Climate Adaptation Master Plan for Water (CAMP4W)

WORKING MEMORANDUM 3

IRP 2020 REGIONAL NEEDS ASSESSMENT SUMMARY

August 2023

Summary

The 2020 Integrated Water Resources Plan (IRP) was organized into a Regional Needs Assessment (Phase 1) and an implementation phase (Phase 2). The Needs Assessment (**Attachment A**) was adopted by the Board in 2022 and established a tool for ensuring regional water reliability through 2045 and incorporated scenario planning to address wide-ranging uncertainties. Building upon this strong foundation of the IRP Needs Assessment, the implementation phase of the IRP will be coordinated through the Climate Adaptation Master Plan for Water (CAMP4W) process.

In collaboration with the Member Agencies, the Board of Directors, and other interested parties, the 2020 IRP Needs Assessment broadened Metropolitan's perspectives compared to past IRPs by constructing and modeling four plausible future scenarios. These scenarios explored uncertainties related to future climate conditions, population growth, regulatory requirements, and the economy. These scenarios represent divergent outcomes of imported supply stability and demands on Metropolitan and are illustrated in Figure ES-1 (see also page 17 of **Attachment A**).

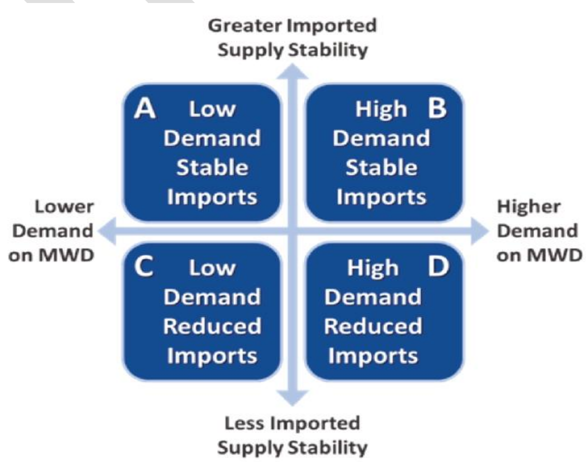


Figure ES-1. IRP Planning Scenarios

The scenario analyses revealed conceivable reliability outcomes through 2045. The potential annual net shortage ranged from none under Scenario A to as high as 1.2 million acre-feet (MAF) under Scenario D.

In order to address the gaps identified within each scenario, Metropolitan conducted a portfolio analysis to quantify the effect of various combinations of supply categories (core supply, flexible supply, or storage). Initial modeling utilized a single category analysis (core supply, flexible supply, or storage) to test how the supply-demand gap in each scenario could be met. After the portfolio categories were modeled in isolation, a mix of all three categories was modeled for each scenario. The analysis concluded that rather than relying on any single category of portfolio actions, it is more practical in every scenario to pursue a more balanced and diversified mix. For example, the analysis found that under rapid climate change Metropolitan and its Member Agencies would need to develop between 50 thousand acre-feet (TAF) and 650 TAF of new core supply to continue to meet the needs of the region assuming no additional storage is developed and a maximum of 100 TAF of flexible supply is developed. However, by expanding existing storage or by developing new storage programs and investments in Metropolitan's distribution system, the need for new core supply can be reduced.

The IRP Needs Assessment identified three categories of supply:

Core Supply: A supply that is generally available and used every year to meet demands under normal conditions and may include savings from efficiency gains through structural conservation.

Flexible Supply: A supply that is implemented on an as-needed basis and may or may not be available for use each year and may include savings from focused, deliberate efforts to change water use behavior.

Storage: The capability to save water supply to meet demands at a later time. Converts core supply into flexible supply and evens out variability in supply and demand.

The Needs Assessment further evaluated the impact of system distribution constraints on system reliability to establish the extent to which water supply shortages can be mitigated by removing those constraints. The analysis found that if distribution constraints were removed entirely, shortages decrease or are eliminated in years prior to 2040. However, in year 2040 and beyond, under Scenarios C and D, frequent shortages and fewer surplus conditions indicate that storage and conveyance capacity alone will not solve the reliability problem without supply improvements.

The Needs Assessment involved extensive modeling across multiple established platforms to conduct a reliability assessment to quantify potential gaps within each scenario. The Needs Assessment resulted in findings across the following five focus areas:

- Demand Management
- Storage Needs
- Imported Supplies
- Local Supplies
- Identification of Gaps by Major Load Area: Modeling by demand load area (the State Water Project (SWP) Dependent Area, the Colorado River Dependent Area, and the Blended Area). This led to findings related to the SWP Dependent Area as an area specifically impacted by future conditions (see page 26 of **Attachment A** for a figure showing the demand load areas).

Metropolitan acknowledges that CAMP4W will require continued close collaboration with Member Agencies to integrate local needs, projects, and priorities. CAMP4W is designed to provide an adaptive decision-making framework to facilitate the selection of projects and the sequencing and timing of each phase of implementation. Scenario planning developed in the IRP Needs Assessment provides a sound foundation for adaptive management. This will allow for flexibility and the opportunity to refine decisions over time so Metropolitan can continue to meet its mission to provide the entire service area with adequate and reliable supplies of high-quality water to meet present and future needs in an environmentally and economically responsible way.

Section 1: Needs Assessment Framework and Scenarios

For nearly thirty years, Metropolitan has embraced integrated resources planning for developing a long-term strategy to provide the region with a reliable, high-quality, and affordable water supply. Between 1996 and 2015, Metropolitan recalibrated its IRP on several occasions, based on a single set of assumptions related to changing conditions and forecasts. Beginning with the 2020 IRP update, Metropolitan integrated scenario planning, which instead focuses on a range of assumptions. This important adjustment to the 2020 IRP allows Metropolitan to consider a wide range of uncertainty, based on several key assumptions, including future climate conditions, population growth, regulatory requirements, and the economy (see page 14 of **Attachment A**). To develop the scenarios used in the 2020 IRP Needs Assessment, there was extensive coordination and consultation with Member Agencies, and Board input was integrated throughout the process.

Recent severe drought in California followed by record rainfall provides a real-world example of the challenges facing the region and emphasizes the need to consider future climate change projections in the IRP process. The climate change assumptions were developed in consultation with an expert panel and based on IPCC Assessment Reports (and corresponding global climate models) using the most recent projections available at the time the IRP was developed.

Following is a list of key assumptions included in the IRP Needs Assessment. **Attachment B** provides a comprehensive summary of assumptions for each scenario.

> **Uncertainty and the Establishment of Assumptions**
>
> There is **inherent uncertainty** whenever an assumption is made, and in the IRP Needs Assessment, each scenario is defined by numerous assumptions. **Scenario planning and adaptive management capture that uncertainty** in the space between each scenario – the spectrum along which real-world conditions are likely to unfold. Each scenario presents a data point along that spectrum, where any number of variables could shift the outcome in one direction or another.
>
> By adapting and modifying investment decisions over time, **Metropolitan will align implementation with real-world conditions** to reduce the risk of over or under developing resources.

- Assumptions related to future climate conditions:
  - RCP 4.5 represents moderate climate change (reflected in Scenarios A and B)
  - RCP 8.5 represents more pronounced climate change (reflected in Scenarios C and D)
- Assumptions related to population growth and water demands:
  - Low demands (represented in Scenarios A and C)
    - Aggressive conservation practices
    - Low economic growth and population growth
  - High demands (represented in Scenarios B and D)
    - Moderate conservation effectiveness
    - High economic growth which accelerates population growth
- Assumptions related to regulatory impacts:
  - Low regulatory impacts (less restrictive) (Scenarios A and B)
  - High regulatory impacts (more restrictive) (Scenarios C and D)
- Assumptions related to local supplies:
  - Higher local supplies
    - (Scenarios A and C assume higher local supplies relative to Scenarios B and D)
  - Diminishing local supplies
    - (Scenarios B and D assume lower local supplies relative to Scenarios A and C)

Utilizing these primary assumptions, Metropolitan developed four scenarios that represent potential futures, as shown in Figure 1.

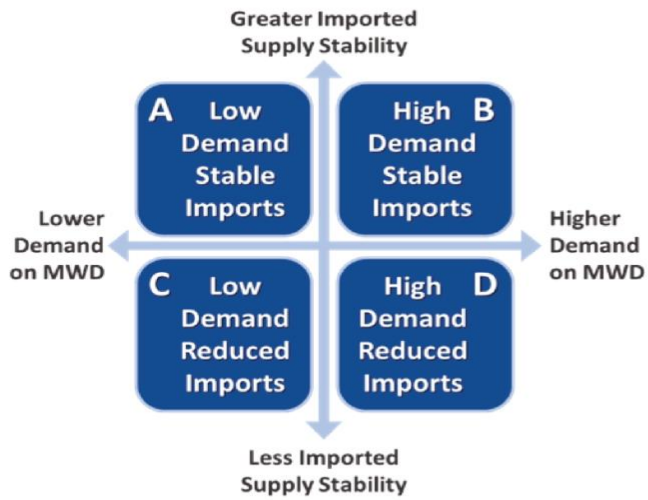


Figure 1. IRP Planning Scenarios

Section 2: 2020 IRP Regional Needs Assessment Evaluation Process

A key goal for Metropolitan is to provide all its Member Agencies with 100 percent water supply reliability through a combination of Metropolitan supplies, local supplies, and increased conservation. Scenario planning allows Metropolitan to consider multiple, plausible future scenarios with a corresponding range of possible shortcomings.

To establish and evaluate each of the four scenarios, the IRP Needs Assessment utilized several prominent modeling platforms to thoroughly analyze the impacts of each set of assumptions. Figure 2 presents a summary of the complex modeling process conducted during the Needs Assessment, followed by a summary of each input (see page 19 of **Attachment A**).

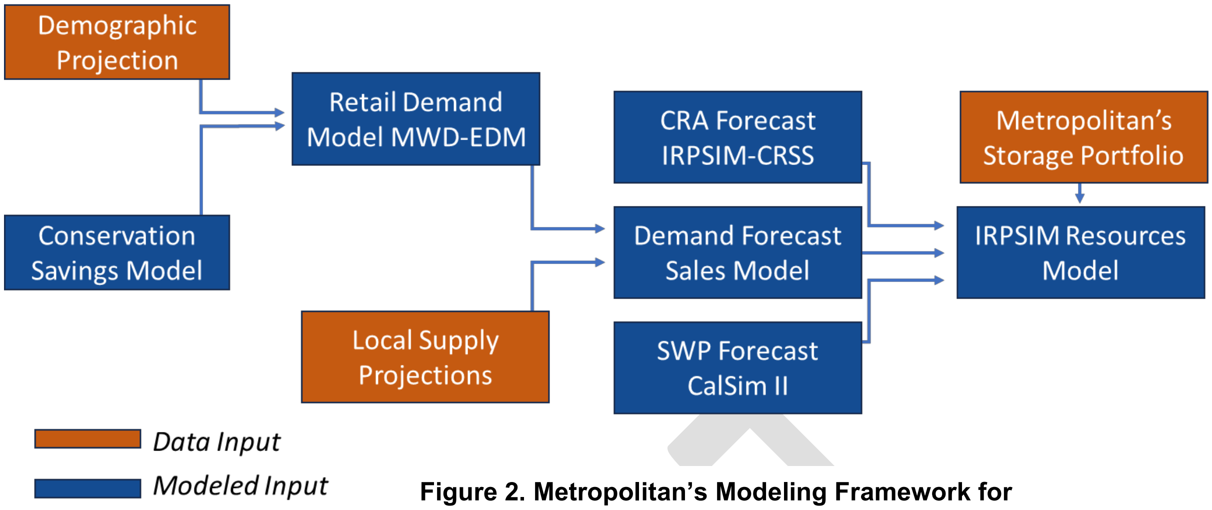


Figure 2. Metropolitan's Modeling Framework for Quantifying Uncertainties

MWD-EDM:

- Demographic growth projections were developed with support from the Center for Continuing Study of the California Economy (CCSCE), which utilizes studies published by the U.S. Census Bureau.
- Drivers for change were evaluated such as smaller lot sizes for future homes, future conservation, water use ethic and rebound behavior (where complete rebound assumed a 10 percent higher forecast compared to a forecast without rebound).
- Conservation savings (structural and behavioral conservation) were established using Metropolitan's Conservation Savings Model based on plumbing code compliance, Metropolitan and Member Agency conservation programs, and price-effect conservation.
- Demands from retail agricultural, seawater barrier, and replenishment were established considering climate change impacts within each scenario (e.g., additional seawater barrier needed when seawater levels increase, and additional supply is needed to combat increased hydraulic pressure).

Local supply projections:

- Includes groundwater, surface water, the Los Angeles Aqueduct, recycled water, groundwater recovery, and seawater desalination. Values were established based on Metropolitan's annual local supply surveys, coordination with local agency staff, and local Urban Water Management Plans.
    - Focused workshops were held with Member Agencies and groundwater management agency staff to gain valuable insights into challenges and reliability impacts of local supplies based on climate change, economic conditions, and regulatory restrictions.

Demand Forecast Sales Model:

- Model calculates the demands on Metropolitan by Member Agencies where local supplies are insufficient to meet retail demand.
- Model accounts for weather-related variations in demands and local supplies, resulting in a range of forecasted demands on Metropolitan.
- Climate expert consultants were engaged to develop techniques and ranges for incorporating climate change impacts into the local precipitation and temperature assumptions.

CRA Forecast IRPSIM-CRSS

- Model provides a base supply from the Colorado River Aqueduct (CRA) utilizing hydrological inputs provided by the United States Bureau of Reclamation, utilizing Metropolitan's generated surplus and shortage characterization of the Colorado River system.
- Based on consultation with climate experts and previous research, climate change is incorporated into CRA supplies by adjusting the Lake Powell and Lake Mead inflow hydrology and evaporation rates.
- Stability of Colorado River supplies were considered based on potential impacts of existing agreements related to operation of the Colorado River and cooperation between the lower basin states and Mexico, with some agreements expiring in 2026. Scenarios A and B assume extension of these agreements (stable imported supply), while Scenarios C and D assume some agreements expire (unstable imported supply) (see page 29 of **Attachment A**).

SWP Forecast-CalSim II

- Model produced by the Department of Water Resources and published in their 2019 Delivery Capability Report (DCR), which provides SWP supply estimates for 1) an existing condition that does not consider climate changes, and 2) an early long-term condition that does incorporate a fixed condition of climate change.
- IRP Needs Assessment utilized the 2019 DCR as a basis for incorporating guidance from climate experts to reflect the regulatory and climate change impacts used in the IRP scenarios to establish the supply estimates from the SWP.

IRPSIM Resources Model:

- IRPSIM is a water supply and demand mass balance simulation model, which analyzes the supply-demand gaps. It integrates inputs from the models described above, including:
    - CRA Forecast (using the IRPSIM-CRSS model)
    - SWP Forecast (using the CalSim II model)
    - Metropolitan's storage portfolio, where IRPSIM considers operational constraints, put and take capacities, contractual arrangements, and other operational considerations.

    - Demand Forecast Sales Model which provides the input for demands on Metropolitan, which uses retail demand (demographic projections and conservation considerations) and local supply projections.

- The IRPSIM model considers the availability and accessibility of its imported water supply sources, including storage, where forecasted demands were allocated to portions of Metropolitan's regional distribution system, referred to as demand load areas. Based on this, the model identified spatially where across the system gaps exist for each scenario modeled.

    - Three main demand load areas were identified including: SWP Dependent Areas, Colorado River Dependent Areas, and Blended Areas which are areas able to receive supply from both sources including their respective storage programs (see page 26 in **Attachment A** for a map of each demand load area).

    - During surplus years, excess SWP supply can be stored in SWP storage facilities and/or in blended areas, allowing Metropolitan to store imported supply within Colorado River storage facilities.

- To test reliability, IRPSIM utilizes 96 years of historical hydrology (1922-2017) to establish the probabilities of surpluses and shortages (defined in the model as insufficient supply to satisfy a demand <u>or</u> inaccessible supply). The scenario-based climate impacts were overlaid onto the sequential hydrology data within IRPSIM.

Section 3: 2020 IRP Regional Needs Assessment Findings

The modeling conducted first utilized a single category analysis (core supply, flexible supply, or storage), then category-specific tests were performed to understand the impact of utilizing multiple supply categories in a given portfolio. The analysis concluded that rather than relying on any single category of portfolio actions, it is more practical in every scenario to pursue a more balanced and diversified mix. For example, the analysis found that under rapid climate change Metropolitan and its Member Agencies would need to develop between 50 TAF and 650 TAF of new core supply to continue to meet the needs of the region, assuming no additional storage and a maximum of 100 TAF of flexible supply. However, by expanding existing or developing new storage programs and investments in Metropolitan's distribution system, the need for new core supply can be reduced.

The Needs Assessment further evaluated the impact of system distribution constraints on system reliability to establish the extent to which water supply shortages can be mitigated by removing those constraints. The analysis found that if distribution constraints were removed entirely, shortages decrease or are eliminated in years prior to 2040. However, in year 2040 and beyond, under Scenarios C and D, frequent shortages and fewer surplus conditions indicate that storage and conveyance capacity alone will not solve the reliability problem without supply improvements (see page 32 **Attachment A**).

A comprehensive discussion on findings is included in Attachment A (beginning on page 30), and below is a brief summary of findings across five key focus areas.

State Water Project Dependent Areas

- Vulnerabilities in the SWP Dependent Areas are more severe given reduced reliability of SWP supplies and Metropolitan distribution system constraints. Actions identified in the implementation phase must prioritize addressing the SWP Dependent Area's reliability challenge.
- New core supplies must be accessible to the SWP Dependent Areas. Greater access to existing core supplies can also increase SWP Dependent Area reliability.
- Enhanced accessibility to core supplies and storage, both existing and new, will improve SWP Dependent Area and overall reliability. This includes improvements to Metropolitan's distribution system and capacity to deliver non-SWP supply and storage.
- New storage must be accessible to the SWP Dependent Areas.

Storage

- Storage capacity, put/take capabilities, and accessibility are critical considerations in maintaining reliability under the region's current and future conditions, especially for SWP Dependent Areas.
- Maintaining Metropolitan's existing storage portfolio is critical, including the consideration of re-negotiating contracts when they expire.
- Expanding existing or developing new storage programs and investments in Metropolitan's distribution system can reduce the need for new core supply development to meet potential future shortages and adapt to climate change.
- When evaluating storage options, put/take capabilities are essential; even storage programs with modest put/take capabilities help reduce the need for flexible supply.

Retail Demand / Demand Management

- Metropolitan's future supply reliability may fluctuate based on demand increases and decreases.
- Variability in retail demand largely comes from changes in outdoor water use. Outdoor water use behavior is complex, influenced by weather and climate and by awareness of water scarcity and other conservation measures.
- It is important to pay attention to demand rebound, demand growth, and demand reductions, and take appropriate regional measures as necessary.
- Managing long-term demands through the efficient use of water reduces dependency on supplies, helps preserve storage, and helps reduce the need for extraordinary conservation measures.

Metropolitan Imported Supplies

- Existing imported supplies are at risk from various drivers of uncertainty.
- Maintaining existing imported supply reliability reduces the need for new core supply development and leverages years of investments.
- SWP supplies are highly susceptible to varying hydrologic conditions, climate change, and regulatory restrictions.
- Variability and capacity in SWP supplies provide opportunities to store water during wet periods for use in dry years, including Colorado River storage. Metropolitan's ability to distribute or store SWP supplies when they materialize will enhance the region's reliability, particularly the SWP Dependent Areas. The Colorado River system and Colorado River Aqueduct capacity do not offer the same opportunities concerning SWP storage.

- Shortages on the Colorado River will limit the reliability of Colorado River Aqueduct deliveries as a core supply in the future.

Local Supply

- Maintaining existing and developing new local supplies is critical in helping manage demands on Metropolitan.
- Impacts to reliability occur if local supply assumptions are not achieved; therefore, it is important to track the progress of local supply development as one of the signposts in the One Water Implementation phase.
- Additional actions may be needed should existing and future local supply levels deviate from IRP assumptions.

Section 4: Next Steps

Metropolitan’s approach to reliability and resilience brings together Southern California’s interests in managing finite water resources for both community and ecosystem needs. It goes beyond identifying the region’s future water portfolio and embraces collaboration, diverse communities, and a unified approach to problem solving.

The IRP Regional Needs Assessment identified significant threats facing Southern California’s water supply reliability through successive qualitative and quantitative analysis steps. The assessment sizes up the scope of reliability challenges and the management solutions that could be in store for the region by the year 2045 under a wide range of conditions, and it serves as a guide to the deeply uncertain future of Southern California's water supply.

The adoption of the Regional Needs Assessment is an essential precursor, and significantly informs, the CAMP4W implementation phase. This phase will involve the continuation of extensive collaboration among Metropolitan’s Board, Member Agencies, and other interested parties to develop an adaptive management strategy and decision-making framework. CAMP4W will also establish a process for monitoring key reliability indicators and find joint approaches to the regional problems and resource needs identified in this assessment.

Attachment A

THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

BOARD ACTION

- **Board of Directors**
  Integrated Resources Plan Special Committee

4/12/2022 Board Meeting

7-1

Subject

Adopt the 2020 Integrated Water Resources Plan Needs Assessment; the General Manager has determined that the proposed action is exempt or otherwise not subject to CEQA

Executive Summary

The 2020 Integrated Water Resources Plan (IRP) establishes a strategy for ensuring regional water reliability through 2045. The 2020 IRP incorporated scenario planning to address wide-ranging uncertainties rather than focusing on a single set of assumptions as in the past. In collaboration with the Member Agencies, the Board of Directors, and other interested parties, Metropolitan broadened its perspectives by constructing and modeling four plausible scenarios. Staff organized the 2020 IRP into a Regional Needs Assessment (Phase 1) and a One Water Implementation phase (Phase 2). The Regional Needs Assessment is now complete.

This letter recommends adoption of the 2020 IRP Regional Needs Assessment (**Attachment 1**), which includes findings in five broad categories (State Water Project Dependent Areas, Storage, Demand Management, Imported Supplies, and Local Supplies), quantifies supply/demand gaps, and examines the effectiveness of generalized portfolio categories. Adopting the Regional Needs Assessment allows the analysis and findings to serve as both a foundation and as guardrails for the next implementation phase.

Details

Background

The IRP serves as Metropolitan's long-term, comprehensive water resources strategy to provide the region with a reliable and affordable water supply. After its first adoption in 1996, the IRP was updated in 2004, 2010, and 2015 to adapt to changing conditions that affected water resource reliability. With each update, Metropolitan recalibrated to current conditions and incorporated the best information available to update its forecasts. These plans focused on a single set of assumptions about the future.

The 2020 IRP sought a new analytical framework to:

- Define and account for uncertainties affecting water reliability
- Develop a method to assess and communicate the impacts of those uncertainties
- Explain the uncertainties and their relevance in a clear and transparent way
- Allow integration with an adaptive management strategy that will provide ongoing decision support, information generation, and reporting as essential components

The 2020 IRP explicitly plans for a wide range of uncertainties through scenario planning and by embracing a One Water approach to planning and implementation.

2020 IRP – A Phased Approach for One Water Implementation

Although initially envisioned as a single assessment and planning effort, scenario planning required close coordination with the member agencies. Scenario planning departed from the prior single-scenario methods and needed extra time to help member agencies become comfortable with the approach. Additionally, staff valued member agency input and refined the scenarios and analysis through multiple iterative steps. The Covid-19 pandemic also forced changes in outreach methods, dynamics of interacting with member agencies, and the work environment of staff conducting the analyses.

Concurrent with developing and analyzing the scenarios, California again slipped into a severe drought. Several scenarios under development showed that the State Water Project (SWP) dependent areas could experience shortages more quickly and deeply as the SWP imported supply became constrained. Eventually, it became clear that the Regional Needs Assessment could serve as a stand-alone guide to the deeply uncertain future of Southern California's water supply without completion of the implementation phase. Thus, the complete IRP was divided into two phases, and the needs assessment was completed.

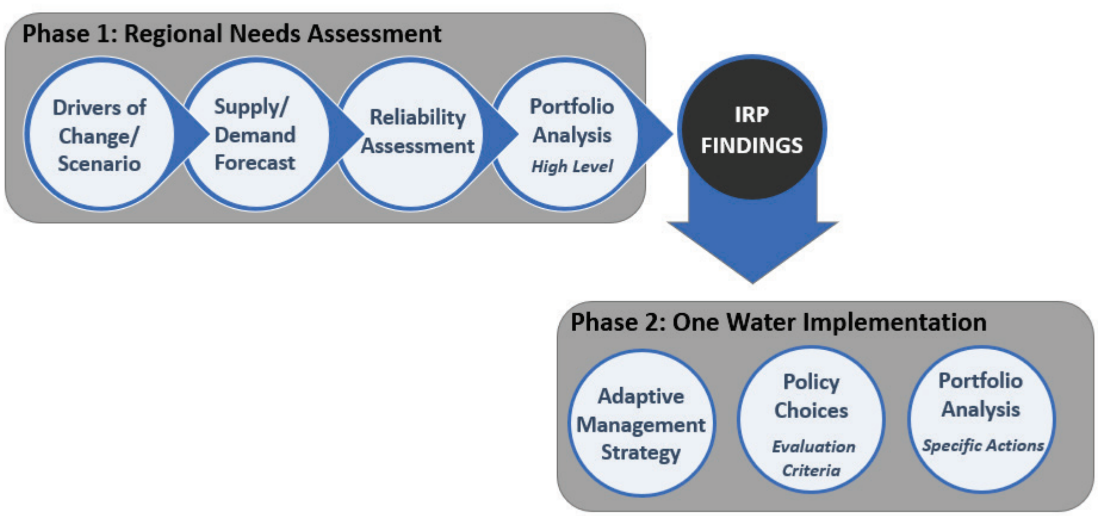
Figure 1 shows the two phases:

- Phase 1: Regional Needs Assessment
- Phase 2: One Water Implementation

The two-phase IRP allows Metropolitan to transition towards a new One Water approach to water reliability and resilience in Phase 2. The One Water approach will focus on balancing Southern California's broad interests in managing finite water resources for both community and ecosystem needs. It will embrace the region's diverse communities through a collaborative approach to addressing water challenges. Establishing a common understanding of the scope of potential water needs of Southern California over the next 25 years is key to the approach in Phase 2. By first defining and identifying a potential range of the region's problems, the IRP Regional Needs Assessment provides the technical foundation to enable the work of identifying specific actions in Phase 2.

Attachment 1 contains the final draft report of the IRP Regional Needs Assessment. It documents the scenario development and subsequent modeling efforts. It then offers a set of findings to inform deliberations and decision-making in Phase 2. In Phase 2, portfolios will be advanced by identifying policies, programs, and projects to address the findings. A comprehensive, adaptive management strategy will be developed in Phase 2 to guide these specific actions.

Figure 1: Process Diagram for Phases 1 and 2 of the 2020 IRP



Recommendation to Adopt Findings of the Phase 1 2020 IRP Regional Needs Assessment

The 2020 IRP Regional Needs Assessment outcomes can be summarized through a set of findings grounded in the scenario reliability analysis. These findings provide the foundation and guardrails for Phase 2. Grouped by topic, the following findings are offered for consideration by the Board:

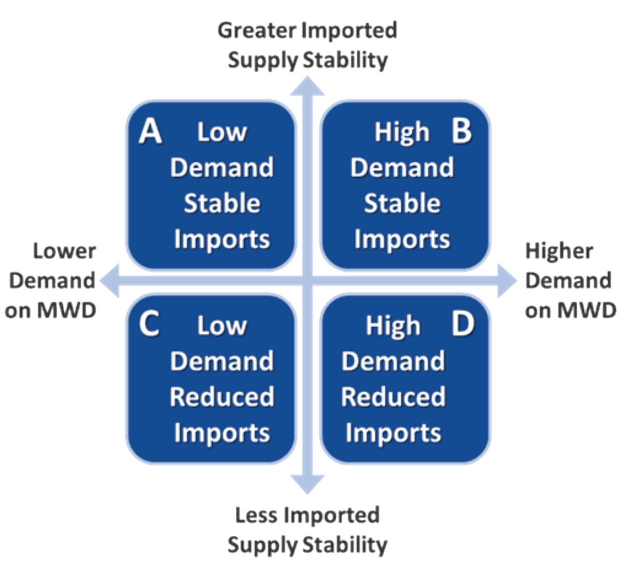
SWP Dependent Areas
• Vulnerabilities in the SWP Dependent Areas are more severe given reduced reliability of SWP supplies and Metropolitan distribution system constraints. Actions identified in the implementation phase must prioritize addressing the SWP Dependent Area's reliability challenge. • New core supplies must be accessible to the SWP Dependent Areas. Greater access to existing core supplies can also increase SWP Dependent Area reliability. • Enhanced accessibility to core supplies and storage, both existing and new, will improve SWP Dependent Area and overall reliability. This includes improvements to Metropolitan's distribution system and capacity to deliver non-SWP supply and storage. • Storage capacity, put/take capabilities, and accessibility are critical considerations for the SWP Dependent Area. New storage capacity and put/take capabilities should be consistent with the portfolio analysis. New storage must be accessible to the SWP Dependent Areas.
Storage
• Storage capacity, put/take capabilities, and accessibility are critical considerations in maintaining reliability under the region's current and future conditions, especially for SWP Dependent Areas. • Maintaining Metropolitan's existing storage portfolio is critical, including the consideration of re-negotiating contracts when they expire. • Expanding existing or developing new storage programs and investments in Metropolitan's distribution system can reduce the need for new core supply development to meet potential future shortages and adapt to climate change. • When evaluating storage options, put/take capabilities are essential; even storage programs with modest put/take capabilities help reduce the need for flexible supply.
Retail Demand/Demand Management
• Metropolitan's future supply reliability may fluctuate based on demand increases and decreases. • Variability in retail demand largely comes from changes in outdoor water use. Outdoor water use behavior is complex, influenced by weather and climate and by awareness of water scarcity and other conservation measures. • It is important to pay attention to demand rebound, demand growth, and demand reductions, and take appropriate regional measures as necessary. • Managing long-term demands through the efficient use of water reduces dependency on supplies, helps preserve storage, and helps reduce the need for extraordinary conservation measures.

Metropolitan Imported Supplies
• Existing imported supplies are at risk from various drivers of uncertainty. • Maintaining existing imported supply reliability reduces the need for new core supply development and leverages years of investments. • SWP supplies are highly susceptible to varying hydrologic conditions, climate change, and regulatory restrictions. • Variability and capacity in SWP supplies provide opportunities to store water during wet periods for use in dry years, including Colorado River storage. Metropolitan's ability to distribute or store SWP supplies when they materialize will enhance the region's reliability, particularly the SWP Dependent Areas. The Colorado River system and Colorado River Aqueduct capacity do not offer the same opportunities concerning SWP storage. • Shortages on the Colorado River will limit the reliability of Colorado River Aqueduct deliveries as a core supply in the future.
Local Supply
• Maintaining existing and developing new local supplies is critical in helping manage demands on Metropolitan. • Impacts to reliability occur if local supply assumptions are not achieved; therefore, it is important to track the progress of local supply development as one of the signposts in the One Water Implementation phase. • Additional actions may be needed should existing and future local supply levels deviate from IRP assumptions.

IRP Scenario Framework

Figure 2 shows the four scenarios used to characterize different outcomes of imported supply stability and demand on Metropolitan. Key drivers of change such as climate, regulatory requirements, and the economy are uncertain and may exert significant effects on both water supply and demands. These and other drivers of change were identified through a collaborative process involving member agencies, expert consultants, research by staff, and the input of other interested parties. The impacts of these drivers within each scenario were quantified using in-house models.

Figure 2. Four Scenarios Used in the IRP



Interaction with Other Planning Efforts

Metropolitan's 2020 Urban Water Management Plan was developed in coordination with the 2020 IRP. When both phases of the IRP are complete, the planning process will serve as Metropolitan's blueprint for long-term water reliability, including key supply development, infrastructure improvements, and water use efficiency goals.

Together, the IRP and the UWMP serve as the reliability roadmap for the region. The UWMP relied on demographic and climate inputs provided by other agencies such as the Southern California Association of Governments, San Diego Association of Governments, California Department of Water Resources, and the U.S. Bureau of Reclamation. The

IRP Regional Needs Assessment extended the planning horizon beyond the single scenario outcomes shown in the UWMP. But importantly, the factors and assumptions used to create the UWMP scenario fall within the bounds of this work.

The IRP Regional Needs Assessment informs other planning efforts and serves as boundary conditions to consider in other planning venues. For example, the IRP Implementation Phase will need to consider the performance of any portfolio under the four scenarios identified in this work.

The General Manager's priorities for the next biennium emphasize action to address findings of the IRP Regional Needs Assessment. For example, substantial effort is underway to provide each member agency access to an equivalent level of water supply reliability and to resolve the constraints of the SWP dependent areas.

Likewise, the portfolio selection will also need to consider Metropolitan's proposed emissions reduction goal in the draft Climate Action Plan to ultimately achieve carbon neutrality by 2045. Finally, the planned rate structure review will also need to ensure the business model can adapt to changing needs of the member agencies and support sustainable local and imported supplies under the same scenarios.

Next Steps

Adoption of the findings and analysis represents a critical juncture; however, the 2020 IRP is far from over. No specific actions are recommended or have been determined from the IRP Regional Needs Assessment. Following adoption of the IRP Regional Needs Assessment, Metropolitan will transition to implementation in Phase 2.

The One Water Implementation phase will take the results and findings of Phase 1 into a collaborative process to identify integrated regional solutions. Using a One Water approach, the implementation phase will translate the high-level portfolio analysis from Phase 1 into specific policies, programs, and projects to address the findings and mitigate the potential shortages. A comprehensive, adaptive management strategy and evaluation criteria will be developed to guide these specific actions. The adaptive management strategy will also establish a process for monitoring key reliability indicators to support decision-making.

Appendices for the 2020 IRP Regional Needs Assessment will be posted to Metropolitan's website at www.mwdh2o.com/IRP. These appendices serve as living documentation for the IRP Regional Needs Assessment, and they will be supplemented and refreshed with updated materials as they become available.

Policy

By Minute Item 14727, dated December 16, 1952, board adoption of a statement of policy with regard to the plans being proposed for the importation or development of large, additional water supplies for the area coming within the scope of this District.

By Minute Item 39412, dated January 14, 1992, board adoption of the revised mission statement of the Metropolitan Water District of Southern California.

By Minute Item 41734, dated January 9, 1996, board adoption of the Integrated Water Resources Plan.

By Minute Item 43810, dated December 14, 1999, board adoption of the Strategic Plan Policy Principles.

By Minute Item 45841, dated July 13, 2004, the Board approved the Integrated Water Resources Plan Update report and the regular interval of IRP Implementation Reports and IRP updates.

By Minute Item 48449, dated October 12, 2010, board adoption of the 2010 Integrated Resources Plan Update.

By Minute Item 50358, dated January 12, 2016, the Board adopted the 2015 Integrated Water Resources Plan Update.

Metropolitan Water District Administrative Code Section 11104: Delegation of Responsibilities.

California Environmental Quality Act (CEQA)

CEQA determination for Option #1:

The proposed action is not defined as a project under CEQA (Public Resources Code Section 21065, State CEQA Guidelines Section 15378(b)(2) and 15378(b)(5)) because it involves organizational or administrative activities and general policy and procedure making that would not result in a direct or indirect physical change to the environment.

CEQA determination for Option #2:

None required

Board Options

Option #1

Authorize the General Manager to adopt the 2020 Integrated Water Resources Plan Regional Needs Assessment.

Fiscal Impact: No immediate impact; Metropolitan's long-term costs will depend upon individual project approvals following a forthcoming One Water Implementation Plan.
Business Analysis: Metropolitan's mission is to provide a reliable supply of water to its service area. The 2020 IRP Needs Assessment findings provide guidance on how Metropolitan may accomplish this mission for the next 25 years

Option #2

Do not adopt the 2020 Integrated Water Resources Plan Regional Needs Assessment.
Fiscal Impact: None
Business Analysis: This option reduces the ability of Metropolitan to consider and plan for major changes in the region's water resources.

Staff Recommendation

Option #1

3/16/2022
Brad Coffey *Date*
Manager, Water Resources Management

3/17/2022
Adel Hagekhalil *Date*
General Manager

Attachment 1 – 2020 IRP Regional Needs Assessment

Ref# wrm12685000

2020 IRP – Regional Needs Assessment

Draft

Executive Summary

Southern California's water future in a word — uncertain.

Higher temperatures in the Southwest have led to a dramatic reduction in Colorado River runoff this century. Variable weather in Northern California and stressed ecosystems have resulted in unprecedented low imports from the State Water Project (SWP). Likewise, in Southern California itself, less stormwater is percolating into groundwater basins, both from too much rain at times or not enough.

As a regional planner for water supply reliability for Southern California, the Metropolitan Water District relied on single, mid-range forecasts during planning efforts for over a generation. At this moment, with so many questions about what lies ahead, planning that narrows in on a single forecast does not capture the breadth of uncertainties.

Scenario Planning: A Fresh Approach

In collaboration with its 26 member agencies, other interested parties, and its Board of Directors, Metropolitan has broadened its perspectives with scenario planning and thoroughly analyzing four potential futures – all different, all plausible. In the scenarios, demands on Metropolitan's imported supplies varied due to different weather and demographic patterns, among other factors. Supplies varied as well, due to reasons such as climate change severity and regulatory impacts.

After analyzing these futures, a potential for water shortages emerged. The planning revealed that a large portion of Metropolitan's service area is vulnerable to Northern California drought and regulatory restrictions. At present, Metropolitan has limited capacity to move Colorado River water to the northern portions of the district's service area served by the SWP.

The member agencies in this area are the City of Burbank, Calleguas MWD, Eastern MWD, Inland Empire Utility Agency, Las Virgenes MWD, Los Angeles Department of Water and Power, San Fernando, Three Valleys MWD, Upper San Gabriel Valley MWD, and Western MWD. About a third of Metropolitan's six-county service area lives within the boundaries of this SWP Dependent Area.

As the scenario planning process identified the potential of water shortages for these communities, the threat began to play out in real life.

The 2020 and 2021 water years experienced record low supply from Northern California due to the drought – a 20 percent SWP allocation in 2020 followed by a historically low 5 percent last year. Metropolitan declared a drought emergency in 2021 because the Dependent Areas were approaching shortage conditions.

With experience confirming analysis, Metropolitan found the possibility of shortage in three of the four scenarios, after exhausting available and accessible supplies. Only in a future with low demands and stable imported supplies would Southern California avoid shortage without additional water supply and system reliability investments. The record low supplies so far this decade from Northern California, coupled with the first-ever shortage declaration for the lower Colorado River in August 2021, suggest the region may not be so fortunate.

Scenario planning led to the following findings:

SWP Dependent Areas

- Vulnerabilities in the SWP Dependent Areas are more severe given reduced reliability of SWP supplies and Metropolitan distribution system constraints. Actions identified in the implementation phase must prioritize addressing the SWP Dependent Area's reliability challenge.
- New core[1] supplies must be accessible to the SWP Dependent Areas. Greater access to existing core supplies can also increase SWP Dependent Area reliability.
- Enhanced accessibility to core supplies and storage, both existing and new, will improve SWP Dependent Area and overall reliability. This includes improvements to Metropolitan's distribution system and capacity to deliver non-SWP supply and storage.
- Storage capacity, put/take capabilities, and accessibility are critical considerations for the SWP Dependent Area. New storage capacity and put/take capabilities should be consistent with the portfolio analysis. New storage must be accessible to the SWP Dependent Areas.

Storage

- Storage capacity, put/take capabilities, and accessibility are critical considerations in maintaining reliability under the region's current and future conditions, especially for SWP Dependent Areas.
- Maintaining Metropolitan's existing storage portfolio is critical, including the consideration of re-negotiating contracts when they expire.
- Expanding existing or developing new storage programs and investments in Metropolitan's distribution system can reduce the need for new core supply development to meet potential future shortages and adapt to climate change.
- When evaluating storage options, put/take capabilities are essential; even storage programs with modest put/take capabilities help reduce the need for flexible supply[2].

Retail Demand/Demand Management

- Metropolitan's future supply reliability may fluctuate based on demand increases and decreases.
- Variability in retail demand largely comes from changes in outdoor water use. Outdoor water use behavior is complex, influenced by weather and climate and by awareness of water scarcity and other conservation measures.

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[1] Core supplies are resource management actions that augment supply or reduce Metropolitan demand and remain available each year.

[2] Flexible supplies are implemented as needed and include savings from deliberate efforts to change water use behavior

- It is important to pay attention to demand rebound, demand growth, and demand reductions, and take appropriate regional measures as necessary.
- Managing long-term demands through the efficient use of water reduces dependency on supplies, helps preserve storage, and helps reduce the need for extraordinary conservation measures.

Metropolitan Imported Supplies

- Existing imported supplies are at risk from various drivers of uncertainty.
- Maintaining existing imported supply reliability reduces the need for new core supply development and leverages years of investments.
- SWP supplies are highly susceptible to varying hydrologic conditions, climate change, and regulatory restrictions.
- Variability and capacity in SWP supplies provide opportunities to store water during wet periods for use in dry years, including Colorado River storage. Metropolitan's ability to distribute or store SWP supplies when they materialize will enhance the region's reliability, particularly the SWP Dependent Areas. The Colorado River system and Colorado River Aqueduct capacity do not offer the same opportunities concerning SWP storage.
- Shortages on the Colorado River will limit the reliability of Colorado River Aqueduct deliveries as a core supply in the future.

Local Supply

- Maintaining existing and developing new local supplies is critical in helping manage demands on Metropolitan.
- Impacts to reliability occur if local supply assumptions are not achieved; therefore, it is important to track the progress of local supply development as one of the signposts in the One Water Implementation phase.
- Additional actions may be needed should existing and future local supply levels deviate from IRP assumptions.

One Water: How a Comprehensive Solution Starts by Understanding the Need

Metropolitan's emerging One Water approach to reliability and resilience brings together all of Southern California's interests in managing finite water resources for both community and ecosystem needs. It goes beyond identifying the region's future water portfolio and embraces collaboration, diverse communities, and a unified approach to problem-solving. This 2020 IRP looks at multiple futures and builds a One Water foundation by understanding the potential needs of Southern California in the next quarter-century.

Metropolitan's stated goal is 100 percent reliability for all its Member Agencies. The first step toward achieving this goal is to identify potential shortcomings, which speaks to the wisdom of analyzing different plausible futures. The scenario analyses revealed conceivable reliability outcomes through

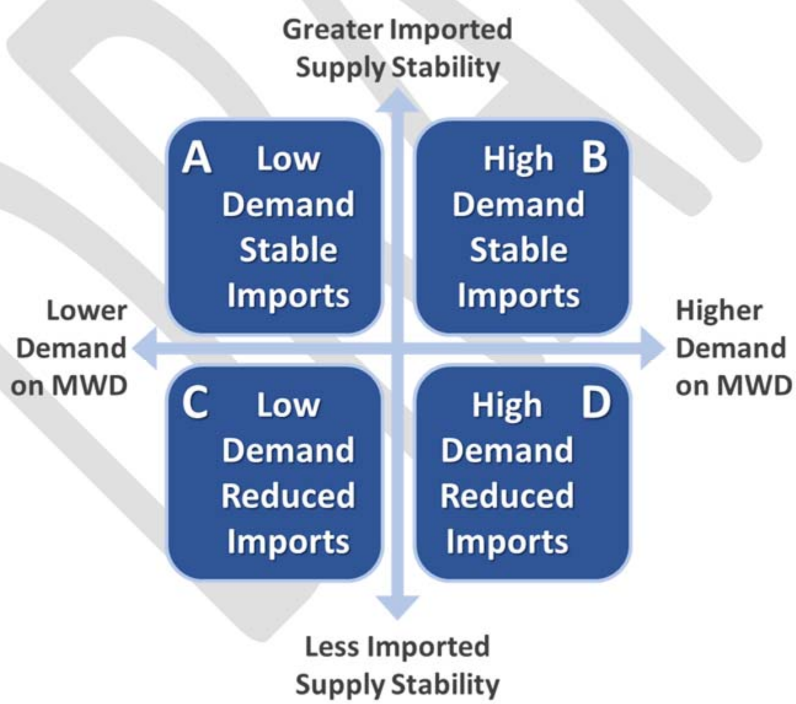
2045. The potential annual net shortage ranged from none under the Low Supply/Stable Imports Scenario (A) to as high as 1.2 million acre-feet (MAF) under the High Demand/Reduced Imports Scenario (D). As Metropolitan proceeds towards implementation in the next phase of the IRP, actions will address these gaps consistent with the portfolio category analysis presented in Chapter 4.

The IRP Regional Needs Assessment identifies significant threats facing Southern California's water supply reliability through successive qualitative and quantitative analysis steps. The assessment sizes up the scope of reliability challenges and the management solutions that could be in store for the region by the year 2045 under a wide range of conditions. The completion of this assessment launches the "One Water Implementation" phase, which will involve extensive collaboration among Metropolitan's Board, member agencies, and other interested parties to develop an adaptive management strategy will also establish a process for monitoring key reliability indicators and find joint approaches to the regional problems and resource needs identified in this assessment. For example, Metropolitan will continue to support the development of local supplies by Member Agencies during the One Water Implementation phase.

IRP Scenario Framework

As illustrated by **Figure ES-1**, the 2020 IRP is based on four scenarios characterized by divergent outcomes of imported supply stability and water demands on Metropolitan.

***Figure ES-1**: 2020 IRP Scenario Framework*



Key drivers of these outcomes include climate change, regulatory requirements, and the economy. These remain uncertain but significantly contribute to water supply and demands. These and other drivers of change were identified through a collaborative process. The impacts of these drivers within each scenario were quantified using Metropolitan's models.

The IRP scenarios serve as learning tools, not predictions. By contemplating four alternative but plausible outcomes, they shed light on what could happen between now and 2045. They also signal the need for future "signposts" to indicate emerging needs that may require the re-prioritization of future investments and other adaptive actions.

Technical Results

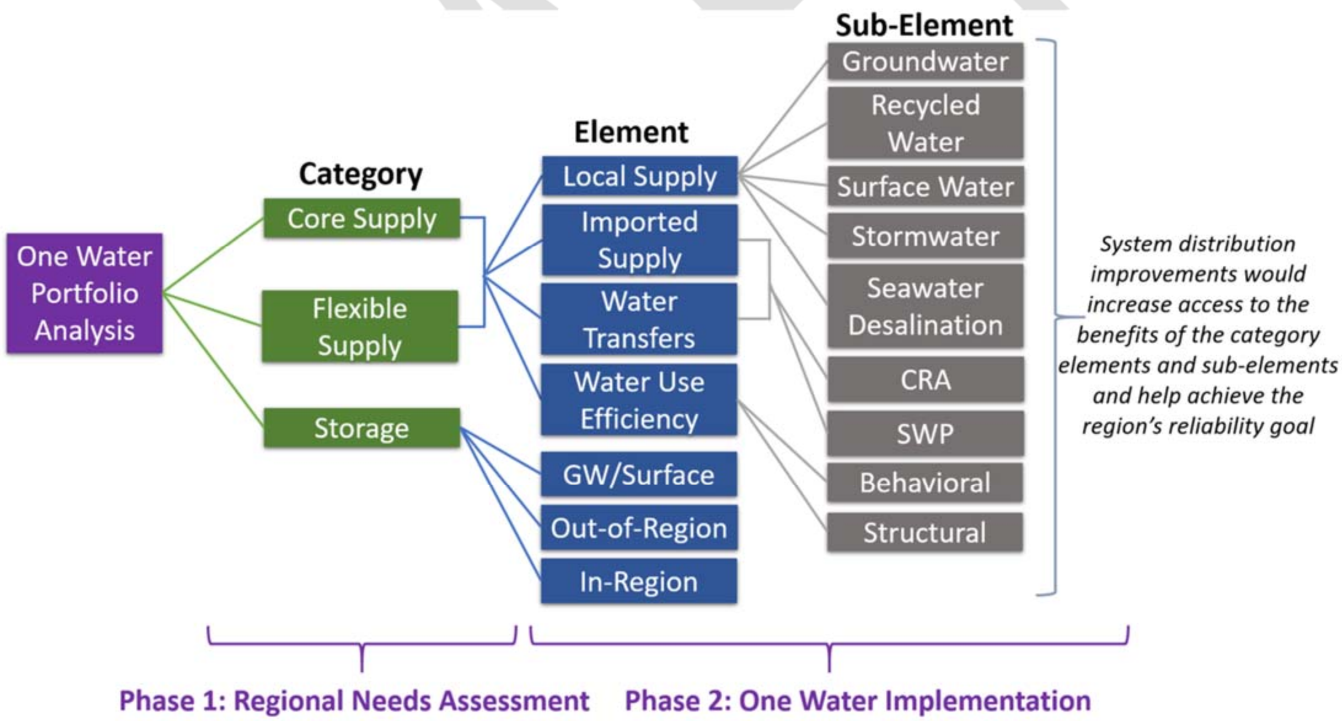
The technical results of the Regional Needs Assessment were based on two analytical processes:

- Reliability assessment to define and quantify potential "gaps" for each scenario, and
- Portfolio analyses to quantify high-level categories of actions that would be needed to achieve reliability in each scenario.

Scenario A (Low Demand/Stable Imports) posed the least challenge to reliability, Scenario D (High Demand/Reduced Imports) the greatest.

As shown in **Figure ES-2**, the portfolio analysis explored the effectiveness of supply categories to reduce or eliminate gaps. The three supply types include core, flexible, and storage. The evaluation determined an effective resource mix for each scenario at the category level.

Figure ES-2: *Levels of One Water Portfolio Analysis*



Note: The elements and sub-elements identified are examples and not meant to be an exhaustive list.

This report, which completes the IRP Regional Needs Assessment phase, offers findings, quantifies supply-demand gaps, and examines the effectiveness of generalized portfolio categories to inform implementation. The One Water Implementation phase will analyze solution portfolios at the Element and Sub-Element levels, consistent with the core supply, flexible supply, and storage configurations identified here.

These results and findings impart optimism for Southern California's water future. Metropolitan has identified the tools necessary to successfully adapt to various plausible futures using the full suite of available solutions — a comprehensive One Water approach. It is also well within Southern California's control to avoid a future with unsustainable increased per-capita water use and demands. With the development of an adaptive management strategy, Southern California can adjust its portfolio of water actions to keep up with our changing times.

Chapter 1 - Introduction

The Evolution of Metropolitan's Integrated Water Resource Planning

The Integrated Water Resources Plan (IRP) is Metropolitan's key planning effort that establishes a long-term, comprehensive water resources strategy to provide the region with a reliable and affordable water supply. At its core, the IRP process is a collaborative effort between key interested parties – Metropolitan, its Member Agencies, other local water agencies, and community, business, environmental, and agricultural interests – to identify preferred solutions to long-term water resource reliability challenges and develop strategies to address those challenges.

The IRP is adaptive – as regional water resource issues evolve, so does the IRP. Since the inaugural IRP in 1996, Metropolitan routinely monitors conditions and measures progress in achieving the plan's objectives. As such, the IRP has been periodically updated to expand Metropolitan's strategy to address changing conditions that affect water resource reliability.

Regional Assemblies and the 1996 IRP

The 1987-1992 drought (California Department of Water Resources, 2021, pp. 4-6) exposed Southern California to significant water supply challenges across six years, prompting a change in water management, investment, and planning. In response, Metropolitan initiated regional assemblies of Metropolitan's board and senior management, member agency managers, local water agencies, and invited public officials. The assemblies established principles for agencies in the service area that would guide the development and adoption of future IRPs:

- Every water supplier, to varying degrees, relies upon the regional imported water supply distribution and storage system.
- Metropolitan is a lead agency in the region's water management.
- Every water supplier is responsible for promoting a strong water ethic to their constituents and is committed to the transparent, equitable, and fair development and implementation of water management programs to achieve regional goals.

With this foundation, Metropolitan developed the first Integrated Water Resources Plan (MWDSC, 1996). The 1996 IRP identified a "Preferred Resource Mix" based on cost-effectiveness, diversification, and reliability to supply the region through 2020. This portfolio balanced the investments between imported supply, local supply, and conservation. Additionally, the 1996 IRP emphasized the need for a coordinated network of surface and groundwater storage.

2004 IRP Update

After the 1996 IRP, drought within the Colorado River Basin resulted in the loss of surplus supplies available to Metropolitan. In 2003, the Quantification Settlement Agreement (QSA) and other related agreements established water use caps for higher-priority users in California, enabling several new water transfer programs to augment Metropolitan's basic apportionment. The 2004 IRP Update updated the original goals set in 1996, quantified the impact of changing conditions, and revised resource development targets through 2025. This first update recognized the need to adapt to changing conditions and anticipate uncertainties. These uncertainties ranged from population and economic growth, increasingly stringent water quality regulations, endangered species protections, and a shifting climate and hydrology. The update addressed these uncertainties by including a planning buffer of

10 percent of regional demands (500,000 AF) that identified additional local supplies and imported supply transfers or exchanges that could be implemented as needed.

2010 IRP Update

By 2010, the Colorado River had experienced below-average precipitation for a decade. The SWP faced new environmental and water quality protections that reduced the Sacramento-San Joaquin Delta supplies, particularly during the 2007-2009 drought. The 2010 IRP Update established adaptive management as a strategy to meet demands under observed hydrology and future uncertainty to address these changed conditions. Elements of the adaptive management strategy included:

- **Core resources.** A strategy to maintain reliability under planned conditions such as published demographic forecasts and historical hydrology.
- **Supply buffer.** This strategy expanded the earlier concept of a planning buffer to respond to shorter-term variability outside of planned conditions. This preventive action included expanding water-use efficiency and local supplies beyond the core resources.
- **Future supply actions.** This new strategy addressed long-term uncertainty by accelerating the development of new water supplies through driving feasibility studies, technological research, and regulatory review.

With the 2010 IRP Update, Metropolitan's planning efforts began to lay the foundation for a more proactive strategy to address future uncertainties.

2015 IRP Update

The 2012-2016 drought (DWR, 2021) further strained imported supplies and local groundwater basins that were already in decline from extended dry conditions and regulatory constraints. However, the region entered this drought with a record quantity of water stored within Metropolitan's network of reservoirs and groundwater banks at the time, highlighting the success of Metropolitan's investments in storage guided by the IRP. These critically dry years acted as both a stress test for Metropolitan's adaptive management strategy and a further indication of the severe challenges the future could hold. The 2015 IRP Update revised resource targets, identified transfers and exchanges to address short-term risk, and reaffirmed the importance of taking action today to accelerate the development of new water supplies through future supply actions. As such, the 2015 IRP Update developed approaches for how Metropolitan could advance conservation and local resources development and maximize its storage reserves in a future that may see more severe and frequent drought.

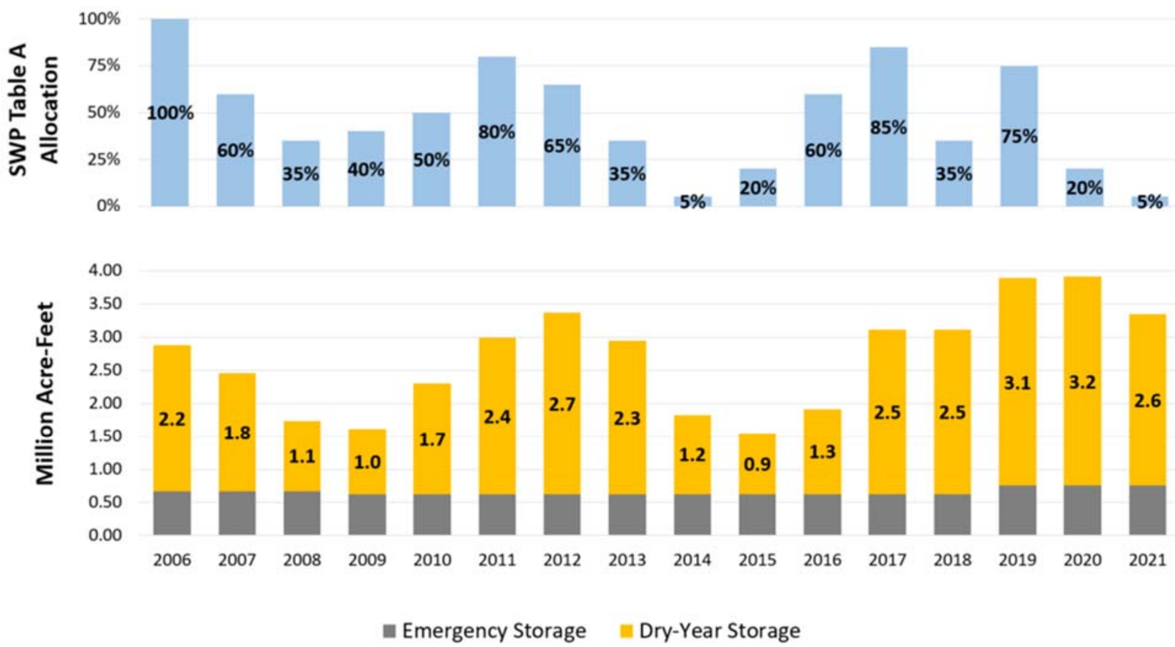
Conditions Underlying the 2020 IRP and Future Uncertainty

After the 2015 IRP Update, the region received a brief respite from drought. From 2016 to 2020, Metropolitan leveraged its prior investments in conservation, local projects, regional storage, distribution, and treatment infrastructure to rapidly improve its water supply position. Metropolitan moved a record amount of water into storage in 2017 and reached a record-high storage balance by the end of 2020 as shown in **Figure 1-1**. This figure also illustrates that Metropolitan has, through these investments, stored water in wet years when the SWP allocation was higher (2010-2012, and 2016-2017, and 2019) for use in drought years when the SWP

Metropolitan Imported Supplies Finding: *SWP supplies are highly susceptible to varying hydrologic conditions, climate change, and regulatory restrictions.*

allocation was lower (2008-2009, 2013-2015, and 2020-2021). Metropolitan's diverse portfolio investments guided by the IRP made this management of wetter hydrologic conditions possible. The region's ability to continue to effectively manage surplus water during wet years to quickly recover from dry conditions will prove vital for managing through future droughts.

Figure 1-1: *SWP Allocation and End of Year Storage Balance*

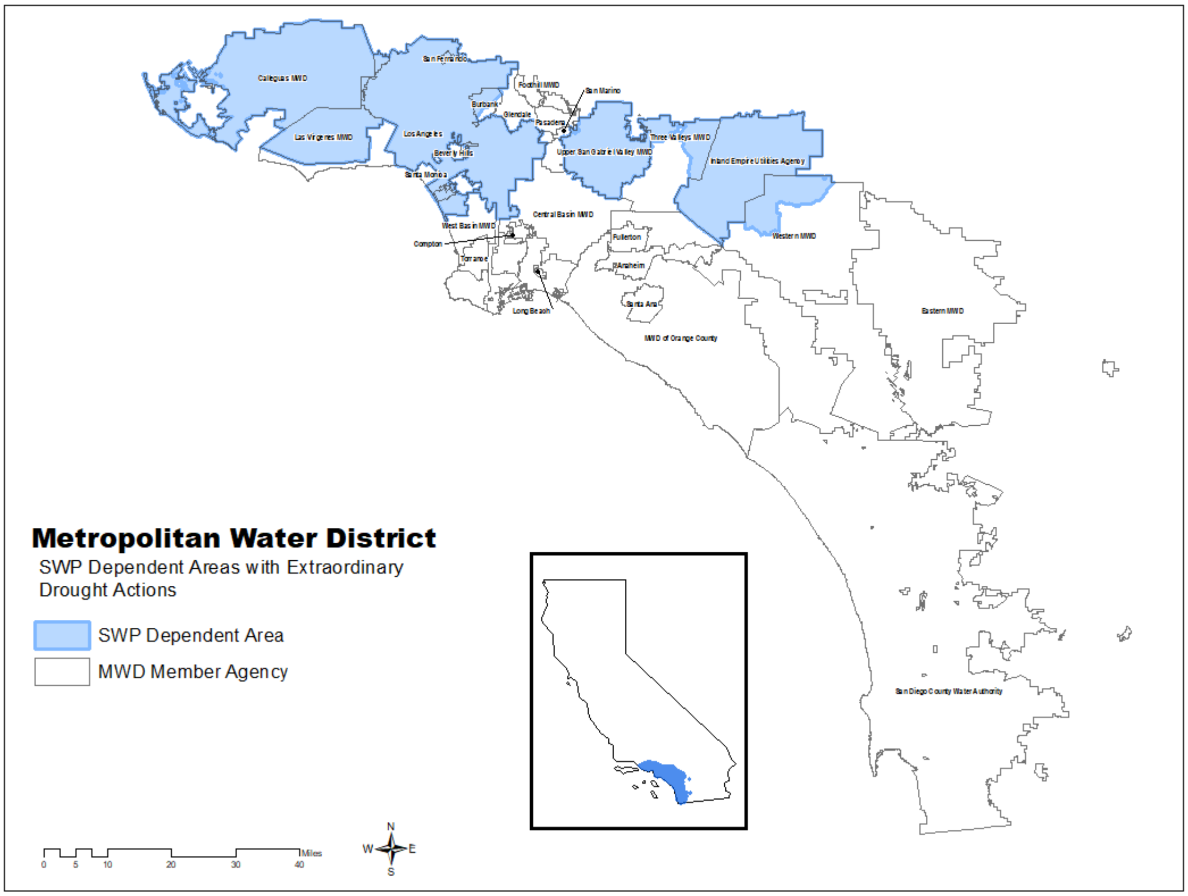


Note: End of year 2021 balance subject to DWR adjustments and USBR final accounting.

The current drought once again brought the need for regional planning sharply into focus. Despite the record amounts of water in storage at the end of 2020, consecutive low SWP allocations in 2020 (20 percent) and 2021 (5 percent) highlighted a critical vulnerability within Metropolitan's existing distribution system. Colorado River supplies cannot serve some parts of the service area that are not otherwise self-sufficient with local supplies. A key challenge for Metropolitan in 2021 was in meeting water demands in these "SWP Dependent Areas," shown in **Figure 1-2**. The very low SWP allocation of 5 percent made it imperative to safeguard the limited SWP supplies. A combination of storage withdrawals, voluntary conservation efforts, and expanded access to Colorado River supplies through extraordinary drought actions preserved SWP Table A supplies and SWP storage to meet SWP Dependent Area demands in 2021.

Vulnerability of the SWP Dependent Areas is both a near-term and long-term concern, as the findings of this 2020 IRP Regional Needs Assessment Report will emphasize. As of the writing of this report, ensuring water reliability for the SWP Dependent Areas continues to be a challenge. Metropolitan declared a regional drought emergency in November 2021 because the SWP Dependent Areas were approaching shortage. On December 1, 2021, the California Department of Water Resources (DWR) announced a zero percent initial SWP Table A allocation for 2022 based on low reservoir levels and dry hydrologic conditions; DWR later increased the 2022 SWP allocation to 15 percent in January 2022 after favorable precipitation events in December[3]. Under a zero percent SWP allocation, there would have been insufficient SWP supplies to fully meet consumptive demands not deemed essential to human health and safety needs in the SWP Dependent Areas. Additionally, Metropolitan would be unable to replenish its regional storage in Diamond Valley Lake. As such, it is vital to maintain and preserve SWP deliveries to ensure reliability throughout Metropolitan's service area. If conditions for Metropolitan's crucial imported supply systems continue to worsen, then the region may increasingly face similar prospects in the future.

Figure 1-2: *State Water Project Dependent Areas with Extraordinary Drought Actions*



The extreme changes in hydrologic conditions since the 2015 IRP Update underscore why it is vital that the IRP evolves. While past investments have played a key role in managing through the changing conditions experienced over the past 25 years, the continued evolution of the IRP will be essential for guiding the next 25 years of investments. Today, as the forecasts of past IRPs draw inevitable comparisons to present conditions, there is a growing appreciation of the limitations inherent to any projection based on a single set of assumptions. An array of factors shaped water supply and demand trends between then and now, and many uncertainties out of Metropolitan's control loom on the

[3] As of this writing, the SWP allocation of 15 percent is not finalized for 2022. Continued dry conditions may result in a lowering of the allocation.

horizon. Mounting evidence of an increasingly varied climate and a proliferation of other external uncertainties suggest that previous IRPs may have relied on too narrow of a range of outcomes to ensure the avoidance of shortages in the future.

Figure 1-3: *Evolution of IRP Retail M&I Demand Forecast Range and Observed Historical Demand*

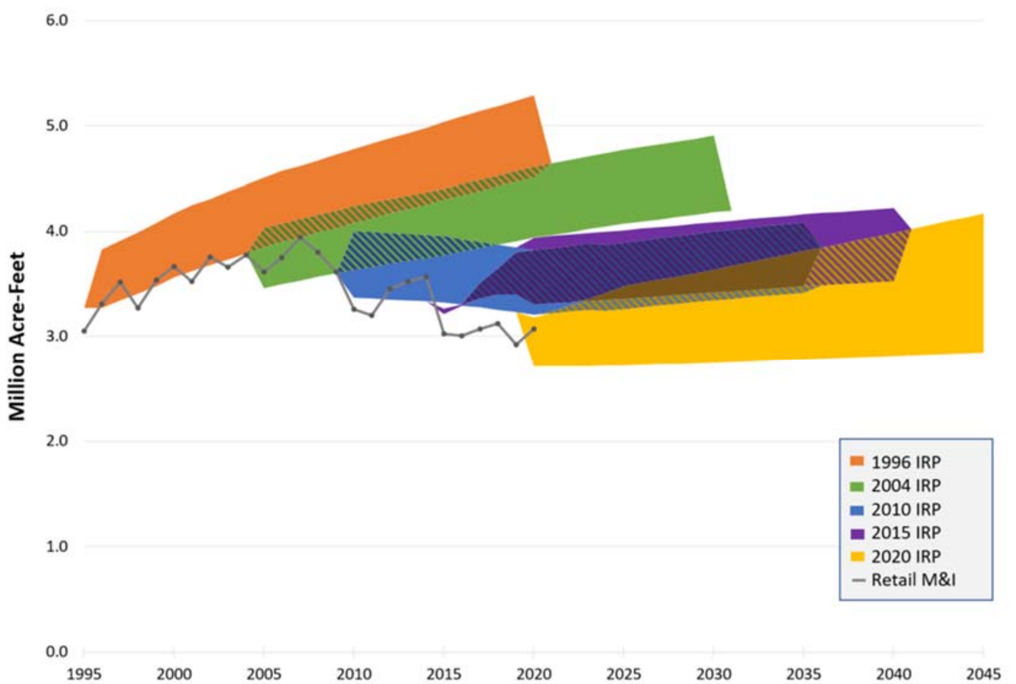


Figure 1-3 illustrates that Metropolitan recalibrated to current conditions as a baseline for each IRP update. Additionally, each IRP update incorporated new knowledge on uncertainties in the forecasts. The 2020 IRP in the yellow shaded area of the chart offers a wider range of retail demand forecasts than previous IRPs. It encompasses a range of assumptions comprising four distinct scenarios. It also takes a step forward from prior IRPs by examining a broader range of outcomes for these uncertainties, rather than just one set of assumptions as in past IRPs. For the 2020 IRP, all four scenarios launch and diverge over time from a common baseline of observed conditions leading up to the year 2020.

The 2020 Integrated Water Resource planning process features a regional needs assessment, as its first phase, that evaluates the impacts of future uncertainties on water resource reliability. This effort resulted in a comprehensive list of findings, the focus of this report, to help guide actions to address those uncertainties. Going forward, Metropolitan has the process and tools to evaluate specific investments and program actions under a range of future scenarios — developing an adaptive management strategy through the One Water Implementation that can guide implementation.

Chapter 2 – IRP Scenario Process

Planning for an Uncertain Future

It is increasingly clear that the underlying mechanisms and assumptions used to make past IRP projections are unpredictable. This means that a single long-term prediction on Southern California's water supplies and demands will provide an underestimation of the uncertainties and overconfidence in a specific presumed future. In this light, being aware of the range of alternative prospects is more useful than relying on a single projection. Thus, a new analytical framework was developed to:

- Define and account for uncertainties affecting water reliability
- Develop a method to assess and communicate the impacts of those uncertainties
- Explain the uncertainties and their relevance in a clear and transparent way
- Allow integration with an adaptive management strategy that will provide ongoing decision support, information generation, and reporting as essential components

Early on, scenario planning was selected to fulfill these objectives (Metropolitan Water District of Southern California, 2020g). Scenario building involves creativity, imagination, introspection, and reality checks based on political, economic, and scientific reasoning. To come up with a broad view of water-related uncertainties and plausible outcomes, Metropolitan undertook a comprehensive engagement process with its Board, member agency staff, other interested parties, and expert consultants.

In shaping the region's long-term water reliability, Metropolitan understood the importance of consensus on uncertainties and evaluating their impact. Public outreach and involvement for the 2020 IRP followed a different approach than before. Due to the onset of the COVID-19 pandemic in 2020, public outreach events pivoted to online presentations and workshops with additional information and public comment opportunities at IRP Committee meetings. The IRP microsite on Metropolitan's website provided access to expert panel discussions, data and analysis, presentations, and white papers. The online outreach broadened the opportunities for interested parties to engage throughout the IRP process.

Reliability Goal

Metropolitan's Board established the Integrated Resources Plan Special Committee (IRP Committee) to provide oversight and input during the development of the 2020 IRP. Early in the process, the IRP Committee reaffirmed a goal to provide 100 percent water supply reliability for the service area. This overarching goal set the tone for the IRP planning process and the basis for the subsequent analyses.

Given the Board's commitment to avoid shortages, scenario planning helped identify critical vulnerabilities and patterns that can mitigate potential shortages with timely interventions. The One Water Implementation phase will be designed to consider reliability measures under multiple scenarios.

Why Scenario Planning?

A look back since the previous 2015 IRP Update validated the collective, integrated efforts to secure water reliability for the 19 million people of Southern California (MWDSC, 2020e). When developing the 2015 IRP Update, California was enduring a historic drought, and the Colorado River watershed moved into its second decade of drought. But with a concerted drought response consistent with

Governor Brown's and the State Water Board's imposed mandatory conservation and Metropolitan's planning and policy efforts, the collective actions of water agencies throughout the region reduced per-capita water demands to historic lows. Combined with decades of planning and infrastructure investment since the original 1996 IRP, the area experienced a remarkable turnaround in water supply reliability. The efforts of individual consumers, local retail agencies, member agencies, and Metropolitan all contributed (MWDSC, 2020e).

Despite this success, long-term threats remain. Although persistently low demands since 2015 allowed storage to recover quickly, questions remain about whether per-capita demand will continue its downward trend. Further, the implication of continuing low demands on Metropolitan and the region's other potable and recycled water suppliers must be considered. For example, lower indoor use results in less wastewater with more highly concentrated effluent. This potentially increases the cost of recycling. Coming full circle, California again faces severe drought, conditions on the Colorado River worsen, and the disruption of the COVID-19 global pandemic has shaken society's conceptions of normality, perhaps causing yet unseen ripple effects in water-using behavior trends (AWWA and AMWA, 2020; MWDSC, 2020f; Smull et al., 2021).

The future can quickly move in unexpected directions. Reliability is a constant concern, both today and over the long term. Financial advisors warn investors that past performance is no guarantee of future results. Even the best-laid plans based on past and recent experience may not be resilient in a highly uncertain future. Because interventions to increase reliability come with different costs and benefits, decision-makers must consider affordability, environmental, and equity tradeoffs when deciding upon the timing and scale of those investments. Within this backdrop of emerging and unpredictable threats to water supply reliability and affordability, Metropolitan has considered the potential effects of major drivers and long-term threats as it moves into the IRP's One Water Implementation phase. Scenario planning offers a powerful tool to address these uncertainties.

With scenario planning, plausible futures are envisioned and explored. As described by Varum and Melo (2010), scenario planning helps one "gain confidence by 'pre-experiencing' future scenarios" (p. 361). This approach improves understanding of a broader range of potential outcomes. In turn, those outcomes allow a greater understanding of potential challenges to water supply reliability and the impacts of possible policy direction, helping to inform actions.

Throughout 2020 IRP's scenario planning process, the following points should be considered:

- Scenarios represent outcomes resulting from groupings of drivers of change, which are selected to be internally consistent and whose outcomes are outside of Metropolitan's control
- No scenario should be regarded as "most likely" or "preferred" as each scenario has outcomes that are entirely plausible relative to each other, and there are many other plausible scenarios that could be considered
- Each scenario reveals the potential challenges and choices that Metropolitan could face given the conditions of the scenario
- The value of scenario planning to Metropolitan is to increase awareness and preparedness, with no attempt to control, select, or predict the likelihood of the uncertain and uncontrollable conditions found in the scenario

As a decision support method, scenario planning provides Metropolitan a means to confront uncertain futures with choices that increase preparedness, improve resiliency, and manage vulnerabilities across a broad range of plausible outcomes. It also allows Metropolitan to properly weigh the tradeoffs and opportunity costs for those choices under a broad range of contingencies. Choices that perform well in several scenarios are potentially more beneficial than those that only perform well under a single group of assumptions.

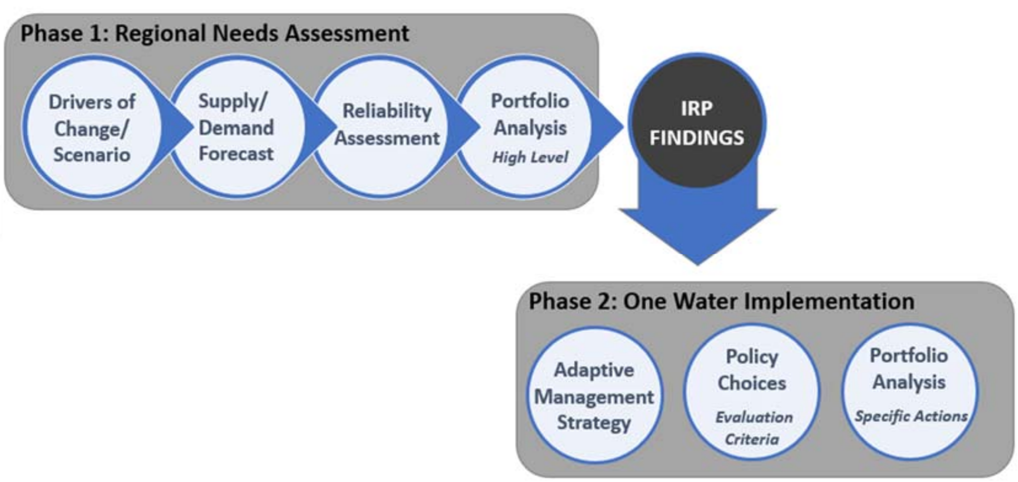
IRP Process Roadmap

With the 2020 IRP decision support method, Metropolitan explicitly examined underlying drivers of change for the water supply and demand outlook for Southern California. It used that knowledge to follow the causes and consequences of different outcomes logically. The 2020 IRP process followed the roadmap depicted in **Figure 2-1** and is divided into two phases:

- Phase 1: Regional Needs Assessment
- Phase 2: One Water Implementation

This report completes the IRP Regional Needs Assessment phase and offers findings to inform implementation. In the One Water Implementation phase, portfolios will be advanced by identifying policies, programs, and projects which provide regional solutions to the IRP Regional Needs Assessment findings. A comprehensive, adaptive management strategy will be developed in the One Water Implementation phase to guide these specific actions.

***Figure 2-1**: Roadmap for Phases 1 and 2 of 2020 IRP*



Identify Drivers of Change

The first step of the Regional Needs Assessment was to identify major sources of unavoidable and external uncertainty, or "drivers of change." This step included engaging stakeholders to help identify the drivers and select major ones to move forward into the scenario analysis. Key drivers such as climate change, regulatory requirements, population growth, and the economy have uncertain but potentially significant effects on both water supply and demands in Southern California. Outcomes of these factors greatly affect future water supply reliability.

Drivers of change were investigated through a collaborative and iterative process. Metropolitan staff engaged with the Board, member agencies, and other interested parties to solicit input on drivers of change. This involved defining and grouping a coherent set of drivers and assessing their relative impacts on Southern California's water supplies and demands. This process included an online survey collecting input from Board, member agencies, and other interested parties, asking respondents to indicate the relative importance of drivers of change. The most important drivers that emerged from the process ultimately became the basis for the IRP Scenarios discussed in this report. **Table 2-1** shows the rank order of the drivers of change based on the survey (MWDSC, 2020c).

Table 2-1: *Metropolitan's Drivers of Change Survey, Ranked by Cohort*

Board Members	%	Member Agencies	%	External Interested Parties	%
Colorado River Cooperation	95%	Colorado River Cooperation	91%	Hydrologic Variations	92%
Hydrologic Variations	90%	Stress on River Basins	87%	Outages & Disasters	87%
Stress on River Basins	90%	Direct Potable Reuse	83%	Stress on River Basins	84%
Emerging Regulations	86%	Hydrologic Variations	83%	Direct Potable Reuse	81%
Direct Potable Reuse	76%	Groundwater Contamination	78%	Groundwater Contamination	78%
Outages & Disasters	76%				

Note: Percentages are based on responses that indicated each driver of change to be either "extremely important" or "very important."

Develop Scenarios

The next step of Phase 1 was to establish alternative planning scenarios. This involved the development of separate sets of assumptions for the key drivers of change. These sets of assumptions became the basis for IRP scenarios.

Metropolitan then developed three increasingly refined iterations of IRP scenarios. The first iteration used hypothetical "Strawman Scenarios" as a proof of concept to demonstrate the feasibility of constructing scenarios from the drivers of change (MWDSC, 2020a). In September 2020, staff presented a draft set of "preliminary scenarios" that used initial drivers of change assumptions (MWDSC, 2020b). Staff incorporated extensive feedback by Board members, member agency staff, groundwater basin managers, and experts in demographics, water demand, and climate science. This process resulted in the "refined scenarios." The refined scenarios are the final scenarios that formed the basis for the reliability assessment analyses and resulting findings discussed in this report.

Supply and Demand Forecasts

The work to this point was largely qualitative. The next step was to quantify the impacts on supply and demand given the drivers-of-change assumptions for each scenario. Metropolitan conducted extensive modeling to forecast the region's retail demand, local supply projections, and resultant demand on Metropolitan over the 25-year time horizon. Additional modeling was performed to determine Metropolitan's imported supply capability for the conditions reflected in each scenario. For each of the three iterations of the four scenarios leading up to the "refined scenario," a corresponding set of retail demand forecasts, local supply projections, demands on Metropolitan, and supply capability were produced and presented to the Board IRP Committee, member agencies, and external workshops.

Reliability Assessment

After the scenarios were quantified in terms of supply and demand, the next step was to perform the reliability assessment. This began by establishing what was projected to occur if the trends identified in the scenarios continued without intervention. These was labeled the "Take No Action" case. Here, "Take No Action" means what would happen to water supplies and demands without intervention and as a result of the scenario's assumptions such as externalities outside of Metropolitan's control. The "Take No Action" case showed what would happen if Metropolitan relied solely on existing supply resources and trends. The resulting difference between supplies and demands became the "supply-demand gap," which quantifies levels of reliability.

This analytical technique isolated reliability problems posed by each scenario from the influence of presupposed solutions, allowing like-for-like comparisons between scenarios. The next analytical step enabled a clean slate for applying quantified solutions appropriate to each scenario's unique circumstances. The reliability assessment modeling was performed on each scenario to quantify the supply-demand gap projected to occur over a 25-year planning horizon ending in 2045. Reliability assessments for the preliminary and refined scenarios were presented to the Board IRP Committee in December 2020 and June 2021, respectively (MWDSC, 2020d; MWDSC, 2021a).

High-Level One Water Portfolio Analysis

The final step of the IRP Regional Needs Assessment was completing a portfolio analysis. This analysis examined each scenario to determine, in concept, what combinations of investments would be necessary to fill the gaps identified in the reliability assessment. This analysis used three mutually exclusive supply categories: core, flexible, and storage. These categories encompass different characteristics, and all resource management options are subsets of these categories. **Core supplies** are resource management actions that augment supply or reduce Metropolitan demand and remain available each year. **Flexible supplies** are implemented as needed and include savings from deliberate efforts to change water use behavior. **Storage supplies** are the capability to save water supply to meet demands later. Using a combination of three supply categories allows for a more diverse and balanced portfolio approach.

The results of these high-level portfolio analyses were presented to the Board IRP Committee in July and September 2021 (MWDSC, 2021a, 2021c). Draft findings were presented at the November 2021 Board IRP Committee (MWDSC, 2021b). The quantitative work of the Regional Needs Assessment is described in detail in Chapter 4, "Results: Phase 1 Regional Needs Assessment" of this report. Findings from the Phase 1 Regional Needs Assessment are discussed in Chapter 5, "Findings."

Phase 2: One Water Implementation

The next phase of the IRP will take the results and findings of the Phase 1 Regional Needs Assessment into a collaborative, deliberative process to come up with regional, integrated solutions. Using a One Water approach, the implementation phase will translate Phase 1's high-level portfolio analysis into potential policies, programs, and projects needed to address the findings and mitigate the potential shortages identified in this work. A comprehensive, adaptive management strategy and evaluation criteria will be developed in the implementation phase to guide these specific actions. The adaptive management strategy will also establish a process for monitoring key reliability indicators to support policymaking.

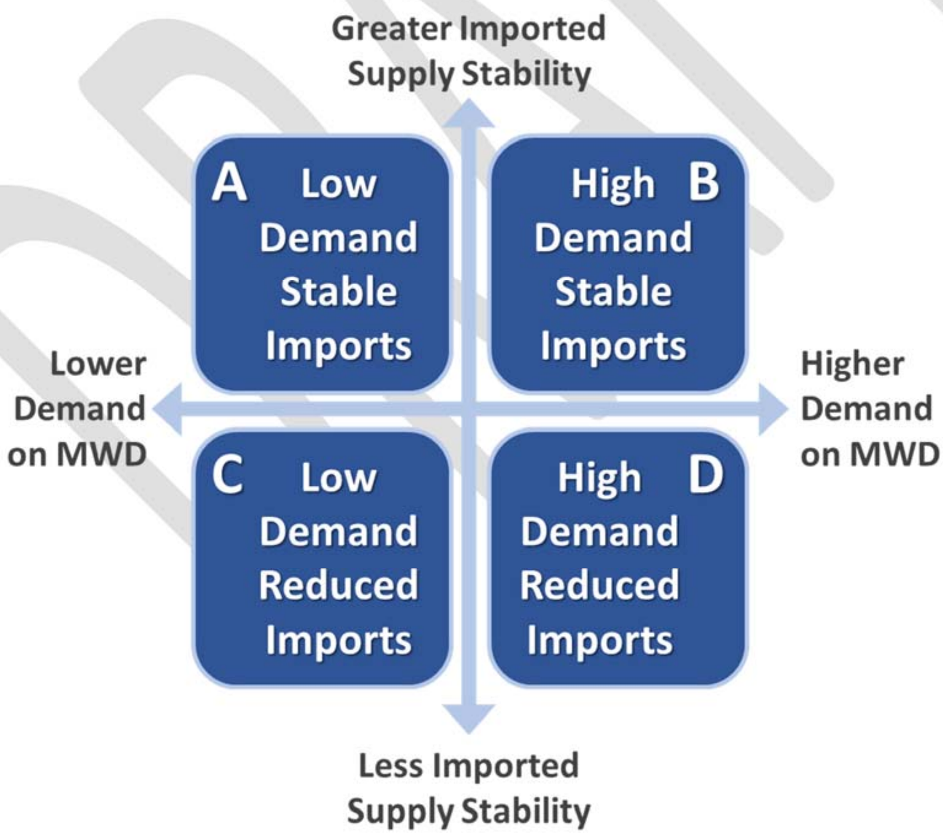
Chapter 3 – Quantifying Uncertainties

Scenario Framework and Descriptions

Quantifying uncertainties began with developing scenarios built on a comprehensive identification of drivers of change that affect supply stability and demands on Metropolitan. These drivers of change encompass basic phenomena such as climate change, economic trends, regulations, and demographic growth outside of Metropolitan's ability to control (i.e., exogenous) but fundamentally shape water reliability. Drivers of change were quantified where possible and defined to avoid double-counting their individual effects and establishing linkages between drivers.

Building on input received from the Board, member agencies, and the expert consultants, **water demands on Metropolitan** and **stability of imported supply** were identified as being the most impactful to water reliability for the region. Metropolitan then examined the drivers of change within this framework, ensuring internal consistency. This resulted in four plausible scenarios. Metropolitan then quantified the associated assumptions to reveal supply-demand gaps, against which actions could be tested. These four scenarios are shown in **Figure 3-1**.

***Figure 3-1**: 2020 IRP Scenario Framework*



As illustrated by **Figure 3-1**, the scenario framework contrasts four distinct plausible scenarios for water supply reliability planning in Metropolitan's service area. Each scenario examined a range of plausible high/low water demand coupled with a range of potential stable/reduced imported water supplies to meet the region's water demand. Inherent in determining demands on Metropolitan are consideration of local supply resources.

The major themes and narrative for the four scenarios are:

- **Scenario A – Low Demand/Stable Imports:** Gradual climate change impacts, low regulatory impacts, and slow economic growth.

  This scenario is characterized by lower retail water demands and stable regional and local supplies. Demands are impacted by lower economic and demographic growth and a continuing water use ethic across the region. Both regional and local supplies show more stable production due to less severe climate change, less restrictive regulatory constraints on existing water supply projects, and relatively robust implementation of new water supply projects at the local level.

- **Scenario B – High Demand/Stable Imports:** Gradual climate change impacts, low regulatory impacts, high economic growth.

  This scenario is characterized by higher retail demands and stable regional and local supplies. Demand is impacted by higher economic and demographic growth and a rebound of water use. Both regional and local supplies show more stable production due to less severe climate change impacts, less restrictive regulatory constraints on existing water supply projects, and relatively robust implementation of new water supply projects at the local level.

- **Scenario C – Low Demand/Reduced Imports:** Severe climate change impacts, high regulatory impacts, slow economic growth.

  This scenario is characterized by lower retail water demands and less stable imported supplies. Demand on Metropolitan is suppressed by lower economic and demographic growth and successful efforts among member agencies to manage water-use behavior and drought-proof local supplies. This scenario couples a struggling economy (i.e., slow growth) with the rapid onset of climate change impacts affecting imported supplies more than less-vulnerable local supplies.

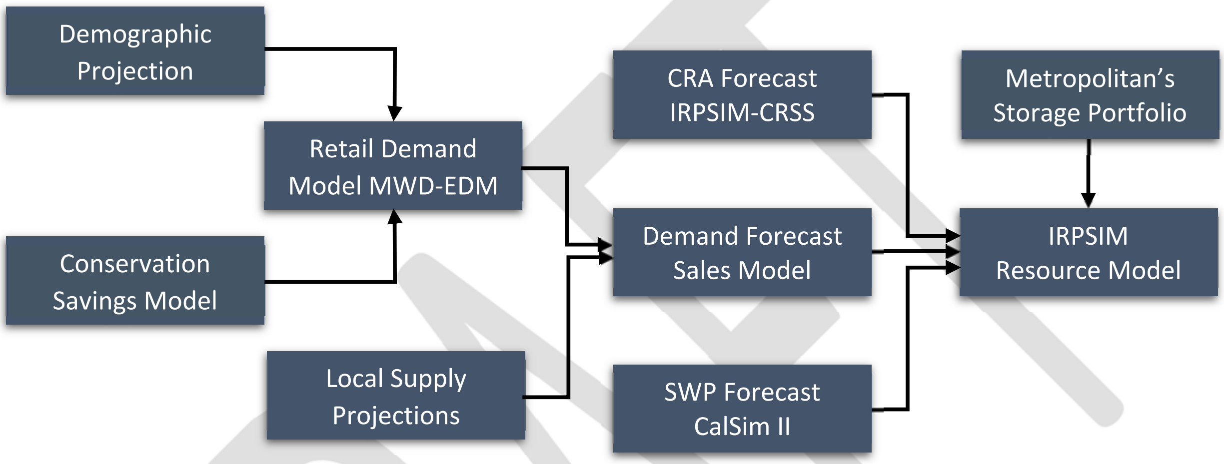
- **Scenario D – High Demand/Reduced Imports:** Severe climate change impacts, high regulatory impacts, and high economic growth.

  This scenario is characterized by higher retail demands, unstable imported, and diminishing local supplies. Demands are impacted by higher economic and demographic growth and a rebound of water use. In this scenario, severe climate change impacts both imported and local supplies. Demands on Metropolitan are increasing due to rapidly increasing demands and diminishing yield from local supplies. Local efforts to develop new local supplies are unable to mitigate these losses. Losses of regional imported supplies are equally dramatic.

Forecasting Supplies and Demands

Reliability means meeting all of the region's water demands through a combination of Metropolitan supplies, local supplies, and increased conservation. The Regional Needs Assessment quantified the range of plausible future water needs for the region through a detailed projection of demographic growth, conservation, local supply production, and the resultant need for imported water. **Figure 3-2** shows the modeling components which create the demand forecast. The demand forecast is then combined with the imported supply forecasts and the storage portfolio to assess reliability.

Figure 3-2: *Metropolitan's modeling framework for quantifying uncertainties.*



Total Retail Demand

Total demand includes M&I, agriculture, seawater barrier, and replenishment uses. Metropolitan's IRP modeling framework assesses each demand category by member agency based on characteristics unique to the member agencies.

Retail M&I Demand Forecast

Metropolitan uses a retail demand model, known as MWD Econometric Demand Model (MWD-EDM), to forecast future retail municipal and industrial (M&I) demands for each scenario using projected demographic growth and conservation savings for each of the four IRP scenarios. Metropolitan constructed demographic growth projections for Southern California with assistance from the Center for Continuing Study of the California Economy (CCSCE). CCSCE's projections were based on studies published by the U.S. Census Bureau. In addition to demographic growth, MWD-EDM also included drivers of change such as smaller lot size for future homes, future conservation, and water use ethic and rebound. MWD-EDM produces retail M&I forecasts for each scenario and member agency.

Conservation savings input for MWD-EDM were estimated using Metropolitan's Conservation Savings Model to produce post-conservation forecasts. The model calculates savings from plumbing code compliance, savings from conservation programs administered by Metropolitan and member agencies, and from price-effect conservation where water saving is realized by retail customers attributable to the effect of changes in the price of water. The Conservation Savings Model calculated conservation savings for each scenario and member agency.

At the retail consumer level, some types of water use vary more than others. Much more variability (i.e., discretion) in water using behavior is associated with outdoor use than indoor use. Because most outdoor use is for watering lawns and gardens, it makes sense that outdoor use and overall water use would increase during warmer and drier weather conditions, all else being equal. Metropolitan's modeling framework simulates the effects of weather conditions on retail demand over time.

Retail Demand/Demand Management Findings:

1) *Variability in retail demand largely comes from changes in outdoor water use. Outdoor water use behavior is complex, influenced by weather and climate and by awareness of water scarcity and other conservation measures.*
2) *It is important to pay attention to demand rebound, demand growth, and demand reductions, and take appropriate regional measures as necessary.*

However, not all things are held equal over time. Consumer behavior and ethics appear to have changed significantly since the 2015 IRP Update, as can be inferred from regional per capita water use that has remained relatively low since the 2015 drought. Consumers are influenced to reduce their water using behaviors through greater environmental awareness, rising water prices, and conservation messaging and restrictions. These consumer signals have been increasing in frequency and intensity, coinciding with the severity of recent droughts, which in turn may be a symptom of climate change. For instance, with incentives from Metropolitan and local water agencies and perhaps encouraged by the example of early-adopter neighbors, more and more Southern California residents have taken action to permanently reduce outdoor water use by removing their lawns since 2015. Conscientious outdoor water use reinforced by ongoing drought conservation measures, combined with the improving efficiency of new water using devices, have kept the region's retail water demands relatively low every year through 2019, the year that Metropolitan used to calibrate its demand projections for the 2020 IRP Regional Needs Assessment. This is despite fluctuations in weather conditions that would have otherwise driven demands higher. This is not to say that consumer ethic would not revert back to higher-use, especially in the absence of continued intervention. With regard to scenario planning, consumer water use ethic will continue to be a considerable force for greater or lesser water reliability, and future trends are uncertain in a long-term planning horizon. This uncertainty is reflected in the scenarios.

MWD-EDM calibrates the forecast to 2019 M&I water use by member agency, which serves as the anchor point of the forecast. Calibrating the model to 2019 assumes that the water-use ethic from 2019 would continue. However, the IRP scenarios also assume some rebound in water use. Conservation savings were categorized as (1) **structural** based on efficiency improvements such as replacing water fixtures with more efficient ones, and (2) **behavioral** reflecting changing consumer water use behavior in response to conservation messaging and education. Structural conservation is more permanent and unidirectional, while behavioral conservation can fluctuate over time. For example, outdoor behavioral conservation such as reducing the number of watering days for lawns during a drought reduces water use. Returning to previous watering schedules after the drought would increase water use which can be described as a demand rebound. If a complete rebound were to occur, overall retail demand would be more than 10 percent higher than a forecast without any rebound.

Other Retail Demand Forecast

In addition to retail M&I demand, the IRP reliability assessment considered retail agricultural, seawater barrier, and replenishment demands. Retail agricultural demand consists of water use for commercial irrigation of crops. Uncertainties about agricultural use include land-use changes, regulatory requirements, and economic conditions, which ultimately impact the operation cost for agricultural water users. Higher costs for agriculture could plausibly lead to a decline in water use. Additionally, a warmer climate could increase the water use requirements of existing crops. For the 2020 IRP, Metropolitan coordinated with member agencies to develop agricultural demand projections.

Seawater barrier demand prevents seawater intrusion into coastal groundwater basins. Metropolitan worked with groundwater basin managers to determine the barrier requirements based on groundwater levels, injection wells, and regulatory permits. Uncertainties include climate change impacts from rising sea levels. For example, overcoming hydraulic pressure from rising seas necessitates increasing seawater barrier demands from local recycled water projects and supplementing imported water. For the 2020 IRP, Metropolitan assumed seawater barrier demands could plausibly increase in scenarios with higher relative sea-level rise associated with severe climate change impacts.

Replenishment demand maintains sustainable groundwater basin health and production. Metropolitan quantified replenishment demand only from recycled water and imported water. Replenishment demand projections provided by member agencies are informed by groundwater basin management policies, groundwater production, and natural and artificial recharge assumptions. For the 2020 IRP, Metropolitan held workshops with groundwater basin managers and member agencies to discuss impacts to replenishment demands, including climate change and regulatory requirements. Outcomes of these discussions highlighted the importance of the timing and implementation of indirect potable reuse and stormwater capture projects and potential changes to natural and artificial recharge due to climate change. Feedback from these workshops was incorporated into replenishment demand projections for each scenario.

Local Supply Projections

Local supplies are produced to meet individual agency demands and are key to determining how much Metropolitan supply is needed. They include groundwater, surface water, the Los Angeles Aqueduct, recycled water, groundwater recovery, and seawater desalination. Local supply projections use information from several sources, including local Urban Water Management Plans, Metropolitan's annual local supply survey, and coordination with local agency staff.

For the 2020 IRP, Metropolitan held focused workshops with the member agencies to gain insights on the challenges facing local supplies and the potential impact on water reliability. These workshops discussed the same drivers identified earlier (economic conditions, climate change, and regulatory restrictions). Through these workshops, the effect of the drivers on existing local supplies and the timing and implementation of future local supply projects was considered.

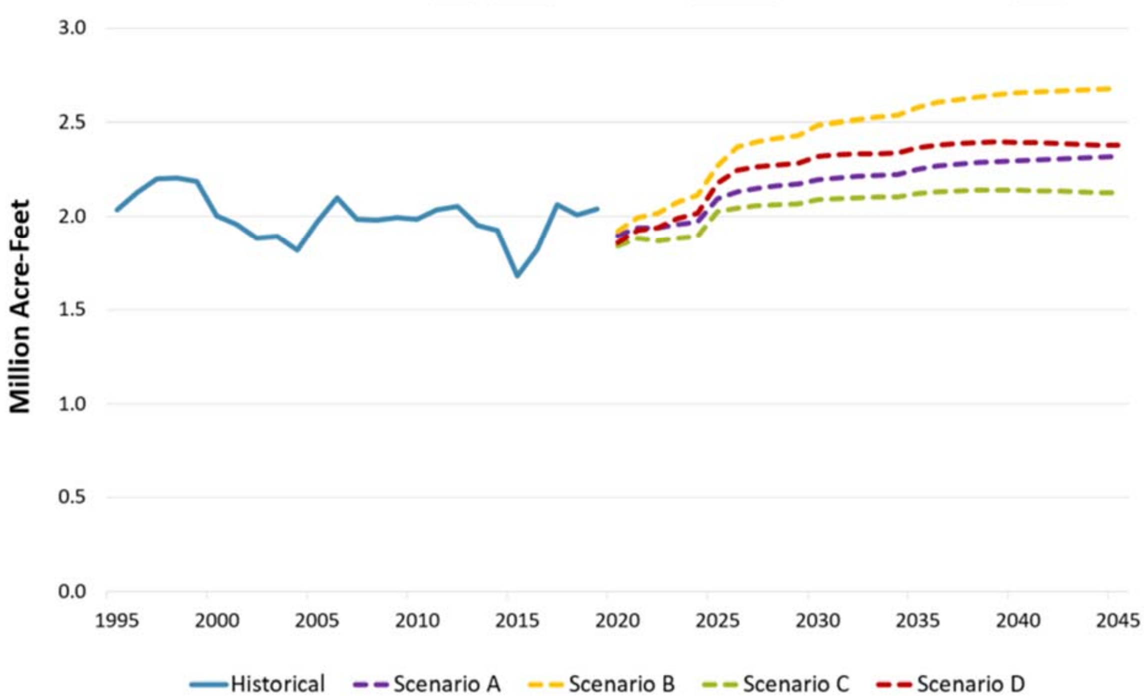
From these discussions, Metropolitan developed local supply projections that examined the degradation of existing supplies in combination with different timing and implementation of the inventory of future local supply projects provided by member agencies. One example of local supply degradation is decreased groundwater production due to a loss of replenishment from changing precipitation patterns or reduced return flows from outdoor irrigation. Additionally, while there was a large inventory of future local supply projects, many still require additional permitting and design. Thus, there remains uncertainty in when projects will come online and how much new water those projects will produce.

Local Supply Findings:

1) *Impacts to reliability occur if local supply assumptions are not achieved; therefore, it is important to track the progress of local supply development as one of the signposts in the One Water Implementation phase.*
2) *Additional actions may be needed should existing and future local supply levels deviate from IRP assumptions.*

Figure 3-3 demonstrates the broad range of potential outcomes of local supply production. Depending on the region's success in implementing new projects and preventing the degradation of existing supplies, the region may continue to see modest growth in local production. The level of growth in future local supply is important to offset varying levels of growing demands, as any growth in demand that cannot be offset by new local supply adds additional demand on Metropolitan.

Figure 3-3: *Total Local Supply under Average Conditions*



Determining Demands on Metropolitan

Once retail demand forecasts and local supply projections are developed, the next step is to calculate future demand on Metropolitan. Imported water from Metropolitan serves as a supplemental supply source for its 26 member agencies. For some member agencies, their primary sources of water are produced locally. When local supplies are insufficient to meet retail demands, member agencies purchase supplemental water from Metropolitan. These purchases constitute the demands on Metropolitan.

Retail Demand/Demand Management Finding: *Metropolitan's future supply reliability may fluctuate based on demand increases and decreases.*

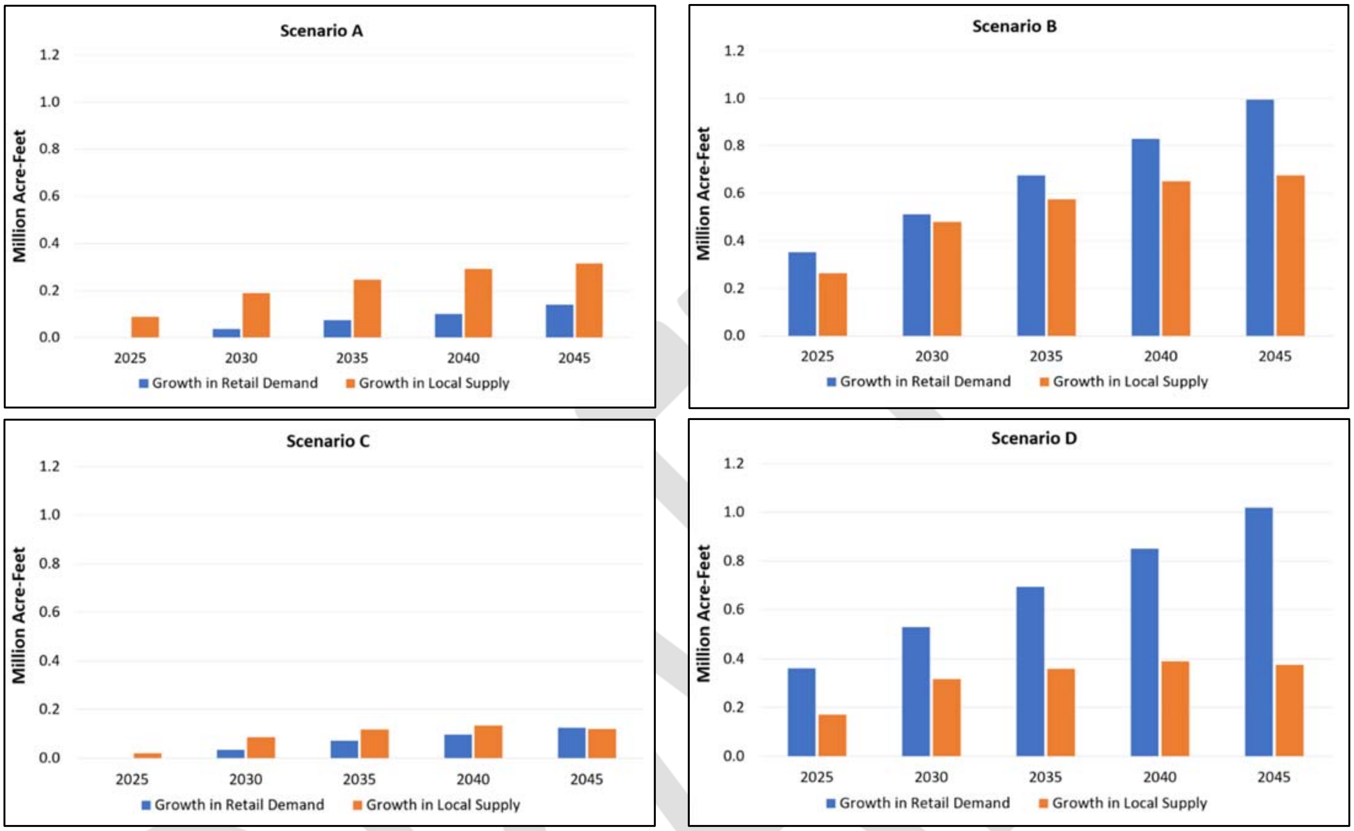
Demands on Metropolitan are calculated using Metropolitan's Sales Model. This model accounts for weather-related variations to retail demands and local supplies and ultimately produces a range of forecasted demand on Metropolitan. For the 2020 IRP, Metropolitan engaged with climate expert consultants to develop techniques to incorporate climate change impacts to local precipitation within the Sales Model's existing 96 hydrologic sequence methodology. These modifications increased the frequency and intensity of dry years and decreased the frequency of wet years (but increased their intensity) while maintaining a similar long-term average precipitation. The Sales Model forecasts a range of demands on Metropolitan for each IRP scenario as shown in **Figure 3-4**.

Figure 3-4: *Total Net Demand on Metropolitan*

> ***Local Supply Finding:***
> *Maintaining existing and developing new local supplies is critical in helping manage demands on Metropolitan.*

Demand on Metropolitan is driven by the relative growth of the region's retail demand and local supply production. The difference between retail demand and local supply production is the assumed demand on Metropolitan. **Figure 3-5** shows the relative growth compared to 2020 of retail demand versus local supply production growth for each scenario. In Scenarios B and D, where retail demand growth is high, the proportion of unmet demand needed to be satisfied by Metropolitan is larger than the proportion for the lower demand Scenarios A and C. Despite having the highest assumed local supply growth in Scenario B, retail demand growth outpaces local supply production growth and additional actions would be needed to manage growing demands on Metropolitan in that scenario. In Scenarios A and C, the projected growth in local supply production is greater than the forecasted growth in demand, highlighting the importance in growing and maintaining local supply production in all scenarios.

Figure 3-5: *Growth in Demand vs. Growth in Local Supply Production Relative to 2020 in Average Conditions, Scenarios A, B, C, and D*

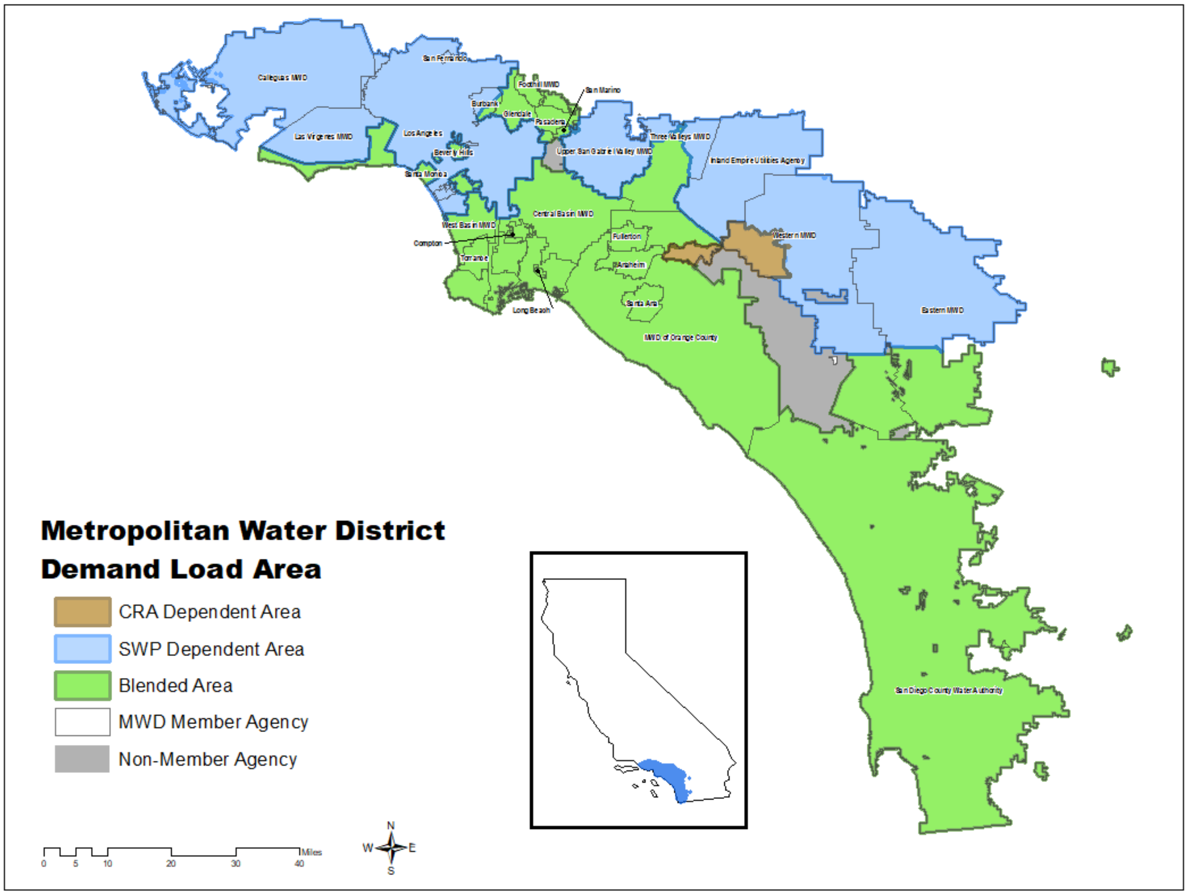


IRPSIM Resource Model

Water supply-demand gaps for the scenarios were analyzed with IRPSIM Resource Model (IRPSIM). IRPSIM is a water supply and demand mass balance simulation model. IRPSIM simulates water resources needed to meet demands, which allows Metropolitan to identify supply-demand gaps and measure whether a potential resource mix is likely to be reliable. IRPSIM considers the availability and accessibility of its imported water supply sources, including its storage portfolio to the demand load areas. The forecasted demands on Metropolitan are allocated to different portions of Metropolitan's regional distribution system, referred to as demand load areas.

IRPSIM models three primary demand load areas. The first is the "SWP Dependent Area," shown in **Figure 3-6**, where demands can only be satisfied with SWP supplies and associated storage programs. The second and smallest is the "Colorado River Dependent Area," where demands can only be satisfied with Colorado River supplies and associated storage programs. The third and largest is the "Blended Area," where demands can be satisfied by both SWP and Colorado River supplies and their respective storage programs.

Figure 3-6: *Demand Load Area Map*



> ***Metropolitan Imported Supplies Finding:*** *Variability and capacity in SWP supplies provide opportunities to store water during wet periods for use in dry years, including Colorado River storage. Metropolitan's ability to distribute or store SWP supplies when they materialize will enhance the region's reliability, particularly the SWP Dependent Areas. The Colorado River system and Colorado River Aqueduct capacity do not offer the same opportunities concerning SWP storage.*

Through entitlements and the development of long and short-term supply programs, Metropolitan has secured the ability to deliver the full capacity of the Colorado River Aqueduct of roughly 1.2 million acre-feet in any given year. In conjunction with local supply production and storage, this supply can satisfy demands in the blended areas. The SWP has system capacity and hydrologic variability that creates an annual supply that historically ranged from 100 TAF to 1.9 MAF. When the SWP supply exceeds the SWP Dependent area demand, water can be stored directly into SWP storage facilities and/or used in the blended areas, enabling Metropolitan to store imported supply within Colorado River storage facilities.

IRPSIM uses a sample of 96 years of historical hydrology (1922--2017) as a reliability test. This methodology generates 96 different outcomes for each forecast year and thus allows Metropolitan to evaluate the probabilities of surpluses and shortages over the 25-year planning horizon. IRPSIM generates the magnitude and frequency of shortages, which is the metric of reliability used in the reliability assessment analyses. Shortages within an IRPSIM simulation occur when there is insufficient supply to satisfy a demand or when available supplies are not accessible, resulting in an unmet need within Metropolitan's service area.

As represented in **Figure 3-2,** IRPSIM has four key inputs: demands on Metropolitan, SWP supply, CRA supply, and Metropolitan's storage portfolio. The Sales Model provides the input for demands on Metropolitan as described in the previous section. IRPSIM is where scenario-specific impacts related to Metropolitan's Colorado River and SWP imported water supplies are considered in the analysis. In addition, IRPSIM simulates Metropolitan's entire storage portfolio by considering operational constraints, put and take capacities, contractual arrangements, and other operational considerations. IRPSIM balances the needs for imported supply and storage as detailed below.

SWP Forecast-CalSim II

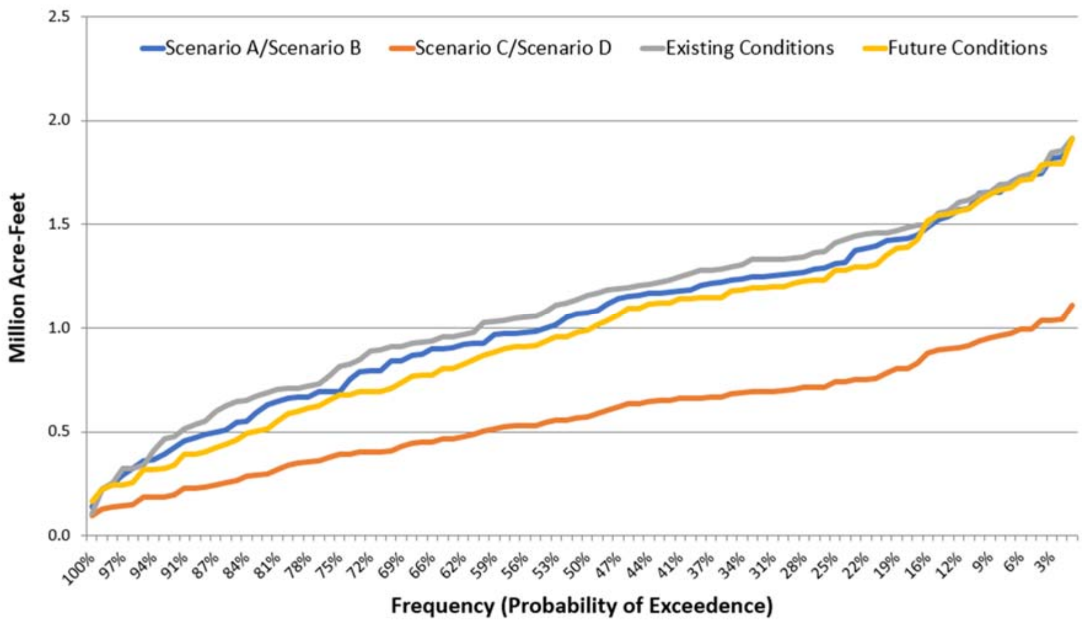
Forecasts of SWP supplies were based on modeling studies produced by DWR using their CalSim-II model. The results of the CalSim-II model are published in DWR's 2019 Delivery Capability Report (DCR) (DWR, 2020). The 2019 DCR provides SWP supply estimates for an existing condition that does not include climate change and a future condition that includes climate change. As shown in **Figure 3-7**, the SWP reliability curve for Scenarios A and B reflect a moderate climate change and regulatory future while Scenarios C and D reflect severe climate change and regulatory impacts.

> ***Metropolitan Imported Supplies Finding:*** *Existing imported supplies are at risk from various drivers of uncertainty.*

Metropolitan used the 2019 DCR existing and future study projections as a starting point and guidance from climate experts to reflect the regulatory and climate change impacts assumed in the IRP scenarios.

The resulting SWP deliveries for Metropolitan in 2045 are shown in **Figure 3-7** and compared to the 2019 DCR existing and future condition projections.

Figure 3-7: *Metropolitan's 2045 SWP Imported Supply Reliability Based on the 2019 DCR*



CRA Forecast - IRPSIM and CRSS

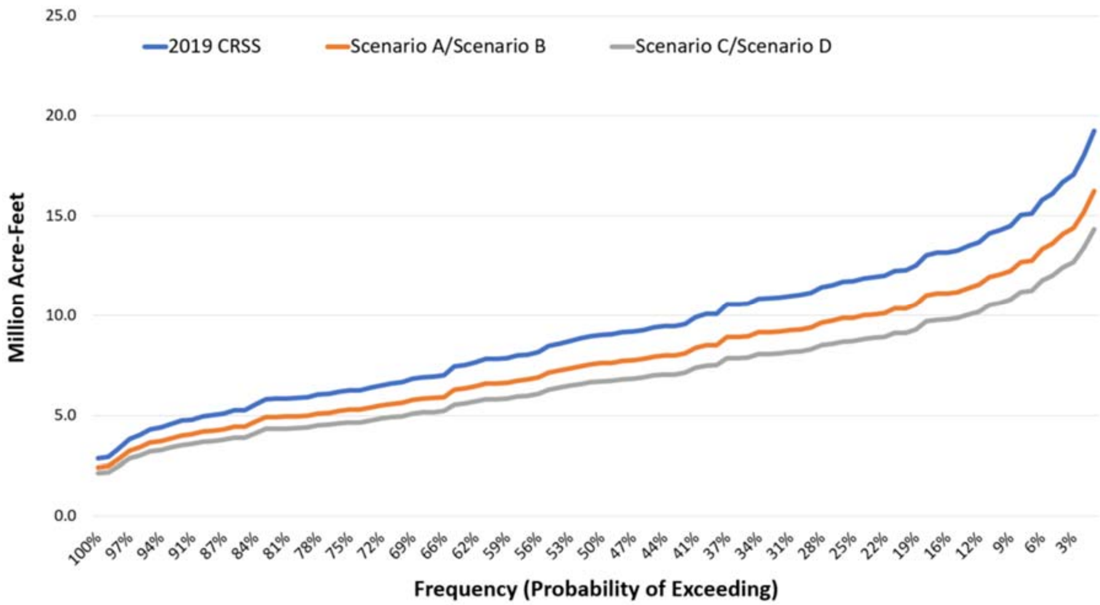
Forecasts of base supplies from the Colorado River were generated within IRPSIM with hydrological inputs provided by the United States Bureau of Reclamation (USBR).

In prior IRPs, projections for Colorado River supplies were generated directly by the Colorado River Simulation System Model (CRSS) and used in IRPSIM. This is a modeling package developed, maintained, and used by USBR to simulate future operations and deliveries of the Colorado River reservoir system. Given major changes in the operations of the Colorado River and to better reflect Metropolitan's use of its Intentionally Created Surplus storage account, Metropolitan now generates its own surplus and shortage characterization of the Colorado River system. IRPSIM still uses the same inputs as CRSS, including initial reservoir conditions and hydrologies for Lake Powell and Lake Mead. The model inputs used in the 2020 IRP are used in USBR's January 2020 official CRSS run (USBR, 2021).

As previous chapters have discussed, Scenarios A and B are characterized by stable imported supplies, and Scenarios C and D by unstable imported supplies. For future Colorado River supplies, this stability is influenced by differing assumptions for climate change and future cooperation between the lower basin states in Colorado River operations.

Climate change is incorporated into CRA supplies by adjusting the Lake Powell and Lake Mead inflow hydrologies and evaporation rates. Through consultation with climate change experts and previous research, a relationship between the decrease in runoff and increase in atmospheric temperature was incorporated in the hydrology (Woodhouse, et al 2021). **Figure 3-8** shows the reduction of Powell inflows due to modeled climate change for the IRP scenarios.

Figure 3-8: *2045 Lake Powell Inflows*



Future operations of the Colorado River and cooperation between the lower basin states and Mexico also influence the stability of Colorado River supplies. The Interim Guidelines, Binational Agreement 323 and the Drought Contingency Plan (DCP) all act to stabilize the elevation of Lake Mead and prevent shortages. The 2007 Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (Interim Guidelines), DCP and Minute 323 will expire in 2026. Without a future agreement taking its place this could lead to a greater chance of shortage and less available Colorado River water in the future. For Scenarios A and B that reflect stable imported supply, these three agreements were assumed to extend through the life of the forecast. For Scenarios C and D that reflect less stable imported supplies, the Interim Guidelines were extended, but the DCP and Minute 323 were modeled to expire in 2026.

Chapter 4 – Results: Phase 1 Regional Needs Assessment

Technical results for the Regional Needs Assessment were based on two distinct analytical processes:

1. Reliability Assessment
2. High-Level Portfolio Analysis

The reliability assessment defined and quantified the problems presented by various scenarios. The high-level portfolio analysis explored how different categories of actions could address the reliability needs of each scenario. These results inform the forthcoming IRP One Water Implementation phase. This chapter provides details of the results and explains how to interpret those results (**Figures 4-1** through **4-3**).

Reliability Assessment

The reliability assessment used IRPSIM to quantify the frequency and magnitude of shortage or surplus for each scenario on an annual basis between 2020 through 2045. For ease of interpretation, results are either presented in five-year increments (beginning with 2025 and ending in 2045) or in a single year (2045). The assessment also considers Metropolitan's storage capacity. The terms "gross" and "net" are used to describe the types of surplus and shortage conditions that occur. **Gross shortage** refers to supply-demand gaps before any take from available storage; **net shortage** refers to the remaining supply-demand gap after using available storage. Similarly, **gross surplus** refers to supplies before filling storage, while **net surplus** refers to surplus supplies that occur after all available storage has been filled. The following section summarizes the results for each scenario.

Low Demand/Stable Imports Scenario A

Scenario A was characterized by **low** demands on Metropolitan and **stable** local and imported supplies. The reliability assessment for Scenario A highlights how gaps can be addressed with existing resources and storage programs/supplies. As a result, there are no net shortages throughout the forecast horizon through 2045, as seen in **Figure 4-4**.

Scenario A reliability assessment details are shown for the forecast year 2045 in **Figures 4-5** and **4-6** with highlights listed below:

- All of the gross shortages are met with available storage, leaving no net shortage.
- Metropolitan's existing conveyance and storage capacity would only manage a portion of the gross surplus supplies, leaving up to 770 TAF of net surplus supply occurring 50 percent of the time.
- End-of-year storage is expected to be full 87 percent of the time.
    - Supplies above capacity regularly remain after satisfying the supply-demand gaps identified in this scenario and present an opportunity for new exchanges or to fill new storage capacity and improve water reliability in the Southwest.

High Demands/Stable Imports Scenario B

Scenario B is characterized by **high** demands on Metropolitan and **stable** imported supplies.
Net shortages occur between 1 to 5 percent of the time during the planning horizon, as shown in **Figure 4-7**. All net shortages occur in the SWP Dependent Areas (**Figure 3-6**). There are no net shortages in the blended areas (areas that receive both SWP and CRA water) or areas that receive just

CRA water, indicating that accessibility or lack thereof to CRA water is not driving shortages. When system constraints are removed in IRPSIM (e.g. when Colorado River water and blended area storage is allowed to reach SWP Dependent Areas) the shortages in Scenario B are eliminated as seen in **Table 4-8**. This further supports the finding that for Scenario B, the projected shortages may be reduced with system flexibility investments.

Scenario B reliability assessment details are shown for the forecast year 2045 in **Figures 4-8** and **4-9** with highlights listed below:

- A majority of the gross shortages can be reduced with available storage, decreasing the probability of net shortage to 5 percent.
- Maximum net shortage is expected to be up to 300 TAF.
- Metropolitan's existing conveyance and storage capacity would only manage a portion of the gross surplus, leaving up to 400 TAF of net surplus supplies occurring 25 percent of the time.
- The end-of-year storage is expected to be full approximately 45 percent of the time.
    - Metropolitan would face challenges storing available supplies, presenting an opportunity for new exchanges or to fill new storage capacity and improve water reliability in the Southwest.

SWP Dependent Area Findings:

1) *Vulnerabilities in the SWP Dependent Areas are more severe given reduced reliability of SWP supplies and Metropolitan distribution system constraints. Actions identified in the implementation phase must prioritize addressing the SWP Dependent Area's reliability challenge.*
2) *New core supplies must be accessible to the SWP Dependent Areas. Greater access to existing core supplies can also increase SWP Dependent Area reliability.*
3) *Enhanced accessibility to core supplies and storage, both existing and new, will improve SWP Dependent Area and overall reliability. This includes improvements to Metropolitan's distribution system and capacity to deliver non-SWP supply and storage.*

Low Demands/Reduced Imports Scenario C

Scenario C is characterized by **low** demands on Metropolitan and **reduced** imported supplies. Net shortages occur between 1 to 5 percent of the time during the planning horizon, as shown in **Figure 4-10**. Note that no net shortages occur in the forecast year 2030, due to the Arvin-Edison Banking Program assumed to return online in 2025. With low demands in this scenario, the additional storage capacity provided by this banking program is sufficient to meet the supply-demand gap in 2030. Similar to Scenario B, all shortages occur in SWP Dependent Areas. When system constraints are removed in IRPSIM, the shortages are eliminated as seen in **Table 4-8**. This further supports the finding that for Scenario C, the projected shortages may be reduced with system flexibility investments.

Scenario C reliability assessment details are shown for the forecast year 2045 in **Figures 4-11** and **4-12,** with highlights listed below:

- The majority of the gross shortages can be reduced with available storage, leaving a 5 percent probability of net shortage.
- The maximum net shortage is expected to be up to 200 TAF.

- After filling gross surplus supplies in available storage, Metropolitan could still expect up to 350 TAF of net surplus supplies occurring 25 percent of the time.
- The end-of-year storage is full roughly 41 percent of the time.
    - Metropolitan would face challenges storing available supplies presenting an opportunity for new exchanges or to fill new storage capacity and improve water reliability in the Southwest.

High Demands/Reduced Supplies Scenario D

Scenario D is characterized by high demands on Metropolitan and **reduced** imported supplies. Shortages occur between 2 to 66 percent of the time during the planning horizon, as seen in **Figure 4-13**.

Before 2035, the net shortages occur exclusively in the SWP Dependent Areas. After 2035 the likelihood and magnitude of these net shortages increase, but net shortages also emerge in blended areas. The expanded net shortages point to impacts from not enough Colorado River supply. Shortages occurring in both the SWP Dependent and blended areas in later forecast years highlight that current imported supplies may be insufficient for Metropolitan to meet its reliability goal for the entire service area.

Metropolitan Imported Supplies Finding: *Shortages on the Colorado River will limit the reliability of Colorado River Aqueduct deliveries as a core supply in the future.*

When system constraints are removed in IRPSIM, the shortages are eliminated or decreased in years prior to 2040 as seen in **Table 4-8**. However, the same analysis does not show a decrease in shortages in the later years and also shows that there is a slight increase in shortages in 2040 and 2045. This further supports the finding that for Scenario D, the projected shortages may be reduced with system flexibility investments until such time where challenges to Colorado River and other blended area supplies become more severe. The later increase in shortage magnitude is a result of Colorado River water being utilized to meet demands in the SWP Dependent Areas in earlier years. Because of this, there is less Colorado River and blended area supplies being stored and available to meet the total demands of the service area in later years.

Scenario D reliability assessment details are shown for the forecast year 2045 in **Figures 4-14** and **4-15** with highlights listed below:

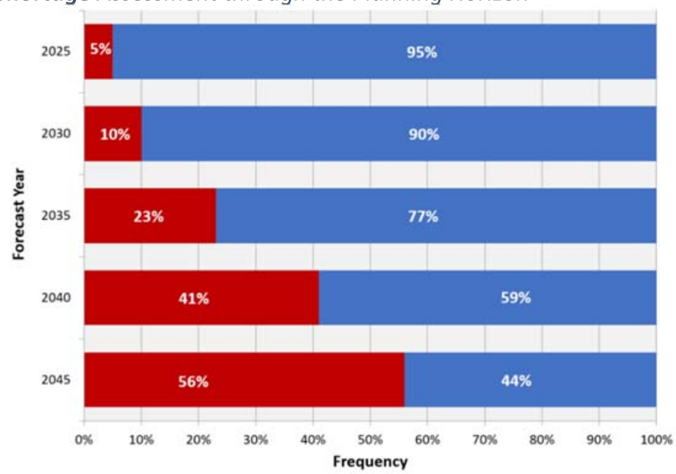
- The majority of the gross shortages cannot be reduced with available storage, leaving a 66 percent probability of net shortage conditions.
- The maximum net shortage is expected to be up to 1.22 MAF.
- Under Scenario D, frequent shortages and fewer surplus conditions indicate that storage and conveyance capacity alone will not solve the reliability problem without supply improvements.
- Scenario D shows there will not be enough surplus water for Metropolitan to fill storage.
    - This stems from the impacts of climate change and regulatory restrictions limiting imported water supply development, paired with the need to use stored supplies to satisfy demands.

The next section shows a series of example graphs and their related interpretations, followed by detailed graphs corresponding to each scenario.

Detailed Reliability Assessment Results

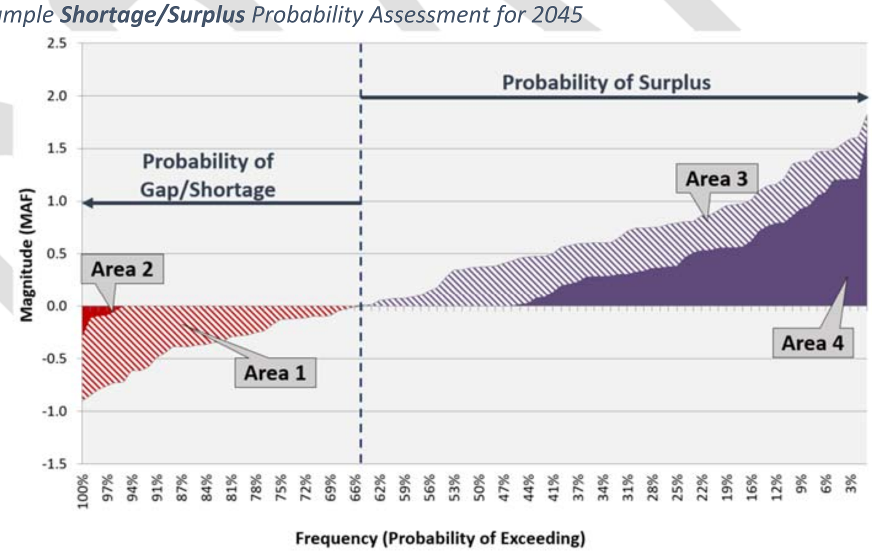
Figures 4-1 to **4-3** are examples of the three graphics that detail the reliability assessment results. These examples are illustrative to aid the reader in interpreting the later graphs.

***Figure 4-1**: Example **Net Shortage** Assessment through the Planning Horizon*



<u>**Net Shortage Assessment**</u> – This graph shows the frequency and timing of net shortage conditions (red) and all other conditions (blue). Net shortages are defined when all available supplies, including accessible storage, are depleted and there remains an unmet demand. All other conditions are defined when storage is withdrawn to satisfy a demand, and/or when water is available and stored to manage supplies not needed to meet a demand.

***Figure 4-2**: Example **Shortage/Surplus** Probability Assessment for 2045*



<u>**Shortage/Surplus Probability Assessment**</u> – This exceedance curve provides magnitude and probability of gross and net shortages/surpluses and the impact of storage actions.

Area 1 & 2 – <u>Gross Shortage</u>: Magnitude and frequency of supply-demand gap prior to taking from available storage

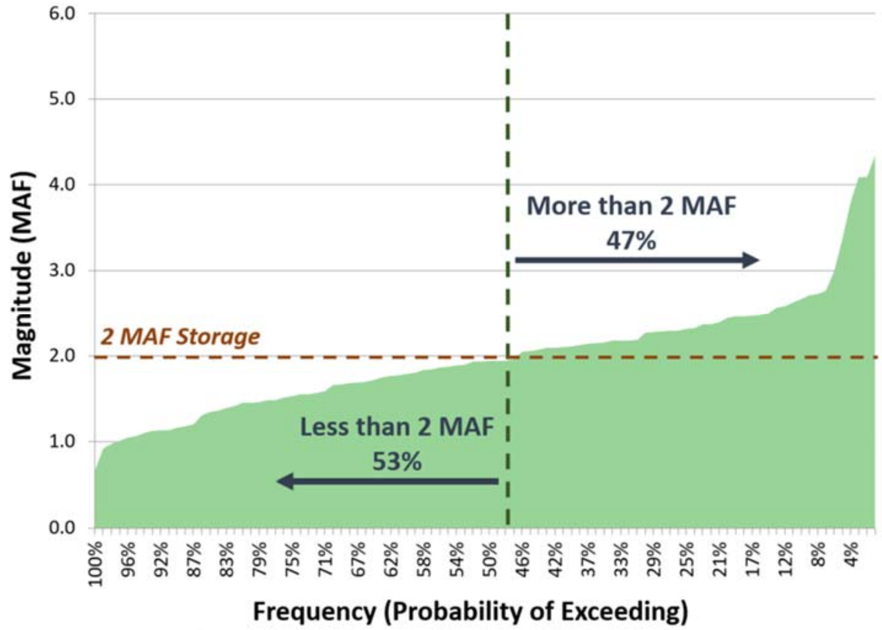
Area 2 – <u>Net Shortage:</u> Magnitude and frequency of supply-demand gap after taking from available storage

Area 3 & 4 – <u>Gross Surplus</u>: Magnitude and frequency of surplus prior to putting into available storage

Area 4 – <u>Net Surplus:</u> Magnitude and frequency of surplus after putting into available storage

Actions that decrease shortage probabilities and magnitudes generally appear as an increase in surplus probability and/or magnitude. Eliminating shortage requires an increased probability/magnitude of surplus.

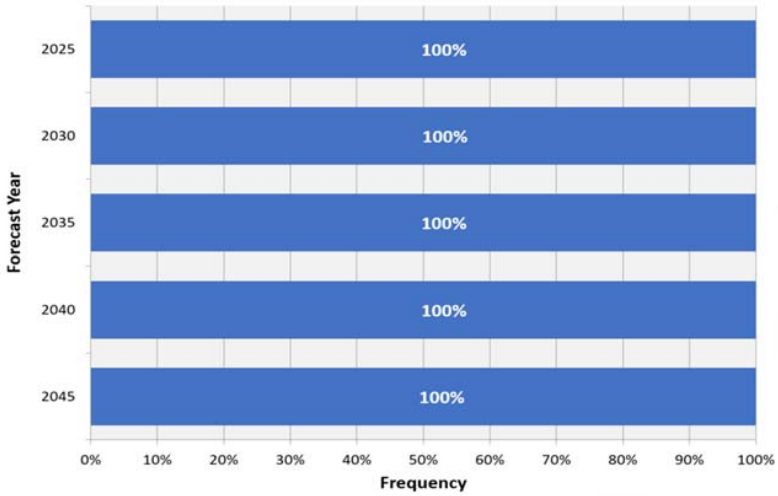
Figure 4-3*: Example* ***Storage*** *Graph for 2045*



Storage Graph – This graph shows end of year storage level probabilities. The probability of a given end of year storage level can be determined by locating the intersection of a selected storage level (y-axis) with the storage curve (green shaded region). To the left of the intersection shows the probability of an end of year storage less than the desired amount, while the right of the intersection shows the probability of more than the desired amount. The volume of water necessary to achieve full storage varies by scenario based on hydrologic conditions, contractual arrangements, and program operations.

Low Demands/Stable Imports Scenario A Reliability Assessment Results

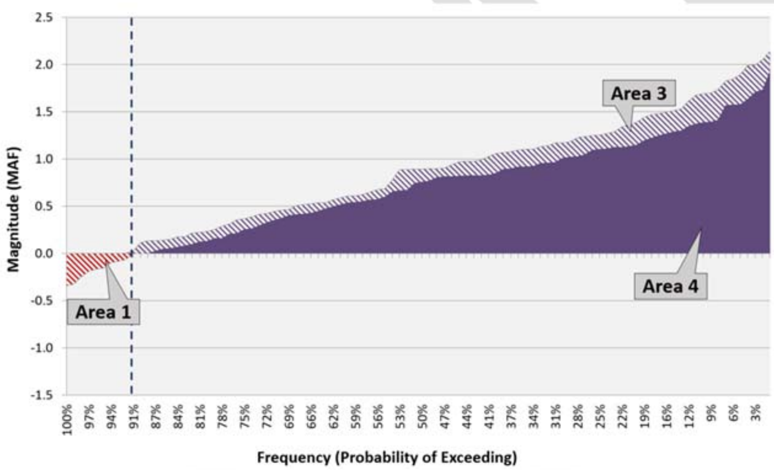
***Figure 4-4:** Scenario A – **Net Shortage** Assessment through the Planning Horizon*



Scenario A: **Low** demands
Stable imports

All supply-demand gaps can be managed through available storage. This scenario shows 100% reliability across the planning horizon.

***Figure 4-5:** Scenario A – **Shortage/Surplus** Probability in 2045*



Prior to taking available storage actions, surplus conditions have a 91% frequency and shortages conditions have a 9% frequency.

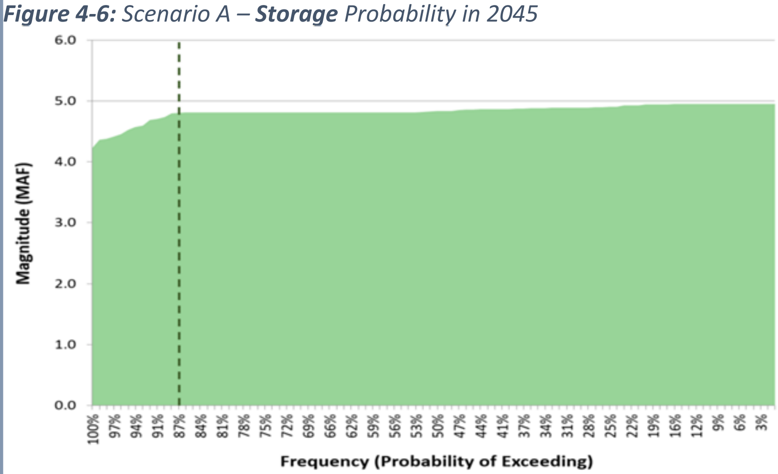
Area 1 & 2 – All supply-demand gaps are managed by taking from available storage

Area 2 (Not shown) – No net shortage

Area 3 & 4 – Gross surplus

Area 4 – Up to 770 TAF of net surplus supply occurs 50% of the time

***Figure 4-6:** Scenario A – **Storage** Probability in 2045*

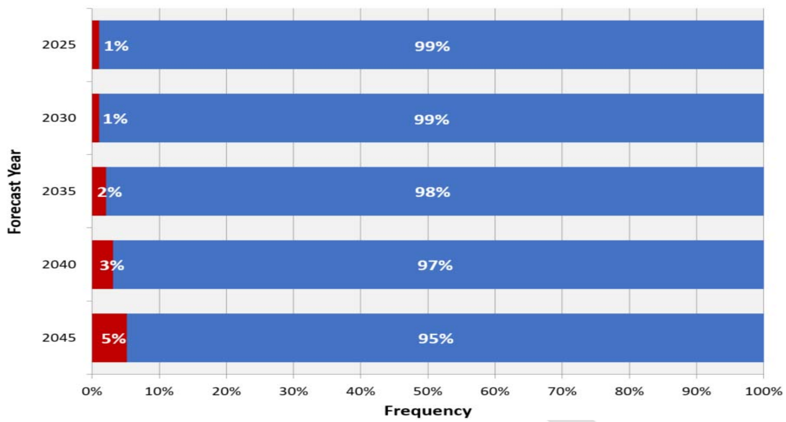


Storage expected full 87% of the time.

The probability of total storage less than 1.0 MAF is 0%.

High Demands/Stable Imports Scenario B Reliability Assessment Results

Figure 4-7: *Scenario B –* ***Net Shortage*** *Assessment through the Planning Horizon*



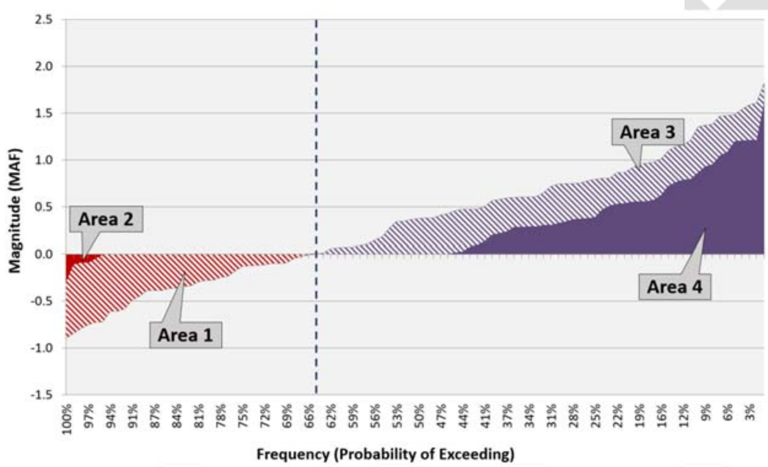
Scenario B: **High** demands **Stable** imports

Net shortages possible across entire planning horizon.

Net shortage probability grows from 1% in 2025 to 5% in 2045.

Net shortages occur only in **SWP Dependent Areas**.

Figure 4-8: *Scenario B –* ***Shortage/Storage*** *Probability for 2045*



Prior to taking available storage actions, surplus conditions have a 65% frequency and shortage conditions have a 35% frequency.

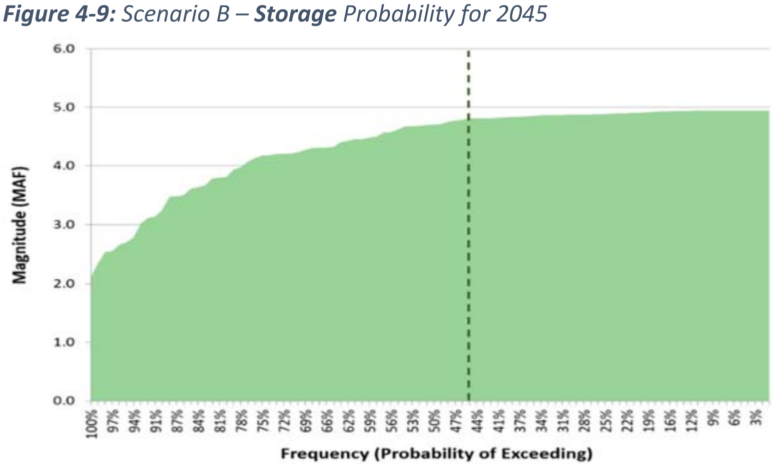
Area 1 & 2 – Gross shortage

Area 2 – Net shortages occur 5% of the time with a maximum magnitude of 300 TAF

Area 3 & 4 – Gross surplus

Area 4 – Up to 400 TAF of net surplus supply occurs 25% of the time

Figure 4-9: *Scenario B –* ***Storage*** *Probability for 2045*

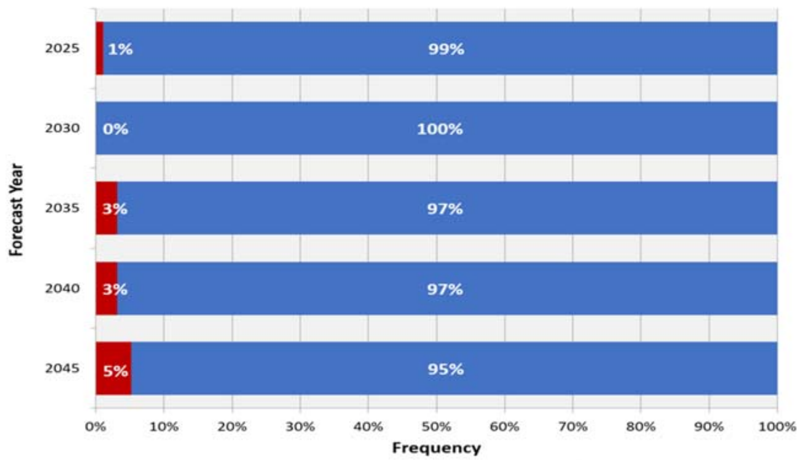


Full storage expected 45% of the time.

The probability of total storage less than 1.0 MAF is 0%.

Low Demands/Reduced Imports Scenario C Reliability Assessment Results

***Figure 4-10:** Scenario C – **Net Shortage** Assessment through the Planning Horizon*



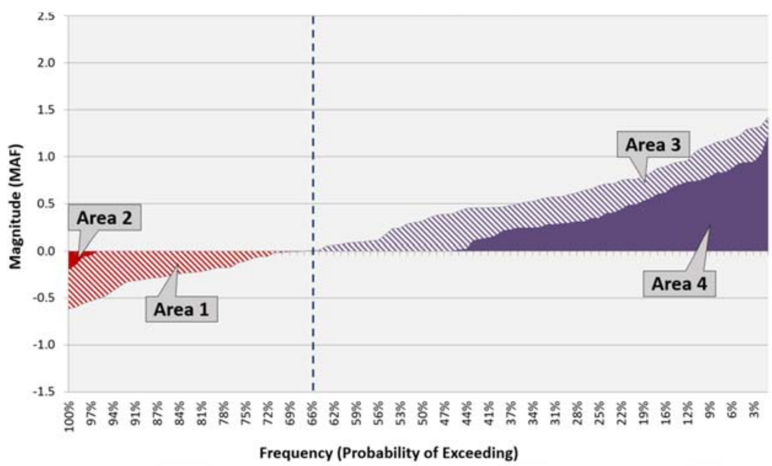
Scenario C: **Low** demands
Reduced imports

Net shortages possible across entire planning horizon.

Net shortage probability grows from 1% in 2025 to 5% in 2045.

Net shortages occur only in **SWP Dependent Areas**.

***Figure 4-11:** Scenario C – **Shortage/Surplus** Probability for 2045*



Prior to taking available storage actions, surplus conditions have a 66% frequency and shortage conditions have a 34% frequency.

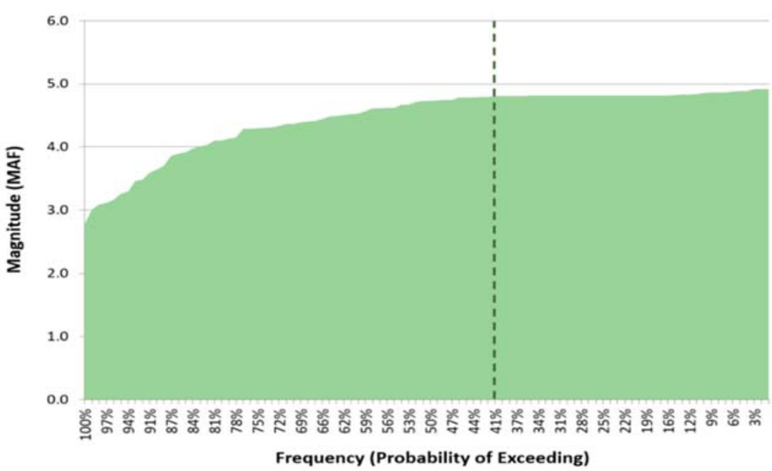
Area 1 & 2 – Gross shortage

Area 2 – Net shortages occur 5% of the time with a maximum magnitude of up to 200 TAF

Area 3 & 4 – Gross surplus

Area 4 – Up to 350 TAF of net surplus supply occurs 25% of the time

***Figure 4-12:** Scenario C – **Storage** Probability for 2045*

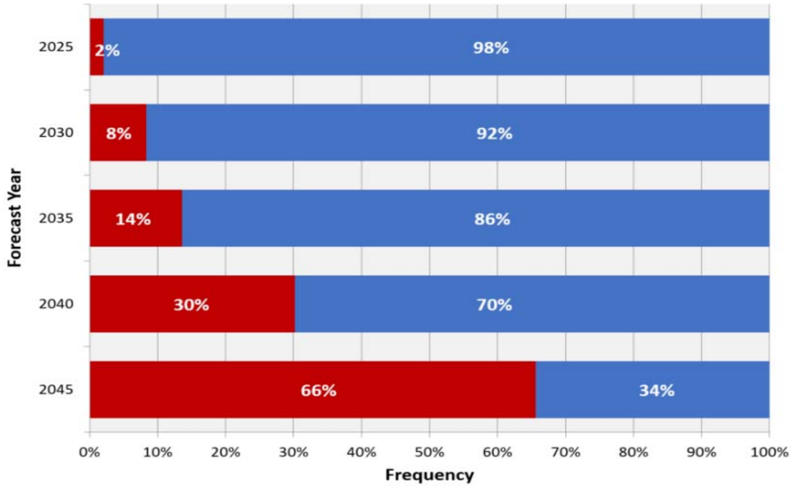


Full storage expected 41% of the time.

The probability of total storage less than 1.0 MAF is 0%.

High Demands/Reduced Imports Scenario D Reliability Assessment Results

Figure 4-13: *Scenario D – **Net Shortage** Assessment through the Planning Horizon*



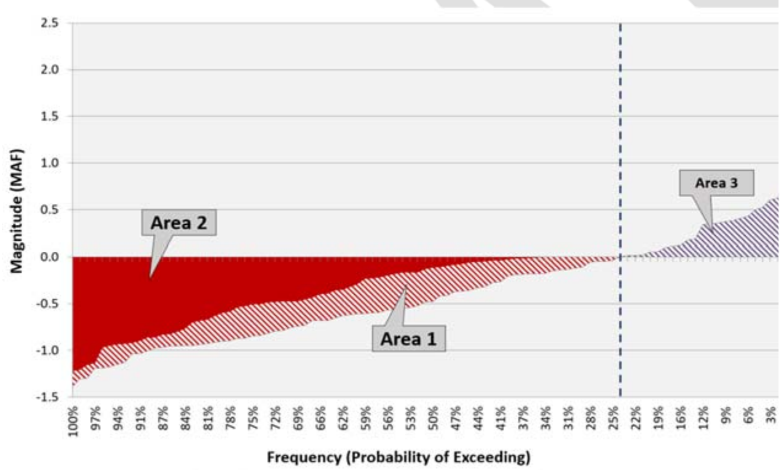
Scenario D: **High** demands
Reduced imports

Net shortages possible across entire planning horizon, and greater than 10% after 2030.

Net shortage probability grows sharply from 2% in 2025 to 66% in 2045.

Net shortages occur **system-wide** beyond 2035.

Figure 4-14: *Scenario D – **Shortage/Surplus** Probability for 2045*



Prior to taking available storage actions, surplus conditions have a 24% frequency and shortage conditions have a 76% frequency.

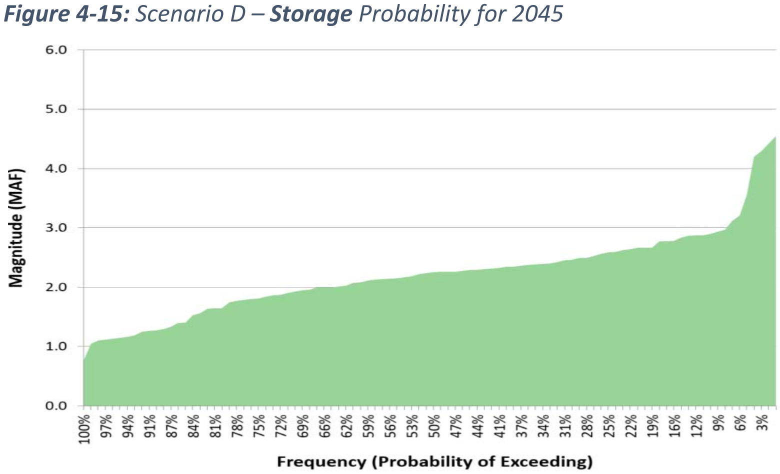
Area 1 & 2 – Gross shortage

Area 2 – Net shortages occur 66% of the time with a maximum magnitude of 1.22 MAF

Area 3 – Gross surplus

Area 4 (Not shown) – Does not exist in this scenario. Supplies, when available, can be stored

Figure 4-15: *Scenario D – **Storage** Probability for 2045*



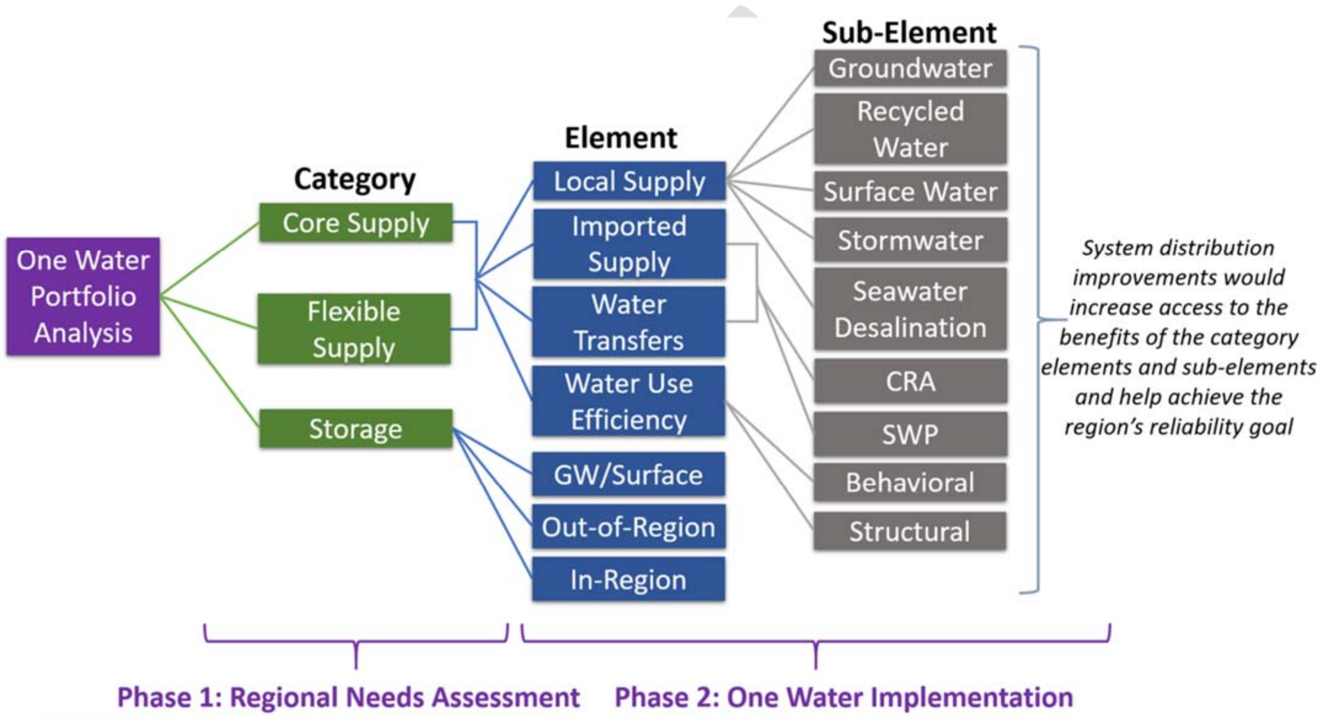
Full storage not expected in 2045. Limited imported supply along with the need to use stored supplies to satisfy demands prevents this scenario from filling storage capacity.

The probability of total storage less than 1.0 MAF is less than 2%.

High-Level One Water Portfolio Analysis Results

While the reliability assessment identified the potential shortages in each scenario, the portfolio analysis aimed to determine a high-level resource mix that tackles the supply-demand imbalances faced within each scenario. Eliminating the identified shortages would allow Metropolitan to meet its 100 percent reliability goal.

Figure 4-16: *Levels of One Water Portfolio Analysis*



Note: The elements and sub-elements identified are examples and not meant to be an exhaustive list.

The 2020 IRP's One Water portfolio analysis uses a hierarchical framework, shown in **Figure 4-16**, to characterize the different actions and investments. Metropolitan tested configurations at the highest "Category" level as part of the Regional Needs Assessment. Each category refers to one of three different types of supply (core, flexible, and storage), further defined in **Table 4-1**. With the preferred technical feasibility determined at the category level in the Regional Needs Assessment, further policy direction will be sought in the One Water Implementation phase to establish the basis for a more specific resource mix from the full spectrum of elements and sub-elements that comprise a holistic One Water approach. Below the "Category" level, element-level resource options such as water use efficiency can sometimes fulfill the role of either core supply or flexible supply but not both at the same time. Whether it serves the function of a core supply or flexible supply depends on the nature of the project or program. For example, structural water use efficiency programs that replace fixtures and repair leaks resemble a core supply because they provide a reliable, constant stream of water savings into the future. A conservation media campaign to encourage conscientious water consumption during a drought resembles a flexible supply because it is implemented on an as-needed basis.

Table 4-1: *Category Definitions*

Category	Definition	Notes	Examples
Core Supply	A supply that is generally available and used every year to meet demands under normal conditions and may include savings from efficiency gains through structural conservation.	High reliability and value if used often. Expensive otherwise.	• Colorado River basic apportionment • IID/Metropolitan conservation agreement • Code-based conservation
Flexible Supply	A supply that is implemented on an as-needed basis and may or may not be available for use each year and may include savings from focused, deliberate efforts to change water use behavior.	Expensive if used too much or too often. Better value if used occasionally.	• Palo Verde Land Management, Crop Rotation, and Water Supply Program • North-of-Delta annual transfers • Water Supply Alert • Conservation advertising campaigns
Storage	The capability to save water supply to meet demands at a later time.	Converts core supply into flexible supply. Evens out variability in supply and demand.	• Diamond Valley Lake • SWP Article 56 carryover • SWP flexible storage • Antelope Valley-East Kern High Desert Water Bank

Several assumptions were incorporated into the methodology to determine appropriate high-level resource mixes for Scenarios B, C, and D. Resource mixes for new portfolio actions are comprised of three categories: 1) core supply, 2) flexible supply, and 3) storage (see **Table 4-1** above).

The Regional Needs Assessment showed that net shortages were occurring in the SWP Dependent Areas (areas that cannot receive Colorado River supplies) for Scenarios B, C, and D. As such, additional core supply and storage were modeled as supplies that could reach the SWP Dependent Areas. These modeled supplies could also be used to meet water demand in the blended area (areas that receive SWP and Colorado River water). The additional flexible supply is not location-specific but is assumed to be available wherever the shortage is occurring (SWP Dependent or blended).

The portfolio analyses tested how the supply-demand gap in each scenario might be met using each category (core, flexible, and storage) separately. ***These category-specific tests enabled Metropolitan to conclude that rather than relying on any single category of portfolio actions, it is more practical in every scenario to pursue a more balanced and diversified mix.*** This provided a valuable starting point in determining the most suitable resource mix for each scenario.

After the portfolio categories were modeled in isolation, a mix of all three categories was modeled for each scenario. This analysis examined a range of additional storage to identify a more practical core and flexible supply requirement. The following methodology was used in the portfolio analysis to determine the high-level resource mix for each scenario:

1. **Flexible Supply**
   Identify an achievable, flexible supply threshold not to be exceeded in any given year

   - The flexible supply threshold was set at 100 TAF and represents a realistic supply that can be secured in dry years when they are likely to be needed. Past experience has shown that SWP transfers supplies, an example of flexible supply, has limited availability, high cost, and losses associated with securing those supplies.
   - Absent core supply and storage development, the flexible supply identified is equivalent to the maximum shortage amount in any given forecast year.
   - Development of core supply and storage helps reduce the need for flexible supplies and achieve the established threshold.

2. **Storage**
   Establish a range of additional storage to complement core supply development for each scenario

   - The assessment looked at an additional storage capacity of 0, 100, 250, and 500 TAF.
   - Put/takes for the additional storage were defined as half of the capacity (e.g., 50 TAF put/take for a capacity of 100 TAF). This represents a realistic "middle-of-the-road capability"(between a surface water reservoir and a groundwater banking type program) appropriate for planning purposes.
   - The additional storage was modeled to come online in 2035 to provide a realistic timeline for acquisition, permitting, construction, and other implementation-related requirements. Existing storage programs were extended through 2045 with the assumption that current contracts will be renewed with the same terms.

3. **Core Supply**
   Determine core supply needed to achieve the reliability goal by testing the range of additional storage while not exceeding the flexible supply threshold

   - This core supply is not static and may increase throughout the forecast to ensure that the maximum flexible supply target (shortage amount) is not surpassed.

Low Demands/Stable Imports Scenario A Portfolio Analysis Results

Scenario A is characterized by **low demands** on Metropolitan and **stable local and imported supply**.
In this future, there is no net shortage and no intervention is needed by Metropolitan; the reliability goal is achieved through consumer demand reduction efforts and sufficient local supply development. As such, no new investments in core, flexible or storage are necessary.

High Demands/Stable Imports Scenario B Portfolio Analysis Results

The challenges presented in Scenario B mainly result from **increasing demands** throughout the service area. The portfolio analysis first looked at the development needed for each portfolio category alone to achieve reliability, as shown in **Table 4-2** for the forecast year 2045.

Table 4-2: *Scenario B – Forecast Year 2045 Portfolio Category Need – Not Combined*

New Storage	New Flexible Supply	New Core Supply
TAF 500 TAF (250 TAFY put/take capacity)	300 TAF	150 TAF

The results revealed that upwards of 300 TAF of flexible supplies would be needed to achieve reliability, or a new 500 TAF storage capacity surface reservoir would be required. It was deemed unrealistic and risky to depend on such a large amount of flexible supply in a dry year when these supplies would typically be needed, and excessive to build a reservoir similar in size and scope as Diamond Valley Lake. Instead, to identify possible efficiencies gained through combining these portfolio categories, a mix of these categories was investigated. The results of that analysis are shown in **Table 4-3**.

Table 4-3*: Scenario B – Forecast Year 2045 Portfolio Category Need – Combined*

Modeled Storage	Core Supply Needed by 2045
0 TAF	100 TAF
100 TAF	70 TAF
250 TAF	30 TAF
500 TAF	30 TAF

Table 4-3 illustrates how various surface reservoir sizes impact core supply development need while staying within the flexible supply threshold. Without new storage, 100 TAF of additional core supply is needed by 2045 to eliminate net shortages. The core supply need reduces from 100 TAF to 30 TAF with 250 TAF of new storage capacity. The analysis also reveals no additional reduction in the core supply need if new storage capacity is increased to 500 TAF. This suggests that a new storage capacity above 250 TAF is unnecessary to reduce the core supply need and may be an overinvestment.

Low Demands/Reduced Imports Scenario C Portfolio Analysis Results

Scenario C is characterized by **low demands** on Metropolitan and **unstable local and imported** supplies due to a more severe climate change future. The shortages in Scenario C are mainly due to decreasing local and imported supplies. The magnitude of the net shortages in Scenario C are slightly less than those in Scenario B and indicate that higher demands have a more significant impact on reliability than the modeled unstable local and imported supplies. **Table 4-4** shows the development of each portfolio category alone for the forecast year 2045 to achieve 100% reliability.

Table 4-4: *Scenario C – Forecast Year 2045 Portfolio Category Need – Not Combined*

New Storage	New Flexible Supply	New Core Supply
TAF 500 TAF (250 TAFY put/take capacity)	200 TAF	100 TAF

Results show that developing 100 TAF of new core supply could alone eliminate net shortages in this scenario without the need for additional storage or flexible supply. Additionally, approximately 200 TAF of flexible supplies would be needed to achieve reliability, or a 500 TAF storage capacity surface reservoir would be required. Like Scenario B, the amount of additional storage or flexible supply alone was too great to be a realistic solution in a dry year and a combination of these portfolio categories was examined. The results of that analysis are shown in **Table 4-5**.

Table 4-5: *Scenario C – Forecast Year 2045 Portfolio Category Need – Combined*

Modeled Storage	Core Supply Needed by 2045
0 TAF	50 TAF
100 TAF	15 TAF
250 TAF	15 TAF
500 TAF	15 TAF

Scenario C required less additional core supply than Scenario B under all modeled storage conditions. If no additional storage is contemplated, 50 TAF of additional core supply is needed by 2045 to eliminate net shortages. The core supply need reduces from 50 TAF to 15 TAF with the addition of 100 TAF of new storage capacity. The analysis also reveals no additional reduction in the core supply need if new storage capacity is increased to 250 TAF. This suggests that a new storage capacity above 100 TAF is unnecessary to reduce the core supply need and would be a potential over-investment.

High Demands/Reduced Imports Scenario D Portfolio Analysis Results

Scenario D experiences larger impacts than the other three scenarios due to both **higher demands** on Metropolitan and **unstable imported supplies**. The compounded effects lead to shortages of substantially greater magnitude with a higher likelihood. The efficacy of the individual portfolio categories was determined by first modeling them separately, with results shown below in **Table 4-6**.

Metropolitan Imported Supplies Finding: *Maintaining existing imported supply reliability reduces the need for new core supply development and leverages years of investments.*

Table 4-6: Scenario D – Forecast Year 2045 Portfolio Category Need – Not Combined

New Storage	New Flexible Supply	New Core Supply
Storage up to 1.5 MAF with put/take capacity of 750 TAF/year still does not provide 100% reliability.	1.2 MAF	650 TAF

Adding new storage up to 1.5 MAF with a put/take capacity of 750 TAF were modeled. As the amount of modeled storage increased, results showed diminishing returns regarding decreasing probability and magnitude of net shortage. ***This led to the conclusion that there is no realistic amount of additional storage that could be modeled that would eliminate net shortage in Scenario D.*** Results also indicate that it would take 1.2 MAF of flexible supply or 650 TAF of new core supply to eliminate net shortage alone, both of which are unrealistic management strategies. Even more than Scenarios B and C, a combination of portfolio categories is vital to eliminating net shortages. As with the other scenarios, a combined approach was modeled, and the results of this combination of portfolio categories is shown below in **Table 4-7**.

Table 4-7: Scenario D – Forecast Year 2045 Portfolio Category Need – Combined

Modeled Storage	Core Supply Needed by 2045
0 TAF	650 TAF
100 TAF	600 TAF
250 TAF	550 TAF
500 TAF	500 TAF

Storage Finding: *Expanding existing or developing new storage programs and investments in Metropolitan's distribution system can reduce the need for new core supply development to meet potential future shortages and adapt to climate change.*

Scenario D highlights the need for investments in a combination of core, flexible, and storage supplies. Additions of new core supply and storage work together in tandem; more water in storage reduces how much core supply is needed, while in turn, more core supplies mean water is readily available in non-dry years to accumulate in storage over time. More specifically, Scenario D requires significantly greater amounts of additional core supply than Scenarios B and C. With 500 TAF of additional storage capacity, there is still a need for an additional 500 TAF of core supply by 2045. When extra storage is reduced, the corresponding core supply increases.

Table 4-8: *Probability of Shortage With and Without Distribution System Constraints*

Year	Scenario B		Scenario C		Scenario D	
	Constraints	No Constraints	Constraints	No Constraints	Constraints	No Constraints
2025	1%	0%	1%	0%	2%	0%
2030	1%	0%	0%	0%	8%	0%
2035	2%	0%	3%	0%	14%	5%
2040	3%	0%	3%	0%	30%	31%
2045	5%	0%	5%	0%	66%	67%

Table 4-8 shows the probability of shortage with and without distribution system constraints that restrict deliveries of Colorado River water and other blended area supplies to portions of Metropolitan's service area. This was analyzed by comparing two IRPSIM model runs. The first run contained the existing system configuration that reflects current capacity to deliver water to the SWP Dependent areas. The second run reflects a theoretical removal of these system constraints.

General Observations

The portfolio category analysis revealed similar patterns across scenarios. As a general rule, less core and flexible supply were necessary to achieve the reliability goal when after adding storage. Additionally, there was a notable drop in the flexible supply need in the forecast year 2025 when the Arvin-Edison Banking Program is assumed to return to service after being shut down due to water quality concerns. ***This shutdown shows how important SWP banking programs are to Metropolitan's reliability in light of vulnerabilities in the SWP Dependent Areas.***

Currently IRPSIM models all SWP banking programs to operate throughout the planning horizon. The Arvin-Edison Banking Program result shows that ***extending the contract terms for the other SWP banking programs is vital to Metropolitan's long-term reliability.*** Maintaining existing imported supplies that utilize existing storage programs, including SWP banking, is necessary and may reduce the need for new core supply development and leverages years of investments.

SWP Dependent Areas and Storage Finding:
Storage capacity, put/take capabilities, and accessibility are critical considerations for the SWP Dependent Area. New storage capacity and put/take capabilities should be consistent with the portfolio analysis. New storage must be accessible to the SWP Dependent Areas.

Storage Findings:
1) Maintaining Metropolitan's existing storage portfolio is critical, including the consideration of re-negotiating contracts when they expire.
2) When evaluating storage options, put/take capabilities are essential; even storage programs with modest put/take capabilities help reduce the need for flexible supply.

Chapter 5 - Findings

The IRP's goal in guiding Metropolitan's investments is to avoid retail water shortages and mandatory end-user cutbacks. This reliability goal recognizes that although tolerance for voluntary conservation measures varies among member agencies, Southern Californians clearly distinguish voluntary and responsible conservation from mandatory cutbacks. A vision for regional success is for every Southern California consumer and business to have access to affordable, high-quality water at all times. To this end, the Regional Needs Assessment highlights important areas of vulnerability to Metropolitan's reliability goal. Findings from the Regional Needs Assessment fall within five key focus areas:

1. SWP Dependent Areas
2. Storage
3. Retail Demand/ Demand Management
4. Metropolitan Imported Supplies
5. Local Supply

These findings are summarized and discussed below. The scenario analyses found plausible reliability outcomes by the year 2045, with potential shortages ranging from no net shortage at all under Scenario A to as high as 1.2 MAF under Scenario D. As Metropolitan proceeds towards implementation in the next phase of the IRP, specific actions must address these gaps in a manner consistent with the portfolio category analysis identified in Chapter 4.

SWP Dependent Areas Findings

- *Vulnerabilities in the SWP Dependent Areas are more severe given reduced reliability of SWP supplies and Metropolitan distribution system constraints. Actions identified in the implementation phase must prioritize addressing the SWP Dependent Area's reliability challenge.*
- *New core supplies must be accessible to the SWP Dependent Areas. Greater access to existing core supplies can also increase SWP Dependent Area reliability.*
- *Enhanced accessibility to core supplies and storage, both existing and new, will improve SWP Dependent Area and overall reliability. This includes improvements to Metropolitan's distribution system and capacity to deliver non-SWP supply and storage.*
- *Storage capacity, put/take capabilities, and accessibility are critical considerations for the SWP Dependent Area. New storage capacity and put/take capabilities should be consistent with the portfolio analysis. New storage must be accessible to the SWP Dependent Areas.*

Water demand in Metropolitan's service area is met by combining its imported supplies via the SWP and Colorado River Aqueduct, storage reserves, and local supply production. These spatially diversified water supplies increase reliability by buffering supply impacts with any one source. In general, when one or more supply sources are challenged, the other sources are depended on more to satisfy the region's demand.

Portions of Metropolitan's service area, however, cannot receive water from both imported supply sources and do not have enough local supply to meet demand. Those portions of Metropolitan's service area where Colorado River supply cannot access, referred to as "SWP Dependent Areas" as shown in **Figure 3-6**, are of particular concern if low SWP Table A Allocations become more frequent.

A crucial finding of this IRP recognizes that SWP Dependent Areas present a severe vulnerability to regional water reliability. Across scenarios, this vulnerability emerges as a common thread among foreseeable risks. Whenever shortages occur in any scenario, they involve a mismatch between accessible supplies and demands in the SWP Dependent Areas. This puts additional pressure on the Colorado River, local, and storage supplies to satisfy a larger proportion of the regional demand. Consequently, resolving reliability issues for the SWP Dependent Areas will address the larger reliability issues for the entire region.

As SWP core supplies become less reliable over time, as analyzed in the four scenarios, the risks to reliability posed by the SWP Dependent Areas are exacerbated. Because of these vulnerabilities, actions identified in the One Water Implementation phase should prioritize addressing SWP Dependent Areas. New core supplies and new/or existing storage must first address and reach SWP Dependent Areas. However, investing in conveyance and distribution to improve core, local, and storage supply access to the SWP Dependent Areas should also be evaluated to determine if overall system reliability is compromised. Additionally, potential shortages in the Colorado River, as seen in Scenario D, can limit the effectiveness of system improvements.

Storage Findings

- *Storage capacity, put/take capabilities, and accessibility are critical considerations in maintaining reliability under the region's current and future conditions, especially for SWP Dependent Areas.*
- *Maintaining Metropolitan's existing storage portfolio is critical, including the consideration of re-negotiating contracts when they expire.*
- *Expanding existing or developing new storage programs and investments in Metropolitan's distribution system can reduce the need for new core supply development to meet potential future shortages and adapt to climate change.*
- *When evaluating storage options, put/take capabilities are essential; even storage programs with modest put/take capabilities help reduce the need for flexible supply.*

Storage is vital to reliability under current and plausible future conditions. Core supplies and storage capabilities work together in tandem; dependable core supplies are needed to fill and refill storage before and after dry years, and ample storage capacity is needed to make the most of opportunities for core supplies when they become available. Three major conclusions related to storage emerge from the IRP analysis:

1. Expanding existing or developing new storage programs will be needed to help balance new core supply development and mitigate future shortages. This may include policies and programs enabling Metropolitan's use of local storage during drought conditions.
2. A holistic approach is essential when evaluating storage options. Evaluation of put-and-take capabilities should take into account the amounts and timing of water that can be moved and

spatial considerations, such as the source of water and access to the various parts of Metropolitan's distribution system. New storage development and or expanding distribution flexibility to move existing storage to the SWP Dependent Areas should be investigated in the implementation phase.

3. Furthermore, several of Metropolitan's existing storage programs will expire over the next 15 years, within the planning horizon of the 2020 IRP. Without further action to extend these agreements, Metropolitan will lose more than 1.6 MAF of total storage volume by 2037. The IRP reliability analyses assume that these programs will remain in place. Still, their possible expiration remains a threat to regional reliability until such programs are extended or replaced. This is an example of the active management that is constantly required and highlights the ongoing need for collaboration with Metropolitan's banking partners. These known administrative risks are apart from other, more uncertain operational risks, such as contamination, new regulatory restrictions, and seismic disturbances.

Retail Demand/Demand Management Findings

- *Metropolitan's future supply reliability may fluctuate based on demand increases and decreases.*
- *Variability in retail demand largely comes from changes in outdoor water use. Outdoor water use behavior is complex, influenced by weather and climate and by awareness of water scarcity and other conservation measures.*
- *It is important to pay attention to demand rebound, demand growth, and demand reductions, and take appropriate regional measures as necessary.*
- *Managing long-term demands through the efficient use of water reduces dependency on supplies, helps preserve storage, and helps reduce the need for extraordinary conservation measures.*

Conservation has long underpinned Metropolitan's long-term water supply reliability strategy. Metropolitan administers regional conservation programs and co-funds member agency conservation programs designed to increase water use efficiency and bolster water conservation ethics. Conservation comes from two areas of change: structural conservation which involves increases in water use efficiency, and behavioral conservation, which involves modifying consumer water-using behavior through messaging, education, pricing, and mandates. Of these two forms of conservation, structural conservation is more permanent, akin to a core supply. Water-efficient device retrofits, landscape conversions, plumbing codes, and leak prevention contribute to ongoing structural water savings. Conservation device retrofits help recover storage in future years by lowering demands in all years, not only drought years. In contrast, behavioral conservation is less permanent and can wax and wane due to various influences outside of Metropolitan's direct control. The IRP recognizes water use behavior, represented by per capita water use, as a major uncertainty for regional demands over time. The IRP scenarios confirm that Metropolitan's future reliability is highly sensitive to changes in water demands. Under Scenario A, with low demands and

Retail Demand/Demand Management Finding:
Managing long-term demands through the efficient use of water reduces dependency on supplies, helps preserve storage, and helps reduce the need for extraordinary conservation measures.

stable imports, no net shortages are anticipated through the year 2045. Demands also remain low in Scenario C, with low frequencies of net shortages occurring throughout the planning horizon. Meanwhile, Scenarios B and D consider what might happen if per capita water demands rebound to levels approaching historical usage. While Scenario B shows similar frequencies of net shortages as Scenario C, the magnitudes of such shortages are greater. Under Scenario D, where there is both increase in demands on Metropolitan and significant loss of imported core supply, there is a high risk of shortage and an inability to ever refill storage to capacity by the year 2045.

Increased demands, whether from growth or from per capita use, represent a major risk to reliability. Demands can increase from rebounding per capita water use, but even with efficient use, total demands can still increase as the population and economy grow over time. Variability in retail-level demands mostly comes from outdoor water use, which is influenced by weather and climate and other factors that affect water-using behaviors. Baseline conservation programs help with every scenario. Monitoring demands and intervening as appropriate will be critical. Managing demands through efficient use of water reduces dependency on costly supplies, helps preserve storage, and defers the need for disruptive extraordinary conservation measures such as emergency declarations and water supply allocations.

Metropolitan Imported Supplies Findings

- *Existing imported supplies are at risk from various drivers of uncertainty.*
- *Maintaining existing imported supply reliability reduces the need for new core supply development and leverages years of investments.*
- *SWP supplies are highly susceptible to varying hydrologic conditions, climate change, and regulatory restrictions.*
- *Variability and capacity in SWP supplies provide opportunities to store water during wet periods for use in dry years, including Colorado River storage. Metropolitan's ability to distribute or store SWP supplies when they materialize will enhance the region's reliability, particularly the SWP Dependent Areas. The Colorado River system and Colorado River Aqueduct capacity do not offer the same opportunities concerning SWP storage.*
- *Shortages on the Colorado River will limit the reliability of Colorado River Aqueduct deliveries as a core supply in the future.*

Imported supplies remain essential as core supplies to the region. They are a valuable legacy of decades of planning and investment. As source waters, they provide good water quality and supply benefits that, once lost, are very difficult to replace. Metropolitan's core supplies from the Colorado River Aqueduct are generally less susceptible to volatility from year-to-year hydrologic conditions than Metropolitan's core supplies from the SWP. However, all of the region's imported supplies face significant threats from various drivers of uncertainty, including climate change. While there is little scope for obtaining new additional imported core supplies, taking action to preserve the region's legacy imported supplies is crucial for several reasons.

Imported supplies, primarily the SWP supplies, uniquely reinforce reliability by their ability to leverage Metropolitan's storage capacity in wet periods for use in dry years and by diversifying supply sources across multiple watersheds. Because water resources available to the Metropolitan service area come from three geographically distinct regions—Northern California, the Colorado River, and local resources—a relatively dry year affecting one of these three regions can be offset by relatively abundant supplies from the other two regions. For example, a year of ample precipitation within Metropolitan's service area tends to depress demand and enhances local water resources, further reducing demands on imported supplies. A wet year in the Sacramento-San Joaquin watersheds increases the SWP Table A allocation, facilitating reduced diversions from the Colorado River in favor of storing supplies in Lake Mead or in the Desert Water Agency/Coachella Valley Water District Advanced Delivery Account.

Conversely, a shortfall on the SWP may require system operational modifications to maximize Colorado River diversions and the delivery of Colorado River supplies to the SWP Dependent Areas. Each increment of existing imported supply reliability prevented from loss offsets the need to develop new alternative core and flexible supplies that may be more costly, may take considerable lead time to bring online, and may not be easily integrated into the region's water distribution system. SWP Dependent Areas are so-called because they currently rely on SWP water to meet at least part of their demands; any practical alternative supplies to meet SWP Dependent Area demands would also have to be potable and accessible to those relatively isolated portions of Metropolitan's distribution system.

Local Supply Findings

- *Maintaining existing and developing new local supplies is critical in helping manage demands on Metropolitan.*
- *Impacts to reliability occur if local supply assumptions are not achieved; therefore, it is important to track the progress of local supply development as one of the signposts in the One Water Implementation phase.*
- *Additional actions may be needed should existing and future local supply levels deviate from IRP assumptions.*

Demand on Metropolitan's imported supplies are a function of total regional demands and the local supplies available within the region to meet them. Local supplies are the front line in securing regional reliability. Local supplies regularly meet roughly half of the region's total urban demands; in some years it can be more than 60 percent. Because imported core supplies cannot be expected to increase even in the face of population and economic growth, the region's reliance on existing and new local supplies relative to imported supplies will only grow in the future. The IRP scenarios reveal that safeguarding the region's vast inventory of existing local supplies is as crucial as preserving existing imported supplies.

Continued performance of local supplies cannot be taken for granted, for as with imported supplies, many factors can impede local supply development and production, including funding, contamination, changing regulatory requirements, and climate change. For example, there has been a decline in groundwater production in the past 20 years, affected by limited availability of imported supplies for replenishment, variability in natural replenishment from rainfall, and emerging contaminants. At the same time, the region has made substantial gains in recycled water development, but continued success will be more difficult moving forward. This is due to the reduction of available of wastewater effluent, which stems from conservation, constraints in distribution systems, and rising costs from increasing salinity.

The region's reliability is highly sensitive to local supplies, as it comprises such a large portion of the region's total supply. As a part of the Regional Needs Assessment, Metropolitan engaged with member agencies and basin managers to identify the potential timing and implementation of planned projects and operation of groundwater basins appropriate for each IRP scenario. Impacts to reliability will occur if local supply assumptions are not achieved; therefore, it will be important to track progress of local supply development as part of the signposts in the One Water Implementation phase. Metropolitan currently fosters local supplies through various programs and funding support, including its Local Resources Program. Metropolitan will continue to support the development of local supplies by Member Agencies.

Conclusion: Reason for Optimism with a *One Water Approach*

Collectively, these findings instill a sense of optimism about Southern California's water future. Metropolitan has identified the tools necessary to adapt to a variety of plausible futures successfully. It is also well within Southern California's control to avoid a fate with increased per-capita water use and higher demands that would prove unsustainable.

One Water is the collaborative, community approach that matches the right tools for the emerging needs of the future. The precise combination of actions will emerge as more is known about the future that we actually face. Southern California is poised to be agile enough to adjust its portfolio of water actions to keep up with our changing times.

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Attachment B

DRAFT Refined Analysis Assumptions used to Model Retail Demands for Scenarios A, B, C, & D

Data Link: ***Refined Data June 2021***

THEMES (Input from Expert Panel, MAs and MWD Staff)	**Scenario A** (Low Demands, Stable Imports)	**Scenario B** (High Demands, Stable Imports)	**Scenario C** (Low Demands, Reduced Imports)	**Scenario D** (High Demands, Reduced Imports)
↓	*This scenario is characterized by lower retail water demands and stable regional and local supplies. Demands are impacted by lower economic and demographic growth and a continuing water use ethic across the region. Both regional and local supplies show more stable production due to less severe climate change and less restrictive regulatory constraints on existing water supply projects, and a relatively robust implementation of new water supply projects at the local level.*	*This scenario is characterized by higher retail demands, stable regional and local supplies. Demand are impacted by higher economic and demographic growth and a rebound of water use ethic. Both regional and local supplies show more stable production due to less severe climate change and less restrictive regulatory constraints on existing water supply projects, and a relatively robust implementation of new water supply projects at the local level.*	*This scenario is characterized by lower retail water demands and less stable imported supplies. Demands are impacted by lower economic growth, demographic growth and with successful efforts among member agencies to manage water use behavior and drought-proof their local supplies. It couples a struggling economy with the rapid onset of climate change impacts that have affected imported supplies more drastically than less-vulnerable local supplies.*	*This scenario is characterized by higher retail demands, unstable imported and diminishing local supplies. Demand are impacted by higher economic and demographic growth and a rebound of water use ethic. In this scenario severe climate change impacts both imported and local supplies. Demands on Metropolitan are increasing due to rapidly increasing demands and diminishing yield from local supplies. Efforts to develop new local supplies to mitigate losses of underperforming projects. Losses of regional imported supplies are equally dramatic.*
Retail Demand - Demographics The level of demographic (population, households, housing types, employment) growth is an important driver to water demand	• Lower demographic growth ▪ Utilized Center for Continuing Study of the California Economy's (CCSCE's) low growth forecast developed for the 2020 IRP	• Higher demographic growth ▪ Utilized CCSCE's high growth forecast developed for the 2020 IRP	• Same as Scenario A	• Same as Scenario B
Retail Demand - Immigration Immigration is the most important factor for national population growth, California share of national growth stays consistent across scenarios, not impacted by climate change issues.	• CCSCE's forecast considers climate change impacts on international immigration and migration to California ▪ No basis to change population forecast or regional share growth due to climate impacts at this time	• Same across all scenarios	• Same across all scenarios	• Same across all scenarios
Retail Demand - Households New households are modeled separately from existing households to reflect increasing	• This scenario projects a total of **903,000** additional new households. • Assumes a median lot size of 5,000 sq. ft. for new housing units (approximately 30%	• This scenario projects a total of **2.6 million** additional new households. • Same median lot size assumption as Scenario A	• This scenario projects a total of **907,000** new households • Same median lot size assumption as Scenario A	• This scenario projects a total of **2.8 million** new households. • Same median lot size assumption as Scenario A

THEMES (Input from Expert Panel, MAs and MWD Staff)	**Scenario A** (Low Demands, Stable Imports)	**Scenario B** (High Demands, Stable Imports)	**Scenario C** (Low Demands, Reduced Imports)	**Scenario D** (High Demands, Reduced Imports)
efficiency and smaller sizes of new homes and lots. These new households include single family, multi family, and Accessory Dwelling Units (ADUs).	reduction compared to the existing median lot size) to reflect smaller lot sizes and more efficient outdoor use. Reduced lot size equates to less irrigable area.			
Retail Demand - Overcrowding In addition to normal housing growth to accommodate population growth, one-time additional housing units a "catch-up" factor is projected to reduce overcrowding, minimize cost burdened households, and bring vacancy rate back to normal level.	• This scenario assumes the lowest success rate, **340,000** additional households, as the "catch-up" factor. • CCSCE's total housing growth "catch-up" factor reflects a struggling economy and low population growth	• This scenario assumes a moderate success rate, **516,000** additional households, as the "catch-up" factor. • CCSCE's total housing growth "catch-up" factor reflects a strong economy and population growth	• This scenario assumes a low success rate, **344,000** additional households, as the "catch-up" factor. • CCSCE's total housing growth "catch-up" factor reflects a weak economy and slow population growth	• This scenario assumes the highest success rate, **696,000** additional households, as the "catch-up" factor. • CCSCE's total housing growth "catch-up" factor reflects a strong economy and population growth
Retail Demand – Behavioral Retention The lower retail demands observed since the last drought are driven by a structural and behavioral water use component, of which behavior is more reversible or at risk to rebound. Retail demands reflect both use per person and the number of people. Total demand can increase even without a degradation in efficient water use behavior.	• Efficient water use behavior is retained at a high level • Behavioral component: **90% retention** of the behavioral component of the observed reduced demand is retained reflecting continued strong water use ethic. • Structural Component: This permanent reduction in demand is accounted for based on demographic assumptions including a shift from single family homes toward multifamily construction with smaller lot sizes, ADUs, less irrigable area, and increased adoption of device-based conservation	• Efficient water use behavior is retained at a moderate level • Behavioral component: **50% retention** of the behavioral component of the observed reduced demand is retained reflecting a plausible rebound in water use ethic. • Structural Component: This permanent reduction in demand is accounted for based on demographic assumptions including a shift from single family homes toward multifamily construction with smaller lot sizes, ADUs, less irrigable area, and increased adoption of device-based conservation	• Same as Scenario A	• Same as Scenario B

THEMES (Input from Expert Panel, MAs and MWD Staff)	**Scenario A** (Low Demands, Stable Imports)	**Scenario B** (High Demands, Stable Imports)	**Scenario C** (Low Demands, Reduced Imports)	**Scenario D** (High Demands, Reduced Imports)
Retail Demand - Agricultural Demand A hotter and drier climate will impact irrigation needs	• Consistent with member agencies' 2020 UWMP and reflects discussions with member agencies ▪ No additional adjustments assumed	• Same as Scenario A	• Hotter and drier conditions coupled with increased regulatory constraints result in higher operation costs and ag land coming out of production. ▪ 20% decrease in demand by 2045 due to fewer farming operations ▪ 10% increase in irrigation requirements for remaining farms by 2045 due to hotter and drier conditions	• Same as Scenario C
Retail Demand - Seawater Barrier Demand Mitigating overdraft challenges will lead to higher demands on Metropolitan	• No modifications based on member agency discussions	• Same as Scenario A	• Climate change stresses will increase demand • Increased by 10% by 2045. The increase in demand is tempered by lower overall demands in this scenario and less overdraft challenges	• Climate change stresses will increase demand • Increased by 20% by 2045. The increase in demand reflects higher overall demands in this scenario and significant overdraft challenges
Imported Replenishment Demand Changes in natural recharge volume and patterns along with recycled water availability will impact demands on Metropolitan	• Replenishment water purchases from MWD is based on past discussions with member agencies and groundwater basin managers to meet their imported replenishment needs to supplement their natural recharge • Reflects scenario-based climate change impacts on natural recharge • Also reflects recycled water availability for replenishment demands (see recycled water assumption) • Though assumptions are the same across all scenarios, values used vary per scenario			

THEMES (Input from Expert Panel, MAs and MWD Staff)	**Scenario A** (Low Demands, Stable Imports)	**Scenario B** (High Demands, Stable Imports)	**Scenario C** (Low Demands, Reduced Imports)	**Scenario D** (High Demands, Reduced Imports)
Local Supply - Precipitation Precipitation is a major driver on future water supply. Metropolitan's modeling methodology requires use of annual weather variations over time (1922-2017). Adjustments were made to the historic record to reflect climate expert feedback on potential future impacts.	• Historical variation in precipitation from 1922-2017 will continue through 2045	• Same as Scenario A	• Modified 1922 – 2017 precipitation to reflect more extreme conditions. This will impact surface water reservoir and groundwater supply ▪ Increased the frequency and intensity of dry years ▪ Decreased the frequency and increased the intensity of wet years ▪ Kept 1922-2017 average similar	• Same as Scenario C
Desalination – Existing Local Projects	• Claude "Bud" Lewis (Carlsbad Desalination Plant) ▪ Assumed facility to operate at ~85% of capacity in normal and wet years, and full capacity during dry years. ▪ Normal, wet, and dry years vary by scenario	• Same across all scenarios	• Same across all scenarios	• Same across all scenarios
Desalination – Future Local Projects	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate for each scenario • No planned projects incorporated in this scenario	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate for each scenario • Includes Doheny Ocean Desalination Project, Huntington Beach Seawater Desalination Project, and West Basin Seawater Desalination Project • Operation assumed to be **85% of yield** in normal and wet years, full ultimate yield in dry years • Wet, normal, and dry years vary by scenario	• Same as Scenario A	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate foreach scenario • Includes Doheny Ocean Desalination Project, Huntington Beach Seawater Desalination Project, and West Basin Seawater Desalination Project • **Reduced yield by 20%** to approximate impacts from severe climate change and regulatory constraints • Operation assumed to be **85% of yield (after 20% reduction)** in normal and wet years, full ultimate yield in dry years • Wet, normal, and dry years vary by scenario

THEMES (Input from Expert Panel, MAs and MWD Staff)	**Scenario A** (Low Demands, Stable Imports)	**Scenario B** (High Demands, Stable Imports)	**Scenario C** (Low Demands, Reduced Imports)	**Scenario D** (High Demands, Reduced Imports)
Groundwater Recovery - Existing Local Projects	• Engaged with member agencies to confirm yield of projects currently in operation • No modifications to yield in this scenario	• Same as Scenario A	• Engaged with member agencies to confirm yield of projects currently in operation • **Decreased yield by 20%** to approximate increased regulatory requirements and severe climate change impacts to groundwater basins	• Same as Scenario C
Groundwater Recovery – Future Local Projects	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate for each scenario • **Reduced yield by 30%** in this scenario to reflect lower need to develop additional projects due to low demands.	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate for each scenario • **Reduced yield by 10%** in this scenario in recognition of strong project implementation	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate for each scenario • **Reduced yield by 20%** in this scenario to approximate the impact of regulatory requirements, but an increase in local project need due to reduced imports	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate for each scenario • **Reduced yield by 20%** in this scenario to approximate the impact of regulatory requirements, but an increase in local project need due to reduced imports • Though assumptions are the same for Scenario C and D, values used vary per scenario based on member agency feedback
Recycled Water - Existing Local Projects	• Engaged with member agencies to confirm yield of projects currently in operation • **Reduced yield by 20%** to approximate impact of decreased wastewater availability from low demands	• Engaged with member agencies to confirm yield of projects currently in operation • **No change to yield**	• Same as Scenario A	• Same as Scenario B

THEMES (Input from Expert Panel, MAs and MWD Staff)	**Scenario A** (Low Demands, Stable Imports)	**Scenario B** (High Demands, Stable Imports)	**Scenario C** (Low Demands, Reduced Imports)	**Scenario D** (High Demands, Reduced Imports)
Recycled Water - Future Local Projects	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate for each scenario • **Reduced yield by 30%** to approximate the impact of decreased wastewater availability from low demands and less need to develop projects due to stable imports ▪ 30% is based on observed local project development within the service area	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate for each scenario • **Reduced yield by 10%** in this scenario in recognition of strong project implementation	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate for each scenario • **Reduced yield by 30%** to approximate the impact of decreased wastewater availability from low demands and less need to develop projects due to stable imports ▪ 30% is based on observed local project development within the service area • Though assumptions are the same for Scenario A and C, values used vary per scenario based on member agency feedback	• Engaged with member agencies to identify the potential timing and implementation of planned projects appropriate foreach scenario • **Reduced yield by 20%** in this scenario to approximate the impact of regulatory requirements, but an increase in local project need due to reduced imports
LA Aqueduct Supply	• Estimates based on single trace LAA Forecast provided by LADWP in 2020 ▪ Reduced modeled output for each hydrology by 13,000 acre-feet to adjust for approximated bias from what was provided in 2020 and what LADWP used in their UWMP ▪ Note: MWD uses a 96-year hydrology as opposed to LA's 30-year hydrology for modeling methodology purposes	• Same as Scenario A	• Estimates based on single trace LAA Forecast provided by LADWP in 2020 ▪ Reduced modeled output for each hydrology by 13,000 acre-feet to adjust for approximated bias from what was provided in 2020 and what LADWP used in their UWMP ▪ Note: MWD uses a 96-year hydrology as opposed to LA's 30-year hydrology for modeling methodology purposes • Applied annual climate change factor of 0.1652% to reduce LAA supplies per LADWP UWMP	• Same as Scenario D
Surface Water Supply	• Used San Diego Surface Model to approximate annual variance around their UWMP long-term average (43,928 AFY) ▪ Based on 1922-2017 precipitation (see precipitation for local supply assumption) • For all other member agencies used provided scenario specific projections • Though assumptions are the same across all scenarios, values used vary per scenario			

THEMES (Input from Expert Panel, MAs and MWD Staff)	**Scenario A** (Low Demands, Stable Imports)	**Scenario B** (High Demands, Stable Imports)	**Scenario C** (Low Demands, Reduced Imports)	**Scenario D** (High Demands, Reduced Imports)
Groundwater Supply	• For Main San Gabriel Basin developed preliminary model: ▪ Calculates production based on consumptive demand ▪ Estimated passive and active recharge using local precipitation ▪ Tracks estimated key well level ▪ Cuts production by 30% if key well level falls below 160 ft MSL • OC Basin ▪ Assumed long-term Basin Production Percentage (BPP) goal of 85% ▪ PFAS impacts 2020-2024 • All other basins ▪ Used 2010-2019 Production Average or UWMP production data when available	• For Main San Gabriel Basin developed preliminary model: ▪ Calculates production based on consumptive demand ▪ Estimated passive and active recharge using local precipitation ▪ Tracks estimated key well level ▪ Cuts production by 30% if key well level falls below 160 ft MSL • OC Basin ▪ Assumed Basin Production Percentage (BPP) of 85% to 2030; reduced by 5% every 5 years afterwards to adjust for growing demands ▪ PFAS impacts 2020-2024 • All other basins ▪ Used 2010-2019 Production Average or UWMP production data when available	• For Main San Gabriel Basin developed preliminary model: ▪ Calculates production based on consumptive demand ▪ Estimated passive and active recharge using local precipitation ▪ Tracks estimated key well level ▪ Cuts production by 30% if key well level falls below 160 ft MSL • OC Basin ▪ Assumed long-term Basin Production Percentage (BPP) goal of 85% ▪ PFAS impacts 2020-2024 • All other basins ▪ Used 2015-2019 Production Average or UWMP production data when available	• For Main San Gabriel Basin developed preliminary model: ▪ Calculates production based on consumptive demand ▪ Estimated passive and active recharge using local precipitation ▪ Tracks estimated key well level ▪ Cuts production by 30% if key well level falls below 160 ft MSL • OC Basin ▪ Assumed Basin Production Percentage (BPP) of 85% to 2030; reduced by 5% every 5 years afterwards to adjust for growing demands ▪ PFAS impacts 2020-2024 • All other basins ▪ Used 2015-2019 Production Average or UWMP production data when available
State Water Project Supply Used DWR's Delivery Capability Report (DCR) projected SWP deliveries as basis for the scenario analysis. The DCR Existing Condition modeling result reflects SWP deliveries without climate impacts. The DCR Future Condition modeling result reflects SWP deliveries with climate impacts by using the Representative Concentration Pathway (RCP) 8.5 with 1.5 ft of sea level rise.	• Used a hybrid of the DCR Existing Condition (no climate impacts) and Future Condition (climate impacts) modeling results to project "moderate" climate change impacts to SWP deliveries ▪ Used 50% of the difference between Existing Condition and Future Condition deliveries	• Same as Scenario A	• Used a hybrid of the DCR Existing Condition (no climate impacts) and Future Condition (climate impacts) modeling results to project "severe" climate change impacts to SWP deliveries ▪ Move from Existing Condition deliveries to Future Condition deliveries linearly to 2035 • Additional degradation factor by 25% by 2035 to represent future regulations/unknowns/low cooperation	• Same as Scenario C

THEMES (Input from Expert Panel, MAs and MWD Staff)	**Scenario A** (Low Demands, Stable Imports)	**Scenario B** (High Demands, Stable Imports)	**Scenario C** (Low Demands, Reduced Imports)	**Scenario D** (High Demands, Reduced Imports)
Colorado River Supply Utilized expert input to identify evaporative losses, a range of temperature increases (Lukas and Payton, 2020) and a range of runoff decreases to reflect moderate to severe climate impacts (Milley and Dune, 2020)	• Moderate climate change impacts using Representative Concentration Pathway (RCP)4.5 ▪ Linear increase in temp to 2.1 °C by 2045 ▪ 15.6% decrease in runoff by 2045 (Powell and Mead inflows) ▪ 4.5% increase in Lake Mead and Lake Powell evaporation by 2045 • High cooperation-Drought Contingency Plan (DCP) continues after 2026, interim guidelines extended	• Same as Scenario A	• Severe climate change impacts using Representative Concentration Pathway (RCP) 8.5 ▪ Linear increase in temp to 2.75 °C by 2045 ▪ 25.6% decrease in runoff (Powell and Mead inflows) ▪ 4.5% increase in Lake Mead and Lake Powell evaporation by 2045 • Low cooperation- Drought Contingency Plan (DCP) ends after 2026, interim guidelines extended	• Same as Scenario C