APPENDIX B
Preliminary Risk Management Measures Evaluation Process Scenario Results (Scenarios 1 to 4) and Proposed Additional Scenarios

MEMORANDUM

TO: Project Team, Guelph/Guelph-Eramosa Water Quantity Policy Development Study

FROM: Paul Chin and Jeff Melchin, Matrix Solutions Inc.

SUBJECT: Memo #2 - RMMEP Preliminary Scenario Results and Proposed Additional Scenarios Guelph/Guelph-Eramosa WHPA-Q1 Risk Management Measures Evaluation Process

DATE: June 14, 2018

1 PRELIMINARY RISK MANAGEMENT MEASURES SCENARIOS

Matrix Solutions Inc. (Matrix) conducted four preliminary Risk Management Measures (RMM) scenarios as part of the Risk Management Measures Evaluation Process (RMMEP) to evaluate the potential for RMM to mitigate the water quantity threats and reduce the water quantity risk level identified through the Guelph/Guelph-Eramosa Tier Three Assessment (Matrix 2017).

The design of these scenarios was based on RMM selected from the RMM Catalogue (TRCA 2014), a web-based tool that was used to select management measures based on the results of the Threats Ranking, as reported in Memo #1 to the Project Team dated October 20, 2017. The scenarios are described below.

1.1 Risk Management Measures Scenario #1

RMM Scenario #1 was conducted under RMM "Water conservation education systems" and incorporated the average day demand of 69,872 m^3/d projected in the Water Supply Master Plan Update (WSMPU; AECOM and Golder 2014) for 2038. The Allocated rate used in the Tier Thee Assessment was 73,450 m^3/d which is 3,578 m^3/d more than this 2014 revised projection that includes conservation measures as a RMM. This lower demand was distributed amongst the Guelph wells in an effort to reduce the risk level for those wells found to have the greatest percent impact in the Threats Ranking. This was done in consultation with the City to ensure operational constraints for individual wells and the system as a whole were considered. However, actual operational and infrastructure constraints of the water supply system may be different than that achieved through the model predictions.

The pumping rates at the City wells are shown on Table 1 – RMM Scenario #1. The total pumping for the wells during average climate conditions is 63,650 m^3/d and during drought conditions is 68,050 m^3/d. The pumping was varied according to the simulated yield of the Glen Collector which drops to 1,892 m^3/d at the peak of the drought (1964). Thus for Scenario #1, during average climate conditions, the total yield of the water supply system is 70,550 m^3/d (including at least 6,900 m^3/d from the collector), and the total yield during drought conditions is 69,942 m^3/d. These rates meet the WSMPU target average day demand of 69,872 m^3/d, but provide limited excess capacity as buffer against wells being offline for maintenance.

Table 1 - RMMEP Scenario Pumping Rates

Well	Estimated Individual Well Capacity*	Typical Pumped Rates (2008)	T3 Risk Assessment Allocated Rates (Average)	T3 Risk Assessment Allocated Rates (Drought)	RMM Scenario #1 Future Rates (Average)	RMM Scenario #1 Future Rates (Drought)	RMM Scenario #2 Future Rates (Average)	RMM Scenario #2 Future Rates (Drought)	RMM Scenario #3 Future Rates (Average)	RMM Scenario #3 Future Rates (Drought)	RMM Scenario #4 Future Rates (Average)	RMM Scenario #4 Future Rates (Drought)
	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day
Arkell 1	2,000	730	1,400	1,400	1,000	1,000	1,300	1,300	1,300	1,300	1,300	1,300
Arkell 14	7,000	-	3,300	4,400	3,300	4,200	3,300	4,300	3,300	4,300	3,300	4,300
Arkell 15	7,000	-	3,300	4,400	3,300	4,200	3,300	4,300	3,300	4,300	3,300	4,300
Arkell 6	8,000	3,774	4,900	5,300	4,900	5,300	4,900	5,300	4,900	5,300	4,900	5,300
Arkell 7	8,000	3,689	4,900	5,300	4,900	5,300	4,900	5,300	4,900	5,300	4,900	5,300
Arkell 8	7,000	3,694	4,900	4,900	4,500	4,500	4,800	4,800	4,800	4,800	4,800	4,800
Burke	6,500	5,385	6,000	6,300	5,500	5,800	5,800	5,800	5,500	5,800	5,500	5,800
Calico	1,400	748	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100
Carter Wells	5,500	3,400	4,000	4,400	3,400	3,800	4,000	4,000	4,000	4,000	4,000	4,000
Clythe Creek	3,395	-	2,200	2,200	2,200	2,200	2,500	2,500	2,500	2,500	2,800	2,800
Dean Ave.	1,500	1,215	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Downey Rd.	5,236	3,940	5,100	5,200	5,100	5,200	5,100	5,100	5,100	5,100	5,100	5,100
Emma	2,800	2,600	2,100	2,400	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Helmar	1,500	800	1,100	1,200	1,100	1,200	1,300	1,300	1,300	1,300	1,400	1,400
Membro	6,000	3,036	4,200	4,300	4,200	4,300	4,300	4,300	4,300	4,300	4,300	4,300
Paisley	1,400	762	800	1,000	800	1,000	1000	1,000	1300	1300	1300	1300
Park 1 & 2	8,000	6,400	6,400	6,900	6,400	6,900	6,400	6,900	6,400	6,900	6,400	6,900
Queensdale	1,100	702	2,000	2,000	1,000	1,000	1,500	1,500	1,500	1,500	1,100	1,100
Sacco	1,150	-	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150
Smallfield	1,408	-	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
University	2,500	1,648	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Water Street	2,700	1,184	2,300	2,400	2,300	2,400	2,400	2,400	2,400	2,400	2,400	2,400
		Subtotal	66,550	71,650	63,650	68,050	66,550	69,850	66,550	70,150	66,550	70,150
		Glen Collector	6,900	1,892	6,900	1,892	6,900	1,892	6,900	1,892	6,900	1,892
		Total	73,450	73,542	70,550	69,942	73,450	71,742	73,450	72,042	73,450	72,042
		Target Water Demand	71,595	71,595	69,872	69,872	71,595	71,595	71,595	71,595	71,595	71,595
		Excess	1,855	1,947	678	70	1,855	147	1,855	447	1,855	447

Legend:

Wells at Significant Risk Level

Well close to Safe Water Level

Rates decreased from Risk Assmt.

Rates increased from Risk Assmt.

Notes:

* - Estimated capacity needs to be confirmed by the City of Guelph and could vary based on wellfield interactions.

1.2 Risk Management Measures Scenarios #2 to #4

RMM Scenarios #2 to #4 were conducted under RMM "Optimization of Pumping Rates for Sustainable Yield". Three scenarios were designed to optimize the pumping of the Guelph wells such that total pumping was maintained above the Allocated rate of 73,450 m^3/d during average conditions, but was reduced to a minimum of 71,525 m^3/d during drought conditions. This lower rate corresponds to the projected water demand for 2031 that was used in the Tier Three Assessment and based on the Water Conservation and Efficiency Strategy Update (RMSi 2009). Pumping rates for these three scenarios are also shown on Table 1. Similarly to Scenario #1, these scenarios were developed in consultation with Guelph Water Services but the operational and infrastructure constraints of the water supply system may vary from the model predictions.

2 WATER QUANTITY THREAT UPDATE

Before these scenarios were performed, Matrix also conducted the following updates to the water quantity threats within the WHPA-Q1-A:

1) The Permit to Take Water database (PTTW; September 2017 data release) and the Water Taking Reporting System (WTRS; 2009 to 2016) were reviewed to ensure that the non-municipal, permitted takings represented in the Tier Three Assessment model were still representative of the existing conditions. Permits that had expired were removed from the model, and all non-municipal permits for wells and shallow groundwater takings within the WHPA-Q1-A were updated using the 2016 WTRS data. Consumptive use pumping rates were calculated according to the method used for the Tier Three Assessment and assigned to the wells in the groundwater model. Permits with no reported takings in 2016 were not included in the model. This update resulted in a decrease of 15 non-municipal permits within the WHPA-Q1-A from the Tier Three Assessment, for a total of 56 non-municipal permits.

2) The Dolime Quarry Annual Water Reports for 2015 and 2016 were reviewed and it was noted that the quarry pond has typically been operated at 288.39 masl while the Tier Three Assessment represented it at 290 masl. The model was updated with the lower pond level resulting in increased drawdown at municipal wells of up to 1.1 m. The Threats Ranking Scenario III-C-i was updated and the quarry increased in percent impact from 45% to 50%.

3) Potential recharge reductions due to the proposed Clair-Maltby development and other proposed developments in Guelph-Eramosa Township were assessed that were not accounted for in the Tier Three Assessment. An additional 2.4 km^2 of potential areas of recharge reductions were identified throughout the model. These correspond to a reduction in groundwater recharge of approximately 440 m^3/d based on the assumed increase in imperviousness of these areas. The Threats Ranking Scenario I-D was updated and the additional recharge reductions increased the percent impact from 7% to 9%.

The results of the Threats Ranking were updated and are shown in Table 2.

Table 2 – Updated Threats Ranking – WHPA-Q1-A

Rank	Water Quantity Threat	Greatest % Impact	Well under Greatest % Impact
1	Queensdale Well	72%	Queensdale
2	Arkell System	53%	Arkell 8
3	5080-8TAKK2 (River Valley Developments)	45% (+5%)	Membro
4	Clythe Creek Well	32%	Clythe Creek
5	Calico Well	24%	Calico
6	Sacco Well	22%	Sacco
7	Helmar Well	19%	Helmar
8	Smallfield Well	19%	Smallfield
9	Carter Wells	17%	Carter Wells
10	Water St. Well	17%	Water St.
11	Burke Well	15%	Burke
12	Membro Well	13%	Membro
13	Downey Well	12%	Downey
14	All Permitted, Non-Municipal Takings Inside WHPA-Q1-A except Dewatering, Commercial, and Industrial Permits (32 permits as of 2008)	10%	Emma
15	Recharge Reduction (due to future Land Use)	7% (+2%)	Burke
16	University Well	7%	University
17	Dean Well	4%	Dean
18	Paisley Well	2%	Paisley
19	1245-AB8RMW (Gay Lea Foods)	2%	Emma
20	1381-95ATPY (Nestle Waters)	1%	Burke
21	Planned Municipal Takings: Rockwood (GET)	1%	Arkell 1
23	All Non-Permitted Takings (WWIS - Domestic)	1%	Helmar
24	Planned Municipal Takings: Hamilton Drive (GET)	<1%	
25	5448-9FLM5E (Holody Electro Plating)	<1%	
26	5736-8QSS7B (Flochem)	<1%	
27	Planned Municipal Takings: Cambridge	<1%	
28	All Permitted Non-Municipal Takings Outside WHPA-Q1-A	<1%	

3 RISK MANAGEMENT MEASURES SCENARIO RESULTS

The results of the four preliminary RMM scenarios are summarized in Table 3 and compared with the Risk Assessment H1 Scenario result that incorporated drought conditions, future pumping, and future land cover. Detailed results are provided for the Risk Assessment H1 Scenario, and RMM scenarios #1, #3 and #4 in Appendix A. Scenario 2 results are similar to Scenario 3 and have not been shown for clarity. The Risk Assessment results led to a *significant* risk level being assigned to the WHPA-Q1-A due to the drawdown at Queensdale Well exceeding the Safe Water Level (SWL) under the drought scenario.

The water level at Arkell 1 came within 0.5 m of the SWL during the drought scenario, and because the Risk Assessment was assessed as having high uncertainty with respect to the result at Arkell 1, that contributed to the *significant* risk level assignment.

Table 3 – RMM Scenario Results

Scenario	Future Rate (Average) m^3/d	Future Rate (Drought) m^3/d	Wells Triggering Risk	WHPA-Q1-A Risk Level
H1 Risk Assessment (Future Demand, Future Land Use)	73,450	73,542	Queensdale, Arkell 1	*Significant*
RMM Scenario #1 – Lower Demand (WSMPU Target 69,872 m^3/d)	70,550	69,942	Arkell 1	*Significant*
RMM Scenario #2 – Shift Demand (Drought target 71,595 m^3/d)	73,450	71,742	Arkell 1	*Significant*
RMM Scenario #3 – Shift Demand (Drought target 71,595 m^3/d)	73,450	72,042	Arkell 1	*Significant*
RMM Scenario #4 – Shift Demand (Drought target 71,595 m^3/d)	73,450	72,042	Arkell 1	*Significant*

The four RMM scenarios were able to reduce the predicted drawdown at the Queensdale Well such that the water level did not drop below the SWL during the drought scenario, but the water levels at Arkell 1 were still less than 0.5 m above the SWL. Thus these scenarios did not succeed in reducing the water quantity risk level of the WHPA-Q1-A, and additional RMM scenarios are required.

3.1 Additional Risk Management Measures Scenarios

The above results were presented at a meeting of the Project Team and Implementing Municipalities Group on Nov. 6, 2017. The Project Team received input from the participants on the design of additional RMM scenarios to be conducted. Based on the Project Team's direction, the recommended scenarios are summarized below:

- RMM Scenario #5 - Additional optimization to maintain the Allocated rates during drought conditions (drought target 71,595 m^3/d). This scenario will further reduce or eliminate pumping from Arkell 1.

- RMM Scenario #6 - Lower demand with additional optimization to achieve the WSMPU target rate of 69,872 m^3/d during drought conditions. This scenario will further reduce or eliminate pumping from Arkell 1.

- RMM Scenario #7 - Eliminate dewatering from Dolime Quarry and optimize pumping to maintain the Allocated rates during drought conditions (drought target 71,595 m^3/d). This will allow an increase of pumping at wells currently within the area of influence of the quarry.

- RMM Scenario #8 to #10 - Shift pumping away from at-risk wells to potential new water supply wells identified in the WSMPU: 1) Logan Well, 2) South Guelph (GSTW-02-08) well, and 3) Ironwood and Steffler wells. The goal of these scenarios will be to eliminate pumping from Arkell 1, shift pumping

away from the core of the City, while maintaining the Allocated rates during drought conditions (drought target 71,595 m^3/d).

- RMM Scenario #11 – Use the maximum permitted (consumptive) rates for non-municipal PTTWs within the WHPA-Q1-A while maintaining the Allocated rates for the Tier Three wells during drought conditions (drought target 71,595 m^3/d). Representatives of the Ministry of the Environment and Climate Change will review the updated PTTWs within the WHPA-Q1-A to be used in this scenario.

Proposed pumping rates for these scenarios are currently being designed and will be reviewed with the City to ensure they are reasonable given operational constraints.

4 REFERENCES

AECOM and Golder Associates Ltd. (AECOM and Golder). 2014. Water Supply Master Plan Update Draft Final Report. Prepared for the City of Guelph. Kitchener, Ontario. May 2014.

Matrix Solutions Inc. (Matrix). 2017. City Of Guelph and Township Of Guelph/Eramosa Tier Three Water Budget and Local Area Risk Assessment. Prepared for the Lake Erie Source Protection Region. Breslau, Ontario. March 2017.

Resource Management Strategies Inc. (RMSi). 2009. *Water Conservation and Efficiency Strategy Update* (WC&ES). Final Report. Report prepared for the City of Guelph. Guelph, Ontario. May 2009.

Toronto and Region Conservation (TRCA). 2014. *Water Quality and Quantity Risk Management Measures Catalogue.* Version: 7.0. July 24, 2014. Accessed September 20, 2017. http://trcagauging.ca/RmmCatalogue/QuantityIndex.aspx.

APPENDIX A

RESULTS FOR THE PRELIMINARY RMM DROUGHT SCENARIOS

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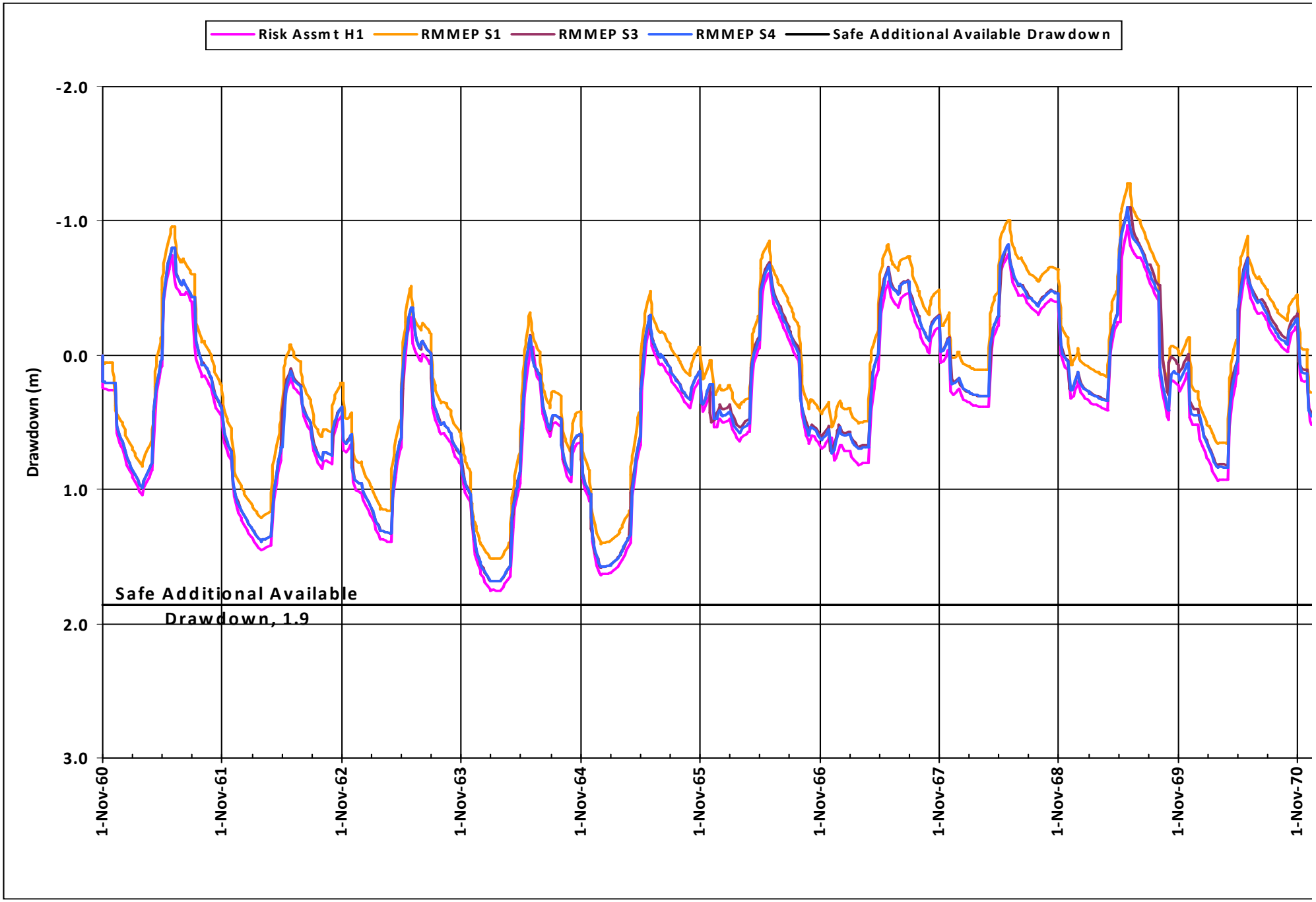

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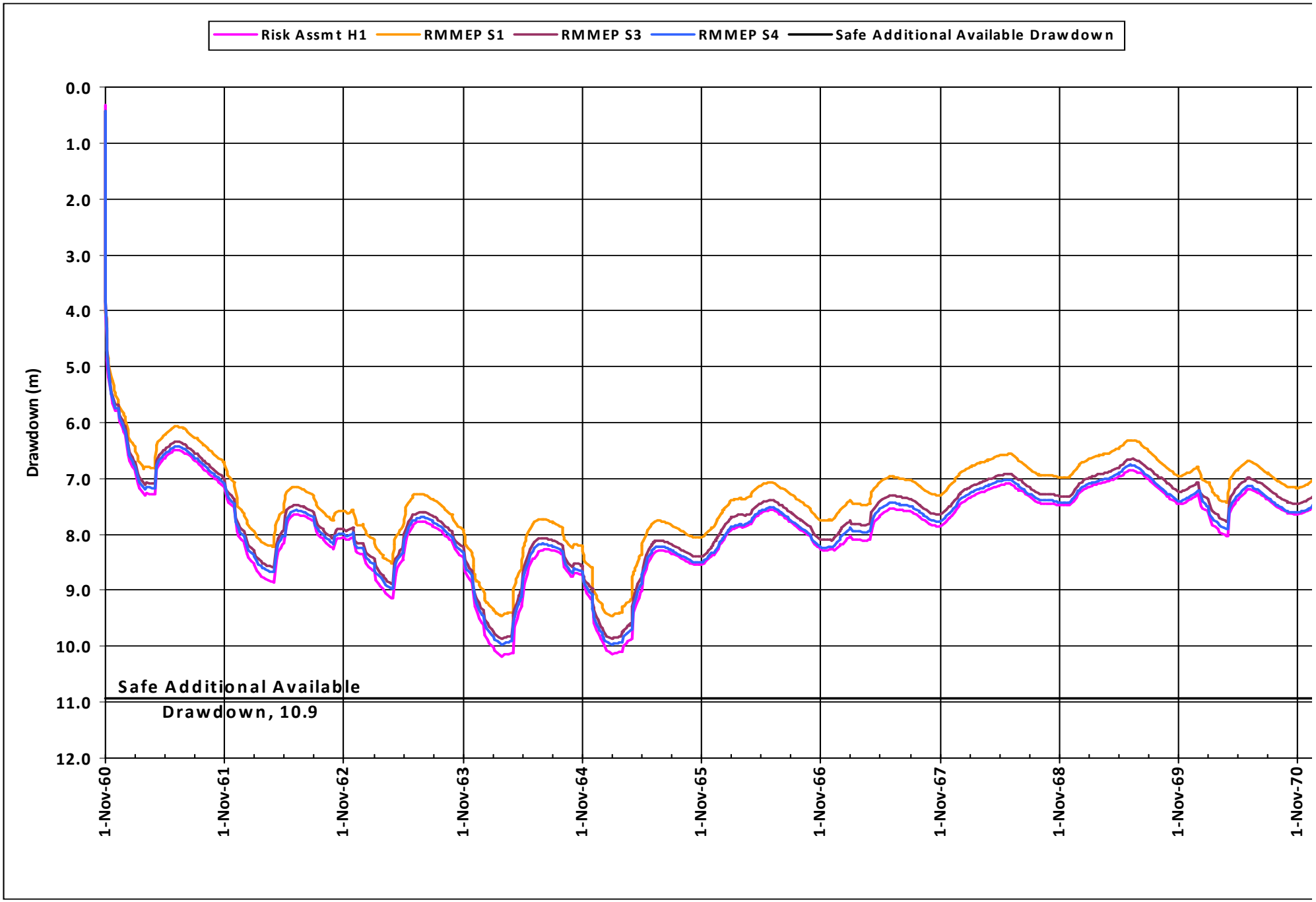

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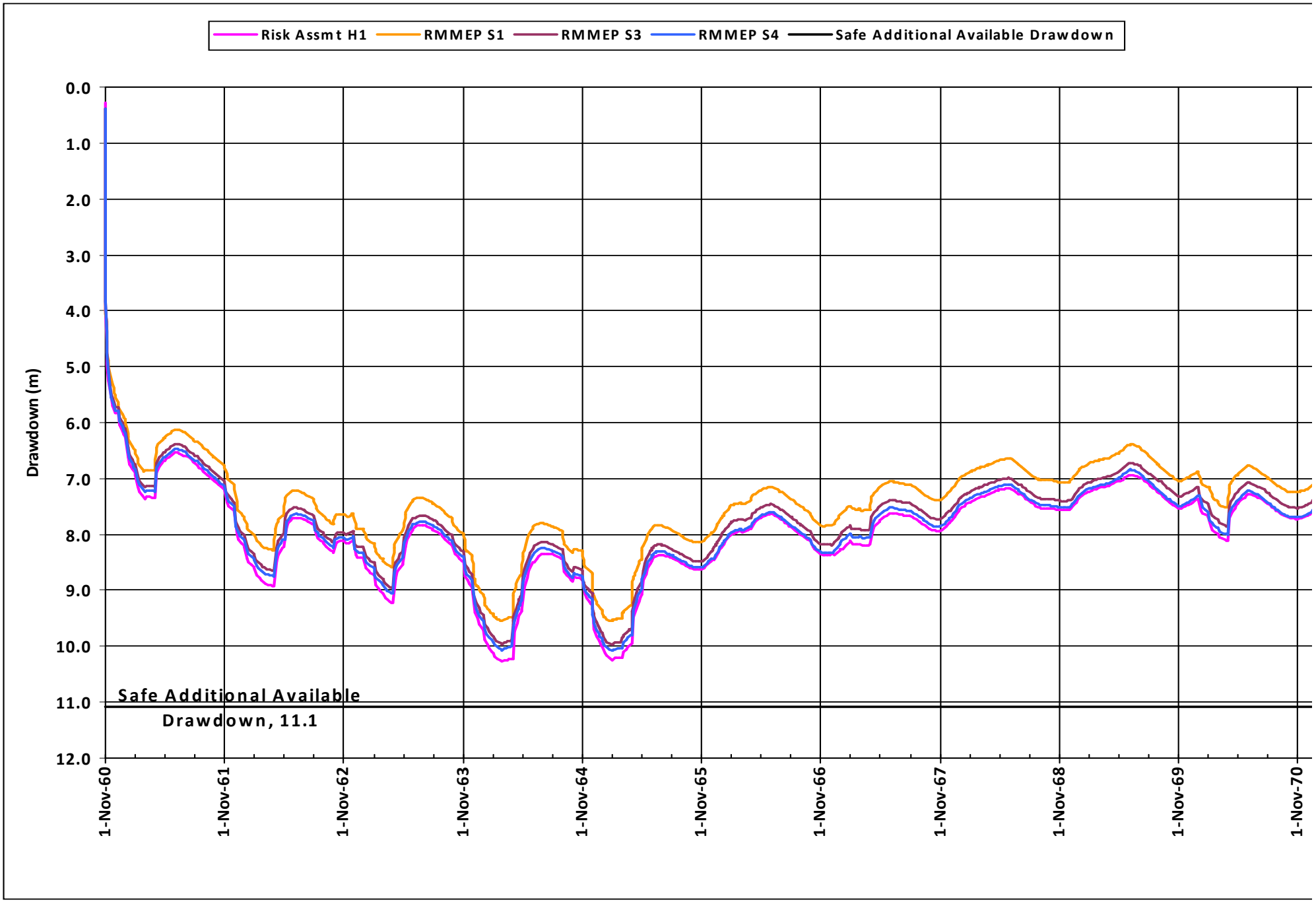

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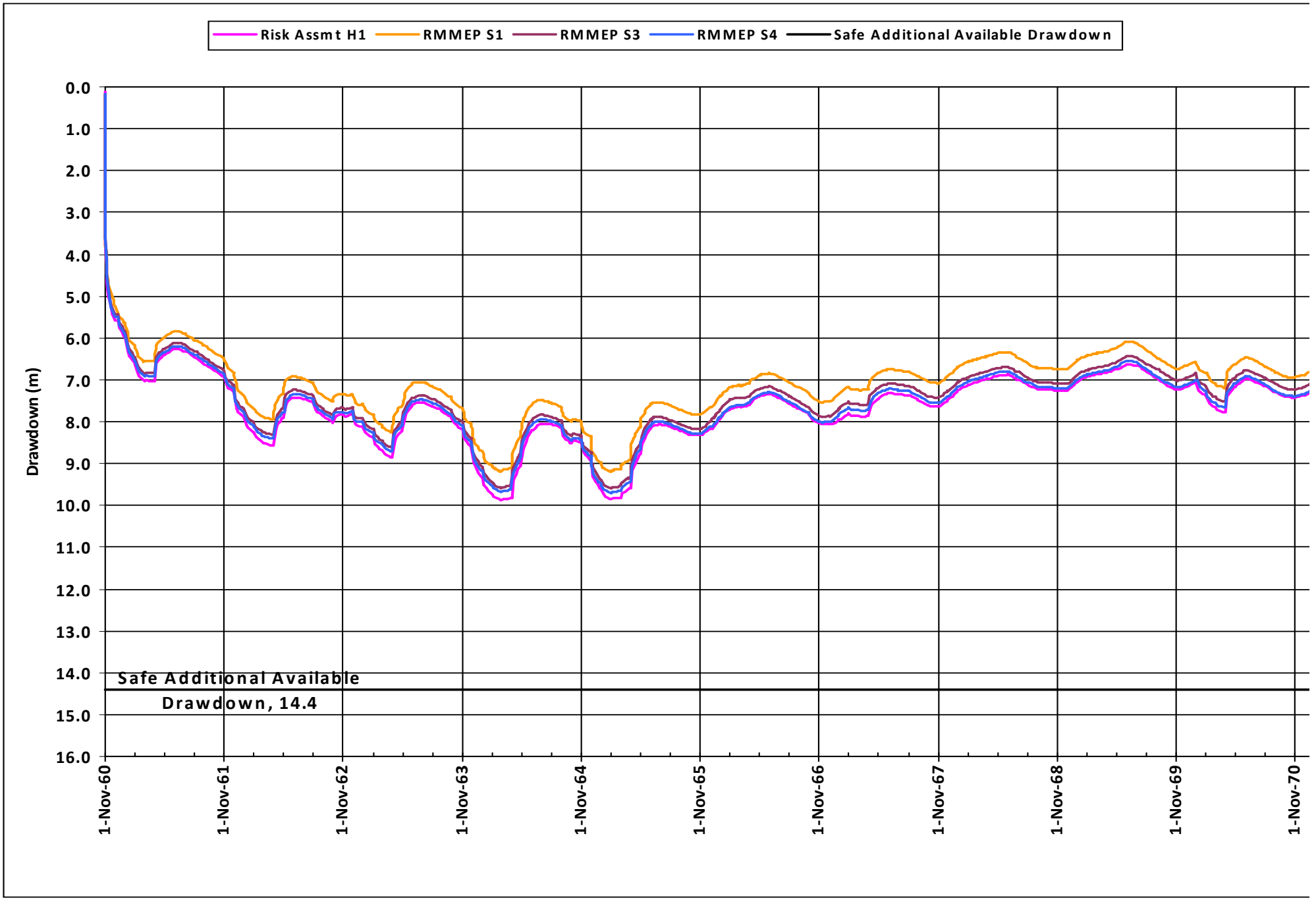

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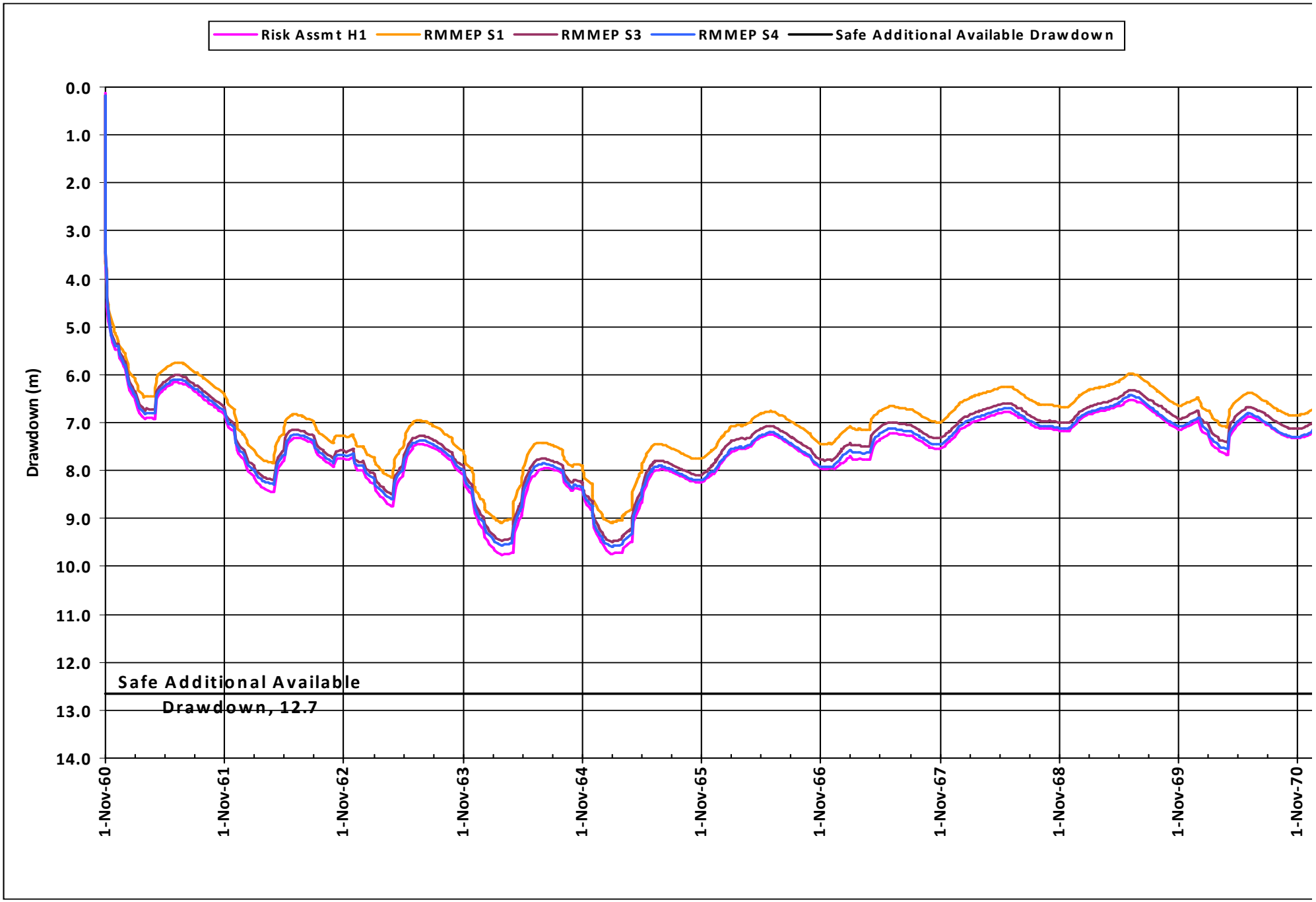

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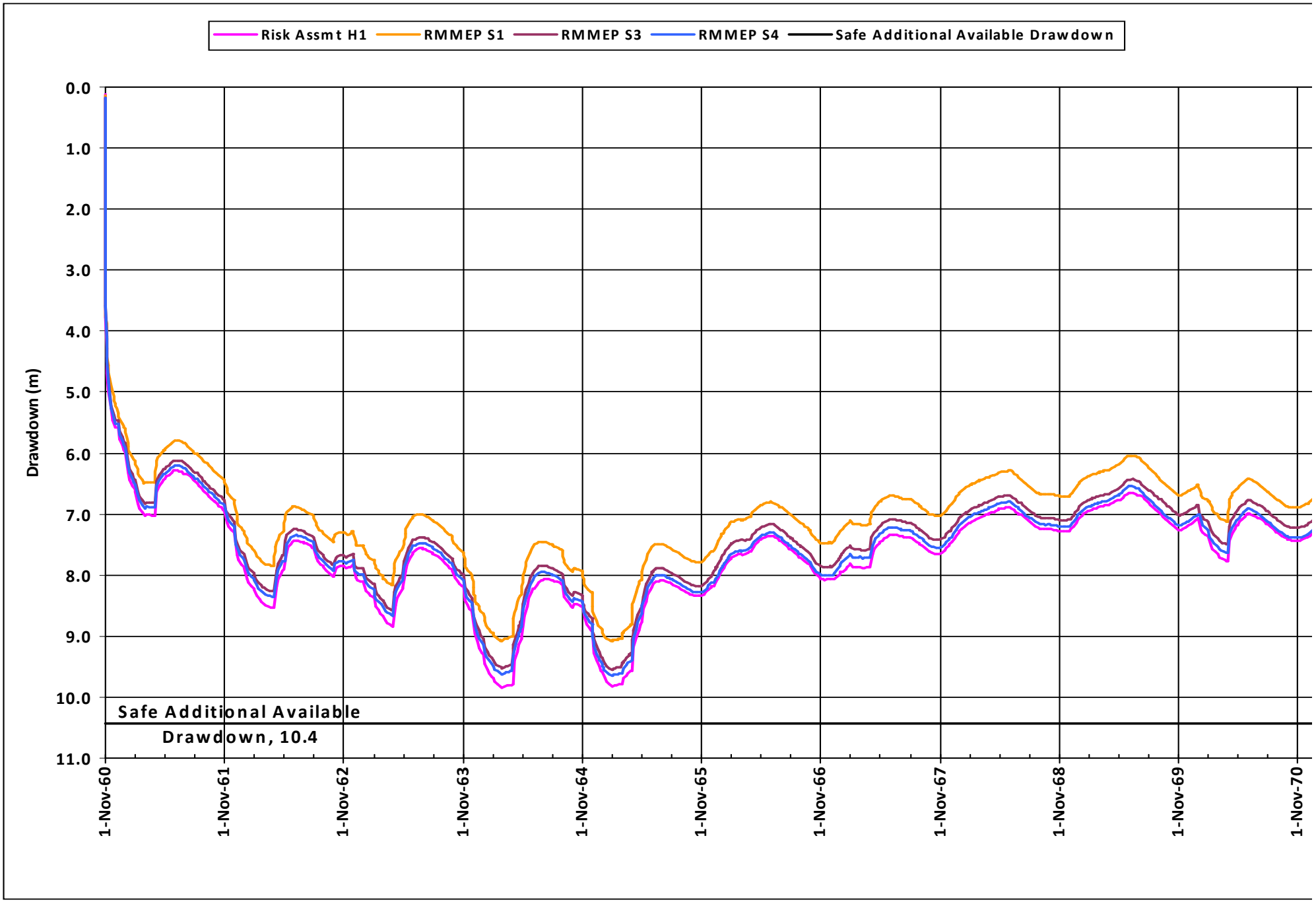

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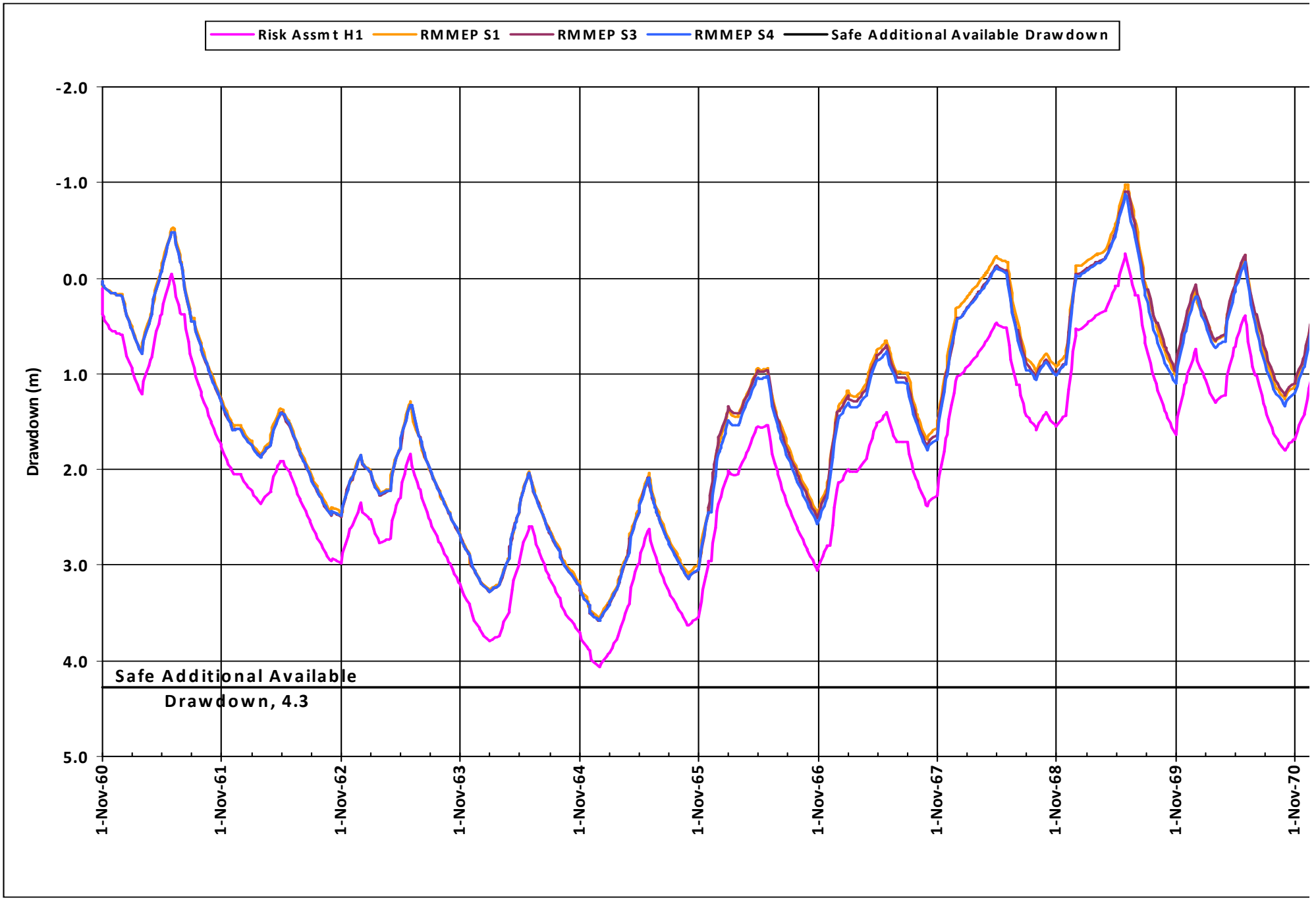

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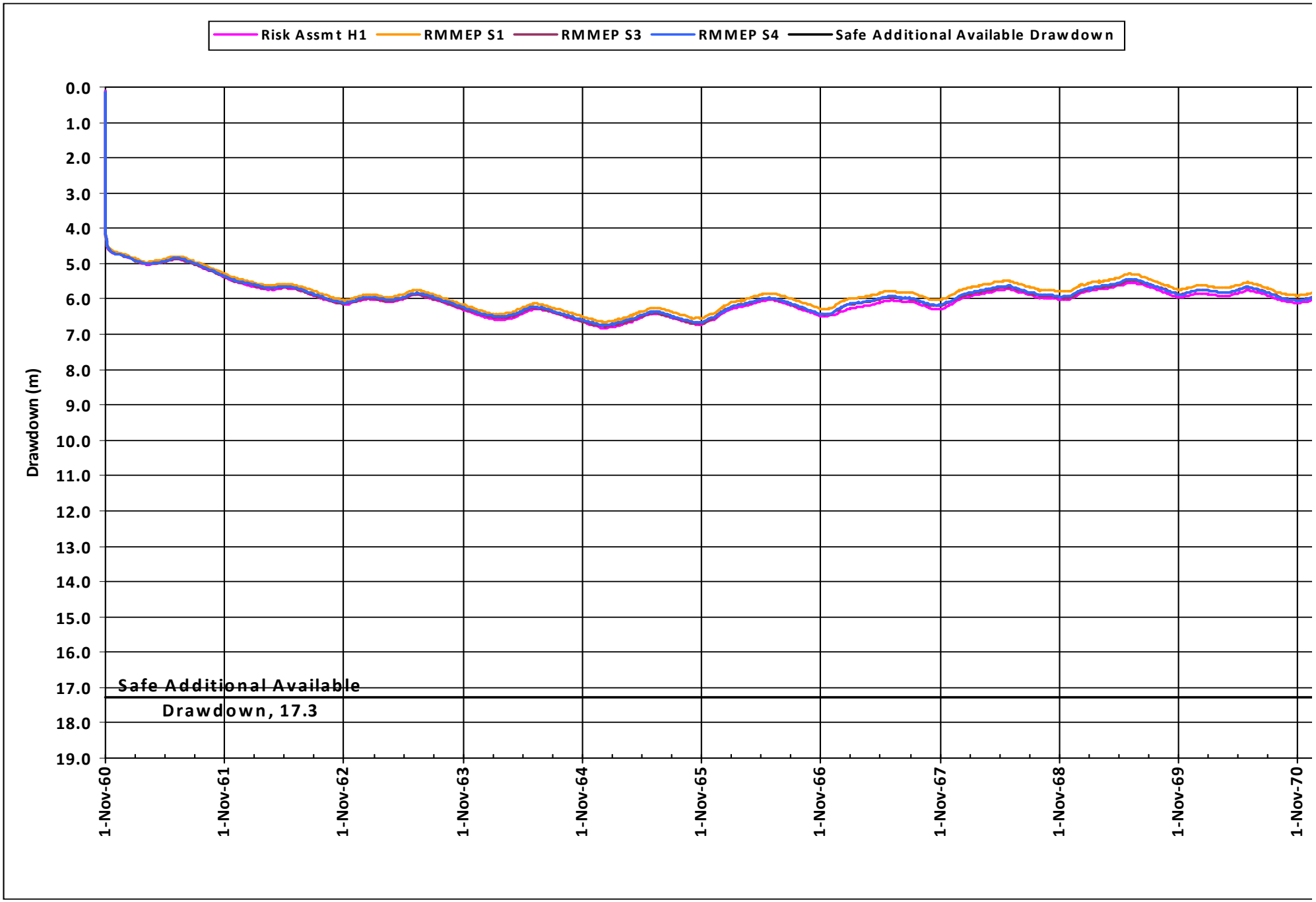

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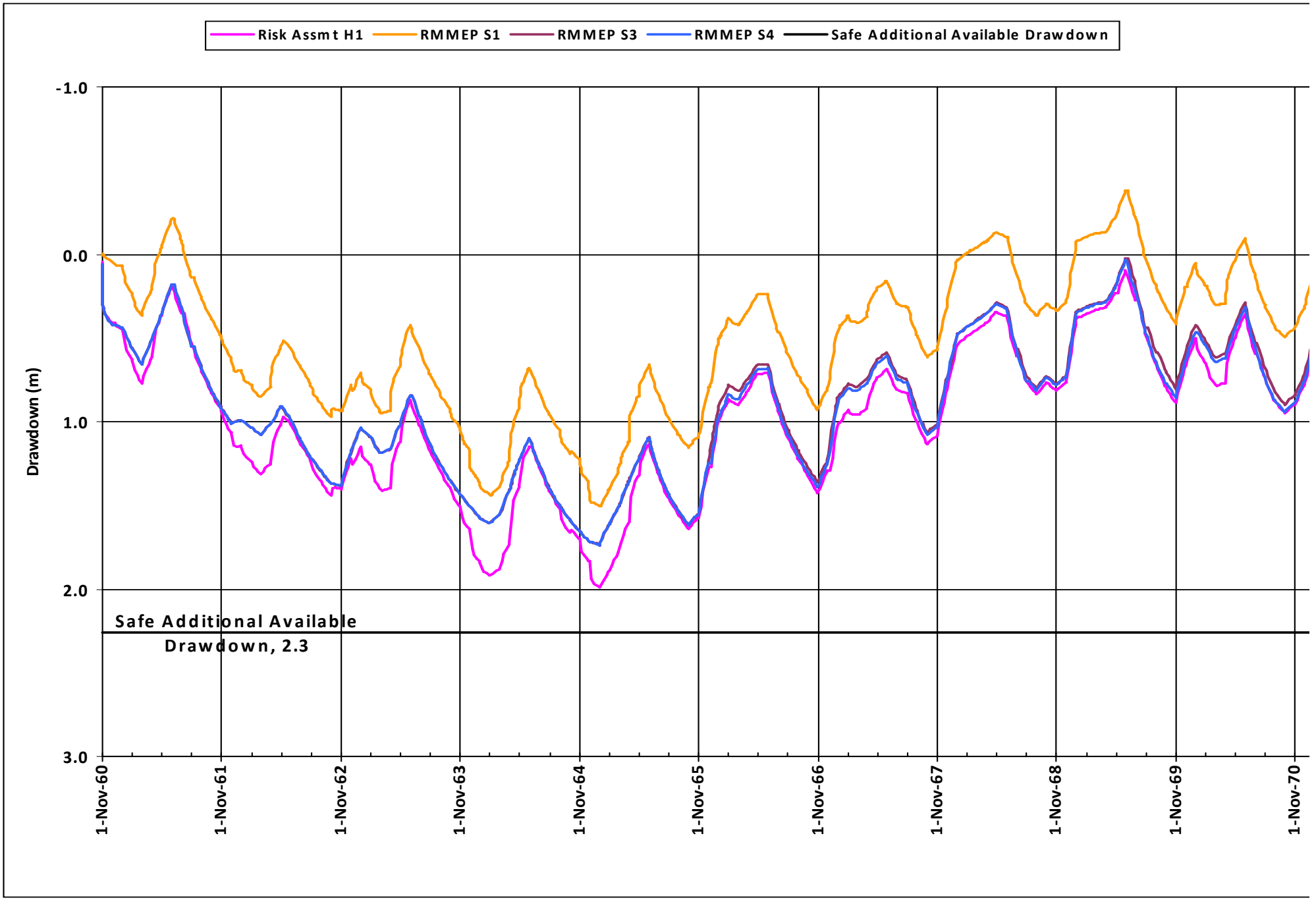

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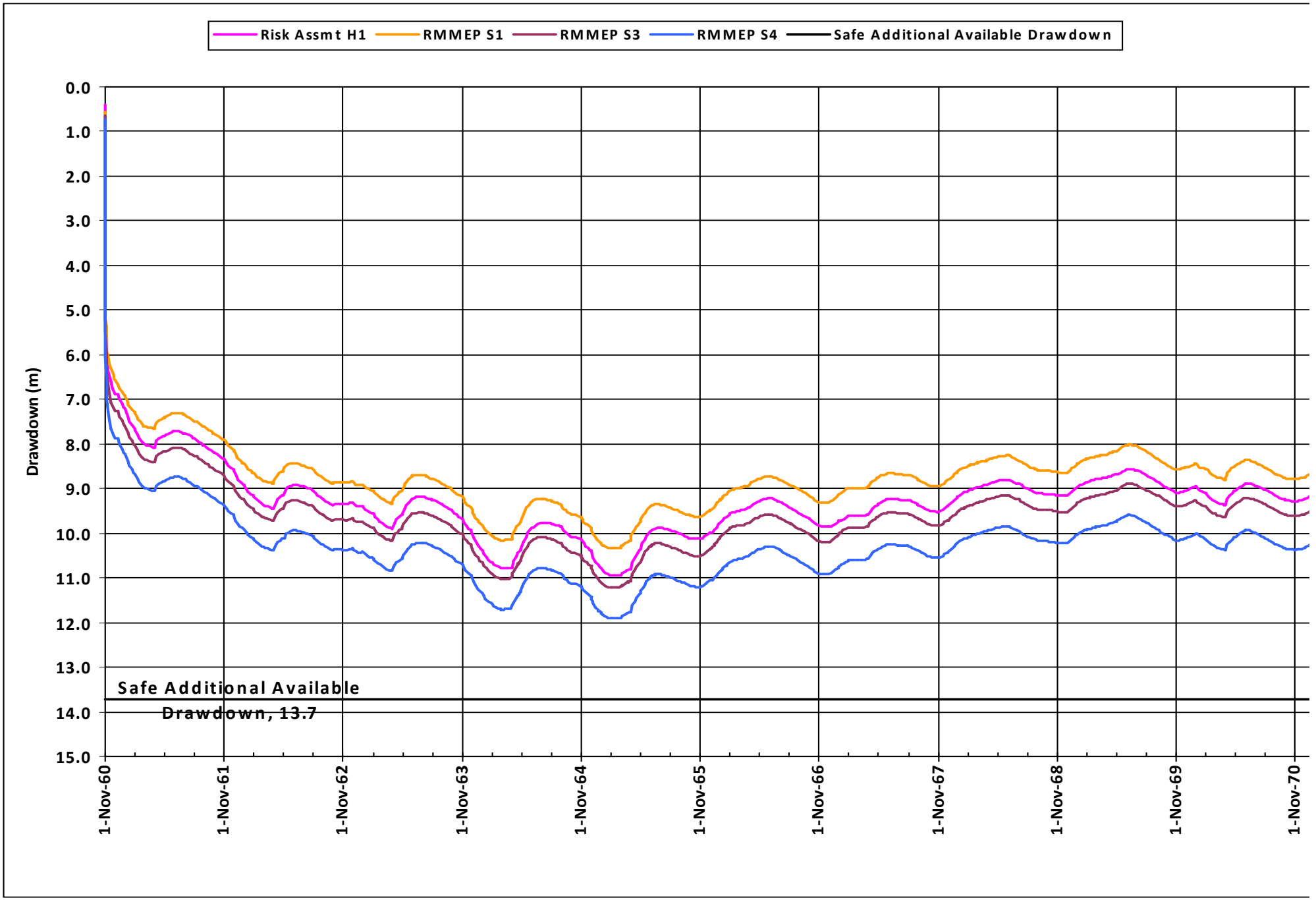

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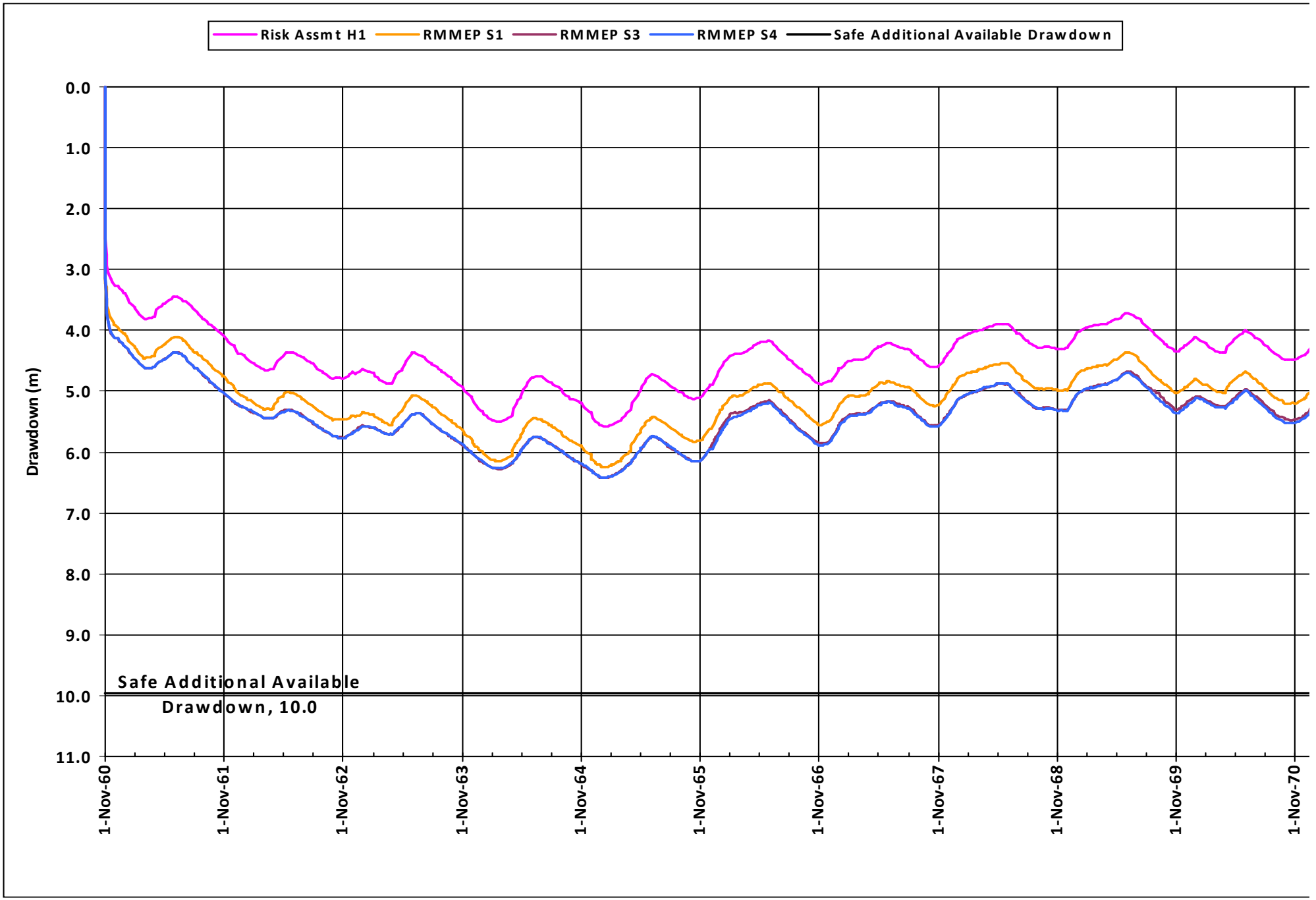

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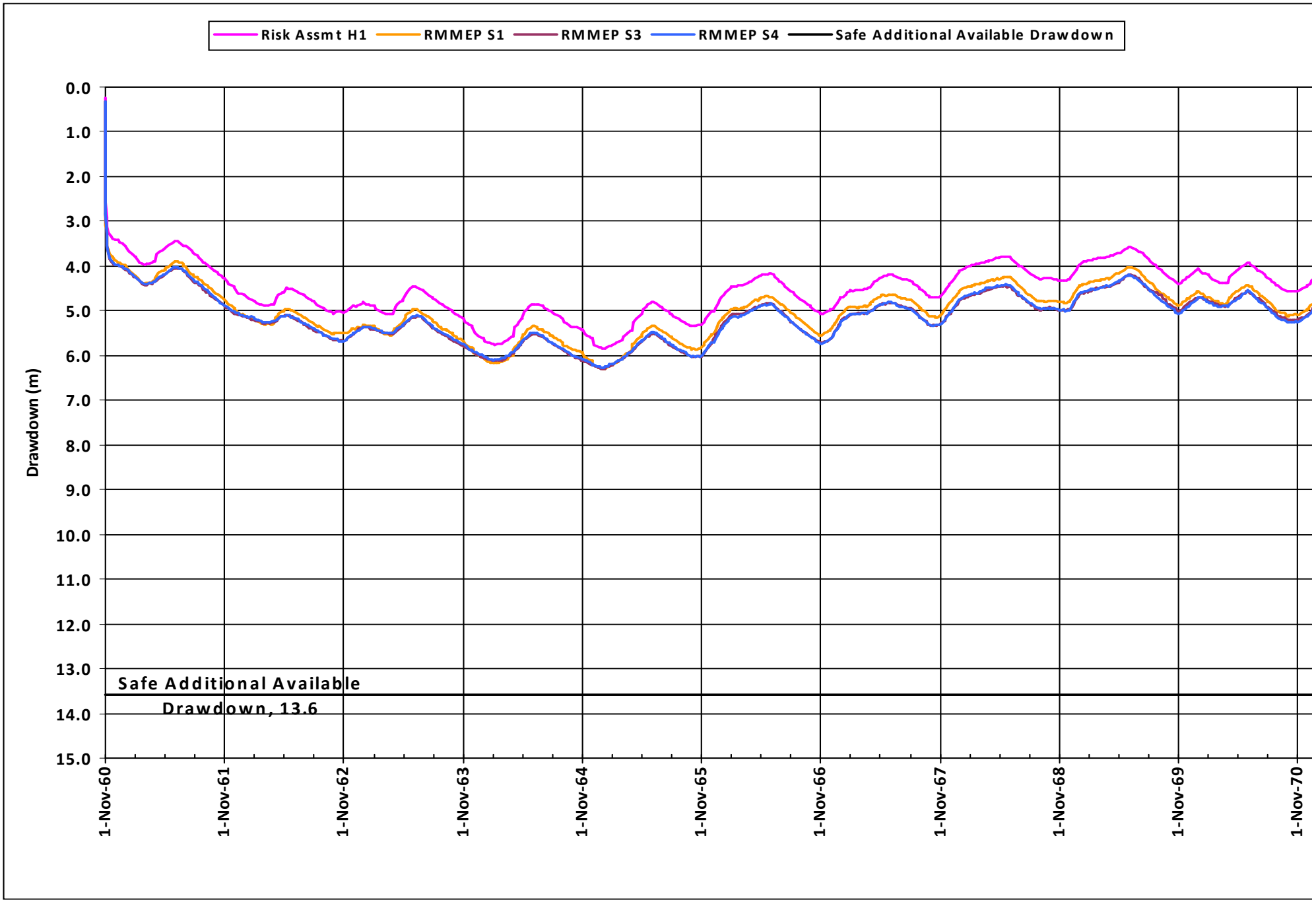

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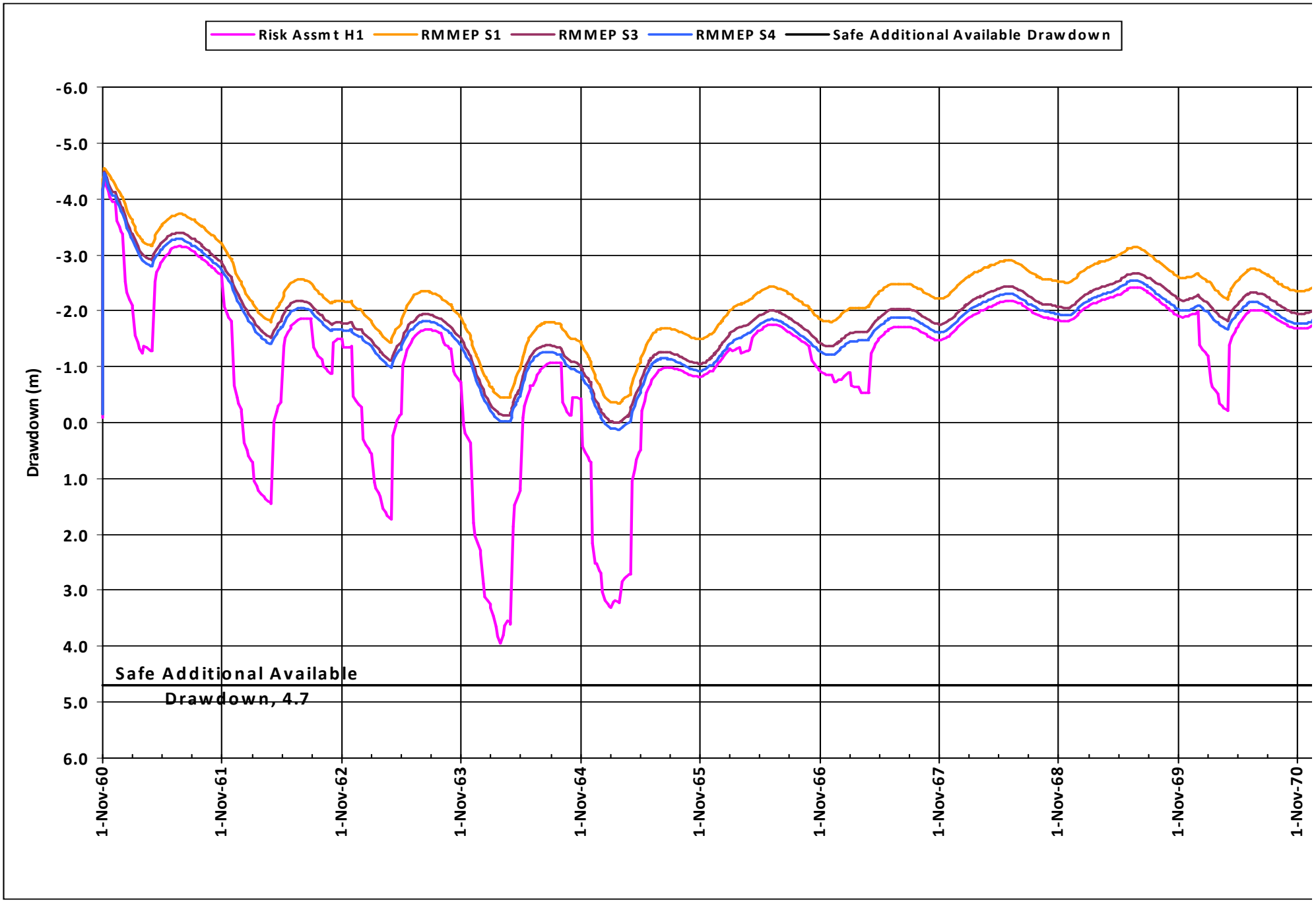
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RMMEP S3
RMMEP S4
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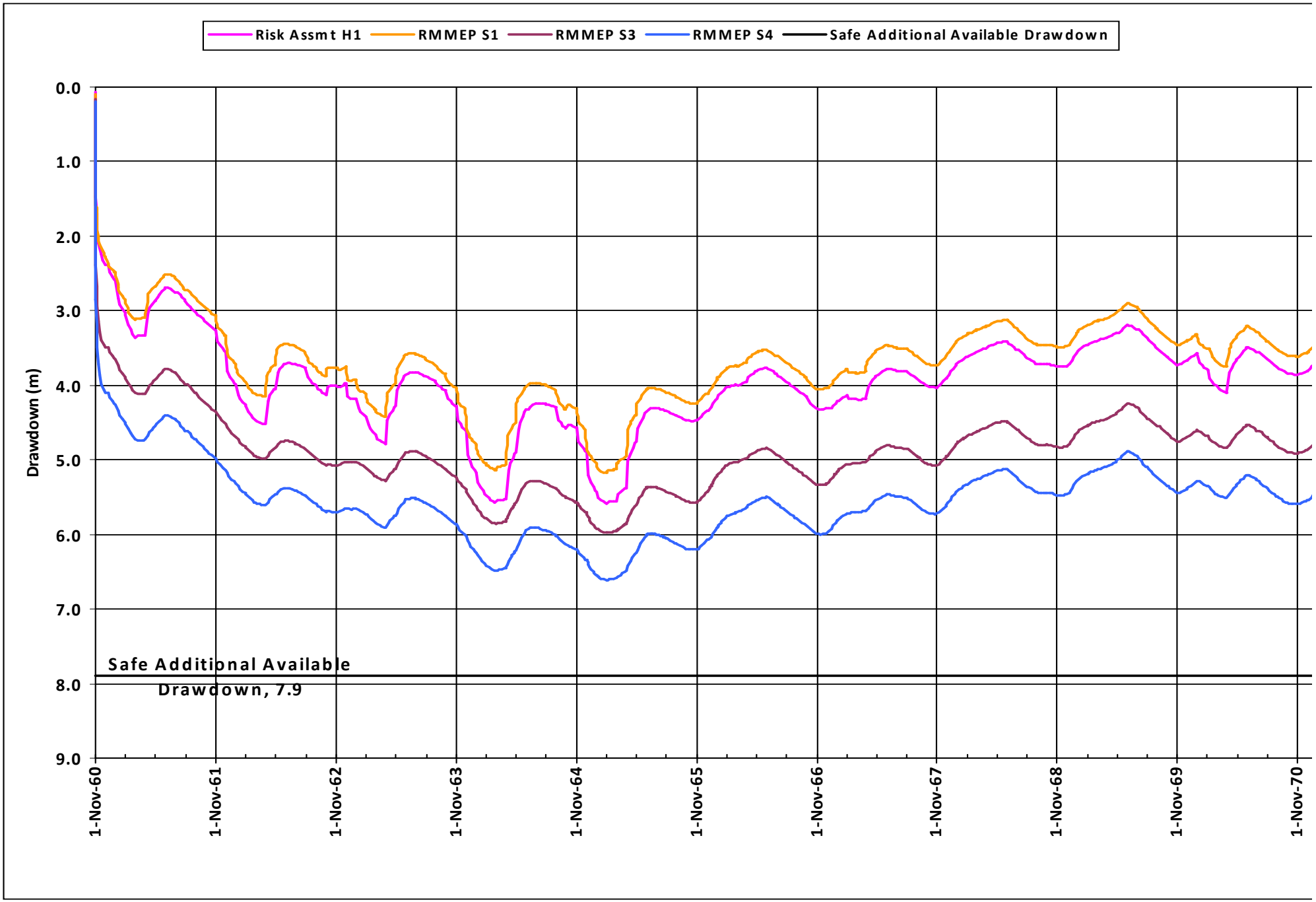

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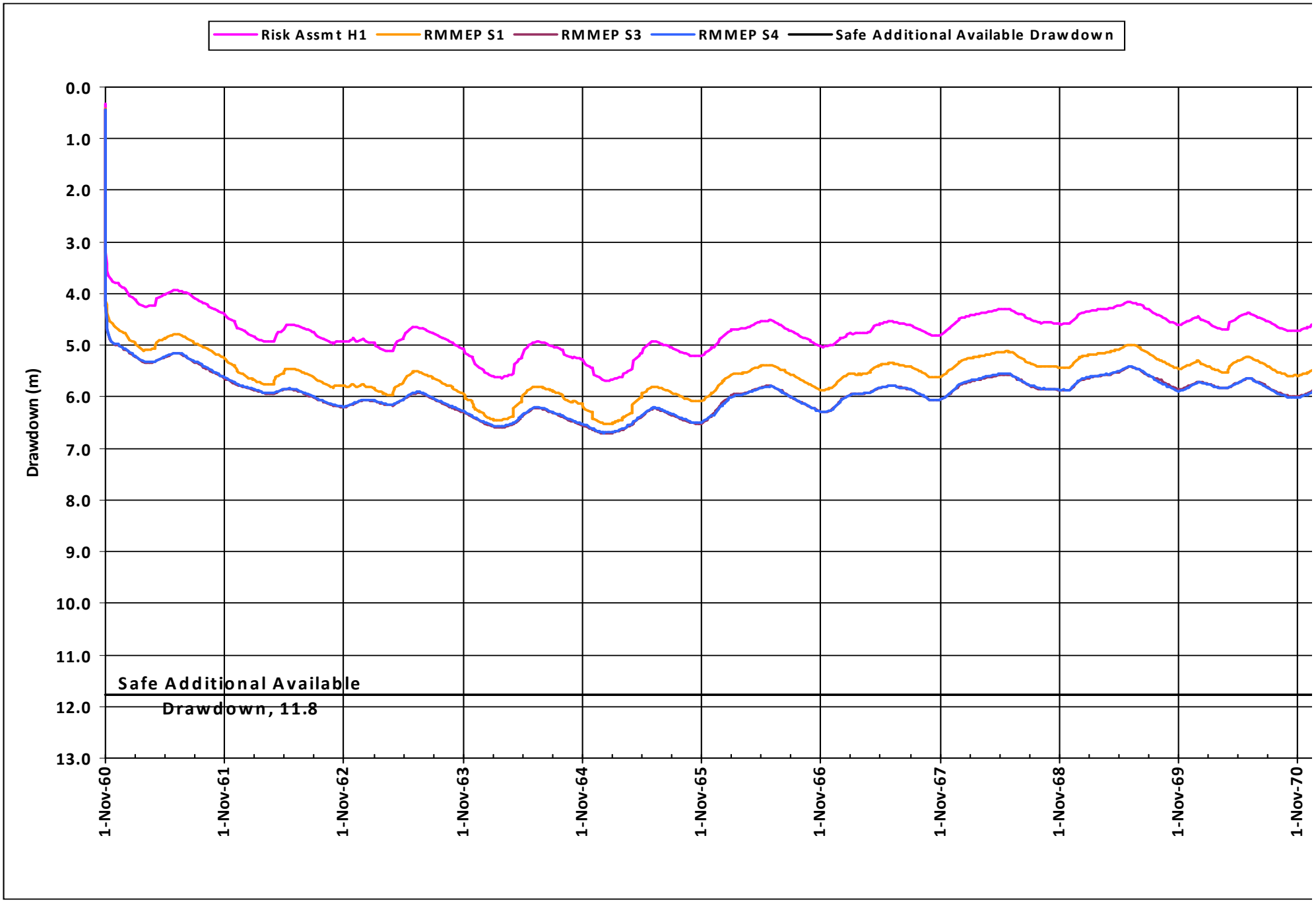

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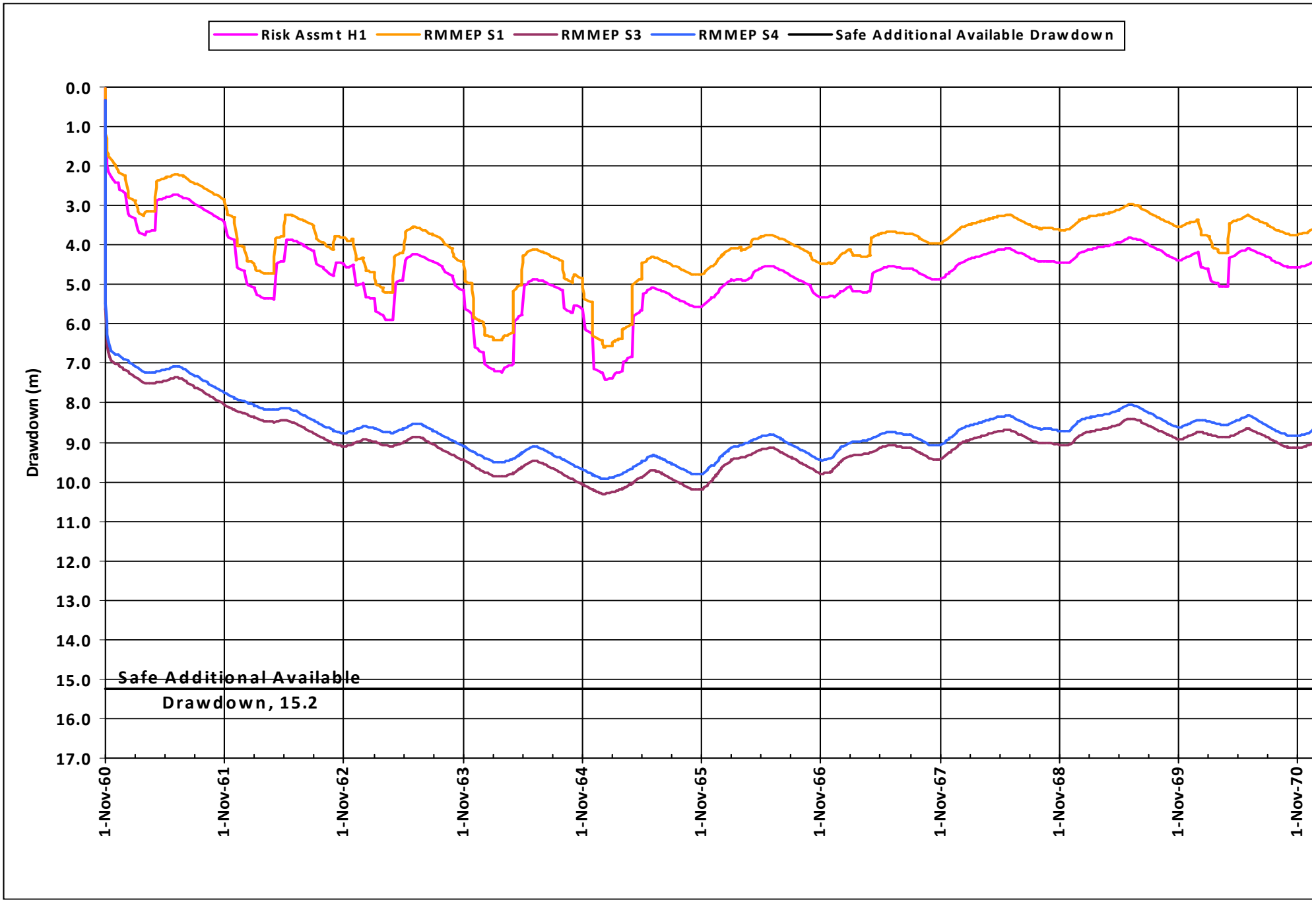

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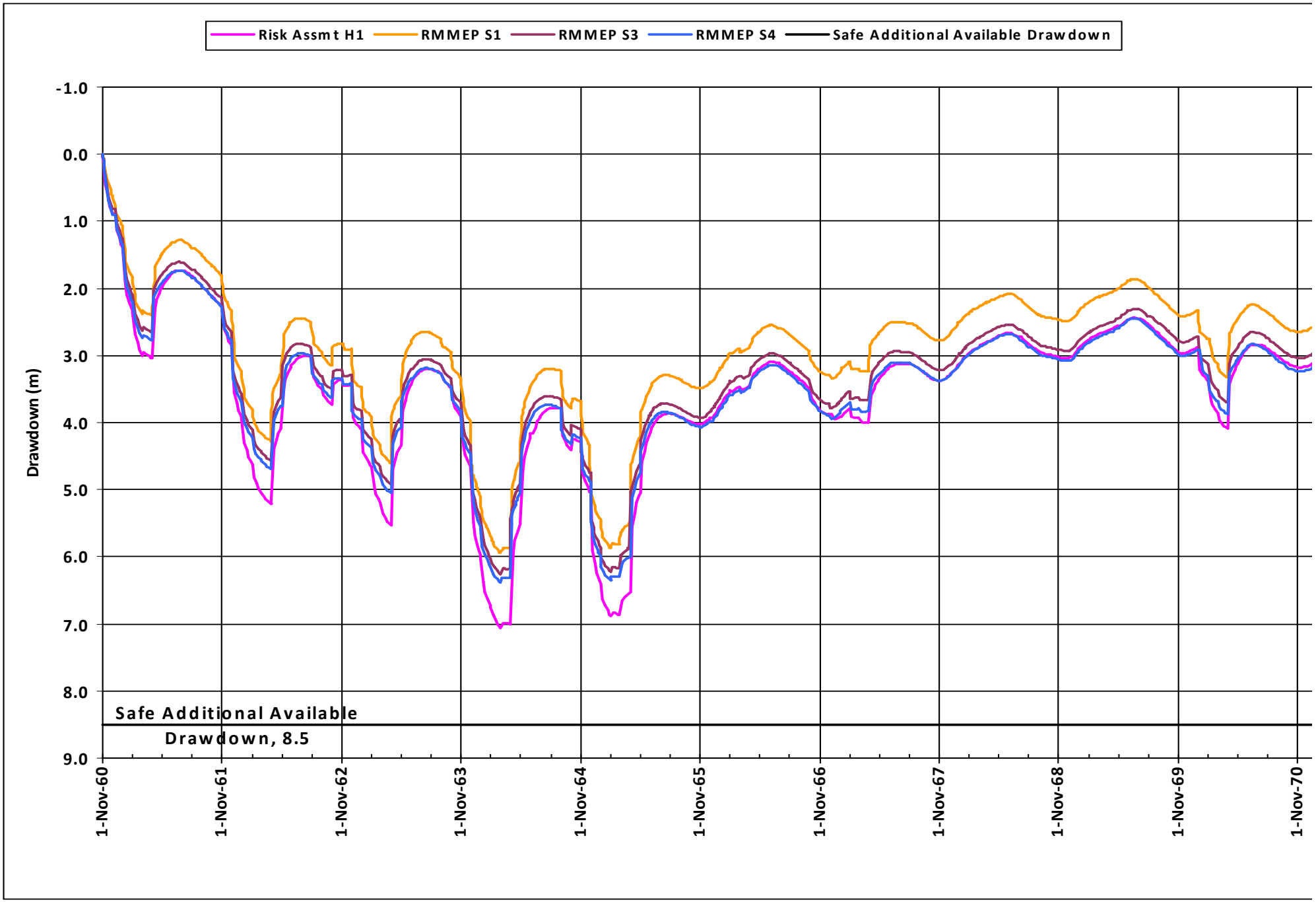

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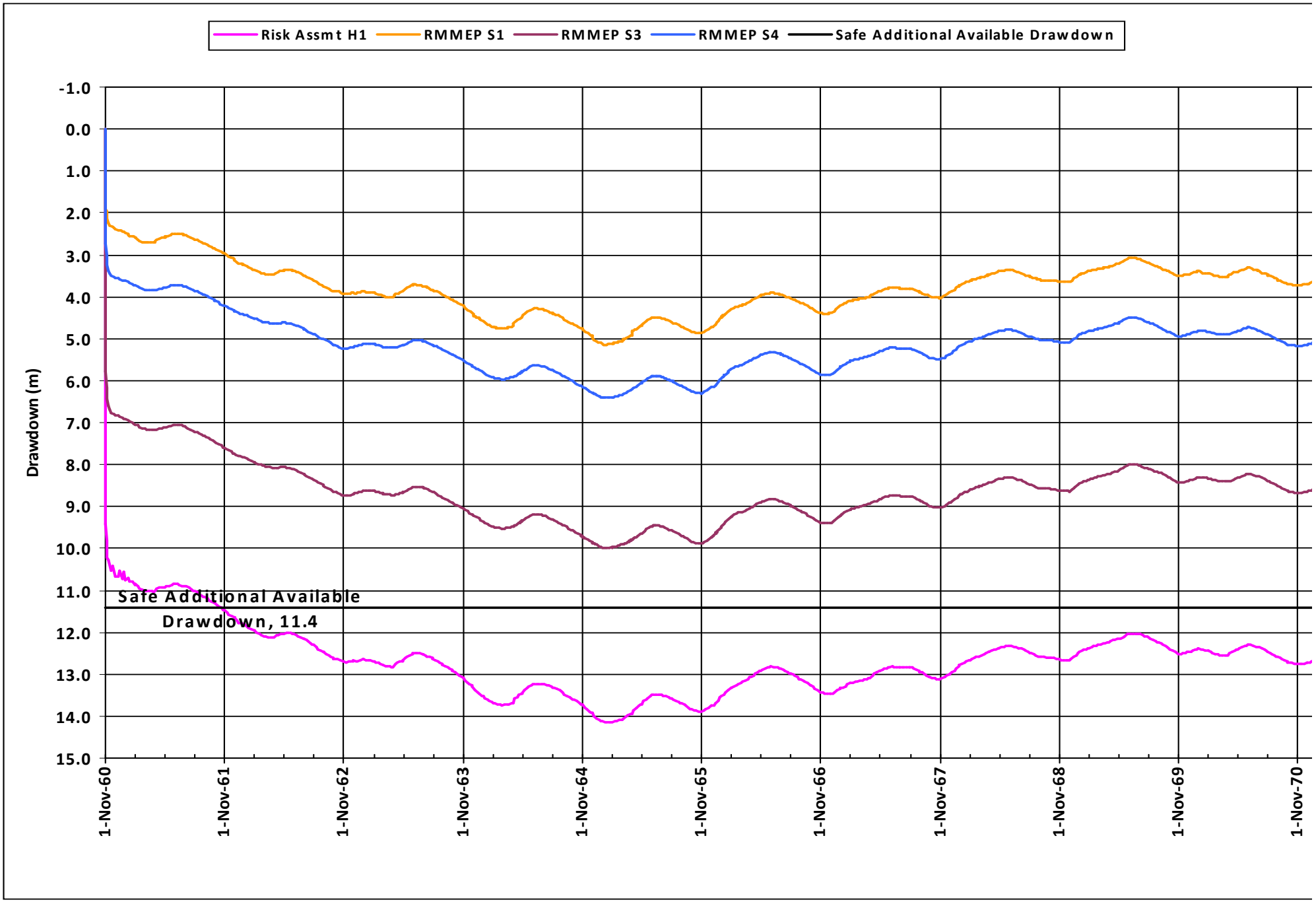

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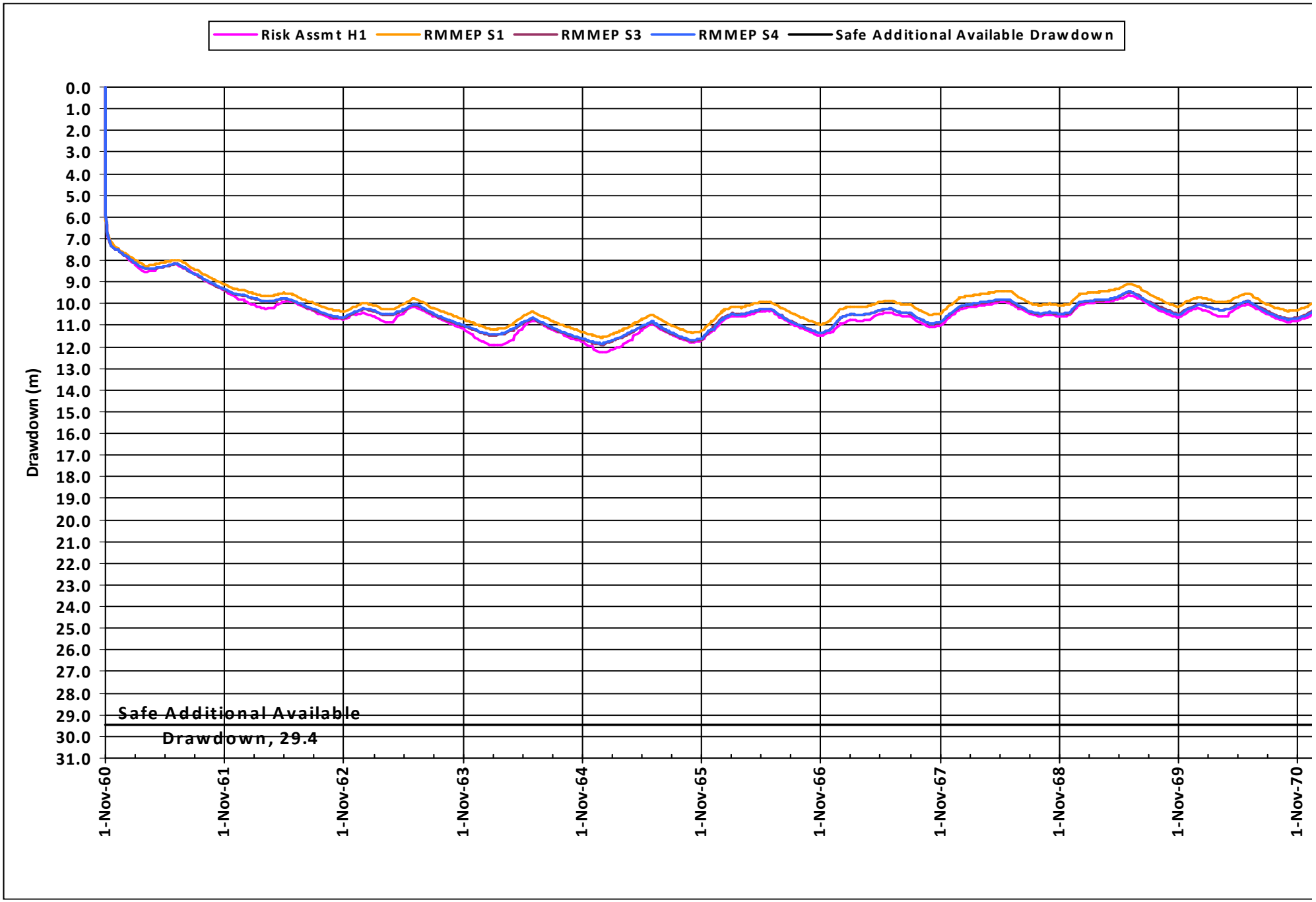

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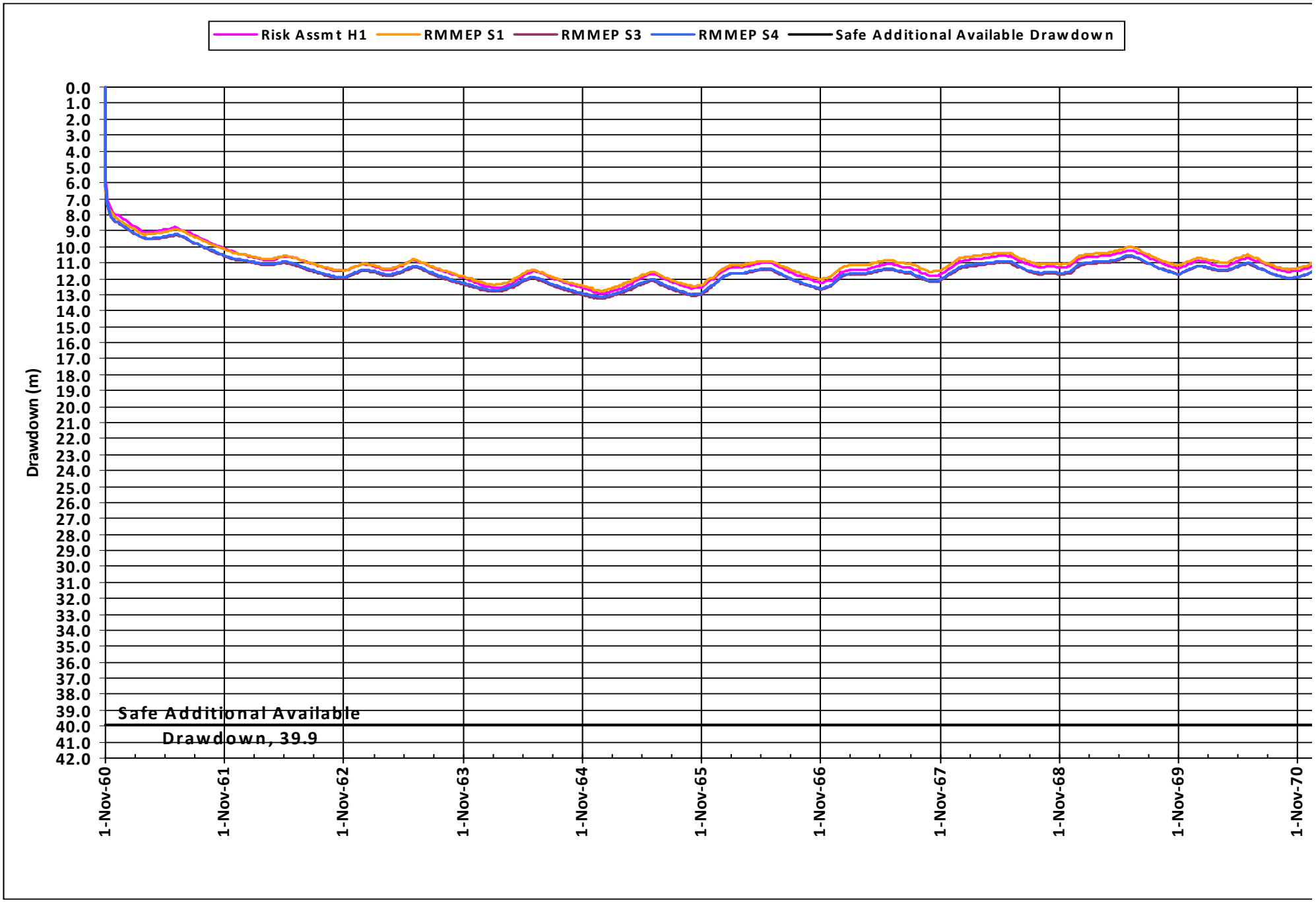

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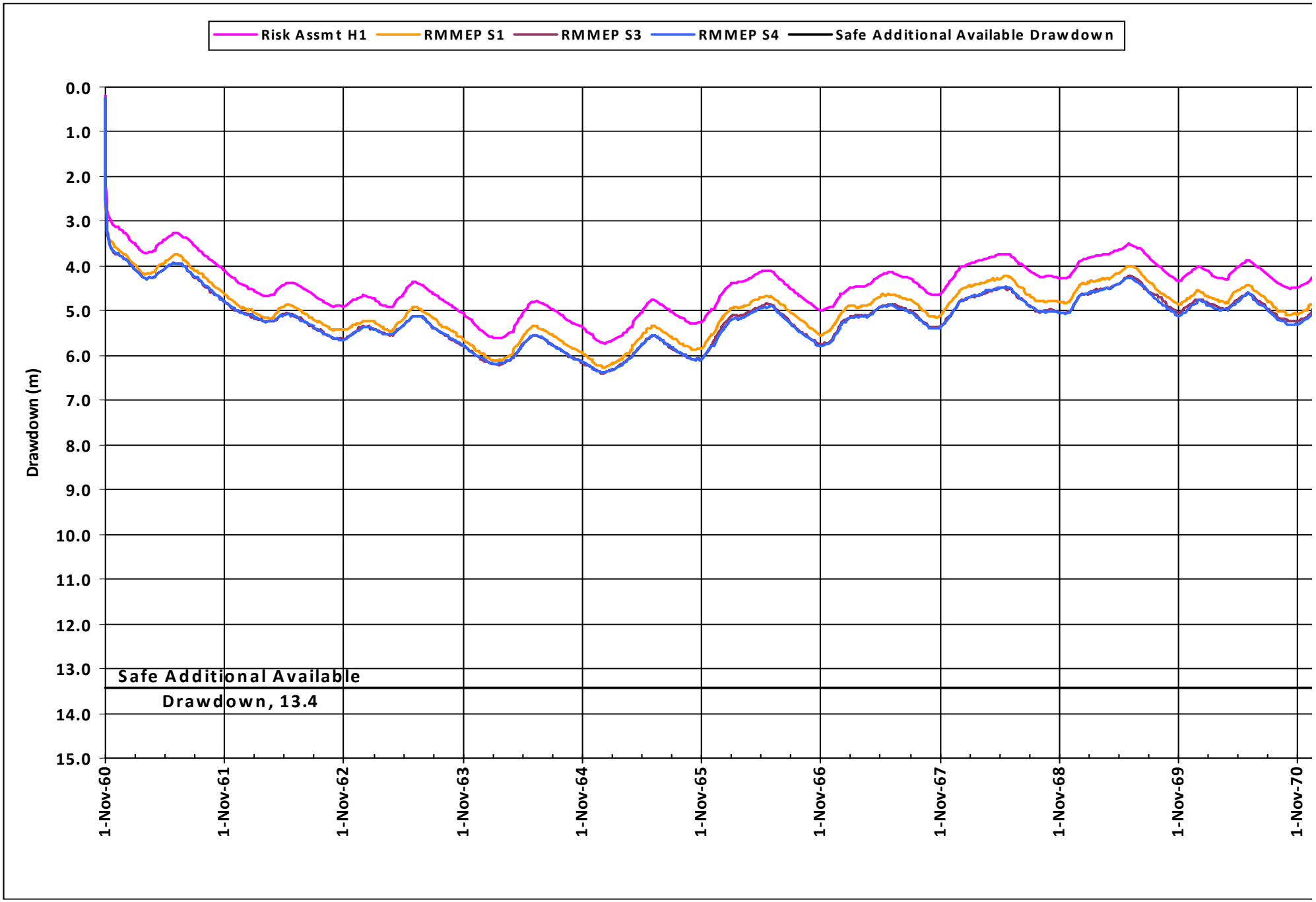

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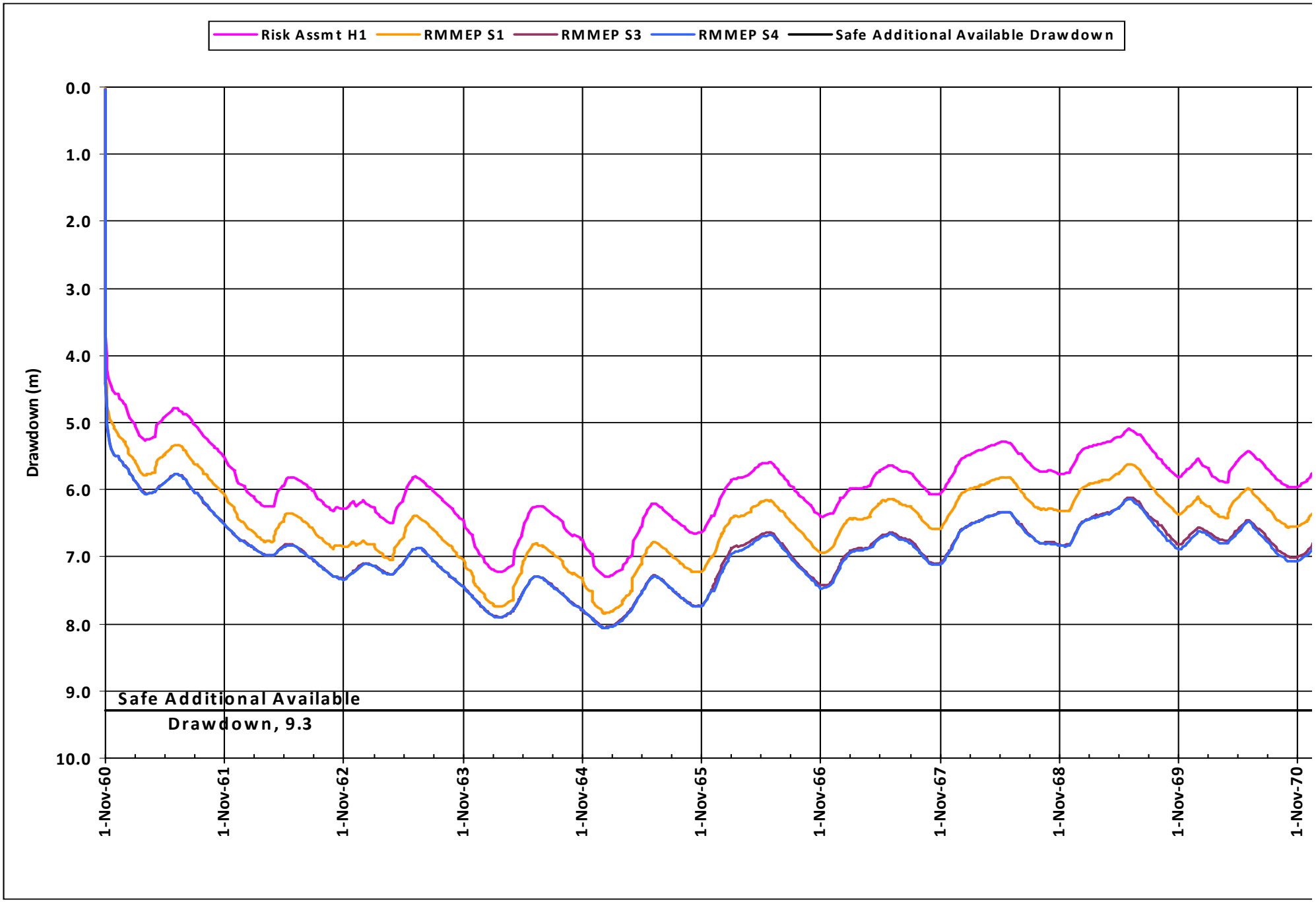
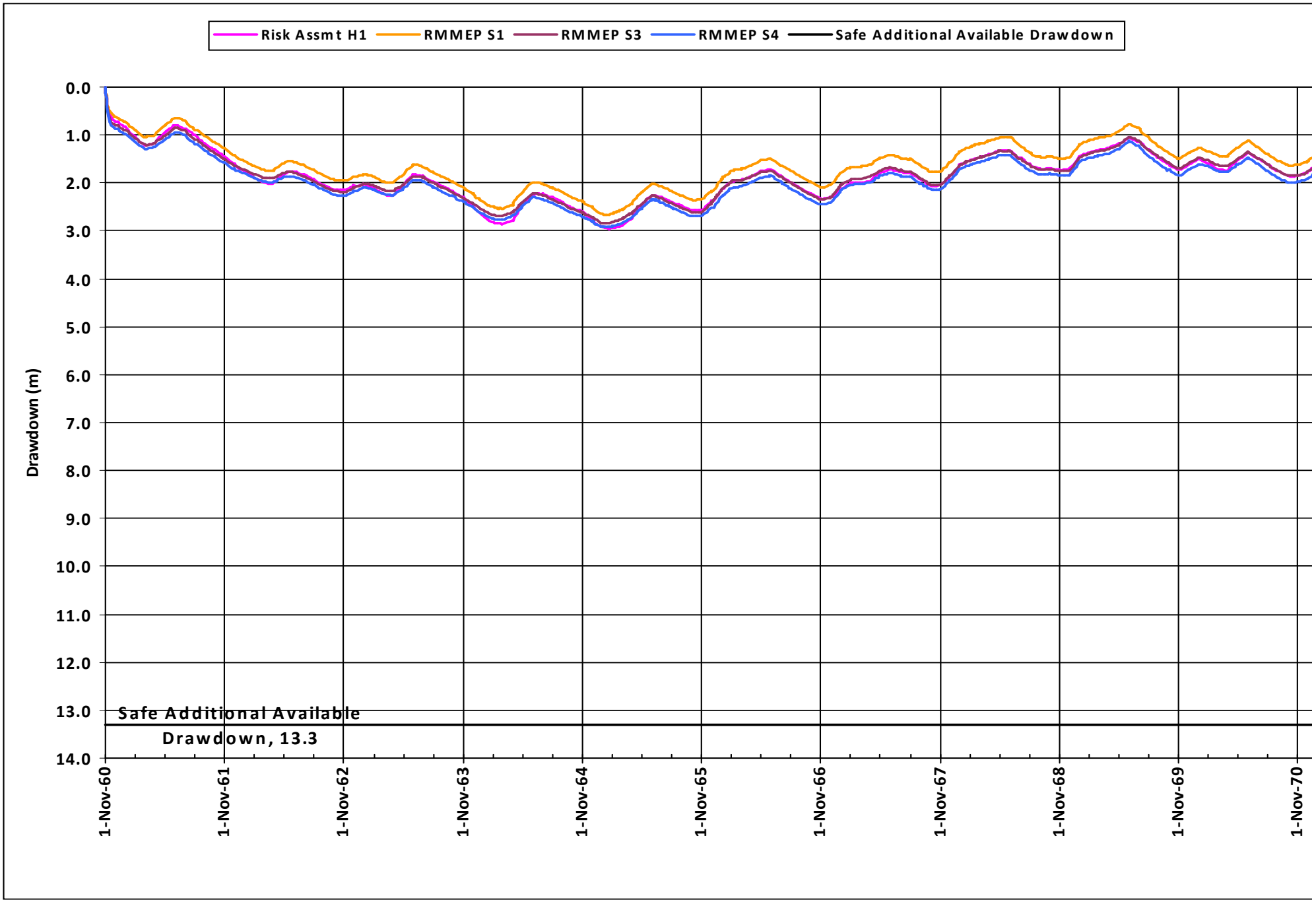


Well: CrossCreekWell



Well: HuntingtonEstatesWell