at over 5,000 percent of SY (2019 WRPP). With cessation of sugarcane production, and implementation of interim instream flow standards (IIFSs) for East Maui streams, irrigation recharge to the Kahului system has decreased in recent years. Availability of ground water in this area will be further explored in Phase 3 of the EMFS.

4.2.1.2 Surface Water Source

Withdrawal of surface water at the Iao WTF is governed by a surface water use permit (SWUP). The Iao-Waikapu Ditch, which provides the source for the facility, is located within surface water hydrologic units designated by CWRM as part of the Na Wai Eha Surface Water Management Area (SWMA).

In 2021 CWRM established IIFS for the Wailuku River through the Na Wai Eha Decision & Order, detailing the amount of water permitted for use by MDWS at the Iao facility. Table 30 illustrates the Wailuku River flow, established IIFS, and amount of water available to MDWS under varying flow conditions.

Table 30. Wailuku River Flow and Allocations from 2021 CWRM Order			
Streamflow measured at USGS 16604500 (mgd)	IIFS (mgd)	MDWS Permitted Use (mgd)	Streamflow ranges 2002-2022
25 (Q_{50})	9.332	3.2	$Q > Q_{50}$ = 44%
17 (Q_{70})	9.332	3.2	Q_{50} to Q_{70} = 21%
12 (Q_{90})	7.827	2.684	Q_{70} to Q_{90} = 22%
11 (Q_{95})	7.153	2.453	Q_{90} to Q_{95} = 4%
8.4 (Q_{99})	5.398	1.851	$Q < Q_{95}$ = 9%

Source: Commission on Water Resource Management. CCH-MA15-01, pp. 301-302. July 2021.

Drought conditions correspond to the highest production demand and affect availability of source at the Iao WTF in the Central District. The MDWS is allocated 3.2 mgd at Q_{50} reducing to 2.684 mgd at Q_{90} for the Iao WTF. The final column of Table 30 reflects an analysis of the Wailuku River stream flows between 2002 and 2022 indicating that drought conditions (Wailuku River flows less than Q_{90}) were present on an average 13 percent of days, over that time.

In other words, for an equivalent 47 days of each year, the Iao WTF is subject to reductions in permitted diversion. It is also unclear whether withdrawal for the purpose of backwash maintenance volumes (approximately 0.1 mgd) will be excluded from this permitted use and effectively lost as production. For this analysis, it is assumed that backflow volumes which are returned to the river will be excluded.

The Na Wai Eha Decision & Order also found that there is a long-term downward trend in stream flows, and that climate change is destabilizing resource reliability. The impact of climate change on source water availability, including drought scenarios, will be explored further in Phase 2 of the EMFS.

4.2.1.3 Central District Source and Production Capacity

Total production capacity for the Central District is detailed in Table 31. The pump ratings correspond to information provided by MDWS, based on the installed equipment. "Permitted" production capacity reflects a limit which accounts for the GWUP or SWUP for those sources in the CWRM-designated management areas, and other agreements as detailed in the table footnotes. "Constrained" production capacity incorporates operational limitations associated with production at the source combined with the lesser of the pump rating or permitted capacity columns. The "16-hr" capacity numbers reflect the WSS requirement to meet MDD with 16-hours of runtime.

Table 31. Source Availability and Production Capacity Based on Permit Limits and Operational Constraints, Central District

Source Name	Source System	Pump rating (mgd)		Permitted Production Capacity (mgd) [a]	Constrained Production Capacity (mgd) [k]		Limitations and Constraints
		24-hr	16-hr		24-hr	16-hr	
Kepaniwai Well	Iao Aquifer – High Level Dike	0.720	0.480	0.791	0.720 [i]	0.480 [i]	Rated pump capacity and 2021 GWUP
Iao Tunnel	Iao Aquifer – High Level Dike	N/A	N/A	1.610	1.610	1.610	2021 GWUP
Iao WTF	Iao-Waikapu Ditch	N/A	N/A	3.200 [b]	2.500 [b]	2.500 [b]	CWRM SWUP, maintenance outages and source water availability
Mokuhau 1	Iao Aquifer – Basal	3.701	2.467	1.500 [g]	0.327 [e, h]	0.327 [e, h]	Chlorides and 2021 GWUP
Mokuhau 3	Iao Aquifer – Basal	5.969	3.979	2.353 [g]	2.353 [e]	2.353 [e]	2021 GWUP
Waihee 1	Iao Aquifer – Basal	4.032	2.688	6.800 [g]	6.800	6.800	Wellfield GWUP
Waihee 2	Iao Aquifer – Basal	3.917	2.611				
Waihee 3	Iao Aquifer – Basal	5.443	3.629				
Waiehu Heights 1	Iao Aquifer – Basal	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Waiehu Heights 2	Iao Aquifer – Basal	1.714	1.142	1.000 [g]	1.000 [e]	1.000 [e]	2021 GWUP
Iao Tank Site	Iao Aquifer – Basal	2.002	1.334	2.083	2.002 [f,i]	1.334 [f,i]	Rated pump capacity and 2021 GWUP
Waikapu Tank Site	Iao Aquifer – Basal	2.232	1.488	1.285 [g]	1.285	1.285	2021 GWUP

Table 31. Source Availability and Production Capacity Based on Permit Limits and Operational Constraints, Central District

Source Name	Source System	Pump rating (mgd)		Permitted Production Capacity (mgd) [a]	Constrained Production Capacity (mgd) [k]		Limitations and Constraints
		24-hr	16-hr		24-hr	16-hr	
Wailuku 1	Iao Aquifer – Basal	2.290	1.526	2.190	2.190 [f]	1.526 [i]	2021 GWUP
Wailuku 2	Iao Aquifer – Basal	2.160	1.440	1.852 [g]	1.852 [f]	1.440 [i]	2021 GWUP
North Waihee 1	Waihee Aquifer	1.584	1.056	4.000 [c,g]	4.000 [c,g]	4.000 [c,g]	CWRM "admin approval" for aquifer system (no formal agreement in place)
North Waihee 2	Waihee Aquifer	1.577	1.051				
Kanoa 1	Waihee Aquifer	1.771	1.181				
Kanoa 2	Waihee Aquifer	1.951	1.301				
Kupaa 1	Waihee Aquifer	1.670	1.114				
Maui Lani 5	Kahului Aquifer	0.763	0.509	1.200 [d,g]	1.200 [d,g]	1.200 [d,g]	2005 operating agreement with Maui Lani Partners, chlorides
Maui Lani 6	Kahului Aquifer	0.720	0.480				
Maui Lani 7	Kahului Aquifer	0.706	0.470				
Total				**29.864**	**27.839**	**25.850**	

Notes:

a. *CWRM WUP for all sources in Iao Aquifer; pump rating for all sources in Waihee Aquifer, and agreement with Maui Lani Partners for sources within the Kahului Aquifer.*

b. *Current WTP CWRM WUP maximum.*

c. *CWRM recommended limit for aquifer system.*

d. *2.16 mgd over 30 days, 1.44 mgd over 180 days, 1.2 mgd annual average, not pumped over 1.2.*

e. *Increasing chlorides with pumpage (MDWS, 2021).*

f. *Cannot serve South Maui due to transmission constraint.*

g. *16-or 24-hour pump capacity greater than wellfield agreement or WUP.*

h. *From current 12-month moving average for production.*

i. *Pump capacity less than WUP, therefore pump capacity used in calculation.*

j. *Drought scenario includes a reduction of Iao permitted production from 3.2 to 2.684 mgd at Q_{90} per CWRM IIFS.*

k. *Constrained capacities refined with MDWS operations, planning and engineering input during MDWS workshops held 01/26/23, 02/01/23 and 02/16/23.*

l. *Calibrated pump capacities provided by MDWS operations via email (2023).*

Constraints for the Central District which affect production include: (1) CWRM SWUPs and GWUPs, (2) operating agreement limitations for the Maui Lani wells, (3) CWRM-recommended aquifer system pumping limits, (4) operational considerations, (5) transmission bottlenecks, (6) drought/surface water availability, and (7) chloride levels.

In general, determination of overall source water availability for the Central District involves the following steps:

1. Summarize CWRM-approved pumping limits for the Iao Aquifer sources (ground and surface) subject to WUPs.
2. Add well capacity for non-permitted wells or well fields.
3. Adjust for known production capacity constraints outlined in Table 31.

4.2.2 Upcountry District

The Upcountry District is supplied by three surface water facilities and five ground water wells. Surface water accounts for 80 to 90 percent of Upcountry supply. Table 32 details production sources supplying the Upcountry District, along with the associated system and agreements in place related to the wells and WTFs. There are no CWRM-designated surface or ground water management areas associated with the Upcountry District.

Table 32. Source, Aquifers, and Agreements Permits – Upcountry District

Source Name	Aquifer System	Permits/Agreements
Kamole WTF	Haiku, Honopu and Waikamoi Aquifers -Wailoa Ditch	EMI agreement and IIFS.
Olinda WTF	Haiku, Honopu and Waikamoi Aquifers - Waikamoi, Puohokamoa, and Haipuaena Streams	EMI agreement.
Piiholo WTF	Haiku, Honopu and Waikamoi Aquifers - Waikamoi, Puohokamoa, Haipuaena, and Honomanu Streams	EMI agreement.
Pookela	Makawao Aquifer	None.
Kaupakalua	Haiku Aquifer	None.
Haiku	Haiku Aquifer	None.
Hamakuapoko 1	Paia Aquifer	Emergency only - use limited to water shortage declaration, or backup per MCC 14.01.050.
Hamakuapoko 2	Paia Aquifer	Emergency only - use limited to water shortage declaration or backup per MCC 14.01.050.

4.2.2.1 Ground Water Source

Five ground water wells serve the Upcountry District, with some operational and regulatory limitations for transport between the three upcountry systems.

The CWRM updated statewide SYs in the WRPP. Ground water wells supplying the Upcountry Maui District are located within the Central and Koolau aquifer sectors (Paia, Makawao, and Haiku aquifer systems).

Table 33 outlines the SY for those aquifer systems, ranges identified between 2008 and 2019, and comments from the WRPP relevant to future ground water supply.

Table 33. Sustainable Yield – Upcountry District

Aquifer Sector	Aquifer System	SY Range (mgd)	2019 SY (mgd)	CWRM Comments
Central	Paia	7-33	7	Represents SY under natural conditions, which ignores significant return irrigation recharge from East Maui. Upper range of sustainable yields are more likely for current situation.
Central	Makawao	7-25	7	No comment (unchanged from 2009 SY).
Koolau	Haiku	24-31	24	No comment (reduced from 2008 SY of 27 mgd).

Source: CWRM Water Resources Protection Plan 2019 update, Table F-10.

In contrast to the Central District, all three aquifers are relatively undeveloped, with the 12-month pumpage mean average value in 2016 ranging between three and seven percent (2019 WRPP). Future availability of ground water in this area will be further explored in Phase 3 of the EMFS.

4.2.2.2 Surface Water Source

The MDWS relies on three surface water sources, accounting for approximately 80 to 90 percent (13 mgd) of water delivered through the system. One is delivered by East Maui Irrigation Company (EMI) through the Wailoa Ditch, and the other two through two MDWS higher-elevation aqueducts maintained by EMI that transport water to the Olinda and Piiholo WTFs; via a contractual agreement originating under the East Maui Water Agreement and subsequent amendments (CWRM, p. 211).

- **Upper Kula System**. The Olinda facility diverts water from the Waikamoi, Puohokamoa, and Haipuaena streams. Water is stored in the 30-million-gallon (mgal) Waikamoi Reservoirs (two, at 15 mgal each) and the 100-mgal Kahakapao Reservoirs (two, at 50 mgal each).
- **Lower Kula System**. The Piiholo facility diverts water from the Waikamoi, Puohokamoa, Haipuaena, and Honomanu streams into the 50-mgal Piiholo Reservoir.
- **Wailoa Ditch**. The Kamole-Weir facility, which has no raw water reservoir, relies on water from the Wailoa Ditch. Average daily withdrawal by the MDWS from the Wailoa Ditch includes water processed by the Kamole WTF and non-potable water for the Kula Agricultural Park (KAP). The KAP is fed by the Hamakua Ditch, an extension of the Wailoa Ditch. Wailoa Ditch supply to MDWS is subject to maintenance of IIFS as outlined int the CWRM 2018 Order.

The variability in production of the surface water facilities is evident when looking at the annual average daily production by the three WTFs. Figure 32 illustrates the average daily production by the Upcountry WTFs from 2010 through 2020, as well as the average for the 11-year period for each facility.

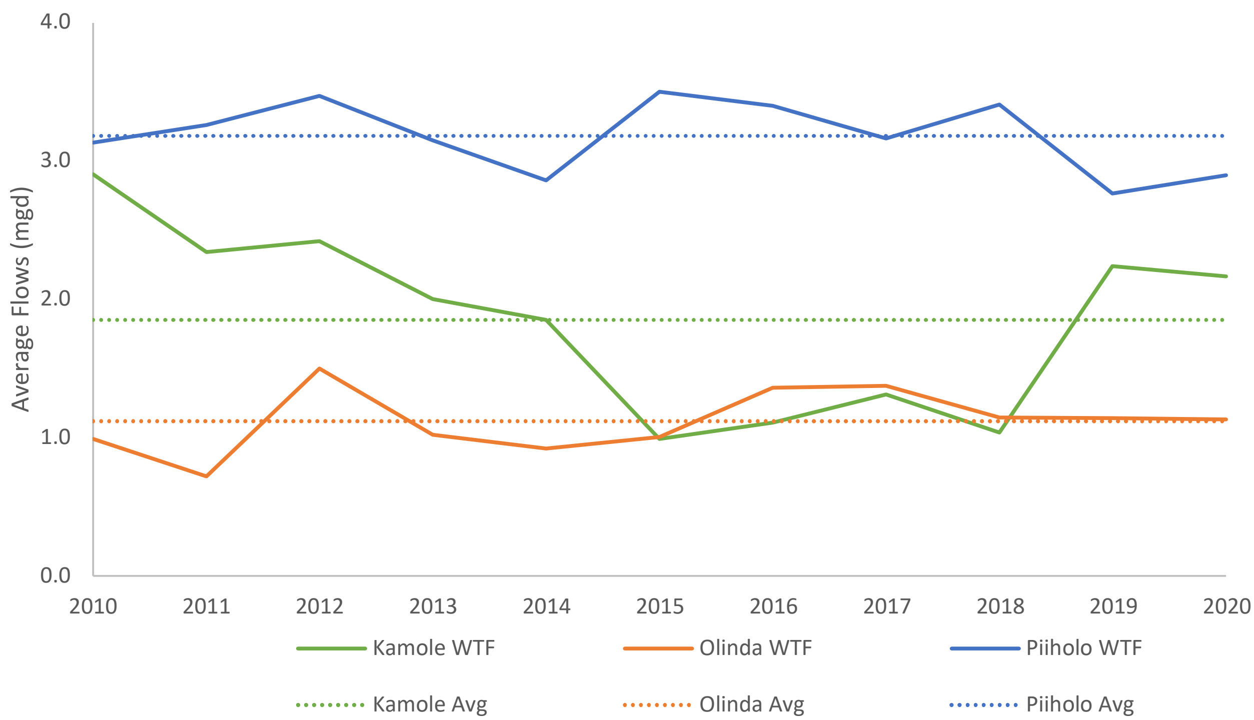

Figure 32. Upcountry WTF Daily and Average Flows 2010-2020

While the average production reflects overall water produced to meet demand, deviation from the annual average of the maximum and minimum production over the 11-year analysis illustrate the highly variable nature of Upcountry water production from surface water sources. The extent of this variation is reflected in

Table 34, with the Kamole WTF showing the greatest variability (+57 percent to -47 percent), followed by Olinda and Piiholo WTFs.

Table 34. Variation in Average Daily Production 2010-2020 - Upcountry (mgd)					
Facility Name	Max	Min	Avg	Deviation of Max/Min from Average	
Kamole WTF	2.90	0.99	1.85	+57%	-47%
Olinda WTF	1.50	0.72	1.12	+34%	-36%
Piiholo WTF	3.50	2.77	3.18	+10%	-13%
Total Surface Water	7.39	5.49	6.15	+20%	-11%

4.2.2.2.1 Flows in Wailoa Ditch and raw water availability at the Kamole WTF

Currently, source associated with the Wailoa Ditch and Kamole WTF is subject to IIFS and additional consideration of other off-stream users as outlined in the 2018 Decision & Order (2018 D&O).

The water available over the 1984-2013 period at the Koolau/Spreckels/Wailoa Ditch elevation from Nahiku to Maliko gulch, estimated from record augmentation, modeling, and seepage gains prior to the 2018 D&O, had a Q_{50} of approximately 168 cubic feet per second (ft^3/s) (109 mgd), a Q_{75} of approximately 85 ft^3/s (55 mgd), and a Q_{90} of approximately 53 ft^3 /s (34 mgd).

A 2022 CWRM report on Low-Flow Characteristics and Surface Water Availability in East Maui estimated flows for the Wailoa Ditch using mean daily flow at continuous-record ditch-flow gaging stations and subtracting out mean daily flow from streams with continuous-record gaging stations. Following implementation of IIFS under the 2018 CWRM Order, Wailoa Ditch at Maliko is estimated to have a Q_{50} flow of 69 mgd, a Q_{75} flow of approximately 48 ft^3/s (31 mgd), and a Q_{90} flow of 17 mgd (CWRM 2022. p. 54). This means that ten percent of the time, less than 17 mgd is estimated to be available in Wailoa Ditch.

Under the current agreement between MDWS and EMI, MDWS has an allotment of 12 mgd of water from Wailoa Ditch, with an option for an additional four mgd. During periods of low flow, each party has a minimum allotment of 8.2 mgd. Per the agreement, when the ditch flow drops below 16.4 mgd, each share decreases. Based on the estimated Q_{90} flow of 17 mgd, about ten percent of the time MDWS would have access to less than 8.2 mgd from Wailoa Ditch.

As outlined int the EMI agreement, when the three-day average flow in the ditch falls below 55 mgd, MDWS “shall fully utilize all available ground water sources to supplement the Upcountry system and encourage conservation practices by domestic water users.”

The maximum amount of water that can be awarded through a Water Lease is what is available for diversion after implementation of the IIFS, set in the 2018 CWRM Order. Recent events associated with the 2018 CWRM Order affecting the Wailoa Ditch include:

- In October 2019 the Board of Land and Natural Resources (BLNR) limited EMI diversions to 45 mgd.
- In November 2020, EMI noted that approximately 27.79 mgd, 22.60 mgd, and 18.9 mgd of water was diverted during the first, second, and third quarters, respectively.
- Considering the above, in July 2021, a First Circuit Court judge cut EMI’s permitted water diversions to 25 mgd so as not to “waste” the balance of EMI’s unused 45 mgd allocation.
- In April 2022, the Environmental Court further lowered the amount to 20 mgd until the BLNR decides on a contested case over the 2021 and 2022 revocable permits.

Table 35 provides an historic summary of available flows resulting from implementation of IIFS and subsequent BLNR and Court actions.

Table 35. Water Availability in Wailoa Ditch

Time Period	Flow (mgd)		
	Q_{50}	Q_{75}	Q_{90}
1984-2013	109	55	34
After 2018 D&O	69	31	17
After 2019 DLNR	45	31[a]	17[a]
After 2021 Judgement	25	25[b]	17[a]
After 2022 Judgement	20	20[b]	17[a]

Notes:

a. *Assumes the continued availability of flows in accordance with the 2018 D&O under low flow conditions, as Q_{75} (31 mgd) and Q_{90} (17 mgd) flows are less than the allowable flow resulting from the 2019 BLNR decision and the 2021/2022 judgements.*

b. *Assumes reduction in flow in accordance with the 2021/2022 judgements under low flow conditions, as Q_{75} flows (31 mgd) are greater than the allowable flow resulting from judgements (25 mgd and 20 mgd).*

Table 35 outlines the impact of ongoing court action to Wailoa Ditch source water availability. Previous analyses have been performed looking into reliable capacity (Brown and Caldwell 2014), and reservoir sizing at Kamole (2019 WUDP) considering the impact of predicted ditch flow reductions as a result of establishing IIFS, and an update of these studies is recommended.

4.2.2.2.2 Flows in Upper and Lower Kula and Raw Water Availability at the Olinda and Piiholo WTFs

The 2022 CWRM report also estimated flows for the Upper Kula System by modeling total flow diverted from the three main sources: (1) Haipuaena Stream, (2) Middle Branch Puohokamoa Stream, and (3) Waikamoi Stream. According to the report, the Upper Kula System has an estimated Q_{50} flow of 0.56 mgd and Q_{90} flow of 0.07 mgd.

The water diverted at any single stream via the Lower Kula System can be modeled for the calendar years 1920 to 1926, with flow duration statistics adjusted to the 1984-2013 period. Supply for the Lower Kula System and Piiholo Reservoir has an estimated Q_{50} flow of 8.85 mgd and Q_{90} of 1.75 mgd (CWRM, 2022).

Figures 33 and 34 were derived from daily reservoir level and plant production data between June 30, 2020, and October 31, 2022. Over that 29-month period inflow and outflow associated with the Waikamoi and Kahakapao reservoirs (Figure 33) was highly variable, with four periods of both zero production from the Olinda facility (as indicated by the arrows on the figure) and many periods of zero inflow into the reservoirs (as shown by the jagged top edge of the reservoir level data set). In contrast, over the same period, the Piiholo WTF had two periods of zero production (Figure 34), with the reservoir inflow levels tracking very close to the rate of production.

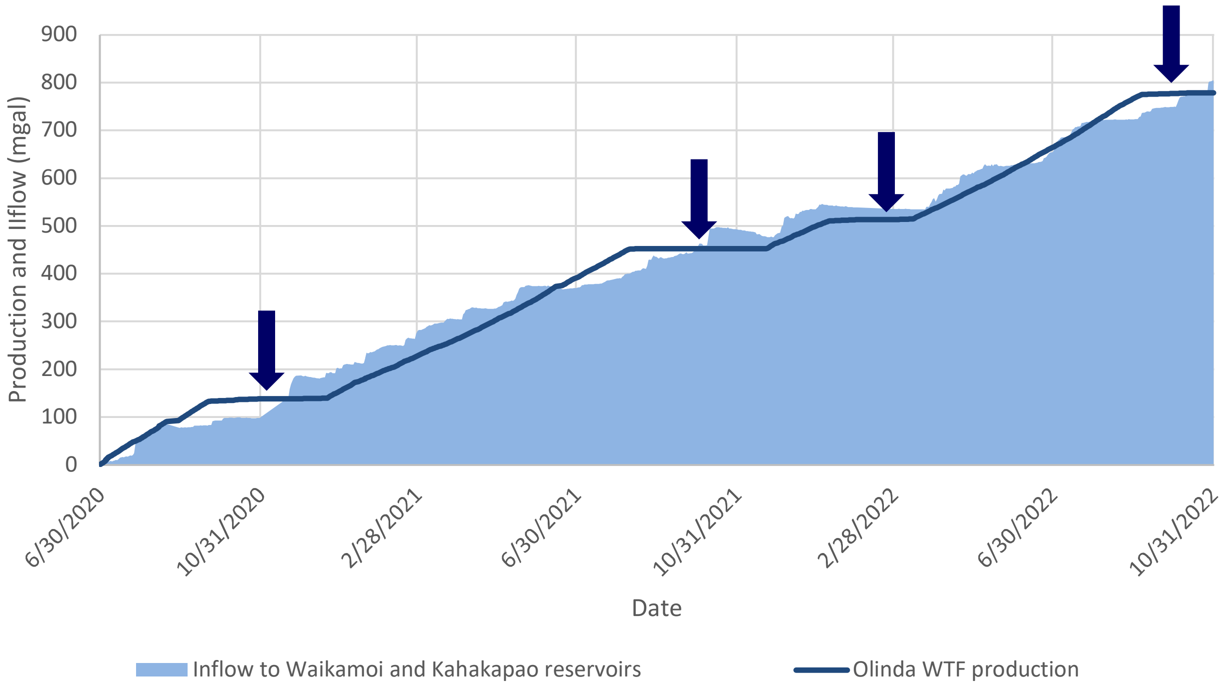

Figure 33. Olinda WTF – Cumulative Production and Inflow Variability 2020-2022

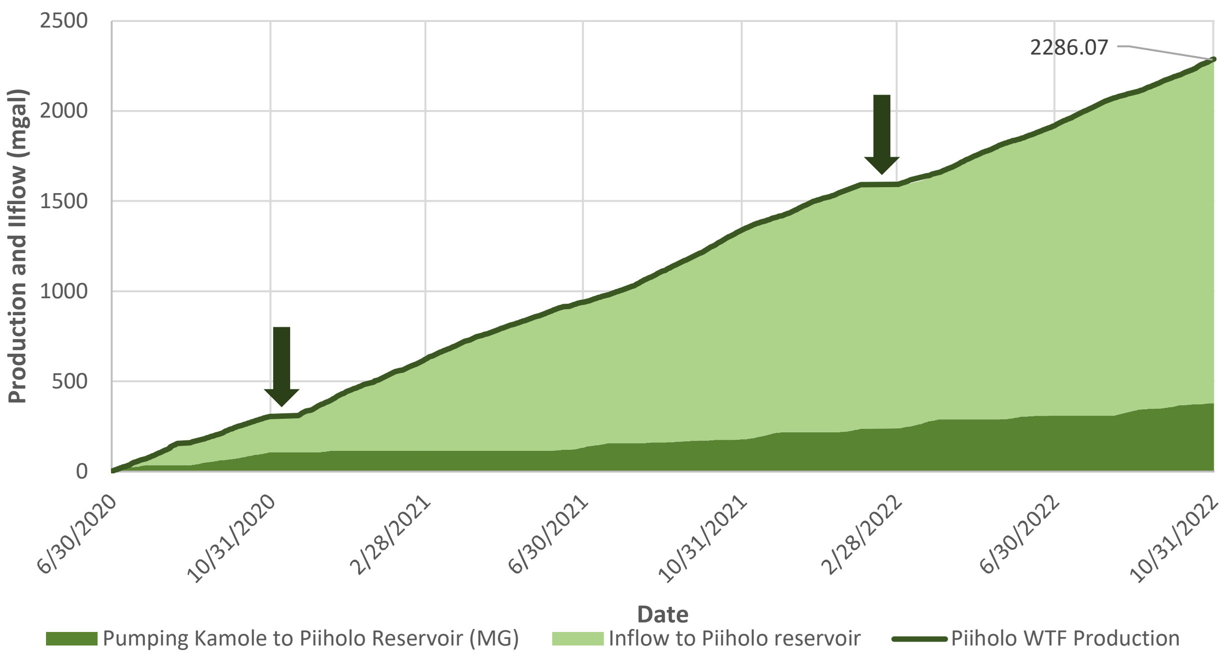

Figure 34. Piiholo WTF – Cumulative Production and Inflow Variability 2020-2022

Table 36 provides a summary of the Upper Kula and Lower Kula inflow capacity analysis conducted with daily flow data over the same period.

Table 36. Olinda and Piiholo WTFs' Supply Analysis from 06/30/2020 to 10/31/2022						
WTF	Average reservoir levels (mgal)[a]	Average inflow to reservoirs from streams and precipitation (mgd)[b]	Percent days where inflow from streams and precipitation = 0	Average inflow to reservoir from Kamole WTF (mgd) [c]	Average WTF production (mgd)	Percent days where inflow from streams and precipitation is less than average WTF production
Olinda	80.7 (62%)	1.0 - 1.2	37%	N/A	1.0	72%
Piiholo	41.7 (83%)	2.4 - 2.5	3%	0.5	2.9	66%

Notes:

a. *Average reservoir levels for the Olinda WTF reflect the total of the two Waikamoi and two Kahakapao reservoirs, which have a combined capacity of 130 MG. Average reservoir levels for Piiholo WTF reflect the Piiholo Reservoir, total capacity 50 mgal.*

b. *Calculated by adding WTF production to change in reservoir volume (and subtracting pumpage from Kamole WTF to Piiholo reservoir). There are some days with "negative" net inflow, reflecting system losses upstream of the WTF. Causes may include evaporation, exfiltration, or raw water diversion.*

c. *Only the Piiholo Reservoir receives supplemental flow from Kamole WTF.*

Based on changing reservoir levels, the number of days with zero inflow from streams and precipitation was very low for the Piiholo supply system (three percent), but common for Olinda supply system (37 percent) over the analysis period. Notably, daily inflow was less than the average WTF production during a significant portion of time for both Piiholo and Olinda WTFs (66 and 72 percent, respectively).

This indicates that raw source water availability is a limiting factor in WTF production. In addition, when large freshet flows are received at the reservoirs, the raw water turbidity levels can exceed WTF specifications and water cannot immediately be treated. Both WTFs are operating at less than their nominal production capacity, likely due in part to the inconsistent availability of raw source water.

At 2.5 mgd, inflow to the Piiholo reservoir appears to be significantly lower than the estimated Q_{50}, indicating limitations associated with the capacity of the raw water transmission system between the stream diversion and Piiholo reservoir.

Olinda WTF appears to be producing as much as delivered by source. While the Upper Kula System has an estimated Q_{50} flow of 0.56 mgd and Q_{90} of 0.07 mgd, this likely underestimates the inflow as evidenced by the Olinda WTF production.

4.2.2.3 Upcountry District Source and Production Capacity

Surface water and ground water production capacity for the Upcountry District is detailed in Tables 37 and 38.

- For the surface water facilities listed in Table 37, theoretical available raw water supply and practical available raw water supply reflect the discussion in Section 4.2.2.2.
- Nominal capacity reflects a sustainable treated water production level that accounts for necessary unit downtimes due to the need for regular backwashing, maintenance, repairs, and equipment longevity. Nominal capacity assumes unlimited raw water source with turbidity and other water quality parameters within equipment specifications and does not account for periods of total plant shutdown.
- "Constrained" production capacity for the WTFs incorporates operational limitations associated with production at the source and is the lesser of practical raw water availability and nominal capacity.

Table 37. Source, Production, and Limitations – Upcountry District WTFs							
WTF	Source	Theoretical Available Raw Water Supply (mgd)	Practical Available Raw Water Supply (mgd)	2020 Production (mgd)	Nominal Capacity [g] (mgd)	Constrained Production Capacity [h] (mgd)	Comments on Constraining Source/Production Factors
Kamole	Wailoa Ditch	12 – 16[a]	6.7[b]	2.17	4.87	4.87	• Plant production is limited by source availability, variability, turbidity and raw water storage. • Supply per EMI agreement.
Olinda	Streams feeding Waikamoi/Kahakapao reservoirs via collection pipelines/flume	0.56[d] - 1.1[e]	1.1[e]	1.13	2.27	1.1[e]	• Plant production is limited by source availability and variability.
Piiholo	Streams feeding Piiholo reservoir via collection pipelines	2.4[c] - 8.85[d]	2.4	2.90[f]	5.99	2.4	• Plant production is limited by source availability and variability. • Source availability may be limited by raw water collection system.
Upcountry Surface Water Total (Constrained Capacity)[b]						8.37	

Notes:

a. *12 mgd per current EMI agreement, with the ability to add additional four mgd, except under drought conditions.*

b. *Assumes supply to KAP of 1.5 mgd. Per EMI agreement for flows less than 16.4 mgd, below which EMI and MDWS experience proportional reduction in flow. This approximately corresponds to the post-IIFS Q_{90} flows of 17 mgd while supplying KAP at 1.5 mgd. The Upcountry total value reflects the total capacity of all potable water sources only and for that reason KAP has been intentionally omitted.*

c. *Corresponds to average inflow to reservoir from 6/20 through 10/22, when discounting inflow pumped from Kamole.*

d. *Struach, 2022 estimate of Q_{50} flows for Upper and Lower Kula System.*

e. *Average Olinda WTF production, 2010-2020.*

f. *Includes an additional 0.5 mgd pumped from Kamole to the Piiholo reservoir.*

g. *Nominal capacity reflects a operational production capacity that accounts for necessary unit downtimes for backwash, maintenance and repair, etc. Reference: Water Treatment Plants Division email 07/07/2022 and Production Data Constraints.xls worksheet 11/30/2021.*

h. *Constrained capacities refined with MDWS operations, planning and engineering input during MDWS workshops held 01/26/23, 02/01/23, 02/16/23 and 03/01/23.*

Summarizing the constrained production capacity for each of the facilities results in a total production capacity of 8.37 mgd from surface water.

An additional constraint not reflected in Table 37 is the WSS 111.04 requirement that demands for surface water systems not exceed 80 percent of the average daily flow from the source. Both the Upper and Lower Kula systems are classified as surface water systems. It is unclear from the WSS whether “the source” can be inclusive of redundancy provided via interconnection between systems and by ground water wells that can serve the Upper and Lower Kula systems. This source availability analysis was performed at a District level, and the 80 percent criteria is not currently taken into account when operating the systems. It is recommended that additional investigation undertaken to determine the need for compliance with the WSS at the system level.

Table 38 outlines the ground water production and associated constraints for the Upcountry wells.

Table 38. Source, Production and Limitations – Upcountry District Wells					
Source	Aquifer System	Pump Rating (mgd)		Constrained Production Capacity (mgd) [a]	Use, Limitations and Constraints
		24-hr	16-hr		
Pookela	Makawao Aquifer	1.296	0.864	1.296	• Can supplement Makawao (concern with water chemistry differences), as well as Lower and Upper Kula systems. • Run when surface water not available, can run 24-hrs due to A and B well redundancy. • Power quality and availability - utility power agreement limits pump starts. • No backup power
Kaupakalua	Haiku Aquifer	2.016 [c]	1.344 [c]	0.6 [b]	• Limited to existing service area (Haiku), cannot run 24-hrs due to wellsite reservoir storage limitation and service area demand. • No backup power
Haiku	Haiku Aquifer	0.504 [c]	0.336	0.336	• Limited to existing service area (Haiku), cannot run 24-hrs due to wellsite storage limitation and service area demand. • No backup power
Upcountry Ground Water Total		**3.816 [c]**	**2.516 [c]**	**2.232**	
Hamakuapoko 1	Paia Aquifer	0.720	0.480	0.480	• Use limited to water shortage declaration. Must currently run through wellsite GAC and then be treated at Kamole before entering potable system due to DOH requirements.
Hamakuapoko 2	Paia Aquifer	0.720	0.480	0.480	
Ground Water Total (Including Emergency)		**5.256 [c]**	**3.476 [c]**	**3.192**	• Total use limited to water shortage declaration

Notes:

a. *Constrained capacities refined with MDWS operations, planning and engineering input during MDWS workshops held 01/26/23, 02/01/23, 02/16/23 and 03/01/23.*

b. *Refelcts 2020 MAV.*

c. *Not operationally achievable due to current inability for Kaupakalua and Haiku wells to supply outside service area.*

Pump ratings detailed in Table 38 correspond to information provided by MDWS, based on the installed equipment. The “16-hr” capacity numbers reflect the WSS requirement to meet MDD with 16-hours of runtime. Because of transmission and wellsite storage limitations at Kaupakalua and Haiku wells, the constrained production capacity for Upcountry groundwater is less than the “16-hr” capacity.

The Hamakuapoko wells are listed for illustration purpose only. At this time, per MCC, the wells are only available for use during times of water shortage and therefore considered as “backup” with production capacity assumed to be brought online only to replace capacity lost due to reduced production by the WTF or other wells. In addition, flow from the Hamakuapoko wells must, per DOH requirements, be run through the Kamole WTF before entering the potable system due to lack of flow monitoring and disinfection at the wells.

Table 39 provides a summary of the total Constrained Production Capacity for the Upcountry District.

Table 39. Constrained Production – Upcountry District	
Source	Constrained Production (mgd)
Upcountry Ground Water Total	2.232

Table 39. Constrained Production – Upcountry District	
Source	Constrained Production (mgd)
Upcountry Surface Water Total (Constrained Capacity)	8.370
Upcountry Total (Excluding Emergency)	**10.602**

4.2.3 Factors Influencing Water Production

Resilience reflects the ability of systems to withstand and continue to perform after damage or loss of infrastructure. Resilience is built into the ground water production system by the WSS, which for Maui requires the MDD be met with a pump operating time of 16 hours. Resilience is also built into both the Upcountry and Central systems with sources diversified between ground water and surface water supplies.

Redundant equipment, storage, and operational options such as alternate transmission pathways and backup power also contribute. Additional resilience will be needed in the future for the MDWS systems as impacts on water supply due to a changing climate become more acute and growth in the service areas necessitate the use of previously redundant options as everyday strategies for service.

This TM focuses on the amount of source that needs to be available to meet projected future demand. Determining where that source will come from (ground water, surface water, conservation measures, desalination, or integrated sources such as utilization of recycled wastewater effluent) or capital improvements necessary to take full advantage of available source (such as transmission and storage) is beyond the scope of this TM.

While drought is discussed in the context of supply availability and reliability, Phase 2 and Phase 3 of this project will investigate new source development options and the impact of a changing climate on the Upcountry and Central Districts.

Many factors influence the ability of a utility to produce water. A workshop was held with MDWS engineering, operations, and administration personnel on February 7, 2022, where factors affecting reliability for MDWS Central and Upcountry systems were identified by the attendees. Those factors are summarized in Table 40.

Table 40. Reliability Factors from 02/07/2022 Workshop	
Factor	Comments
Source Availability	To provide reliability, there must be more source available than there is demand.
Redundancy	The more redundancy provided in the system components, the more options to handle upset conditions and planned outages for maintenance and construction. Examples include redundant wells, backup generators, backup chlorinators, more storage, etc.
Interconnectivity	The more that systems are or can be interconnected, the more resiliency the system will have, allowing the ability to cross feed areas from different sources as an additional backup option. This can also apply to connection with a private utility, if necessary and available. Differing water chemistry between the Upcountry systems affects interconnection.
Surface Water versus Ground Water	Surface water is less reliable than ground water. On Maui overall, surface water treatment plants and ground water wells contribute 30 and 70 percent of the total supply, respectively. The Upcountry district is an exception, where surface water contributes 90 percent. Insufficient ground water source has been developed to back up the large surface water treatment plants in the Upcountry District.
Skilled Operations Staff	The ability to quickly adjust when needed, to ensure continued system performance and supply to customers, is largely dependent on skilled operations staff.
Cost	There is a trade-off between realizing improvements in system reliability and the cost needed to fund the projects that accomplish this. At some point, there is a need to decide whether an incremental improvement in capacity is worth the investment. This is especially difficult regarding the addition of redundant source alternatives that would not be actively used (i.e., on standby) for most of the year.

Table 40. Reliability Factors from 02/07/2022 Workshop	
Factor	**Comments**
System Constraints and Limitations	Changing water quality conditions (such as increasing chlorides with groundwater pumpage), physical constraints (such as the Kihei transmission line bottleneck), and regulatory limitations (such as WUPs) affect the ability of a system to deliver water.
Susceptibility to Extremes in Weather	Both droughts and storms can affect the water supply reliability.
Operational Constraints	Limitations due to operational constraints such as maintenance requirements, backwash, and equipment downtime must be considered in evaluating reliability.

4.2.4 Water Shortages

According to MCC Chapter 14.06A, 050 and .060:

> *"The director, with approval of the mayor, may declare a water shortage whenever the water supply becomes inadequate in any area in the County or County water system because of a period of drought, an infrastructure or mechanical malfunction, natural disaster, or other event causing a water shortage."*
>
> *"Prior to declaring a water shortage, the director shall consider the following: (1) Current and predicted weather patterns. (2) Reservoir water levels. (3) Surface water flow. (4) Current and predicted water usage. (5) Operational status of water production facilities."*
>
> *"A stage 1 water shortage shall exist if the director determines that anticipated water demand in an area is projected to exceed available water supply by one to fifteen percent."*

Table 41 details the water shortage declarations affecting the Upcountry District since 2017.

Table 41. Upcountry Water Shortage Declarations – 2017-2023			
Start	**End**	**Number of Days**	**Stage**
June 30, 2022	Still in effect July 1, 2023	365+	1
July 2, 2021	October 22, 2021	112	1
September 8, 2020	November 27, 2020	80	1
May 24, 2019	January 6, 2020	227	1
July 18, 2017	October 25, 2017	94	1
April 9, 2017	May 1, 2017	27	1
	Total days 2017-2022	905+	

Source: https://www.mauicounty.gov/1085/Upcountry-Water-Levels

Between January 1, 2017, and July 1, 2023, there have been six water shortage declarations issued for Upcountry Maui. A shortage was in effect for more than 905 days, or 38 percent of those six years indicating a lack of supply to meet anticipated demand. Prior to these declarations, Upcountry residents were asked to voluntarily decrease water usage by ten percent for nearly two and a half years between September 2014 and February 2017.

The changing climate will have further effect on future water supply. An increase in the frequency and intensity of extreme weather events, including drought-induced water shortages, will affect both surface water quality and supply and ground water recharge. Drought and other climate impacts associated with the Central and Upcountry Districts will be analyzed further as part of Phase 3 and Phase 4 of the EMFS.

4.2.5 Reliable Capacity

In 2007, Ordinance 3502 passed, creating Chapter 14.12 of the MCC on Water Availability. The MCC requires the director to provide "verification of a long term, reliable supply of water" confirming that source and will be provided for new County water meter reservations.

In 2018, the County of Maui Administrative Rules (MAR Title 16, Ch 201 "Rules Relating to Water Service") was amended to include a definition of maximum reliable capacity.

> *"'Maximum reliable capacity' means the volume of water that the department determines can be reliably produced on an ongoing basis in any given department water system. Such value shall be based on engineering principles and shall take into account various uncertainties, including but not limited to, mechanical failures, human error, and weather events. Transmission and storage infrastructure are not evaluated for this determination."*

The MDWS relies on this definition when determining whether and how much water is available to accommodate additional development (i.e., water service requests). The distinction between ***reliable capacity*** and ***source availability*** is noteworthy. Reliable capacity is calculated by MDWS annually, to determine whether and what type of service requests can be approved each year. Discretion is provided to the Director and Engineering Division for adjustment of this calculation based on current conditions. Source availability, in contrast, reflects water supply available to meet the needs of the County over a long-term horizon, and the information is utilized to plan for development of sufficient water supply to meet those needs.

The methodology for determining reliable capacity currently differs for every County water system, based on the unique conditions of each. The calculated value for ***maximum reliable capacity*** for any given year builds on reliable capacity and allows flexibility for the Director and Department to respond to changing, unanticipated, and often uncontrollable conditions. Inherent in calculation of reliable capacity is consideration of system operability (using realistic production numbers), and resiliency (frequently represented by deduction of all or some production from a critical source from the total to accommodate a planned or unexpected outage).

Table 42 reflects the complexity of determining reliable capacity for the Upcountry District. Two options are presented which consider system operability and resiliency redundancy of the overall District. Reliable capacity is calculated based on the constrained production capacities presented in Section 4.2.2, subtracting either the facility with the largest constrained production capacity (Kamole WTF) or largest 2020 production (Piiholo)and adding in the emergency capacity of the Hamakuapoko wells as appropriate.

Table 42. Reliable Capacity – Upcountry District Example for 2020

Source	Production (mgd)	
Upcountry constrained production capacity (excluding Emergency Wells)	10.602	10.602
Remove facility with largest constrained capacity (Kamole) or largest 2020 production (Piiholo)	-2.9 [a] (Piiholo)	-2.17 [a] (Kamole)
Add Emergency Wells [b]	+1.44	N/A
Total Reliable Capacity	**9.142**	**8.432**

Notes:

a. *Reflects 2020 production.*

b. *Currently, the Hamakuapoko Wells must be run through Kamole prior to entering potable system per DOH due to disinfection and flow measurement requirements. Therefore, until modifications are made to the system, this source is not available to supplement the Upcountry potable water system when Kamole is fully offline.*

Note that by using this methodology for calculating reliable capacity for the Upcountry District, the addition of any source would have a direct effect on the Upcountry District reliable capacity. Adding new ground water wells would increase reliable capacity by the amount of well production. Further, increasing raw water availability (via additional storage or raw water transmission between the source streams and reservoirs at Piiholo) would similarly increase production at the Piiholo WTF and increase reliable capacity in the event of the largest capacity facility (Kamole WTF) being out of service.

Reliable capacity can be increased by: (1) addressing constraints which limit existing production, (2) developing new source, (3) adding resiliency through interconnections, storage, and operational flexibility, and (4) increasing knowledge of system behavior via tools such as a hydraulic model.

Reliable capacity for the Central and Upcountry systems is being investigated further in a separate report.

4.2.6 Impact of Politics, Policy, and Unpredictability

The current MAR definition of reliable capacity leaves room for discretion in calculating and allocating source availability. This discretion allows MDWS the flexibility to accommodate unexpected shortages in water availability such as increased demand and decreased availability during times of drought, and unanticipated outages due to extreme weather events or equipment malfunction.

The MDWS has not currently defined or published “Levels of Service” goals and/or “Key Performance Indicators” related to the impacts of source availability. As a result, policy and operational decisions can affect system users.

For example, when field operations’ staff are required to adjust overall water movement due to a water shortage, valve positions may change and deviate from the original design. In addition, maintaining service may involve additional costs associated with pumping over longer distances or relying less on gravity flow. Consideration must be given to both operational and financial factors, which have potential to affect customer water service pressure and availability.

Policy decisions by elected officials and other departments may also affect how water is allocated and used. There can be a geographic disconnect between where development occurs and where source is available, and water earmarked to supply affordable housing or other uses becomes unavailable for allocation elsewhere – affecting current users. In addition, public perception can influence decisions for water use.

Regulatory requirements and community input can also impact system operations. The Hamakuapoko wells, for example, have detectable levels of legacy pesticides from pineapple production. While this contaminant can be removed using granular activated carbon (GAC) filters, and that process is utilized elsewhere on Maui (in Lahaina) and Oahu, the Hamakuapoko wells are not generally utilized for emergency backup for the Upcountry potable water systems, as intended.

In Hawaii, water is held in public trust, with multiple agencies having jurisdiction. Legislative activities can result in code changes and affect water availability at the County level. One notable example is Ordinance 5313, which was recently passed, allowing exemption from the MCC, Chapter 14.12 Water Availability rules for new development by the DHHL. In addition, through the establishment of IIFS by CWRM, designation of the Iao aquifer as a Water Management Area, and the Decision and Order for the Nai Wai Eha Contested Case has changed the surface and ground water allocations for all users.

A Water Master Plan and island-wide hydraulic model would identify levels of service and deficiencies and outline a long-term Capital Improvement Program for utility-wide upgrades to develop supply to meet maximum daily demand well in advance of need. Some benefits of developing this comprehensive plan, are to document policy and strategy, and provide a roadmap for system management over the long term.

4.2.7 Upcountry District Summary Recommendations

Development of additional ground water source, construction of raw water reservoirs to store water and offset periods of low surface water availability or upgrading the raw water transmission systems to convey additional raw water collected upcountry is needed, to ensure consistent supply is available to serve the Upcountry District and fully utilize the surface water sources. It is anticipated that these strategies will be further explored in Phase 3 of the EMFS.

For Wailoa source, continued daily monitoring of ditch flows and precipitation, and changing ditch operating conditions (i.e., restricting/returning ditch and stream flows) is recommended for further study of the impact of implementation of IIFS on water availability for MDWS.

Although outside the scope of this study, the following recommendations have been identified through the course of the investigation:

- Operational changes such as pumping from Kamole to supplement upper elevation reservoirs levels during dry months could enhance supply.
- At the wells, investment in backup or alternate power to mitigate electric utility fluctuations, additional wellsite storage to accommodate pumpage in excess of immediate service area demand, and infrastructure to allow flow from Kaupakalua and Haiku wells to supply other Upcountry service areas could enhance District resilience. Further investigation is recommended to determine the impacts and feasibility of these strategies.
- An overall review of the 2002 WSS by MDWS is recommended, specifically the pumping and surface water demand limits (§ 100.111.08 and § 100.111.04).

4.3 Accommodating Demand Projections

Water systems require source capacity to provide adequate quantity and pressure to customers under MDD conditions. In addition, there should be excess supply to provide resiliency for the systems to serve customers in the event of a source water interruption or emergency. A supply-to-demand ratio is a target established by many water utilities to ensure system resiliency and maintain service levels during upset conditions.

While storage, transmission infrastructure, and interconnections also need to be in place to ensure continuous supply, implementation of a similar target would be a first step in ensuring the ability of MDWS to provide adequate quantity and pressure to customers in the event of a source water interruption or emergency. It is recommended that a strategy be established to achieve and ultimately maintain this ratio as demand increases over time.

Although a requirement in states such as California (i.e., 22 California Code of Regulations [CCR] § 64554), Hawaii regulations are limited in detailing the amount of source needed as it relates to demand for surface and ground water systems. Ideally, systems should have source and raw water storage available to meet MDD, with long term planning documentation in place to guide source development and accommodate future growth. This TM assumes that sufficient source should be available to reliably meet MDD.

4.3.1 Current Production and MDD

Monthly production information was available for this analysis. The relationship between average day demand (ADD), maximum month (MM) and maximum day demand (MDD) is important in establishing future source requirements. MDD can be estimated using monthly production data in different ways:

1. By identifying the month with the highest water usage (MM) during recent years of operation, calculating the average daily demand (ADD) in that month, and multiplying that by a peaking factor of 1.5. As this method is conservative, it overestimates MDD on Maui, based on analysis.
2. By multiplying the ADD calculated from the annual production numbers by 1.5. This appears to be representative of conditions in the Central and Upcountry Districts and is used in this analysis.

Table 43 details historic production for the Central and Upcountry Districts from 2010 to 2020. Source adequacy was analyzed in terms of both MDD (based on the annual ADD multiplied by a factor of 1.5) and MM (actual data).

Table 43. Average and Max Month Production, by District (mgd)

MDWS District	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
Central District												
Max Month (MM)	26.93	25.54	27.17	26.17	24.83	24.21	25.92	26.78	26.29	28.35	27.04	**26.29**
Average Day Demand (ADD)	24.10	23.23	24.30	23.78	22.17	22.32	23.22	23.80	23.47	25.29	24.06	**23.61**
High Production Demand Multiplier (MM/ADD)	1.12	1.10	1.12	1.10	1.12	1.08	1.12	1.13	1.12	1.12	1.12	**1.11**
Estimated MDD (1.5 x ADD)	36.14	34.84	36.46	35.67	33.26	33.49	34.83	35.69	35.21	37.94	36.09	**35.42**
Upcountry District												
Max Month (MM)	10.36	9.92	9.73	9.36	9.18	7.56	7.77	9.00	7.53	8.71	9.25	**8.94**
Average Day Demand (ADD)	8.20	7.68	8.58	7.76	6.78	6.41	6.69	6.91	6.33	7.18	7.54	**7.28**
High Production Demand Multiplier (MM/ADD)	1.26	1.29	1.13	1.20	1.35	1.18	1.16	1.30	1.19	1.21	1.23	**1.23**
Estimated MDD (1.5 x ADD)	12.30	11.52	12.87	11.65	10.16	9.61	10.04	10.37	9.49	10.78	11.31	**10.92**

Source: MDWS Billing Data, 2015 – 2020, and MDWS Monthly Source Reports and WTP Production Data, 2015 – 2020

Figure 35 details the average and maximum production demand and capacity from 2010 to 2020 for the Central District. The relationship between MM (blue column) and ADD (green column) is a relatively consistent 1.1. While ADD can be met by the 16-hour constrained source production capacity of 25.9 mgd, shown by the solid red line, MM often requires production greater than 25.9 mgd.

To meet the MDD (depicted by the solid green line), the system must operate above the permitted production capacity of 29.864 mgd, indicated by the solid orange line. This indicates that while ADD and MM demands have been met within the permitted production capacity, it appears that MDD has been accommodated to this point by operational flexibility and storage within the systems or running the system outside of the preferred operating limitations.

Figure 36 details the same information for the Upcountry District. The high production demand multiplier ratio of MM to ADD is more variable, with an average value of 1.2 over the 11-year period. While both MM and ADD can be met by the constrained source production capacity of 10.602 mgd (shown by the solid red line), MDD exceeded the constrained capacity more than half the time. For illustrative purposes, the reliable capacity example presented in 4.2.5 has been added to the figure as a black dotted line. While ADD can generally be met with reliable capacity (apart from 2012), MM exceeds reliable capacity for eight of the years. This illustrates the vulnerability of the Upcountry System to an outage of the largest facility (Kamole WTF) due to any reason.

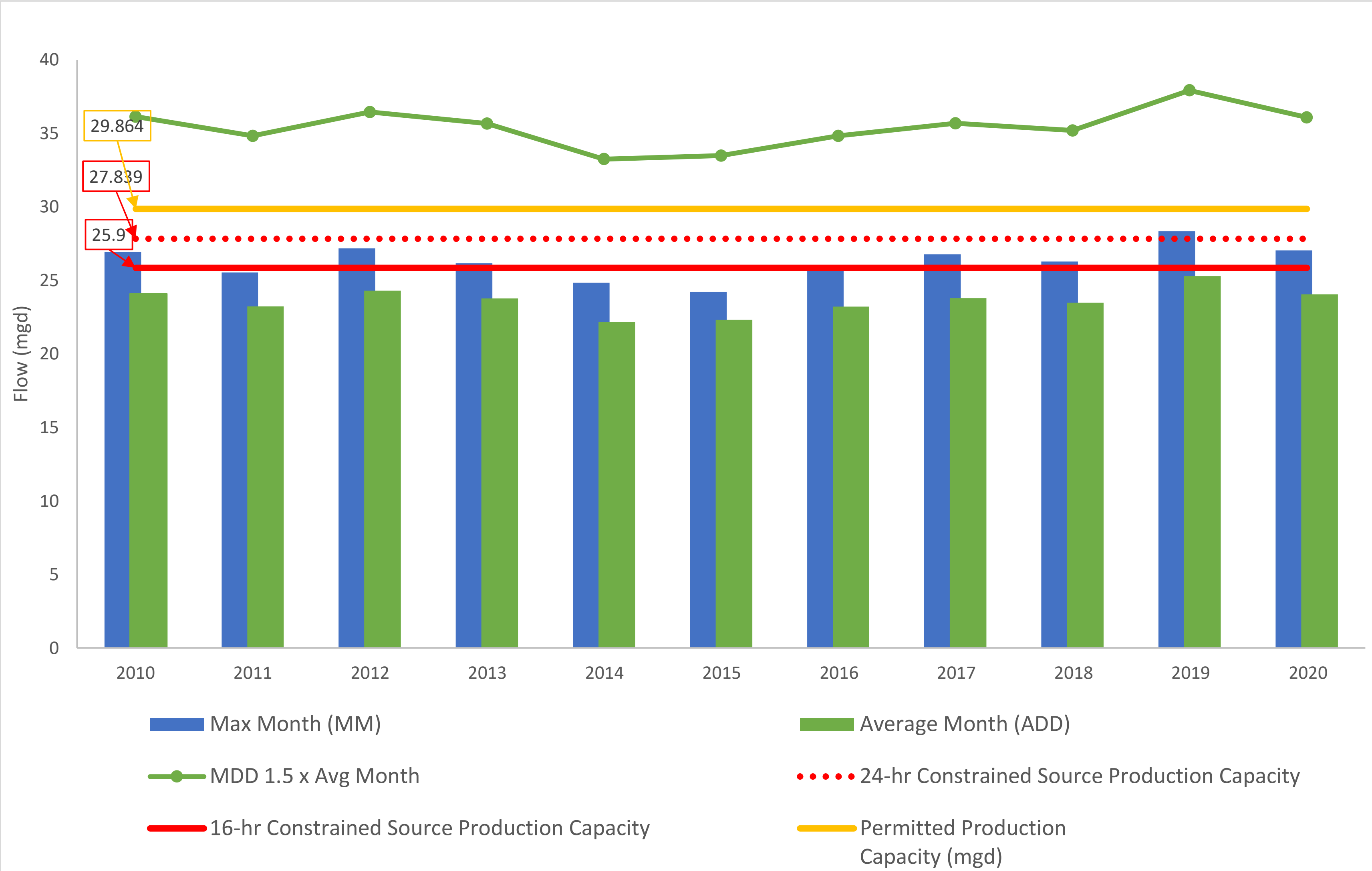

Figure 35. Average and Maximum Production and Source – Central District

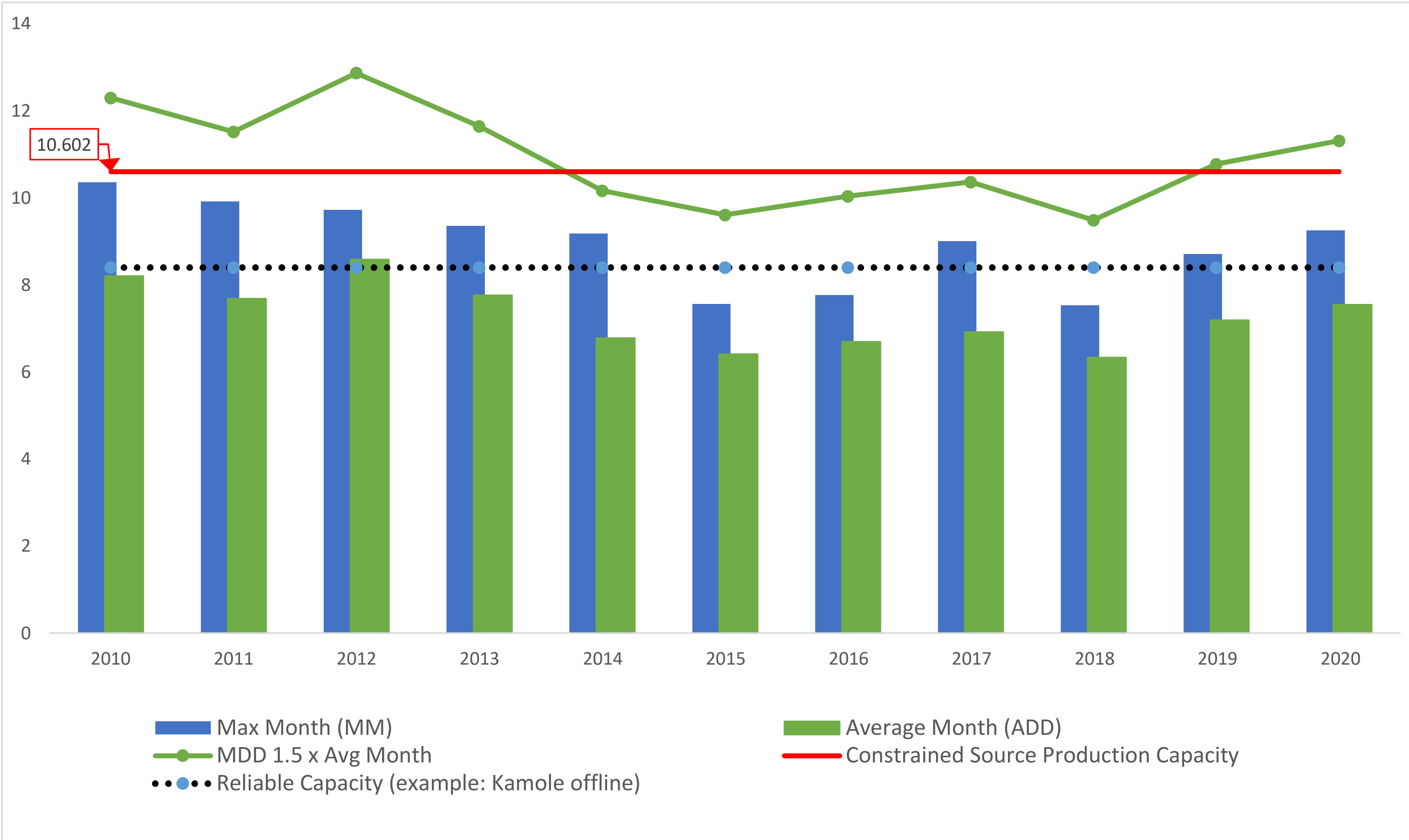

Figure 36. Average and Maximum Production and Source – Upcountry District

4.3.2 Future Source Surplus/Deficit

Table 44 summarizes estimated future production values for the timeframe 2025 through 2040 and 2045, for the Central and Upcountry Districts, respectively. The projected average day production values shown are those previously presented in Sections 2 and 3.

Table 44. Production Demand Ranges (mgd)

Projection Scenario	Calendar Year					
	2020	2025	2030	2035	2040	2045 [b]
Central District						
Most Likely Demand Range	24.033[a]	26.6 – 26.8	28.9 – 29.6	31.0 – 32.3	33.0 – 35.1	–
High-End Conservative Limit		28.4	32.5	36.6	40.7	–
Upcountry District – excluding the Priority List						
Most Likely Demand Range	7.550[a]	7.7 – 8.3	7.8 – 9.2	7.9 – 10.2	8.0 – 11.1	–
High-End Conservative Limit		8.6	9.9	11.2	12.6	–
Upcountry District – including the Priority List (2020-2040) and potential pent-up demand (2045 only)						
Most Likely Demand Range	7.550[a]	8.4 – 9.0	9.3 – 10.7	10.1 – 12.4	11.0 – 14.1	13.2 – 17.2
High-End Conservative Limit		9.3	11.4	13.5	15.6	18.6

Notes:

a. *2020 reflects actual production.*

b. *Projection extension to 2045 was performed for the Upcountry District when considering the Priority List and Pent-Up Demand conditions only, as it is assumed that the Priority List will be fully resolved by year 2040 (at 80 applications processed per year), with subsequent resolution of pent-up demand between 2040 and 2045.*

Figures 37 and 38 display the projected production demand estimates for the Central and Upcountry Districts. Future values for MM and MDD have been forecast using multipliers consistent with those observed in historical data and presented in Table 43. The future ADD range (ADD “Most Likely” High and ADD “Most Likely” Low) is shown as light and dark green columns. The two ADD values have been used to calculate MDD (by multiplying each ADD value by a factor of 1.5), with the upper and lower bound shown as purple lines. MM is presented as blue columns.

Current constrained source production capacity numbers are shown as dotted and solid red lines, with the permitted production capacity depicted as a solid orange line. In 2020, MDD for the Central District exceeded permitted capacity of 29.9 mgd. This exceedance will continue with growth. By 2025, ADD will exceed both the 16- and 24-hour constrained production (of 25.9 mgd and 27.8 mgd). MM currently exceeds the 16-hour constrained production.

The current constrained source production capacity is shown as a solid red line, with the example reliable capacity described in 4.2.5 shown as a black dotted line. In 2020, MDD for the Upcountry District exceeded the constrained production capacity. MM currently exceeds the Upcountry reliable capacity of 8.4 mgd. By 2025, MM will be greater than the constrained production of 10.6 mgd. The “Most Likely” High ADD will exceed reliable capacity by 2025 and exceed the constrained production capacity by 2030.

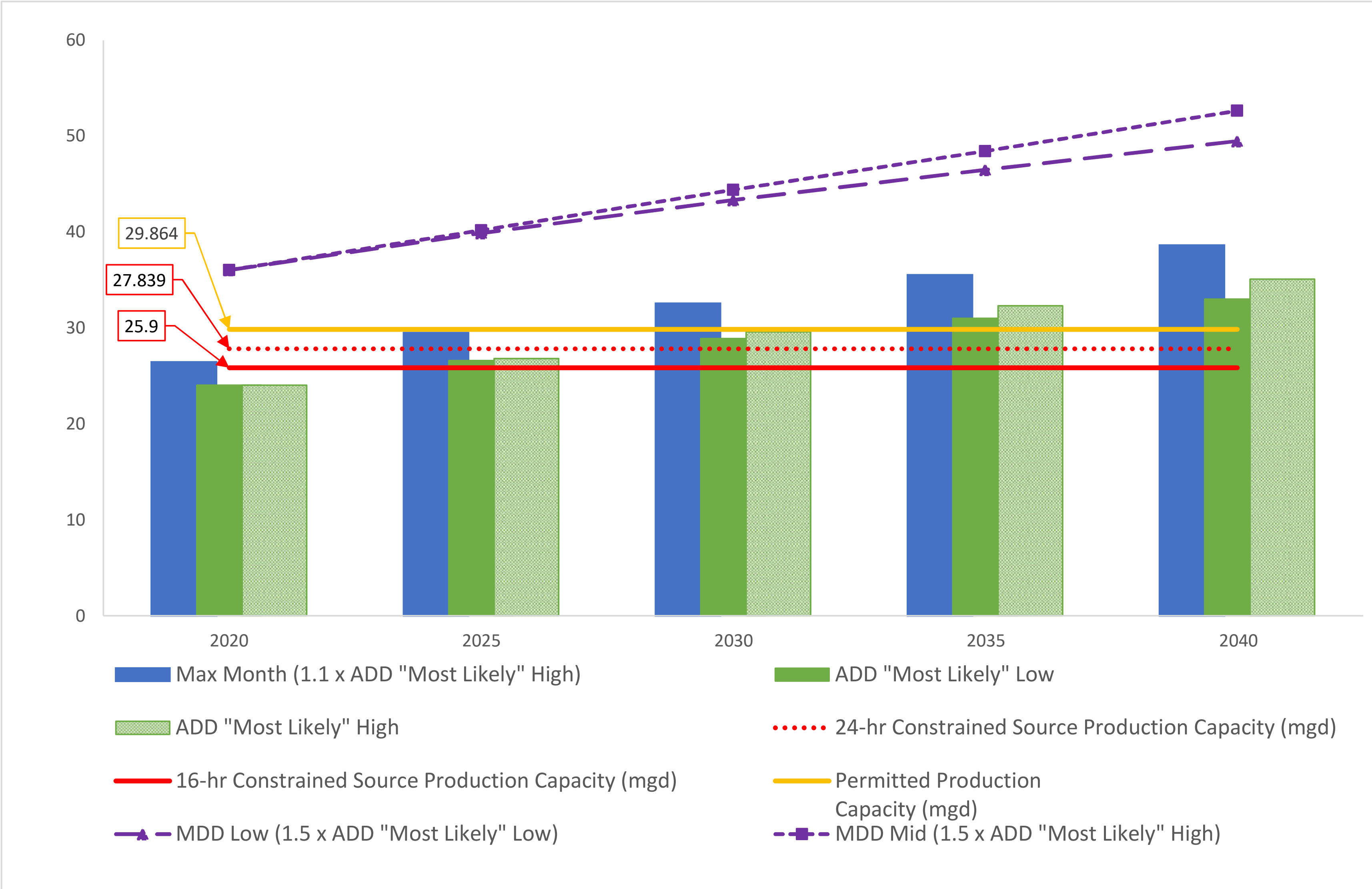

Figure 37. Future Production and Source – Central District

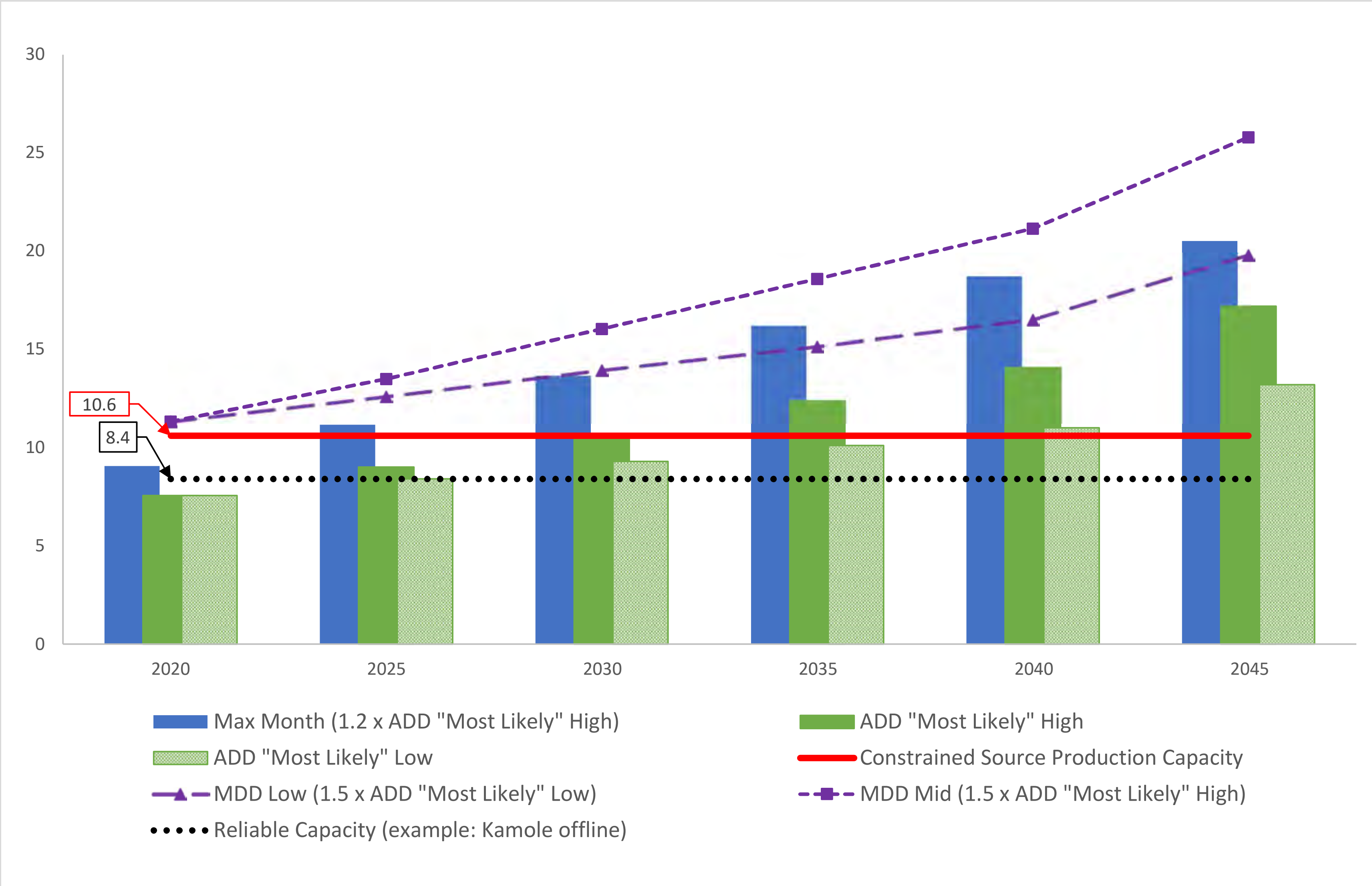

Figure 38. Future Production and Source – Upcountry District

Table 45 summarizes the source deficit to meet ADD and MDD from 2020 to 2040/2045 for the Central and Upcountry Districts.

Table 45. Source Surplus/Deficit through 2040 and 2045 (mgd)

Projection Scenario	Calendar Year					
	2020	2025	2030	2035	2040	2045 [b]
Central District						
Constrained Source Production Capacity	**25.9**	**25.9**	**25.9**	**25.9**	**25.9**	–
"Most Likely" Demand Range (ADD)	24.033[a]	26.6 to 26.8	28.9 – 29.6	31.0 – 32.3	33.0 – 35.1	–
MDD Mid (1.5 x "Most Likely" High ADD)	36.0	40.2	44.4	48.5	52.7	–
Surplus/Deficit to meet ADD	1.8	-1.0	-3.8	-6.5	-9.3	–
Surplus/Deficit to meet MM	-0.6	-3.6	-6.7	-9.7	-12.8	–
Surplus/Deficit to meet MDD	-10.2	-14.4	-18.6	-22.6	-26.8	–
Upcountry District – including the Priority List (to 2040) and potential pent-up demand (2045 only)						
Constrained Source Production Capacity	**10.6**	**10.6**	**10.6**	**10.6**	**10.6**	**10.6**
"Most Likely" Demand Range (ADD)	7.550[a]	8.4 – 9.0	9.3 – 10.7	10.1 – 12.4	11.0 – 14.1	13.2 – 17.2
MDD Mid (1.5 x "Most Likely" High ADD)	11.3	13.5	16.1	18.6	21.2	25.8
Surplus/Deficit to meet ADD	3.1	1.6	-0.1	-1.8	-3.5	-6.6
Surplus/Deficit to meet MM	1.5	-0.6	-3.1	-5.6	-8.1	-9.9
Surplus/Deficit to meet MDD	-0.7	-2.9	-5.4	-8.0	-10.5	-15.2

Notes:

a. *2020 reflects actual production.*

b. *Projection extension to 2045 was performed for the Upcountry District when considering the Priority List and Pent-Up Demand conditions only, as it is assumed that the Priority List will be fully resolved by year 2040 (at 80 applications processed per year), with subsequent resolution of pent-up demand between 2040 and 2045.*

The 16-hour constrained production capacity has been used in the surplus/deficit calculations for Central as it reflects the production capacity of the system while meeting all regulatory, maintenance, and permitting requirements. The upper number of the "Most Likely" demand projection range has been used.

Although both districts have enough production capacity in 2020 to meet ADD, both have a current inability to achieve MDD with the constrained production capacity while meeting all regulatory, maintenance and permitting requirements. MM can be met in both systems in 2020, but if a non-redundant production facility in the Central system is offline there is no buffer to achieve MM production. Similarly, if one of the Upcountry WTFs is out of service, MM demand cannot be met.

Going forward, neither District will be able to meet MDD or MM demands with the current available constrained production capacity. With continued growth, the ADD of both districts may exceed available source by 2025 and 2030, for Central and Upcountry districts, respectively.

4.4 Key Findings and Recommendations

Key findings and recommendations from this analysis include:

- The current constrained production capacity of the Central and Upcountry systems is insufficient to meet MDD for each district.
- By 2025, the Central and Upcountry systems will have insufficient constrained production capacity to meet MM demand for each district, and the Central system will be challenged to meet ADD.
- Additional source is required to meet projected demand for both the Central and Upcountry Districts.
- Piiholo and Olinda WTF production appears to be limited by availability of raw water, with Olinda impacted by raw water supply and Piiholo further limited at times by a transmission bottleneck from source to the Piiholo reservoir.
- Wailoa Ditch flow has been drastically reduced by the implementation of IIFS, and historic flow-durations curves for the Ditch can no longer be relied upon to predict future availability of water at the Kamole WTF. Continued daily monitoring of ditch flows and precipitation, and changing ditch operating conditions (i.e., restricting/returning ditch and stream flows) is recommended for further study of the impact of implementation of IIFS on water availability for MDWS.
- Development of additional ground water source, construction of raw water reservoirs to store water and offset periods of low surface water availability, and upgrading the raw water transmission systems to convey additional raw water collected upcountry are options identified to ensure consistent supply is available to serve the Upcountry District and fully utilize the surface water sources. It is anticipated that these strategies will be further explored in Phase 3 of the EMFS.
- This study has been performed at a District level. Specific supply availability at a system or subdivision development level will vary.

Additional findings and recommendations have also been identified through the course of the investigation:

- Operational changes such as pumping from Kamole to supplement upper elevation reservoirs levels during dry months could enhance supply.
- At the wells, investment in backup or alternate power to mitigate electric utility fluctuations, additional wellsite storage to accommodate pumpage in excess of immediate service area demand, and infrastructure to allow flow from Kaupakalua and Haiku wells to supply other Upcountry service areas could enhance District resilience. Further investigation is recommended to determine the benefits, impacts and feasibility of these strategies.
- An overall review of the 2002 WSS by MDWS is recommended – specifically the pumping and surface water demand limits (§ 100.111.08 and § 100.111.04).
- Development of a Master Plan and hydraulic model would provide opportunities to further identify levels of service, identify system deficiencies, outline a long-term Capital Improvement Program for utility-wide upgrades to develop supply to meet maximum daily demand well in advance of need, and facilitate a detailed analysis for service requests.
- While a detailed investigation of conservation trends, triggers, and efforts is beyond the scope of the EMFS, population and consumption may better correlate if conservation trends are analyzed.
- Alternate supply-related options such as recycled water, conservation, desalination, reduction in non-revenue water and other strategies outlined in the 2019 WUDP have not been considered within this TM.

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