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Household demand forecast 2020

Southern Water Services

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Revision History

Version	Date	Description
1	24 December 2020	First issue
2	08 January 2021	Minor updates and clarifications, addition of detailed WRZ level results

Author	Reviewer 1	Reviewer 2	Reviewer 3	Approver
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Contents

1 Introduction

Ovarro DA Ltd ("Ovarro"), has been asked by Southern Water Services Ltd (SWS) to provide a proposal to produce a household demand forecast to support the Water Resources in the South East (WRSE) regional plan scheduled for publication in 2023 and the 2024 Water Resources Management Plan (WRMP24).

This document details the work undertaken. The following associated spreadsheets implementing the forecast have been provided to SWS:

- J1941_GD016_04_HH_demand_forecast_dWRMP24.xlsm
- J1941_GD020a_01_MicroComponent_model_2020_HA.xlsx through to J1941_GD020n_01_MicroComponent_model_2020_SW.xlsx

The following spreadsheets extracting results for WRSE reporting have also been provided:

- J1941_GD017_04_DLP input template for Demand Forecasts Outage Losses v4 SWS.xlsx
- J1941_GD018_04_Demand_Reduction_Template.xlsx

The intended audience for this document is Faisal Butt and colleagues at SWS in the area of water resources.

2 Overview of demand forecast

2.1 Requirements

The SWS region comprises 14 Water Resource Zones (WRZs) as follows:

- Hampshire Andover (HA)
- Hampshire Kingsclere (HK)
- Hampshire Winchester (HW)
- Hampshire Rural (HR)
- Hampshire Southampton East (HSE)
- Hampshire Southampton West (HSW)
- Isle of Wight (IOW)
- Sussex North (SN)
- Sussex Worthing (SW)
- Sussex Brighton (SB)
- Kent Medway East (KME)
- Kent Medway West (KMW)
- Kent Thanet (KT)
- Sussex Hastings (SH)

In order to support the regional plan and WRMP24, SWS are required to generate forecasts of annual Distribution Input (DI) for each of the following planning scenarios for each WRZ:

- Normal Year Annual Average (NYAA)
- Dry Year Annual Average (DYAA)
- Dry Year Critical Period (DYCP)
- Dry Year Minimum Deployable Output (DYMDO)
- Critical Period during a 1 in 200 years summer (1:200)
- Critical Period during a 1 in 500 years summer (1:500)

In order to support the regional plan, SWS are considering a number of different scenarios under which DI is being derived as follows:

- 6 growth scenarios
- 3 water efficiency scenarios
- 3 non-household demand scenarios
- 4 leakage scenarios
- 3 climate change scenarios

2.2 Outline approach

The demand forecast comprises a number of constituent parts detailed in the following sections:

- A micro-component forecast to determine the likely changes in demand as a result of appliance efficiency and societal trends
- Derivation of base year household demand for each planning scenario
- Derivation of impacts of climate change and water efficiency scenarios on household demand
- Incorporation of forecasts of other components of demand (non-household demand, leakage and minor components)
- Forecasting of DI under each of the scenarios being considered
- Population of WRMP forecasting tables

3 Micro-component forecast

The standard Ownership, Frequency and Volume (OFV) micro-component forecasting approach as previously used by SWS and described in UKWIR research[1] has been applied.

Detailed assumptions for the micro-component modelling are discussed in the following sections. These are based upon previous work carried out by SWS for WRMP19 with reference to published industry research, notably the 2018 Energy Saving Trust (EST) report on water labelling options[2].

[1] Customer Behaviour and Water Use, UKWIR Report ref: 12/CU/02/11

[2] Independent review of the costs and benefits of water labelling options in the UK: EXTENSION PROJECT: Technical Report - FINAL

Three categories of property type are considered within each of the measured and unmeasured customer bases as previously used by SWS. These are as follows:

- Group 1: Detached
- Group 2: Semi-detached or Terraced
- Group 3: Flat or Bungalow

The micro-component modelling is focused on deriving baseline changes in water consumption associated with appliance efficiency and societal trends. Details of the assumptions made are provided in Appendix A.

The modelling is implemented in the associated spreadsheets J1941_GD020a_01_MicroComponent_model_2020_HA.xlsx through to J1941_GD020n_01_MicroComponent_model_2020_SW.xlsx. Separate sheets for each WRZ use specific occupancy assumptions for each WRZ and adjust the frequency factors across the model to align the Per Capita Consumption (PCC) with the base year.

The results of the micro-component modelling are subsequently adjusted to align with the forecast PCC under the scenario being considered as discussed in section 8.1.

4 Base year demand by planning scenario

Consumption for 2019-20 is taken as the base year NYAA. The summer was warmer than average, but wetter than average[3] and hence there is no clear reason to adjust this in either direction.

The following peak factors are applied to NYAA household consumption as advised by SWS for deriving household consumption under other planning scenarios:

Table 1: Peak factors for each planning scenario

WRZ	NYAA	DYAA	DYCP	DYMDO	1:200	1:500
HA	1.00	1.06	1.36	1.02	1.33	1.33
HK	1.00	1.13	1.56	1.11	1.56	1.56
HW	1.00	1.14	1.35	1.11	1.39	1.39
HR	1.00	1.14	1.35	1.11	1.39	1.39
HSE	1.00	1.14	1.35	1.11	1.39	1.39
HSW	1.00	1.14	1.35	1.11	1.39	1.39
IOW	1.00	1.13	1.46	1.07	1.53	1.53
SN	1.00	1.07	1.34	1.05	1.35	1.35
SW	1.00	1.19	1.40	1.15	1.41	1.41
SB	1.00	1.00	1.19	0.98	1.22	1.22
KME	1.00	1.07	1.27	1.04	1.32	1.32
KMW	1.00	1.07	1.27	1.04	1.32	1.32

[3] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/summaries/uk_monthly_climate_summary_summer_2019.pdf

WRZ	NYAA	DYAA	DYCP	DYMDO	1:200	1:500
KT	1.00	1.09	1.41	1.03	1.34	1.34
SH	1.00	1.02	1.24	1.01	1.29	1.29

5 Scenario impacts

5.1 Climate change

As requested by SWS, 3 scenarios regarding climate change have been developed based upon UKWIR research[4]:

- No impact: No adjustment to consumption is made as a result of climate change
- Low impact: Based upon the 50th percentile results in the UKWIR analysis
- High impact: Based upon the 90th percentile results in the UKWIR analysis

The UKWIR report contains two models that forecast the climate change impact on household demand over a 28-year period for the different planning scenarios. Using the average of the two models gives the following climate change scenario impacts for a 28-year period:

Table 2: Climate change scenario impacts

	No climate change impact scenario	Low climate change impact scenario	High climate change impact scenario
NYAA impact after 28 years	0.00%	0.74%	1.45%
DYAA impact after 28 years	0.00%	0.74%	1.45%
DYCP impact after 28 years	0.00%	2.08%	4.09%
DYMDO impact after 28 years	0.00%	1.43%	2.79%

The percentage increase is applied linearly and extrapolated to the end of the forecast period.

5.2 Water efficiency

As requested by SWS, the water efficiency targets for AMP7 are assumed to be met under all scenarios in line with the draft Water Resources Planning Guidance (WRPG)[5], with PCC being reduced to a three-year average of 123.5 l/head/d. 4 scenarios regarding water efficiency post AMP7 have been developed:

- High water efficiency scenario: The average PCC across the SWS region is reduced to 100 l/head/d by 2040 and further reduced to 85 l/head/d by 2050; remaining constant thereafter

4 Impact of Climate Change on Water Demand, UKWIR report ref: 13/CL/04/12

5 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/903694/Water_resources_planning_guideline.pdf

- Medium water efficiency scenario: The average PCC across the SWS region is reduced to 100 litres/head/day by 2040 and remains constant thereafter
- Low water efficiency scenario: The average PCC across the SWS region is reduced to 110 litres/head/day by 2040 and further reduced to 100 litres/head/day by 2050; remaining constant thereafter
- Baseline scenario: Changes in PCC after AMP7 are driven directly by the micro-component analysis with no interventions by SWS to promote water efficiency

5.3 Growth

A total of 54 initial scenarios were developed for WRSE regarding population and property growth, with forecast numbers provided to SWS. The method statement published by WRSE on demand forecasting requires 6 growth scenarios to be incorporated into demand forecasts as detailed in Table 3. The ability to apply any of the growth modelling scenarios has been included in the spreadsheet.

Table 3: Growth modelling scenarios list

WRZ	Baseline scenario reference	Max growth scenario reference	Min growth scenario reference	Median growth scenario reference	Trend based scenario reference	Housing need scenario reference
HA	Housing-Plan-P	Completions-5Y-H	ONS-18-Low-L	ONS-14-P	Completions-5Y-H	Housing-Need-H
HK	Housing-Plan-P	Housing-Req-H	ONS-18-Low-L	ONS-18-Alt-H	Completions-5Y-H	Housing-Need-H
HW	Housing-Plan-P	Housing-Need-H	ONS-18-Low-L	GLA-18-15Y-P	Completions-5Y-H	Housing-Need-H
HR	Housing-Plan-P	Completions-5Y-H	ONS-18-Low-L	Completions-18Y-L	Completions-5Y-H	Housing-Need-H
HSE	Housing-Plan-P	Completions-5Y-H	ONS-18-Low-L	Completions-5Y-L	Completions-5Y-H	Housing-Need-H
HSW	Housing-Plan-P	Housing-Req-H	ONS-18-Low-L	GLA-18-5Y-P	Completions-5Y-H	Housing-Need-H
IOW	Housing-Plan-P	Housing-Need-H	ONS-18-Low-L	Housing-Req-P	Completions-5Y-H	Housing-Need-H
SN	Housing-Plan-P	Completions-5Y-H	ONS-18-Low-L	GLA-18-15Y-P	Completions-5Y-H	Housing-Need-H
SW	Housing-Plan-P	Housing-Need-H	ONS-18-Low-L	GLA-18-Central-P	Completions-5Y-H	Housing-Need-H
SB	Housing-Plan-P	Housing-Need-H	ONS-18-Low-L	GLA-18-15Y-P	Completions-5Y-H	Housing-Need-H
KME	Housing-Plan-P	Housing-Need-H	ONS-18-Low-L	Housing-Need-L	Completions-5Y-H	Housing-Need-H
KMW	Housing-Plan-P	Housing-Need-H	ONS-18-Low-L	Housing-Plan-L	Completions-5Y-H	Housing-Need-H
KT	Housing-Plan-P	Housing-Req-H	ONS-18-Low-L	GLA-18-15Y-P	Completions-5Y-H	Housing-Need-H
SH	Housing-Plan-P	ONS-14-H	ONS-18-Low-L	ONS-18-High-P	Completions-5Y-H	Housing-Need-H

The growth scenarios were provided by SWS.

6 Other components of demand

6.1 Non-household demand

Assumed demand under each of the 3 non-household scenarios being considered has been provided by SWS.

No uplift for alternative planning scenarios has been applied to non-household demand. This is consistent with the approach used by SWS in developing demand forecasts with the previous WRMPs.

No adjustment in respect of climate change has been applied to non-household demand.

No adjustment in respect of water efficiency has been applied to non-household demand.

6.2 Leakage

Assumed leakage levels under each of the 4 leakage scenarios being considered has been provided by SWS.

No uplift for alternative planning scenarios has been applied to leakage.

No adjustment in respect of climate change has been applied to leakage.

No adjustment in respect of water efficiency has been applied to leakage.

This is consistent with the approach used by SWS in developing demand forecasts with the previous WRMPs.

6.3 Minor components

The assumptions for the minor components are based upon the 2019-20 water balance:

- Water Taken Illegally Unbilled (WTIU)
- Water Taken Legally Unbilled (WTLU)
- Distribution System Operational Use (DSOU)

No adjustments to any of these values has been applied in respect of different scenarios. This is consistent with the approach used by SWS in developing demand forecasts with the previous WRMPs.

7 Forecasting future Distribution Input

7.1 Properties and population

The total household population and property counts are taken from the selected growth scenario.

All new households are assumed to be measured with meters installed externally.

A small proportion of previously unmeasured households are assumed to switch annually, despite the completion of the universal metering programme. These properties are assumed to be metered internally, on the basis that if an external meter could be readily installed, they would have been included as part of the universal metering programme. However, it is assumed that there will always be a small number of properties that cannot be metered. The threshold is set at 95% meter penetration and above this no further properties are assumed to switch to metered billing.

It is assumed that the switching households will have the same occupancy as the average occupancy of the unmeasured customer base.

The total measured household population is calculated as the total population minus the remaining unmeasured household population once switching properties are accounted for.

7.2 Household consumption

It is assumed that switching to measured status will lead to a 15% reduction in PCC - in line with the reduction seen upon implementation of the universal metering programme which was reviewed by Southampton University[6] - regardless of the PCC prior to switching. This amount is subtracted from the unmeasured consumption from the previous year and added to the measured consumption.

It is assumed that new properties will be built to defined PCC standards. The PCC figure for new builds is held constant over the AMP7 period and assumed to decline over successive AMP periods until it reaches 90 litres/head/day. If the defined PCC standard for a given year is higher than the PCC of the existing housing stock, then the PCC of existing housing stock is applied to new builds. Occupancy is assumed to be the same as the average for measured properties. The total consumption associated with these properties is added to the measured consumption total.

The results of the micro-component analysis are used to calculate proportional annual changes in consumption for unmeasured and measured households associated with appliance efficiency and societal trends that are not linked to any water efficiency activity. This adjustment is applied to the unmeasured and measured consumption from the previous year.

A percentage uplift for climate change is applied to the resulting consumption based upon the scenario being applied.

A reduction due to water efficiency is then applied to align the overall PCC with the scenario being considered. If the overall PCC is already below that specified for the given water efficiency scenario, no adjustment is made. Note that the water efficiency scenario applies irrespective of the climate change scenario chosen; for example, if a climate change scenario is applied then additional water efficiency is assumed to take place to meet the selected water efficiency scenario.

7.3 Non-household consumption

The non-household consumption in each year is taken directly from the chosen scenario.

7.4 Leakage

The leakage in each year is taken directly from the chosen scenario, including the disaggregation into distribution losses and supply pipe leakage. The supply pipe leakage is apportioned between the different property types based upon the property counts and relative levels of supply pipe leakage assumed in the base year.

7.5 Minor components

WTIU is estimated by assuming 35% of void households are occupied and consuming the same as an average unmeasured household. This is consistent with the assumption made by SWS in its annual water balance calculations.

Other minor components are assumed to remain unchanged.

7.6 Total Distribution Input

The total DI for the NYAA planning scenario is calculated as the total of the above components.

[6] https://www.southampton.ac.uk/economics/research/discussion_papers/area/aplied_economics/1801-the-effects-of-the-universal-metering-programme-on-water-consumption.page

The total DI for each of the other planning scenarios is calculated by applying the relevant uplift factors to household demand.

8 Outputs

8.1 Comparison sheets

A macro within the spreadsheet may be used to population comparison sheets that list DI, overall PCC, measured PCC and unmeasured PCC at company level for each planning scenario under all combinations of the other scenarios.

8.2 Populating planning tables

The population, property and demand estimates are used to populate the relevant planning tables for the chosen growth, water efficiency, leakage, non-household and climate change scenarios for each WRZ and planning scenario.

The micro-component estimates for each year are scaled to align with the unmeasured and measured consumption for the NYAA planning scenario. Uplifts for other planning scenarios are assigned 75% to garden watering and 25% to personal washing.

Results from specific combinations of scenarios as required for WRSE reporting have been extracted into the template spreadsheets provided by SWS.

8.3 Results

Taking account of all growth, water efficiency, non-household demand, leakage and climate change scenarios results in 864 DI scenarios for each WRZ for each planning scenario. The maximum, minimum, median, 25th percentile and 50th percentile DI scenarios for each of the four planning scenarios at the company level are shown in Figures 1-4. The associated PCC forecasts are shown in Figures 5-8. Forecasts at the WRZ level can be found in Appendix B.

Figure 1: Range of NYAA Distribution Input results

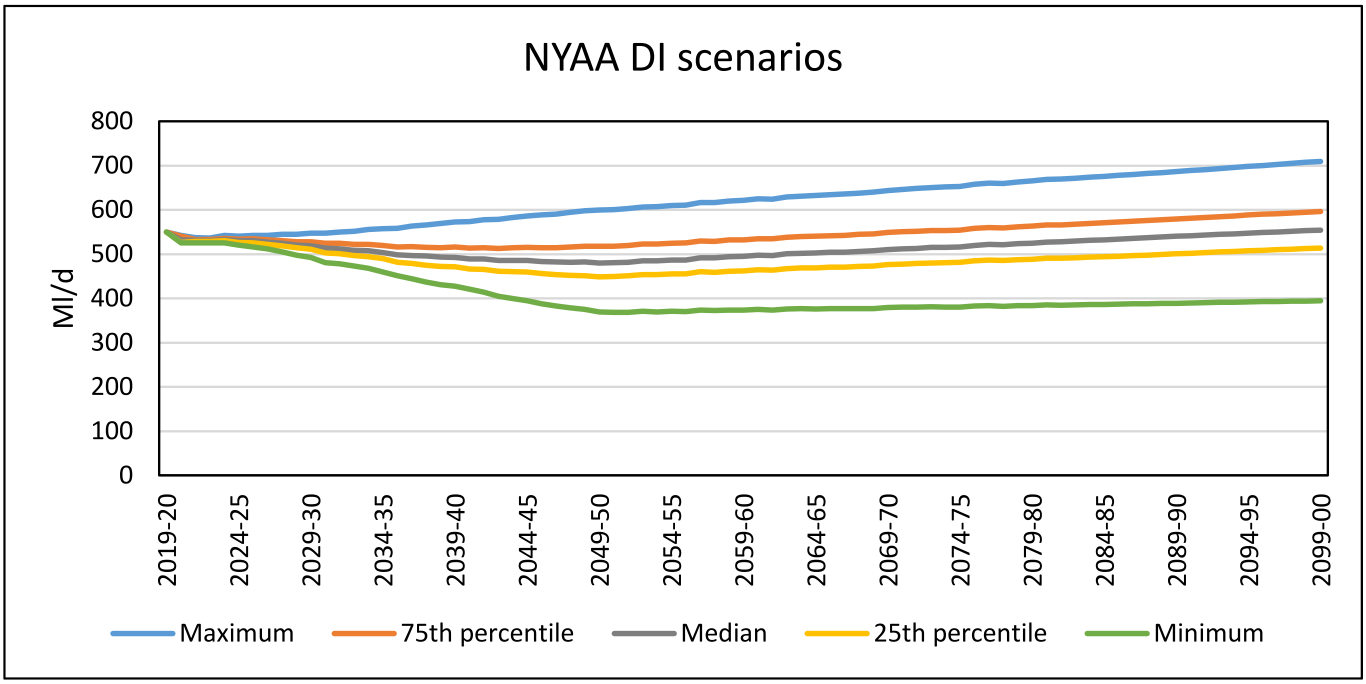


Figure 2: Range of DYAA Distribution Input results

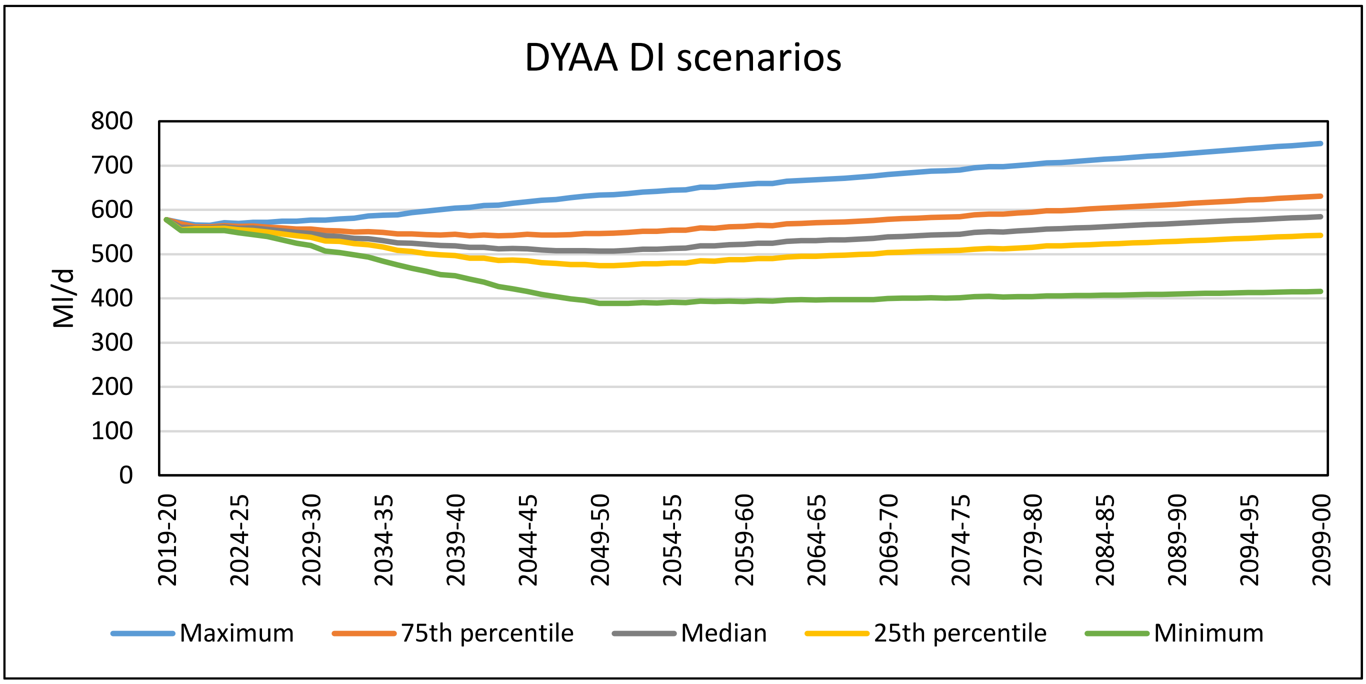


Figure 3: Range of DYCP Distribution Input results

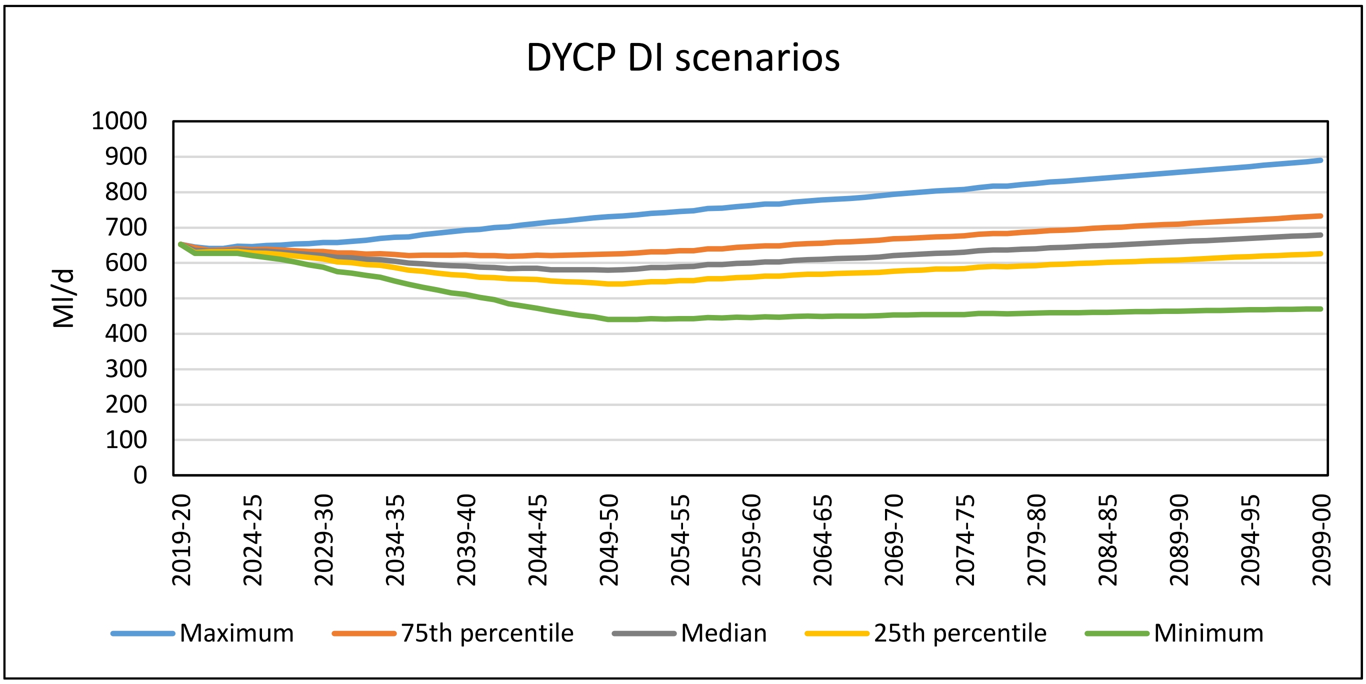


Figure 4: Range of DYMDO Distribution Input results

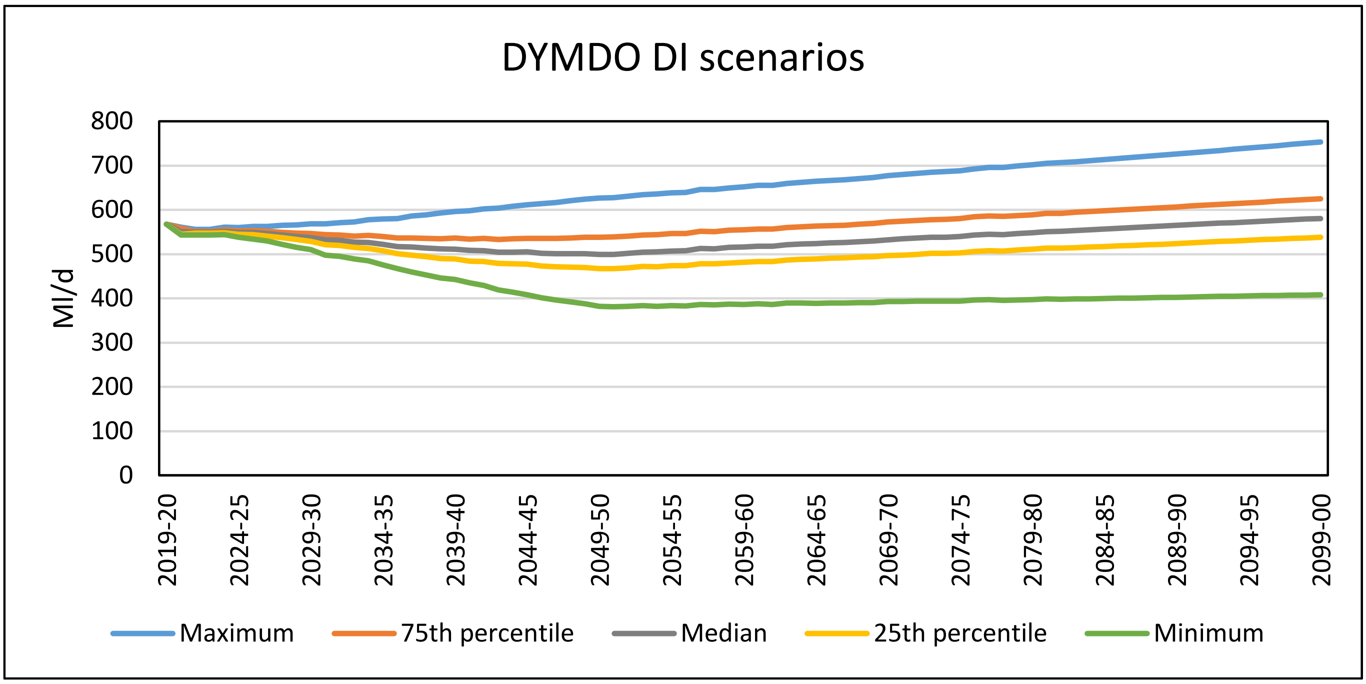


Figure 5: Range of NYAA PCC results

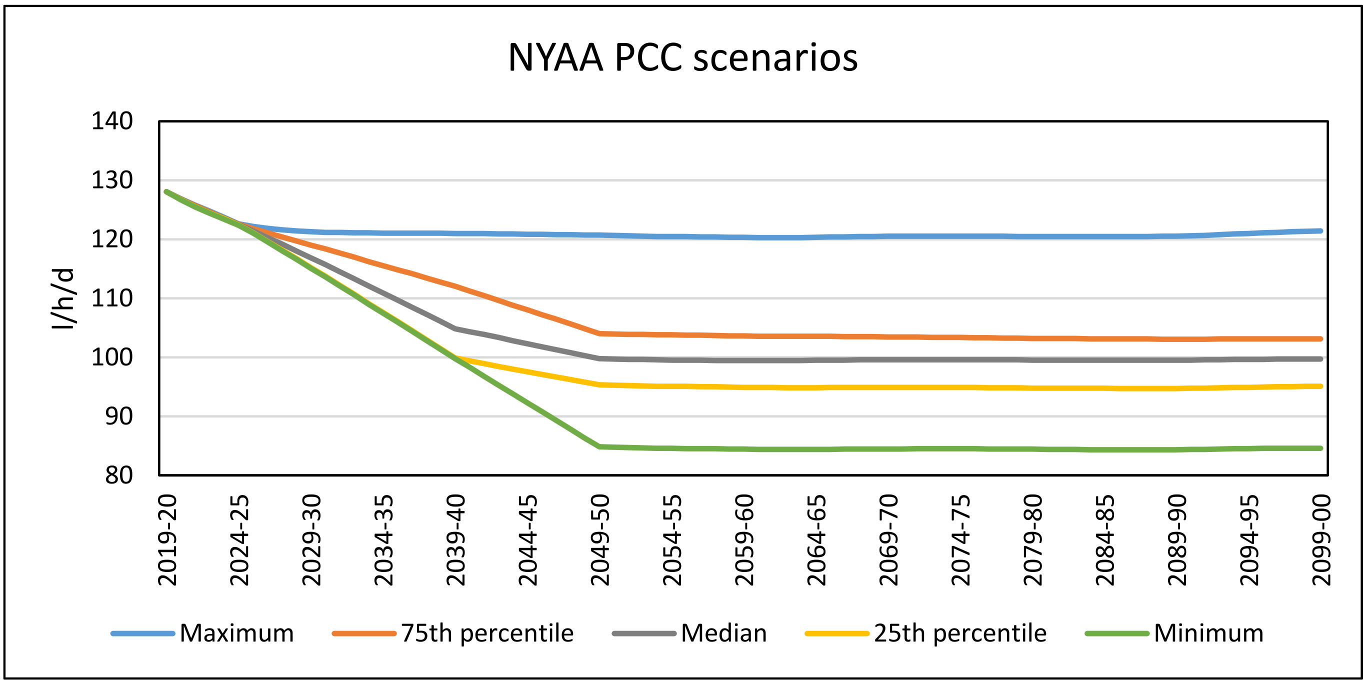


Figure 6: Range of DYAA PCC results

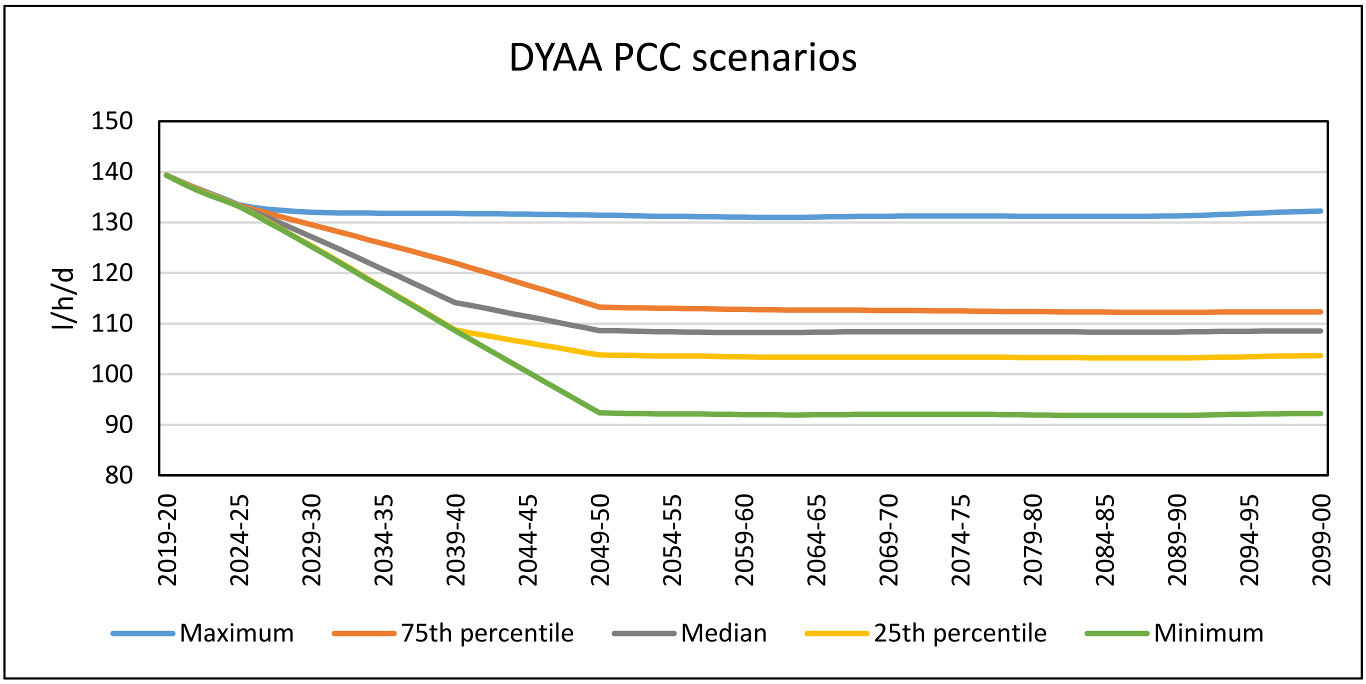


Figure 7: Range of DYCP PCC results

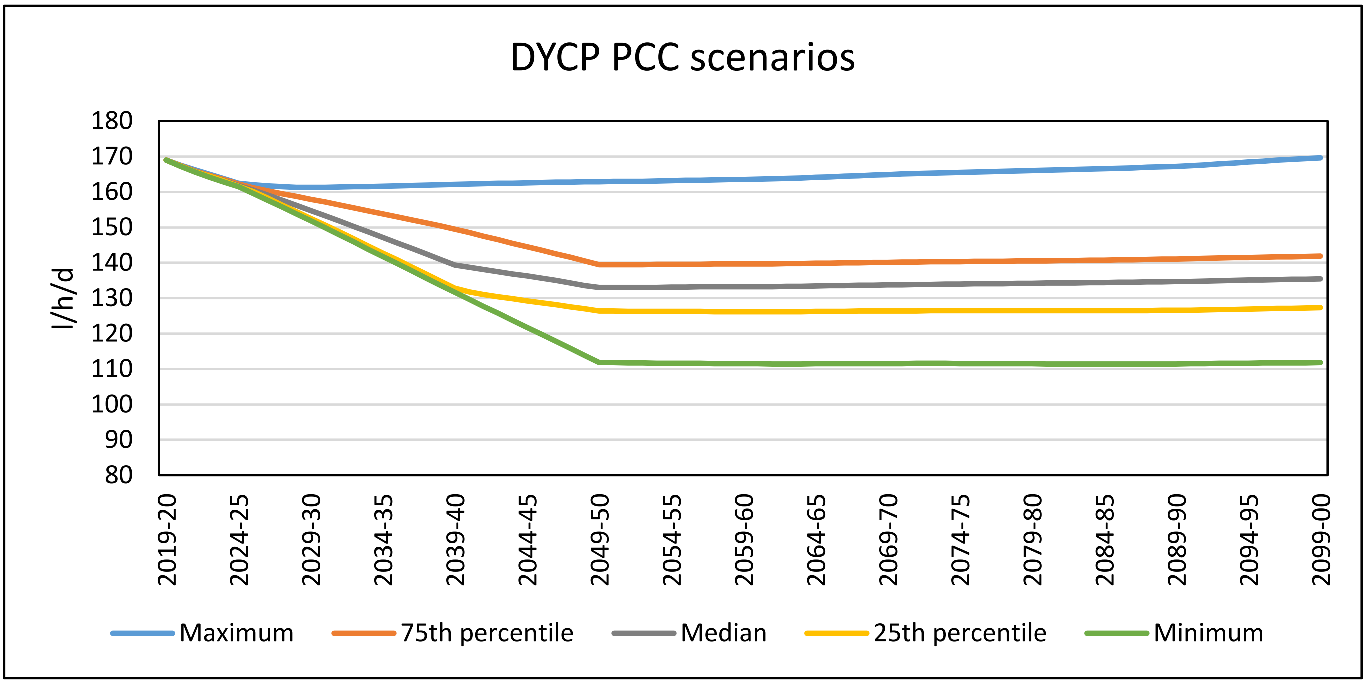
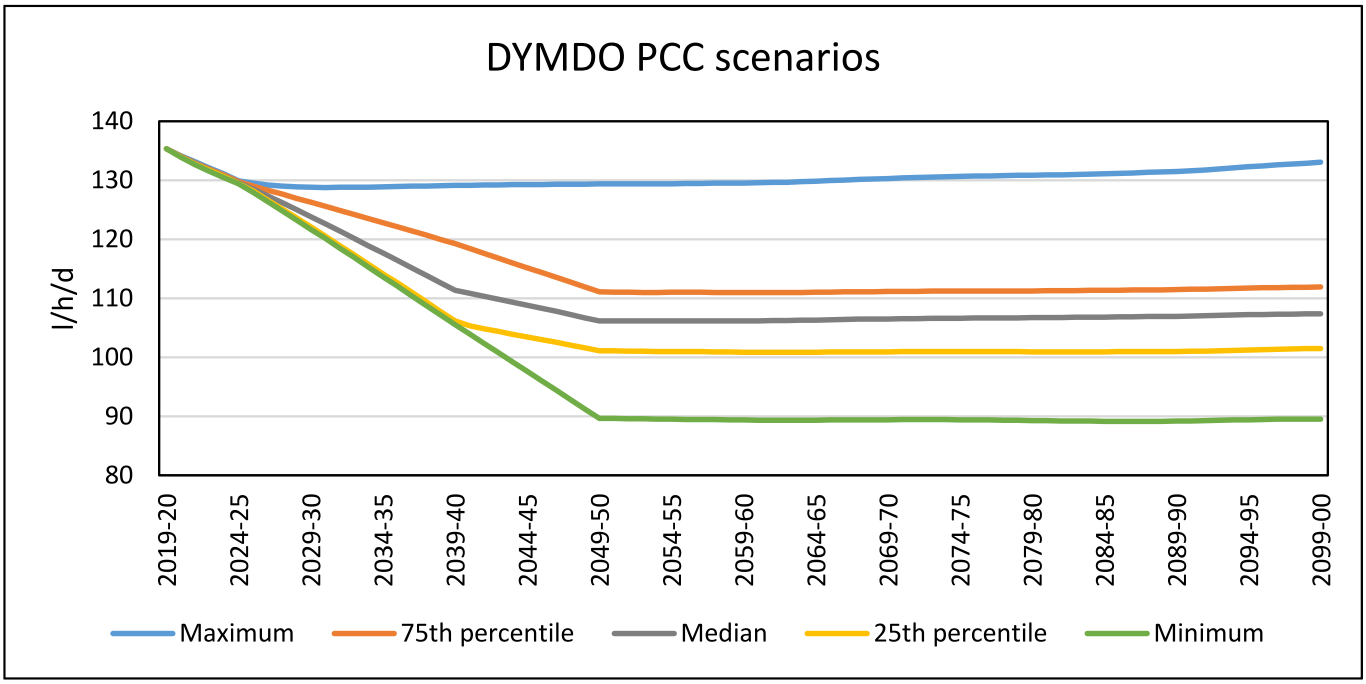


Figure 8: Range of DYMDO PCC results



9 Endpoint

It is expected that the outputs of the analysis will be incorporated within the WRSE and WRMP24 submissions.

Appendices

A. Detailed micro-component analysis

The following sections discuss the detailed assumptions made in the micro-component analysis.

A.1. Occupancy

Occupancy assumptions are required to convert several of the micro-components from the household level to a per-capita basis.

The following occupancies have been assumed in the micro-component analysis, based upon survey data provided by SWS:

Table 4: Occupancy assumptions

WRZ	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
HA	2.80	2.74	1.71	2.80	2.74	1.71
HK	3.21	2.90	1.62	3.21	2.90	1.62
HR	2.61	2.49	1.73	2.61	2.49	1.73
HSE	2.97	2.72	1.68	2.97	2.72	1.68
HSW	2.41	2.37	1.67	2.41	2.37	1.67
HW	2.79	2.68	1.76	2.79	2.68	1.76
IOW	2.70	2.68	2.05	2.70	2.68	2.05
KME	2.97	2.85	1.71	2.97	2.85	1.71
KMW	2.86	2.95	1.86	2.86	2.95	1.86
KT	2.77	2.68	1.86	2.77	2.68	1.86
SB	2.98	2.71	1.83	2.98	2.71	1.83
SH	2.49	2.36	1.75	2.49	2.36	1.75
SN	2.48	2.81	1.71	2.48	2.81	1.71
SW	2.62	2.76	1.80	2.62	2.76	1.80

The survey data provided did not include any customers identified as being charged on an unmeasured basis. Following the completion of the universal metering programme, occupancy levels for unmeasured and measured households are very similar as seen in the annual returns data for 2019/20 provided by SWS. The same occupancy assumptions have therefore been used as for measured customers.

A.2. Toilet flushing

A.2.1. Ownership

All households are assumed to own at least one toilet. Multiple toilet ownership is not assumed to impact on frequency of use.

A.2.2. Frequency

A flushing frequency in the range 4.8-5.6 flushes per person per day has previously been used by SWS. This is relatively consistent with the EST report that assumes 4.71 flushes per person per day in household consumption modelling and suggests total correct toilet use of 1 large flush per day and 5.2 small flushes per day based upon medical research. The total number of flushes is assumed to be an overestimate for households as it will include toilet use in non-households.

For simplicity, in the context of limited evidence to support variation, a constant value of 5 flushes per day has been used. It is reasonable to assume that there is no difference in flushing frequency between measured and unmeasured properties.

It is assumed that there will be no change in flushing frequency across the different planning scenarios.

There are some references in the literature to increased frequency of toilet use in the future due to an ageing population and trends towards working from home. Previous UKWIR research[7] suggested that the evidence is inconclusive and may also be counterbalanced by increased environmental awareness and consequent reduced flushing. It is therefore assumed that there will be no change in flushing frequency in the future.

A.2.3. Volume

Since 2001, a maximum flush volume of 6 litres has been mandated by legislation. Between 1993 and 2001, the maximum flush volume was 7.5 litres. Prior to that flush volumes were higher and could be up to 13 litres in the 1960s. However, these volumes assumed that the toilets work correctly with no need for double flushing.

SWS previously considered 3 generations of toilets:

- Generation 1: 12 litres/ flush
- Generation 2: 9 litres/ flush
- Generation 3: 6 litres/ flush

Given the limitations on evidence regarding ownership, it has not been considered necessary to create a specific generation to handle the 1993-2001 period. The generations have been retained with the following assumed proportions, based upon the previous SWS analysis:

Table 5: WC Ownership by Generation

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Generation 1 (% devices)	16%	24%	21%	15%	20%	19%

7 Customer Behaviour and Water Use, UKWIR Report ref: 12/CU/02/11

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Generation 2 (% devices)	36%	22%	27%	34%	26%	26%
Generation 3 (% devices)	48%	54%	52%	51%	54%	55%

The EST report quotes an assumed toilet lifetime of 15 years, which implies an overall replacement rate of 6.7%. This is considered relatively consistent with the existing SWS assumptions of 5% on Generation 2 toilets and 15% on older Generation 1 toilets. The SWS assumptions have been retained on the basis that replacement of older toilets is more likely than replacement of newer toilets.

A.3. Personal washing

A.3.1. Ownership

It is assumed that all households have some form of shower available, with bath attachments and electric showers included within the scope of standard showers. Power showers with an internal pump to increase flow rate are considered separately.

The assumed split between standard showers and power showers based on the previous SWS analysis is as follows:

Table 6: Shower Ownership by Type

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Standard showers (% devices)	56%	67%	72%	50%	64%	66%
Power showers (% devices)	44%	33%	28%	50%	36%	34%

It is assumed that the following proportions of properties have a bath that is routinely used based upon the previous SWS analysis (baths that are never or rarely used are excluded):

Table 7: Bath Ownership

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Bath ownership (in use devices)	54%	55%	57%	55%	52%	44%

It is assumed that trends in reduced bath use will continue over the period, even in the absence of specific water efficiency activity. A 15% reduction over 50 years has been assumed based upon the previous SWS analysis.

The split between power showers and standard showers has been assumed to remain unchanged.

A.3.2. Frequency

The assumed frequency of baths and showers, based upon the previous SWS analysis, is as follows:

Table 8: Personal washing frequency by Type

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Showers (per week)	5.78	5.64	5.95	5.08	4.95	4.61
Baths (per week; if applicable)	2.28	2.35	2.58	1.29	1.10	0.99
Overall total accounting for bath ownership	7.03	6.98	7.39	5.79	5.52	5.04

The higher values noted in the recent EST report are noted, but the overall frequencies of approximately one bath or shower per day in unmeasured properties and slightly less in measured properties are considered reasonable.

It is assumed that the frequencies for both baths and showers will remain unchanged in that absence of specific activity to promote water-efficiency.

A.3.3. Volume

The bath volume of 75 litres previously used by SWS has been retained. This is reasonably consistent with the 72.2 litres used in the EST report.

The flow rates for normal and power showers are retained from those previously used by SWS as 6 l/min and 12 l/min, respectively.

The current durations of showers previously assumed by SWS have been retained. These are 8 minutes for unmeasured households (irrespective of shower type), 7 minutes for measured households using a standard shower and 6.5 minutes for measured households using a power shower. Unlike in the previous analysis, these have been assumed to remain constant in the absence of specific activity to promote water efficiency.

A.4. Clothes washing

A.4.1. Ownership

Ownership of washing machines is very high and customer surveys indicate that a significant number of households do some washing by hand. Overall assumed ownership of washing machines, based upon the previous SWS analysis, is as follows:

Table 9: Clothes washing Ownership

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Washing machine ownership (% properties)	97%	95%	90%	98%	97%	94%
Routine hand-washing (% properties)	32%	28%	26%	33%	31%	26%

The lower washing machine ownership assumption of 0.82 quoted in the EST research is noted but considered infeasible given that the results of surveys previously carried out by SWS and others[8] consistently report ownership of above 90%.

Given the already high ownership figures, overall ownership of washing machines is assumed to remain unchanged over time.

A.4.2. Frequency

The following frequencies of washing machine and hand clothes-washing use are assumed, based upon the previous SWS analysis:

Table 10: Clothes washing frequency

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Washing machine (per household, per week; if applicable)	5.69	5.73	5.88	5.26	4.91	4.26
Hand clothes washing (per household, per week; if applicable)	1.31	1.34	1.42	1.09	1.05	1.06

The EST analysis appears to use the frequency of 220 uses per year (4.22 per week) quoted in Building Regulations Part G. Given that this is based upon a generic specification rather than a specific study, it is not considered a reason to adjust the washing machine frequency assumptions to better align with this.

A.4.3. Volume

We have retained the four generations of washing machines previously used by SWS:

- Generation 1: 100 litres/ wash

8 https://www.statista.com/statistics/289017/washing-machine-ownership-in-the-uk/

- Generation 2: 80 litres/ wash
- Generation 3: 55 litres/ wash
- Generation 4: 50 litres/ wash

The EST report notes that water-efficient washing machines with volumes of 8.33 l/kg or even 6.70 l/kg (42 l or 34 l for a typical 5 kg load) exist. However, 50 litres/ wash is considered reasonable for a modern washing machine in the absence of specific activity to drive water efficiency of devices and hence it has not been considered appropriate to modify the assumed volume of a modern washing machine as a result.

The generations have been retained with the following assumed proportions, based upon the previous SWS analysis:

Table 11: Washing machine Ownership by Generation

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Generation 1 (% devices)	9%	7%	4%	10%	12%	12%
Generation 2 (% devices)	20%	19%	20%	20%	21%	20%
Generation 3 (% devices)	33%	41%	36%	39%	34%	37%
Generation 4 (% devices)	38%	33%	40%	31%	33%	31%

The EST report does not appear to quote an assumed washing machine lifetime. Previous consumer research indicates an expected lifetime of typically 6-7 years[9]. The existing SWS assumptions (8% for Generation 3, 10% for Generation 2 and 20% for Generation 1) are considered reasonable in this context and have been retained.

It is assumed that when a washing machine is replaced, a Generation 4 washing machine is installed.

Volume used in hand washing of clothes is retained at 30 litres/wash. This is equivalent to a typical basin tap flow rate of 6 l/min running for 5 minutes.

A.5. Dishwashing

A.5.1. Ownership

Overall assumed ownership of dishwashers, based upon the previous SWS analysis, is as follows:

[9] www.wrap.org.uk/sites/files/wrap/WRAP%20longer%20product%20lifetimes.pdf

Table 12: Dishwasher Ownership

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Dishwasher ownership (% properties)	77%	47%	23%	75%	50%	31%

The ownership assumption of 0.41 quoted in the EST research is noted but the previous SWS analysis is considered to be more representative of the region.

As in the previous SWS analysis, all households are assumed to do some dishwashing by hand, irrespective of whether or not they own a dishwasher.

It is assumed that trends in increased dishwasher ownership will continue over the period, even in the absence of specific water efficiency activity. A 50% increase over 50 years has been assumed based upon the previous SWS analysis. A maximum ownership of 90% in any one category has been assumed.

A.5.2. Frequency

The following frequency of dish washing is assumed, based upon the previous SWS analysis:

Table 13: Dishwashing frequency

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Dishwasher use (per household, per week; if applicable)	5.87	5.99	6.31	5.56	5.14	4.51
Hand dish-washing (per household, per week; owning dishwasher)	1.40	1.40	1.40	1.40	1.40	1.40
Hand dish-washing (per household, per week; no dishwasher)	7.00	7.00	7.00	7.00	7.00	7.00

The EST research is based upon the Building Regulations water efficiency calculator which quotes an assumption of 280 uses per year (5.4 uses per week), which is relatively consistent with the previous SWS assumptions.

Daily dishwashing by hand in the absence of a dishwasher is considered reasonable, as is the assumption that hand dishwashing is 20% of this where a dishwasher exists.

Frequencies are assumed to remain unchanged in the absence of specific water-efficiency activity.

A.5.3. Volume

We have retained the four generations of dishwashers previously used by SWS:

- Generation 1: 55 litres/ use
- Generation 2: 40 litres/ use
- Generation 3: 15 litres/ use
- Generation 4: 11 litres/ use

The EST report notes that water-efficient dishwashers with volumes of 0.78 l/place-setting or even 0.5 l/place-setting (9.4 l or 6 l for a typical 12 place-setting load respectively) exist. However, 11 litres/ use is considered reasonable for a modern washing machine in the absence of specific activity to drive water efficiency of devices and hence it has not been considered appropriate to modify the assumed volume of a modern washing machine as a result.

The generations have been retained with the following assumed proportions, based upon the previous SWS analysis:

Table 14: Dishwasher Ownership by Generation

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Generation 1 (% devices)	8%	8%	10%	12%	8%	14%
Generation 2 (% devices)	26%	22%	18%	23%	24%	21%
Generation 3 (% devices)	38%	36%	33%	34%	32%	28%
Generation 4 (% devices)	28%	34%	39%	31%	36%	37%

The EST report does not appear to quote an assumed dishwasher lifetime, but surveys of consumers and manufacturers indicate an expected lifespan of approximately 10 years[10]. The previous SWS assumptions for replacement rates (12% for Generation 3, 6% for Generation 2 and 3% for Generation 1) are considered too low in this context. The following higher replacement rates have been used instead:

- Generation 1: 20%
- Generation 2: 10%
- Generation 3: 8%

It is assumed that when a dishwasher is replaced, a Generation 4 dishwasher is installed.

The previous SWS volume estimates for dishwashing by hand were 10 l for measured households and 12.5 l for unmeasured households. These look low in comparison to research suggesting that manual dishwashing by UK consumers of a full dishwasher load typically uses 49 litres[11]. It is considered reasonable to assume that measured customers would use less Volume estimates of 45 l and 50 l for measured and unmeasured customers have therefore been used instead.

[10] https://www.consumerreports.org/dishwashers/how-to-make-your-dishwasher-last-longer/

[11] Berkholz, Petra & Stamminger, Rainer & Wnuk, Gabi & Owens, Jeremy & Bernarde, Simone. (2010). Manual dishwashing habits: An empirical analysis of UK consumers. International Journal of Consumer Studies. 34. 235 - 242. 10.1111/j.1470-6431.2009.00840.x.

A.6. Miscellaneous internal use

The previous SWS analysis assumed miscellaneous internal use ranging from 2.8-7.5 litres/head/day.

For this analysis, miscellaneous internal use has been assumed at 5 litres/head/day given the limited evidence to support the variation assumed for WRMP19.

A.7. External use

A.7.1. Ownership

The previous SWS analysis referred four modes of garden watering: hosepipes, sprinklers, watering cans and 'other'. Ownership for the 'other' category was reported as 0%, so it has not been used in this analysis. For the identified devices, the following ownership has been assumed, based upon the previous SWS analysis:

Table 15: Garden watering device Ownership

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Hosepipe (% properties)	28%	28%	33%	27%	23%	14%
Sprinkler (% properties)	6%	4%	1%	5%	2%	1%
Watering can (% properties)	30%	32%	31%	32%	34%	39%

A.7.2. Frequency

The following frequencies of use, averaged throughout the entire year, have been assumed based upon the previous SWS analysis:

Table 16: Garden watering device Frequency

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Hosepipe (per property, per week; where applicable)	0.85	0.82	0.68	0.57	0.38	0.25
Sprinkler (per property, per week; where applicable)	0.85	0.82	0.68	0.57	0.38	0.25

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Watering can (per property, per week; where applicable)	0.85	0.82	0.68	0.57	0.38	0.25

A.7.3. Volume

The volumes associated with hosepipes and sprinklers are calculated as the product of flow rate and duration. The previously assumed flow rates of 12 litres/minute for hosepipe use and 6 litres/minute for sprinkler use have been retained.

The EST analysis quotes values of 11 litres per use and 7179 litres per year for hose attachments. It is assumed that this actually means a flow rate of 11 l/min with an implied 10.8 hour total duration of use throughout the year.

The following durations have been assumed, based upon the previous SWS analysis:

Table 17: Garden watering device durations

	Unmeasured Group 1	Unmeasured Group 2	Unmeasured Group 3	Measured Group 1	Measured Group 2	Measured Group 3
Hosepipe use duration (minutes)	44	33	32	34	26	24
Sprinkler use duration (minutes)	45	45	45	45	45	45

The volume of water used by watering cans has been retained as 5 litres.

A.7.4. Miscellaneous external use

Miscellaneous outdoor use (in respect of car washing, cleaning garden furniture, etc) of 1 litre/head/day has been assumed in addition to the devices calculated on the OFV basis. This is similar to the assumption made in the previous analysis.

B. Detailed WRZ level results

B.1. Hampshire Andover (HA)

Figure 9: Range of NYAA Distribution Input results

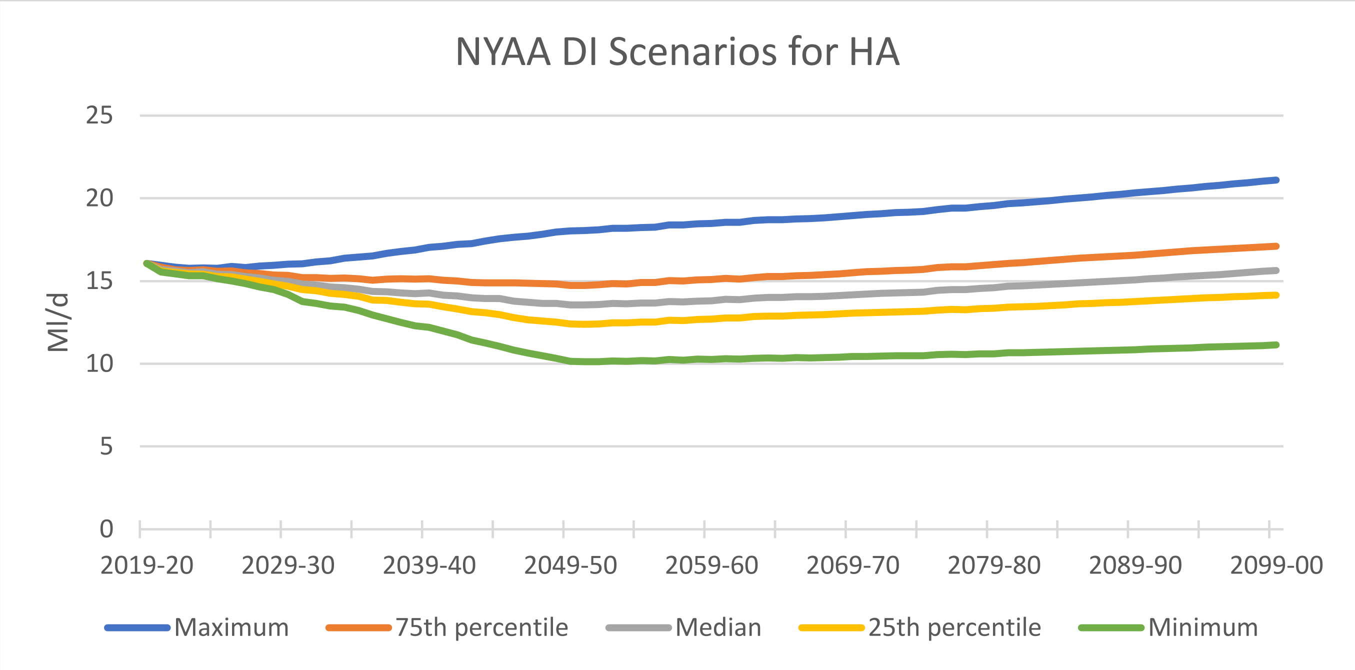


Figure 10: Range of DYAA Distribution Input results

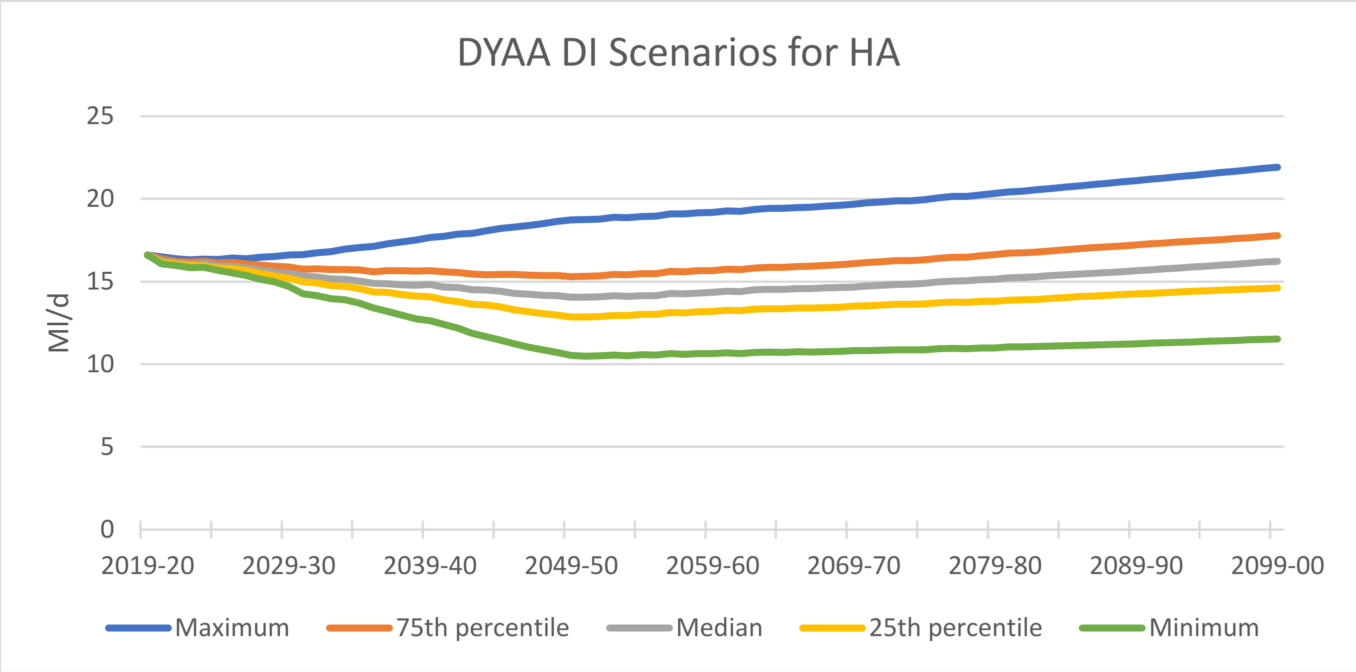


Figure 11: Range of DYCP Distribution Input results

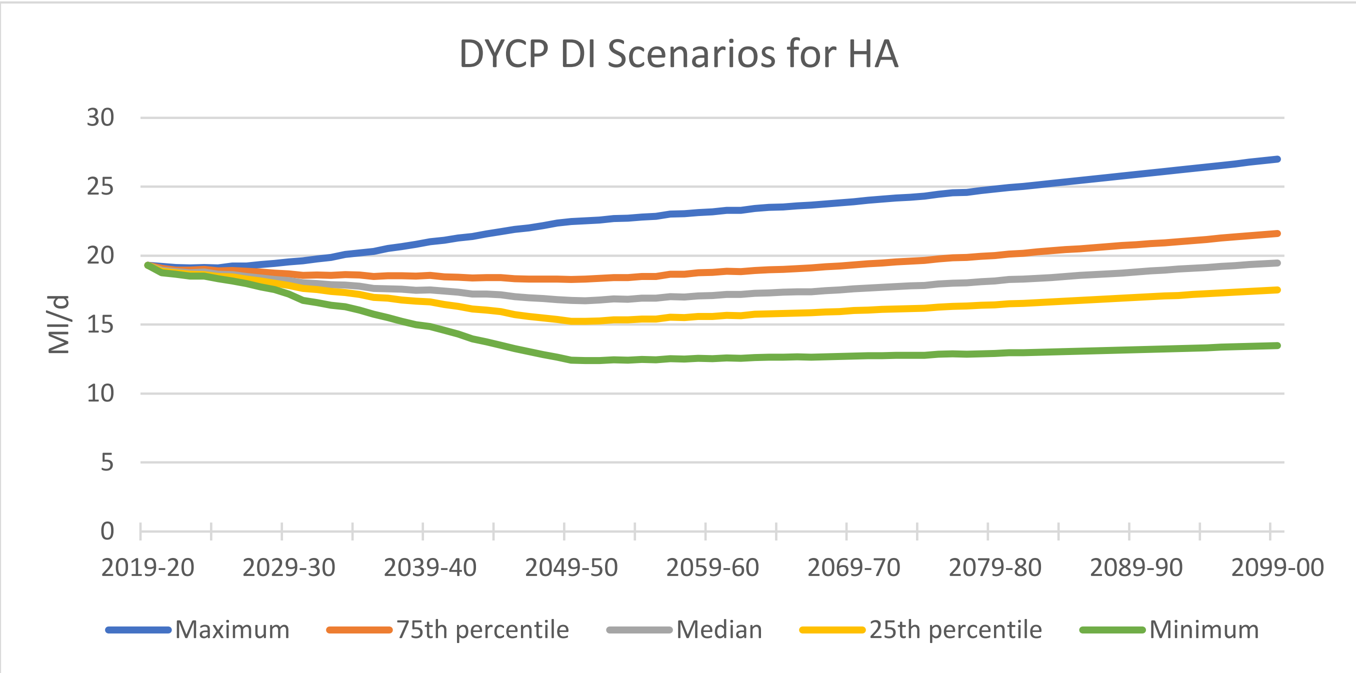


Figure 12: Range of DYMDO Distribution Input results

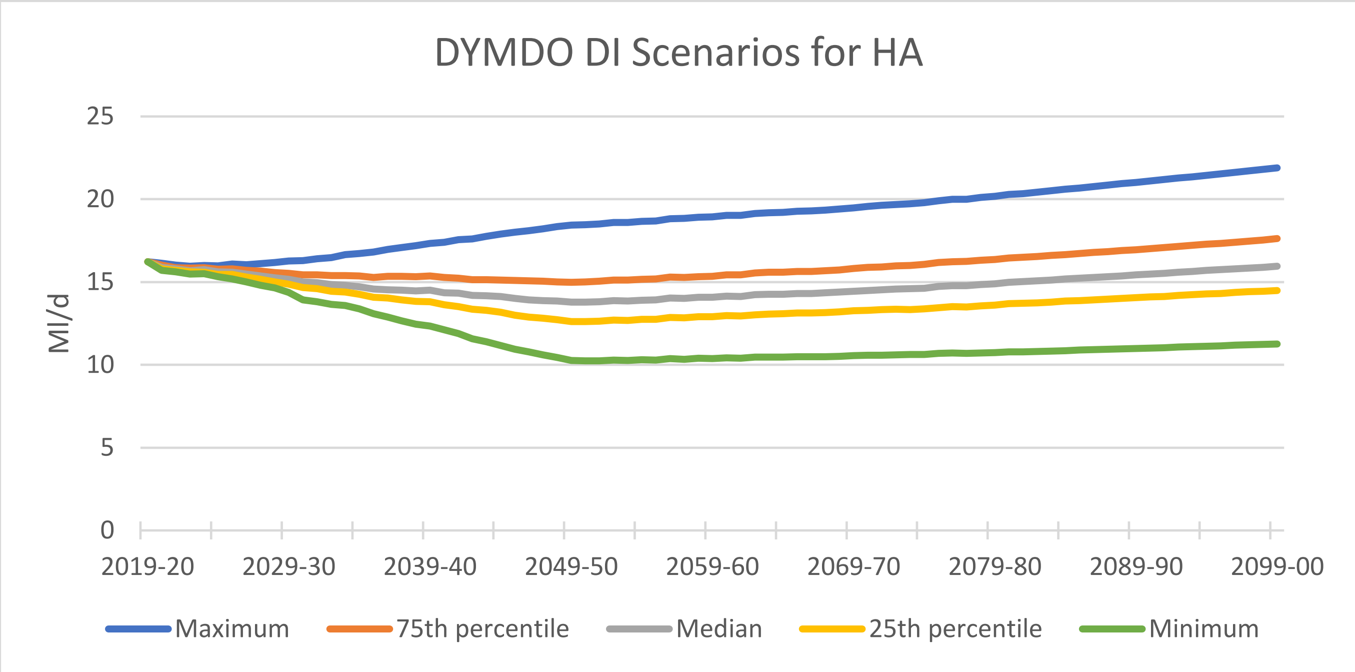


Figure 13: Range of NYAA PCC results

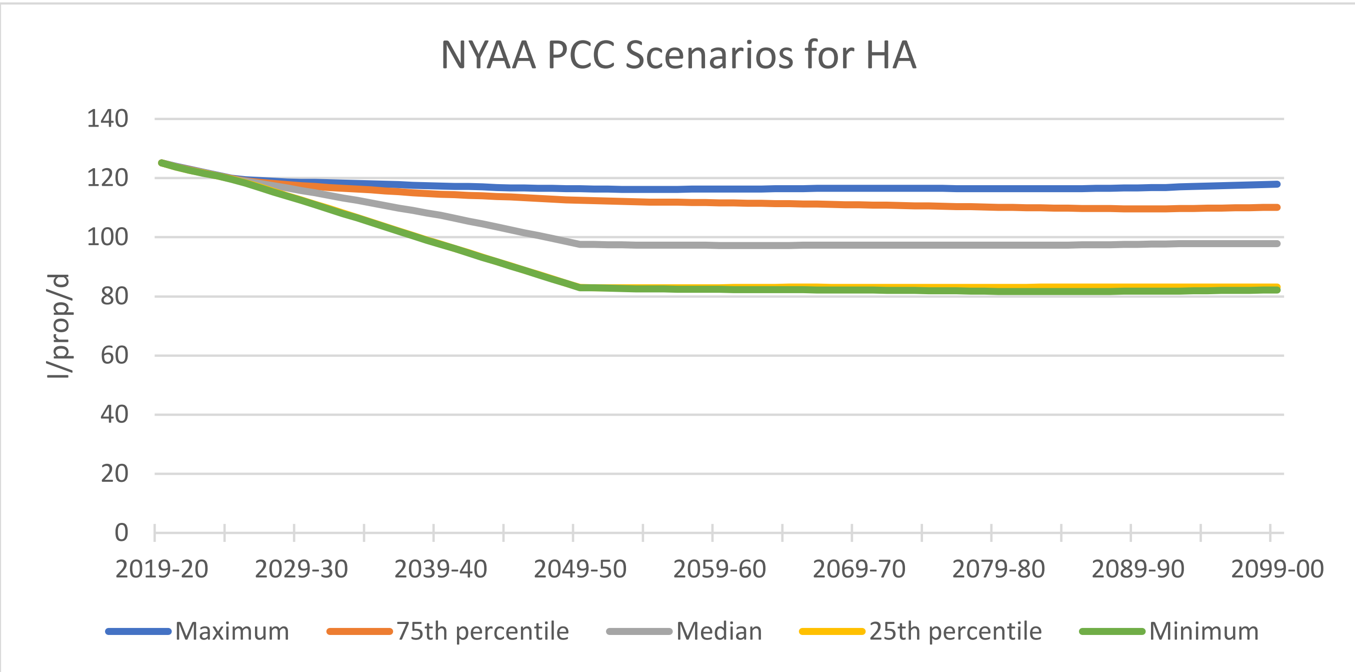


Figure 14: Range of DYAA PCC results

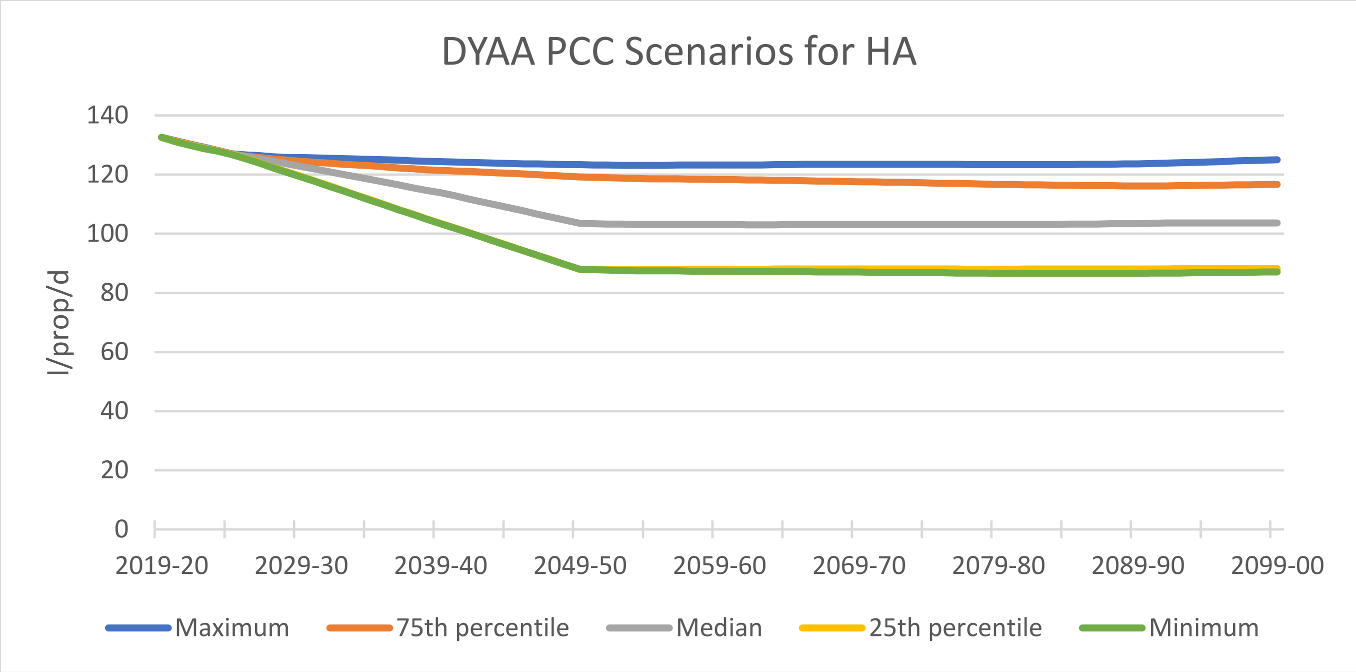


Figure 15: Range of DYCP PCC results

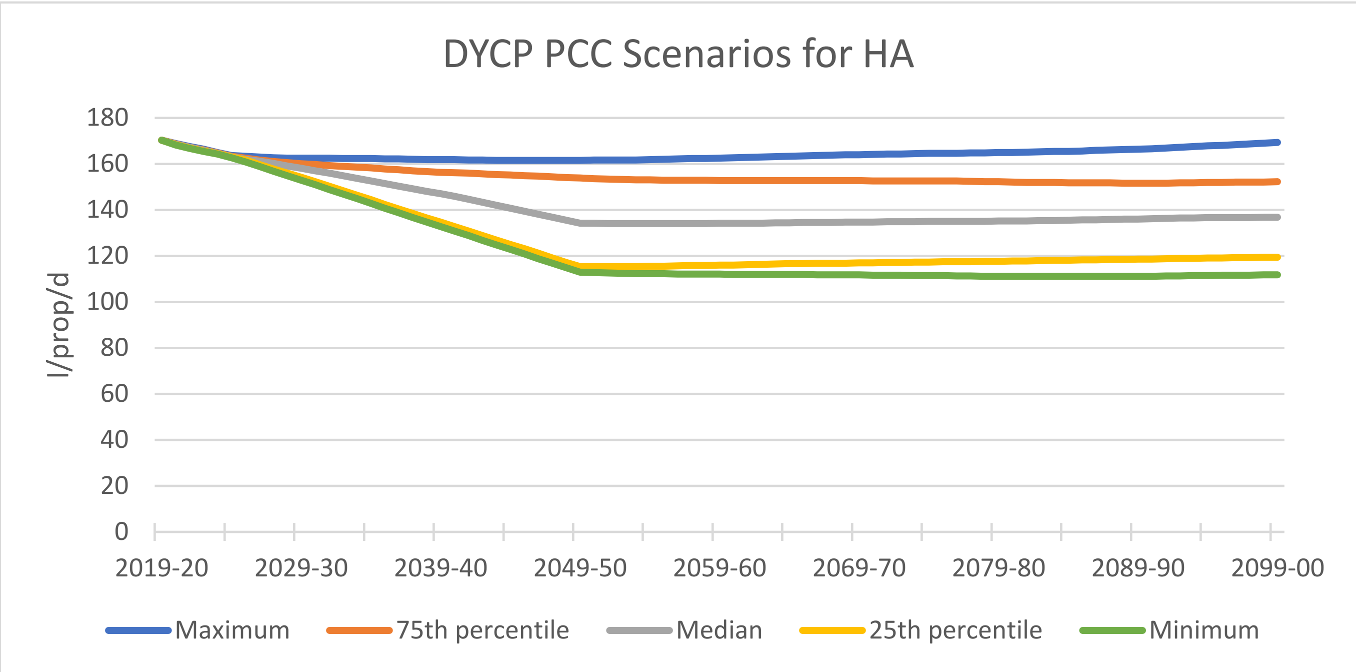
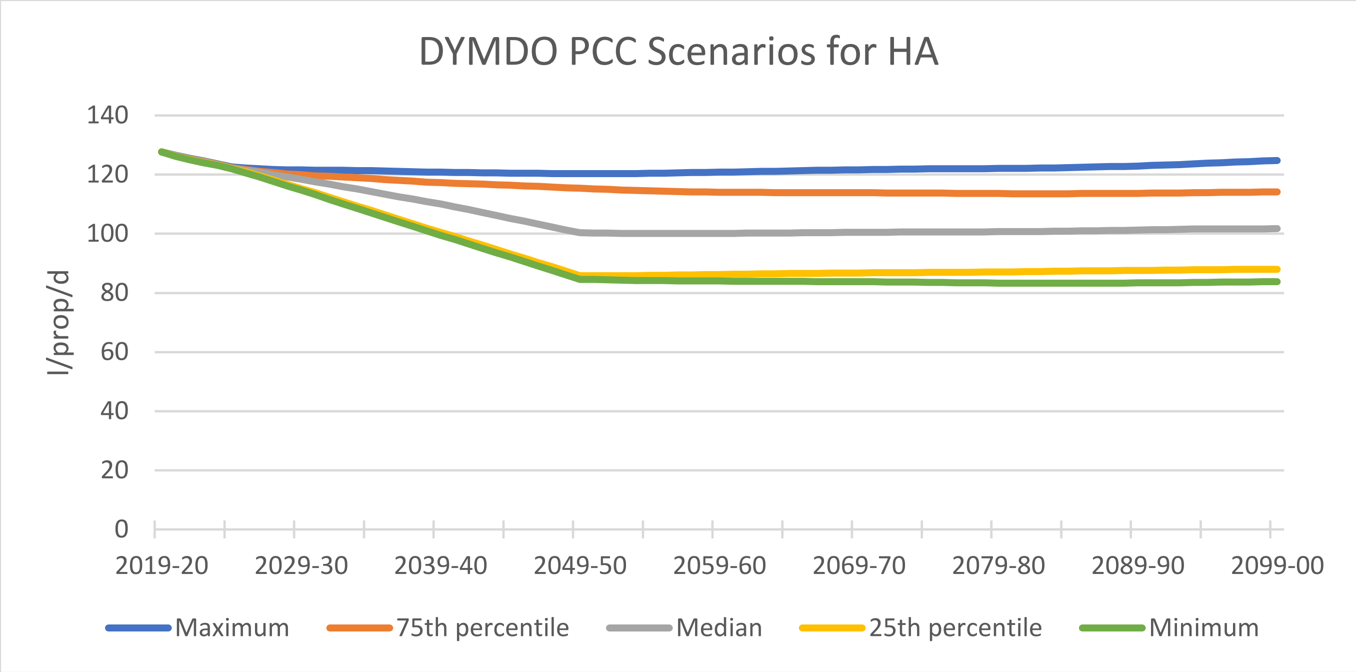


Figure 16: Range of DYMDO PCC results



B.2. Hampshire Kingsclere (HK)

Figure 17: Range of NYAA Distribution Input results

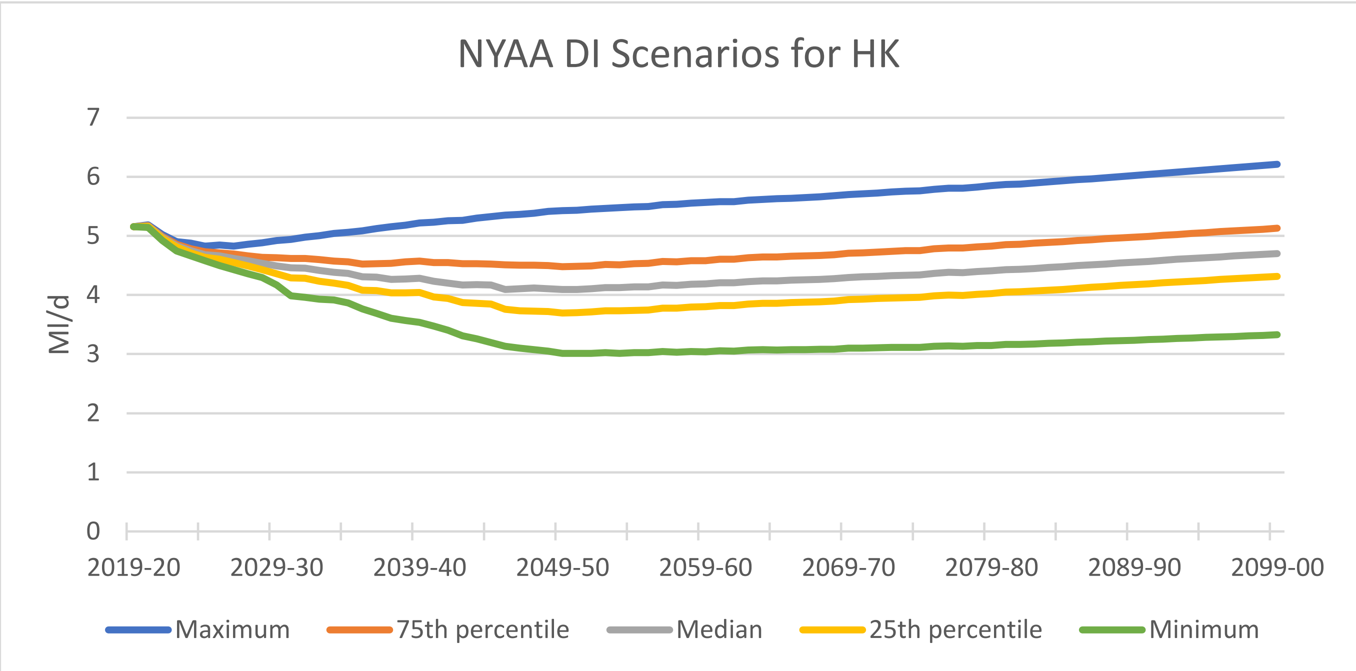


Figure 18: Range of DYAA Distribution Input results

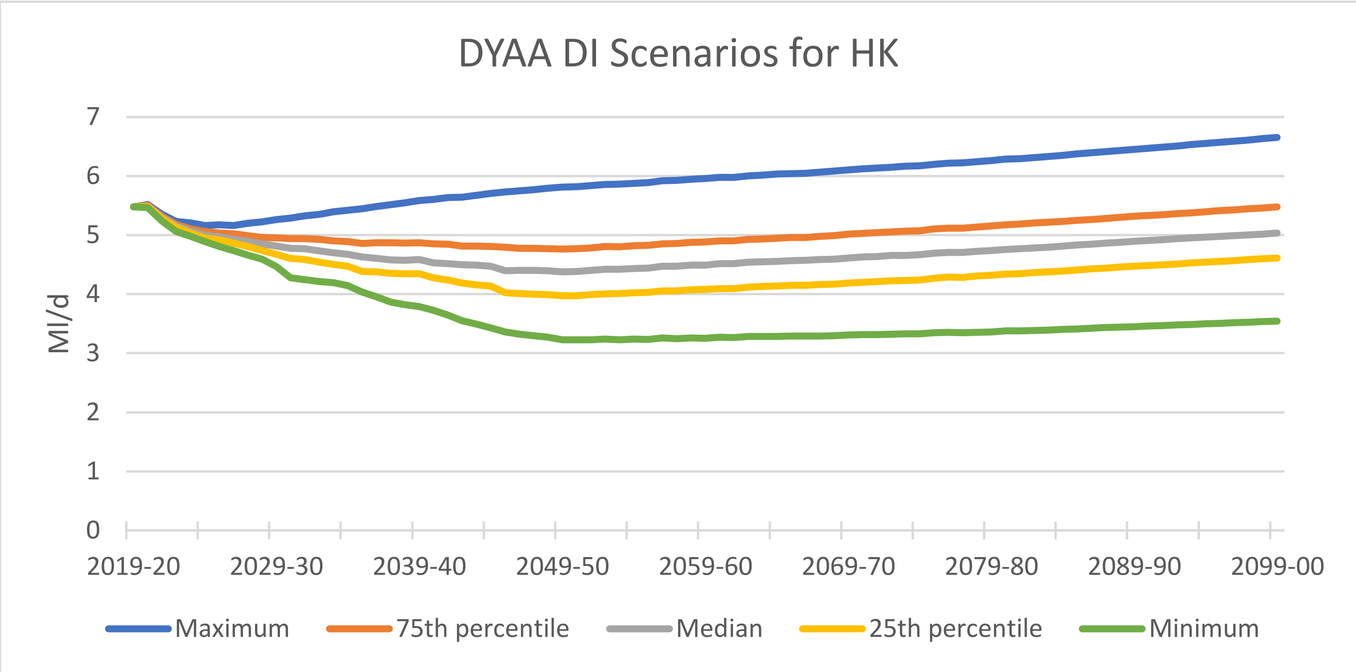


Figure 19: Range of DYCP Distribution Input results

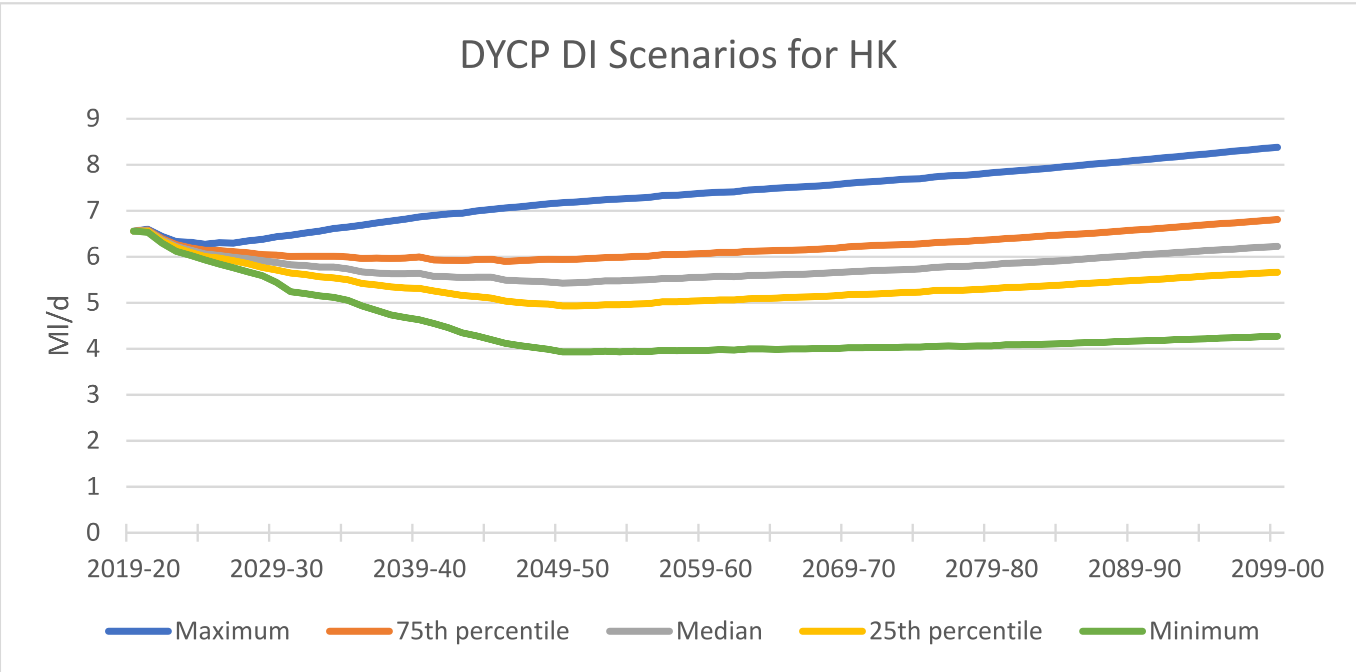


Figure 20: Range of DYMDO Distribution Input results

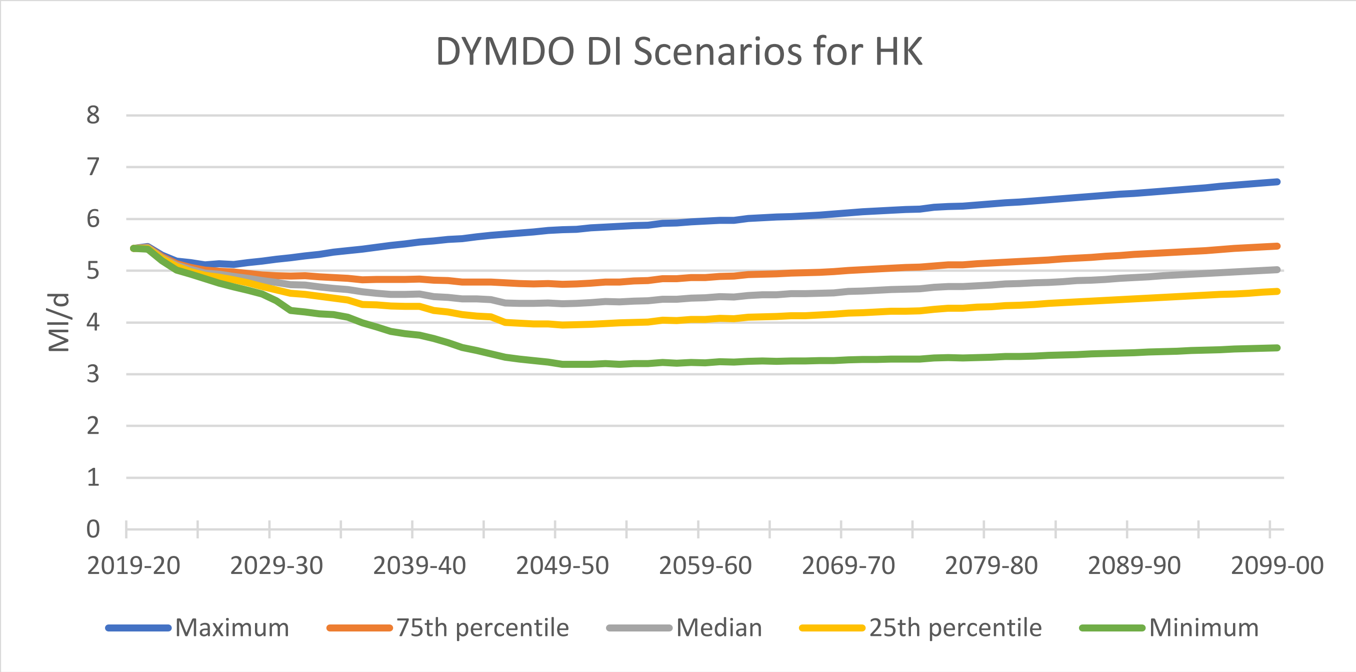


Figure 21: Range of NYAA PCC results

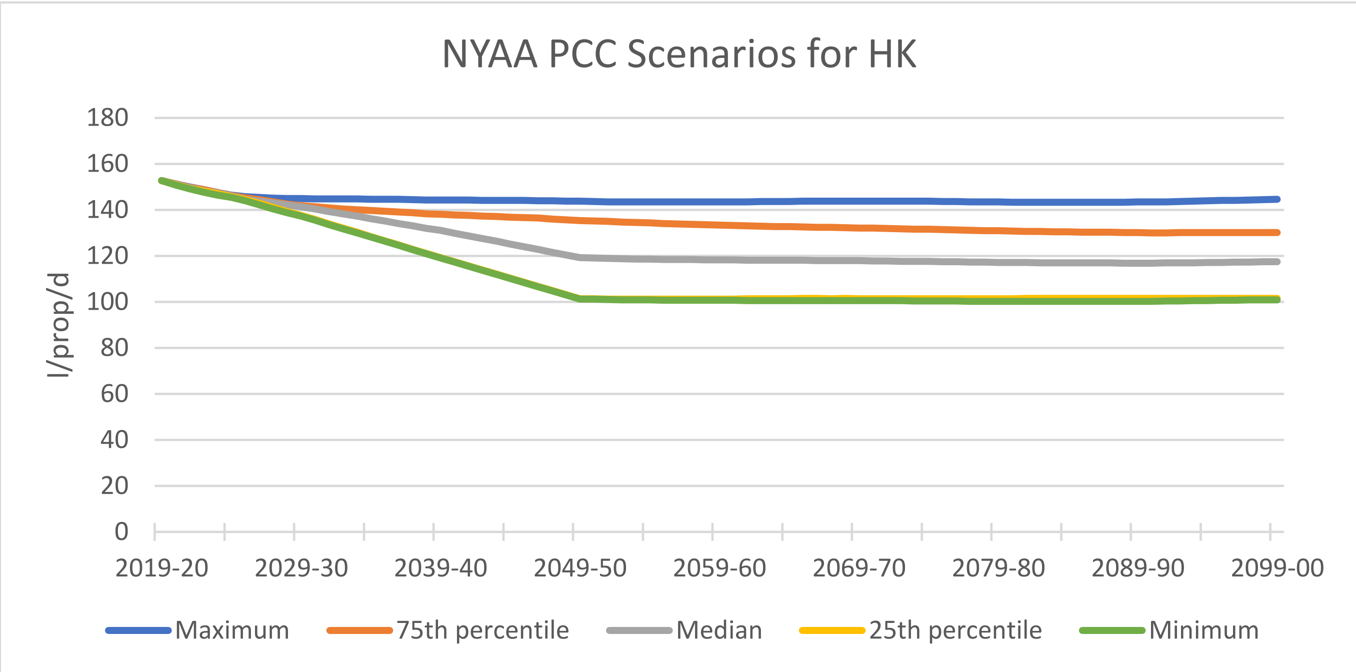


Figure 22: Range of DYAA PCC results

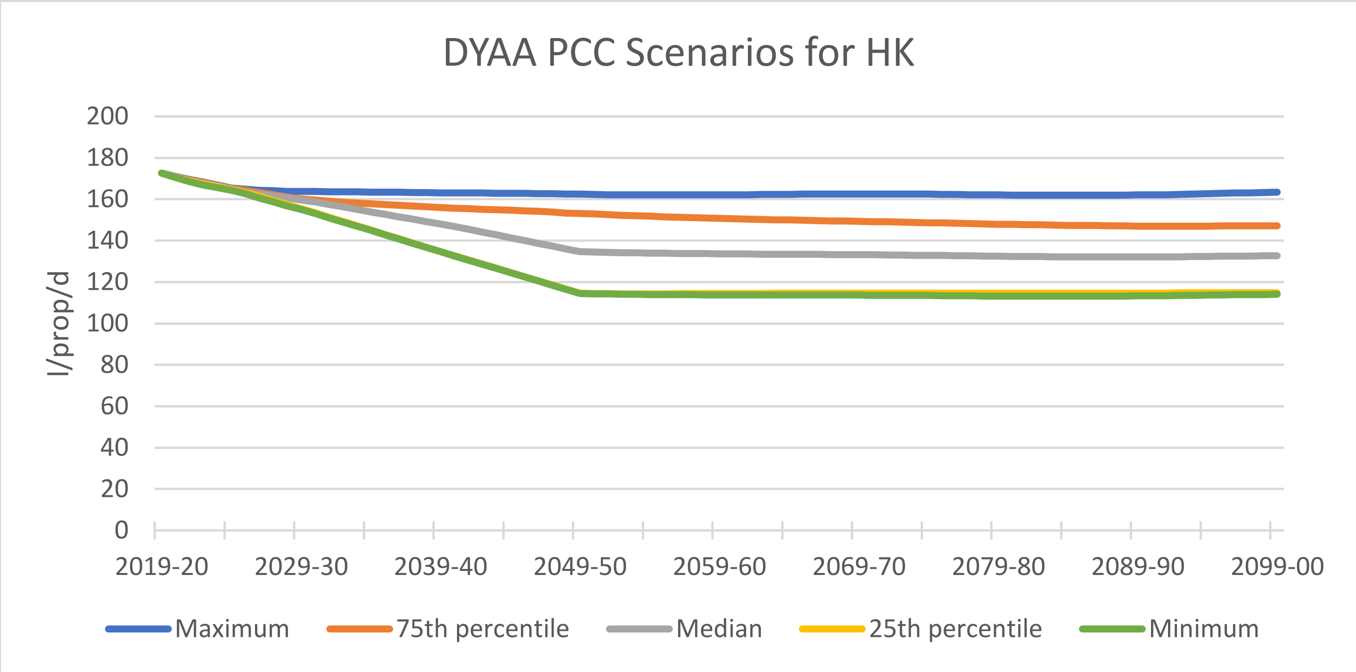


Figure 23: Range of DYCP PCC results

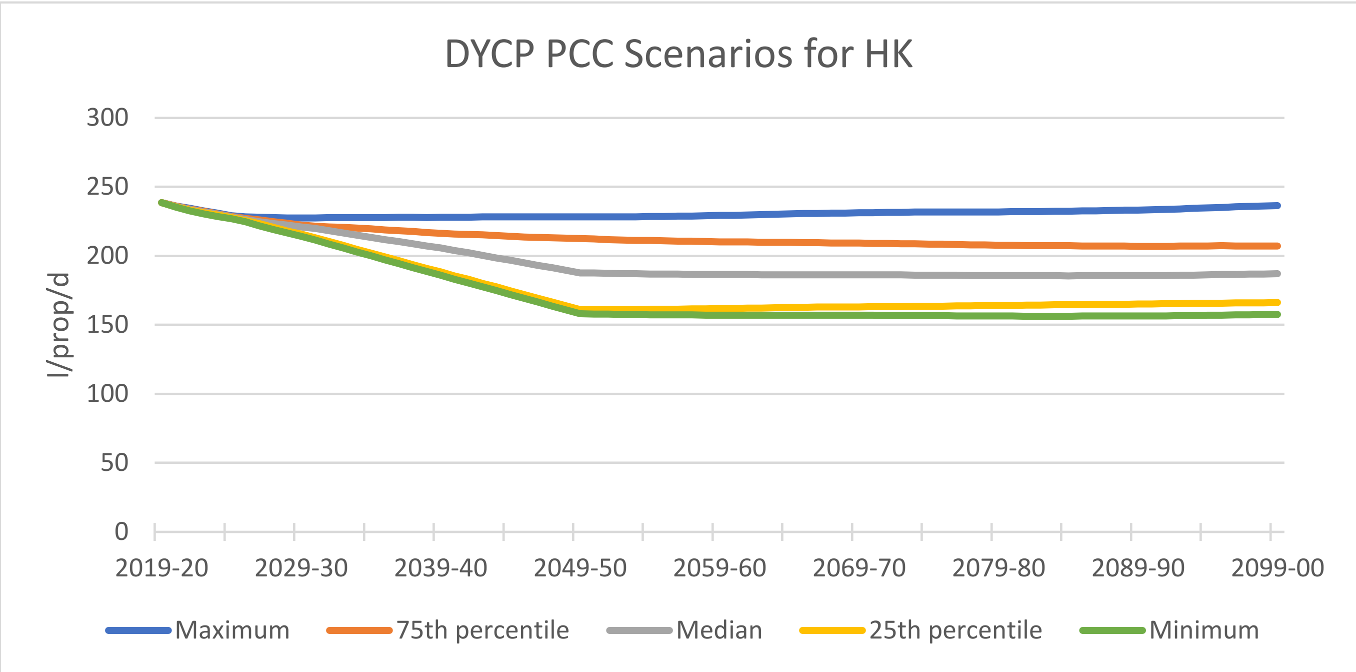
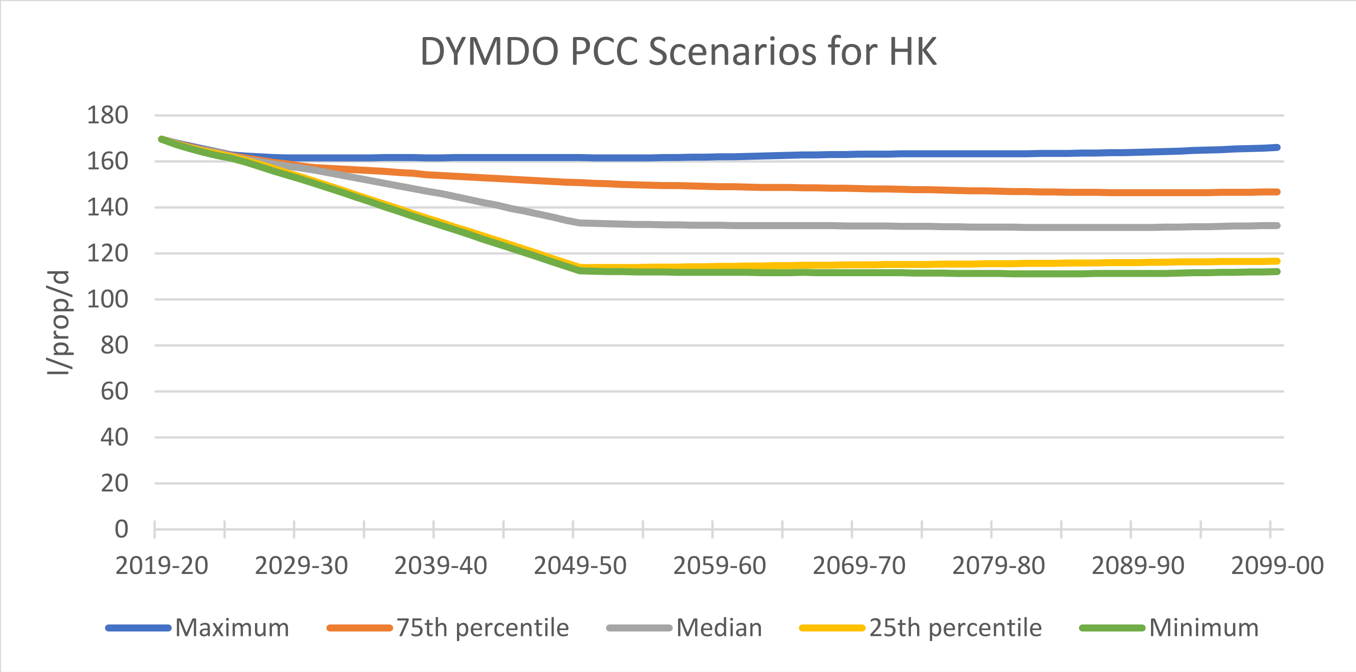


Figure 24: Range of DYMDO PCC results



B.3. Hampshire Winchester (HW)

Figure 25: Range of NYAA Distribution Input results

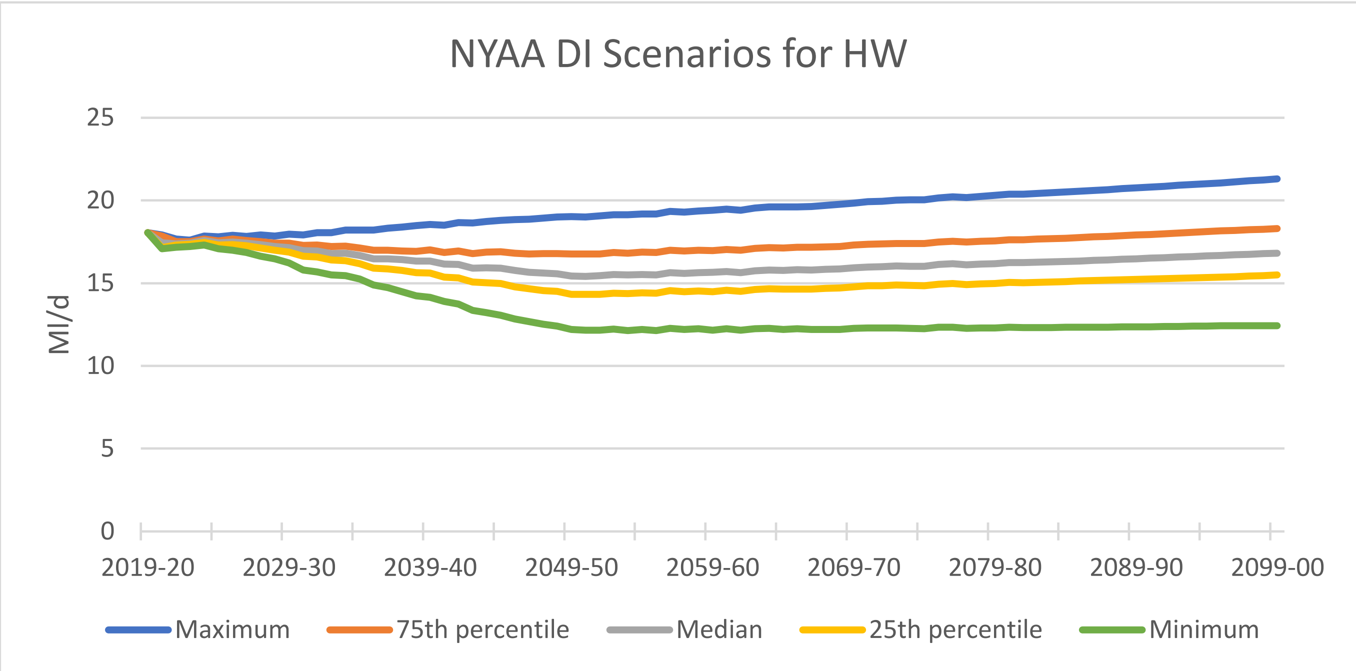


Figure 26: Range of DYAA Distribution Input results

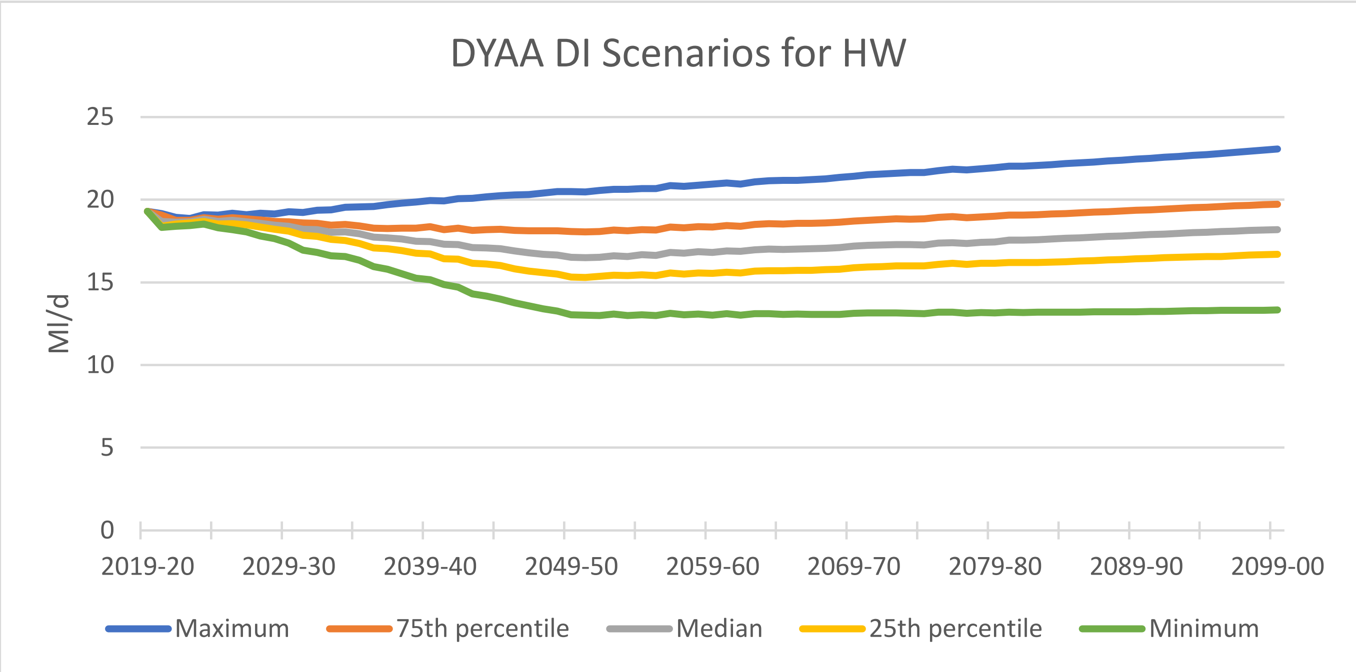


Figure 27: Range of DYCP Distribution Input results

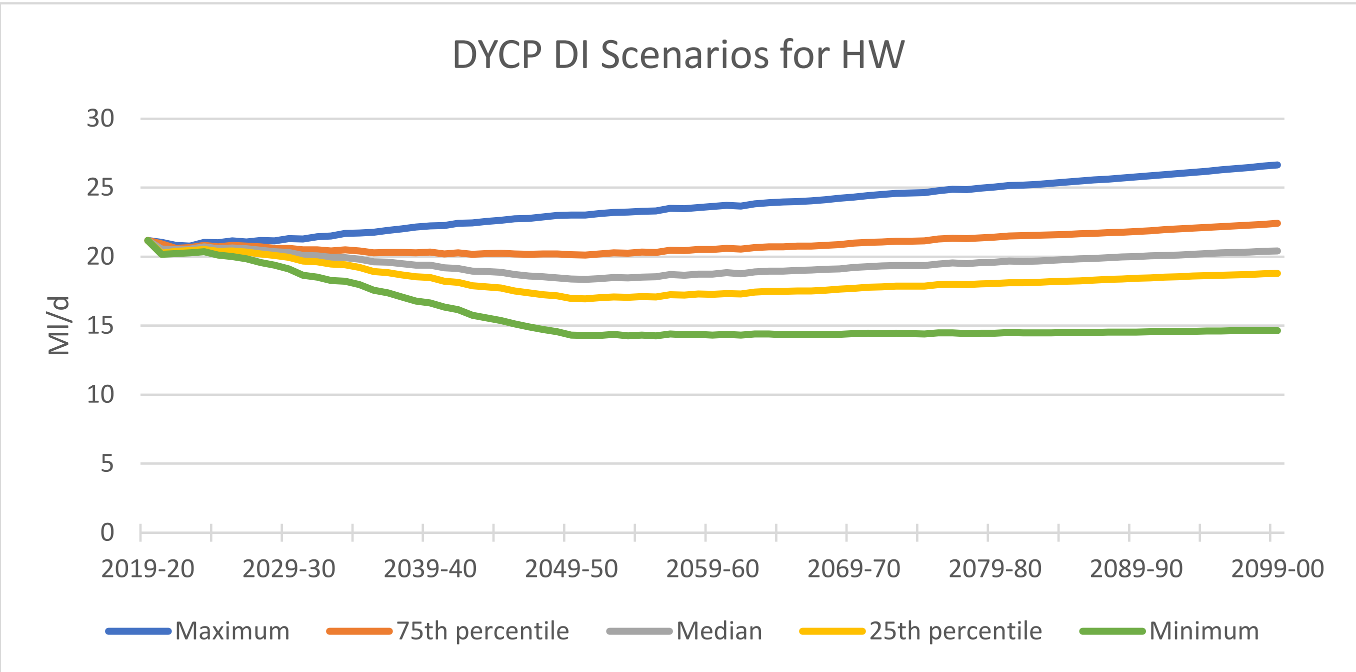


Figure 28: Range of DYMDO Distribution Input results

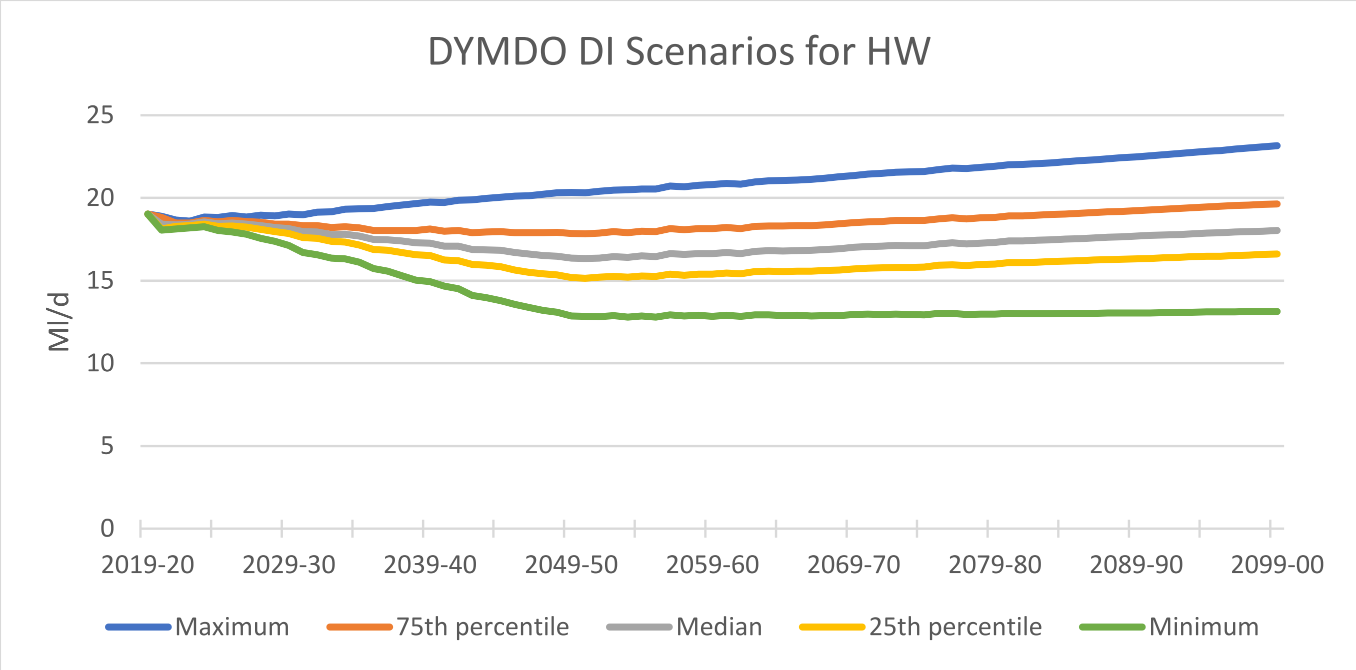


Figure 29: Range of NYAA PCC results

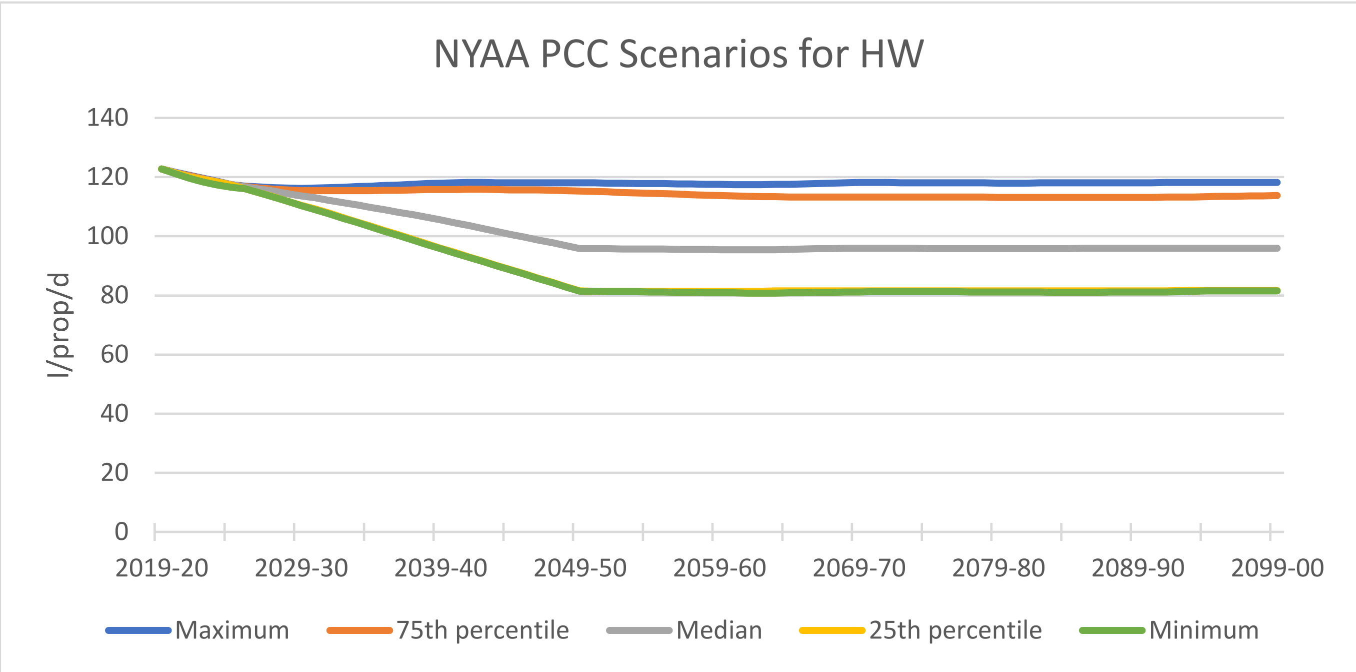


Figure 30: Range of DYAA PCC results

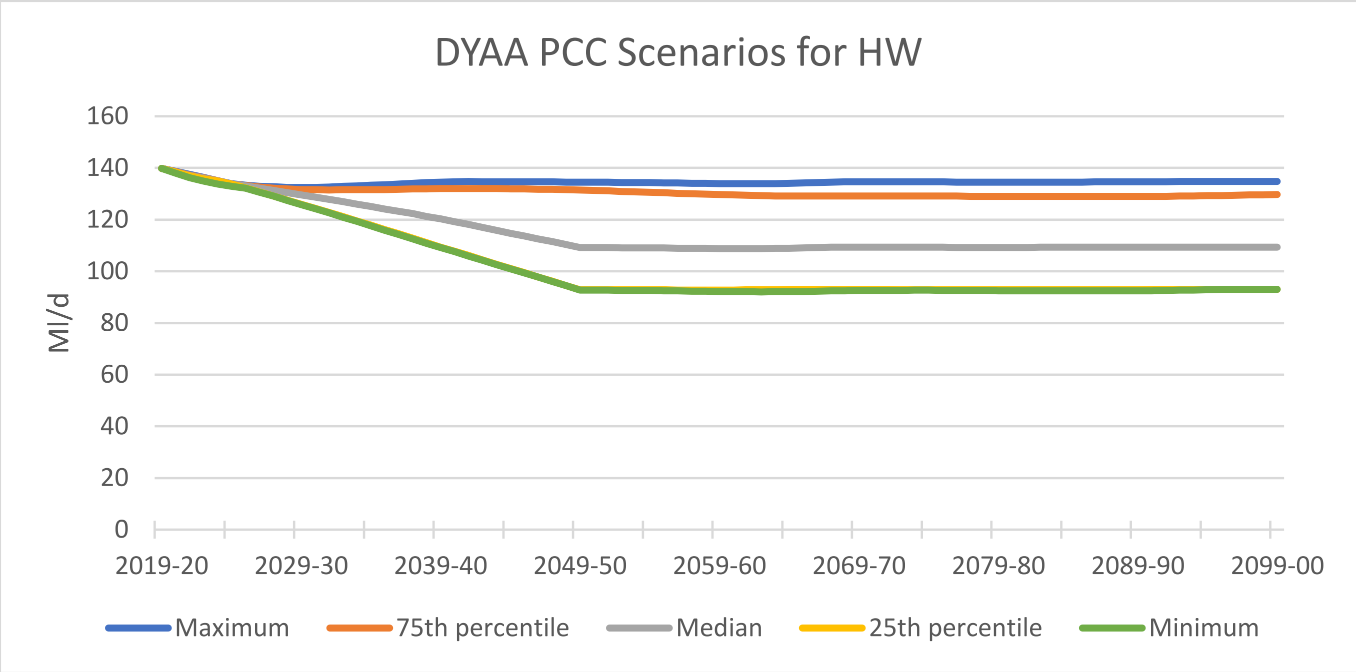


Figure 31: Range of DYCP PCC results

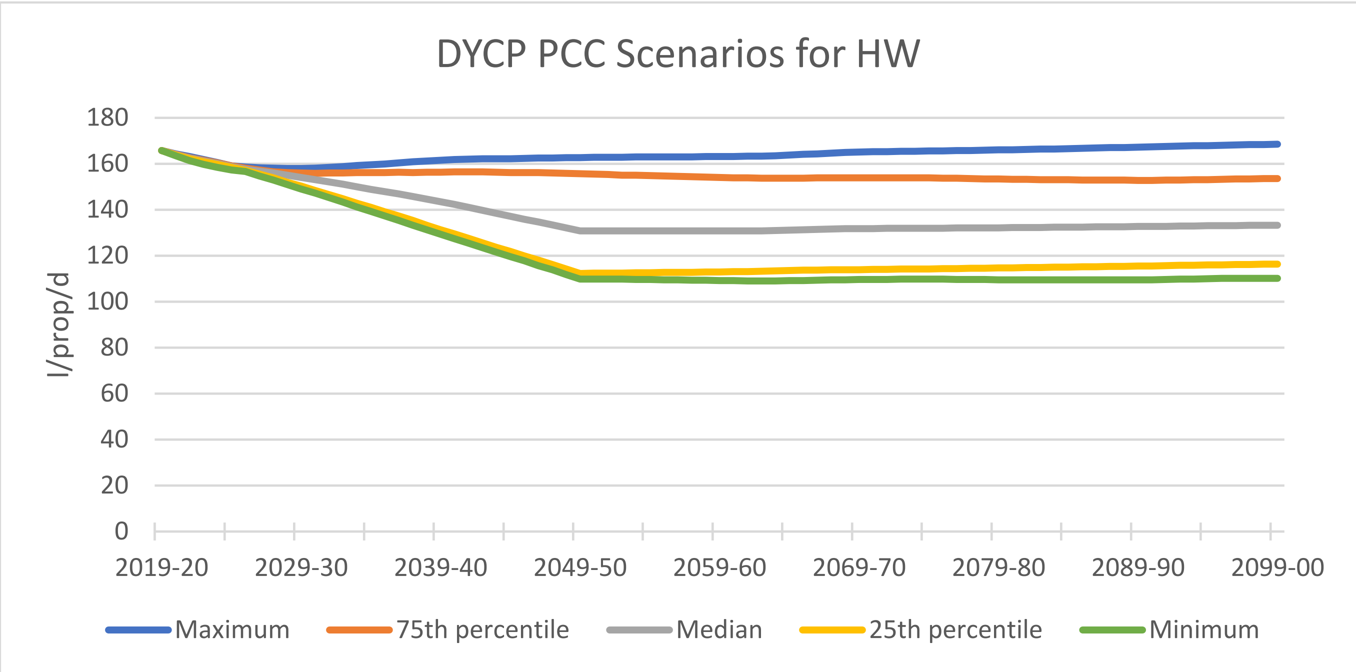
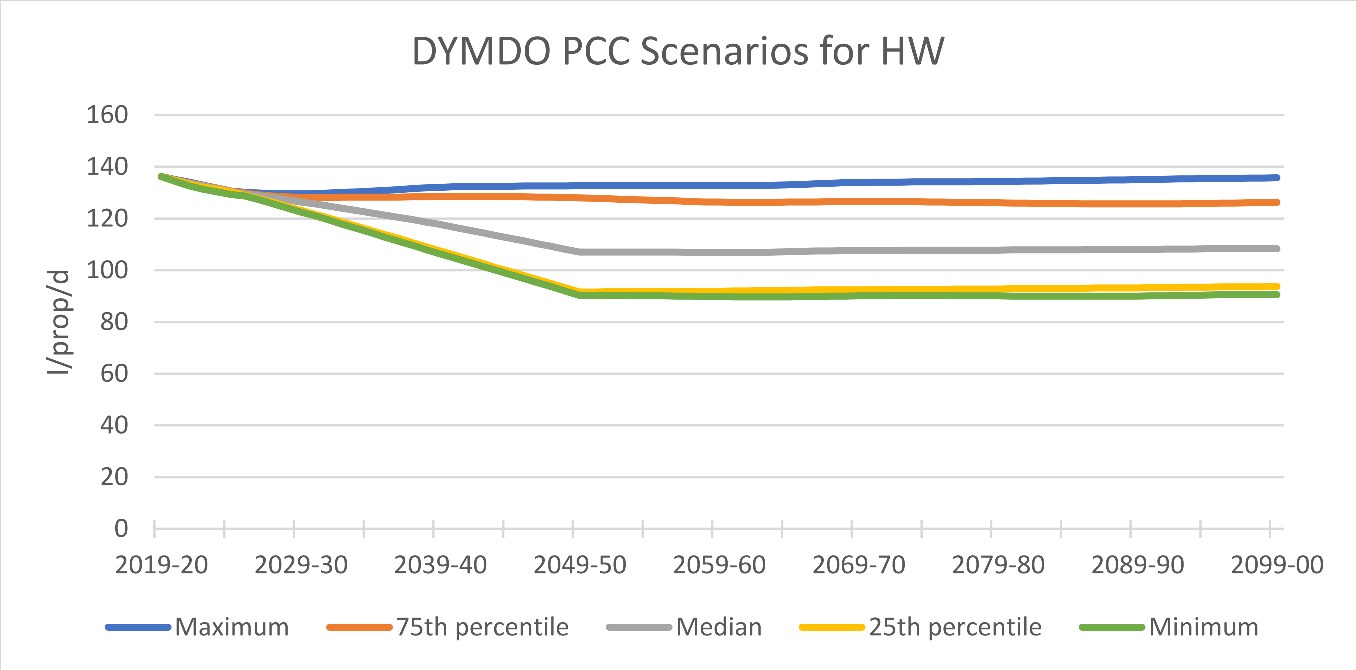


Figure 32: Range of DYMDO PCC results



B.4. Hampshire Rural (HR)

Figure 33: Range of NYAA Distribution Input results

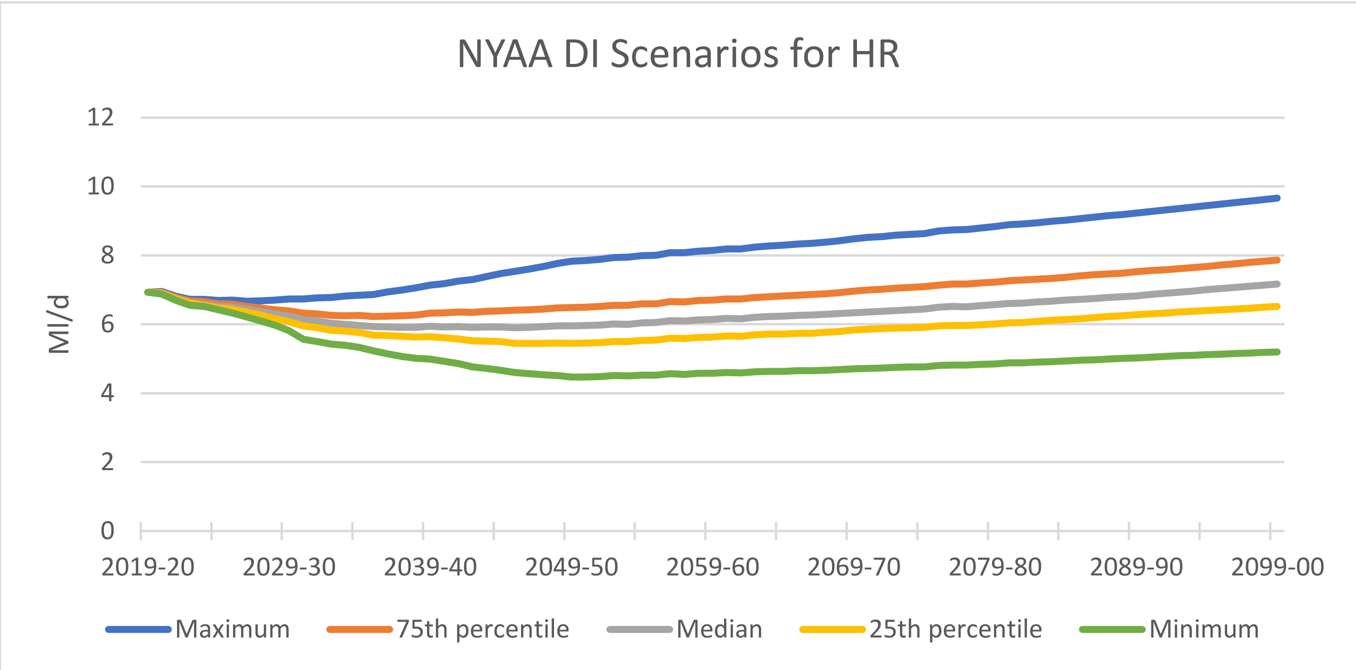


Figure 34: Range of DYAA Distribution Input results

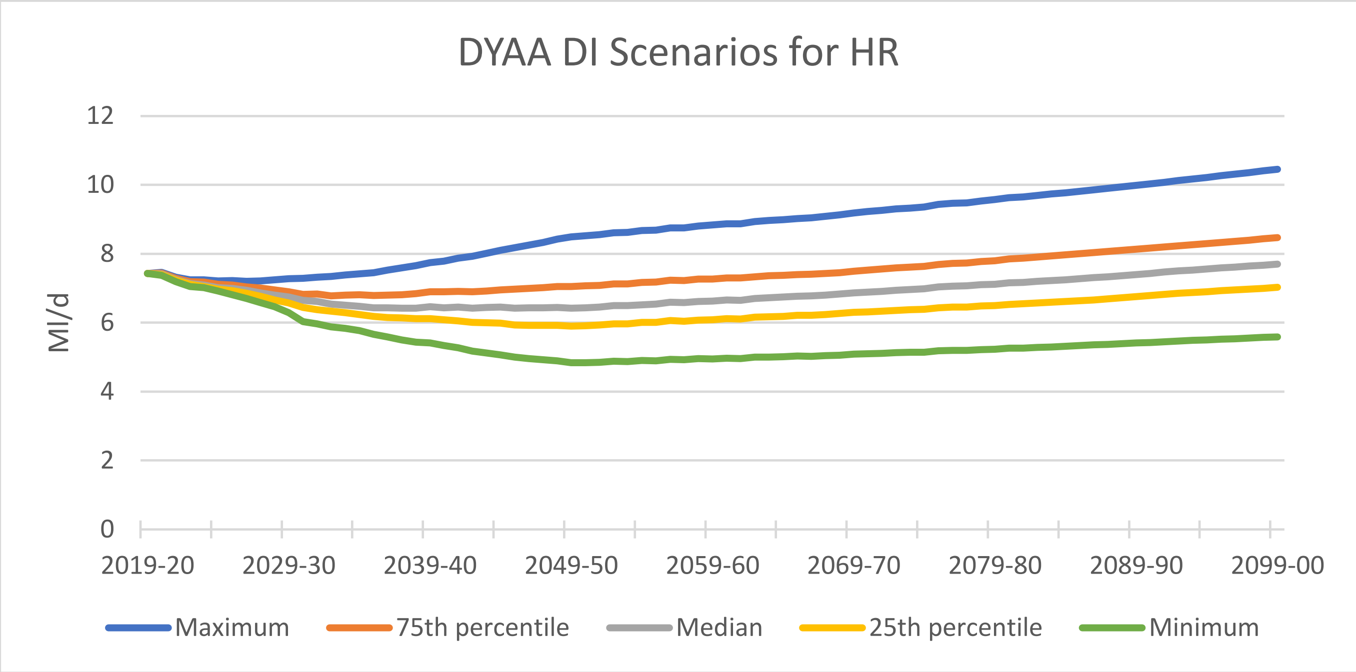


Figure 35: Range of DYCP Distribution Input results

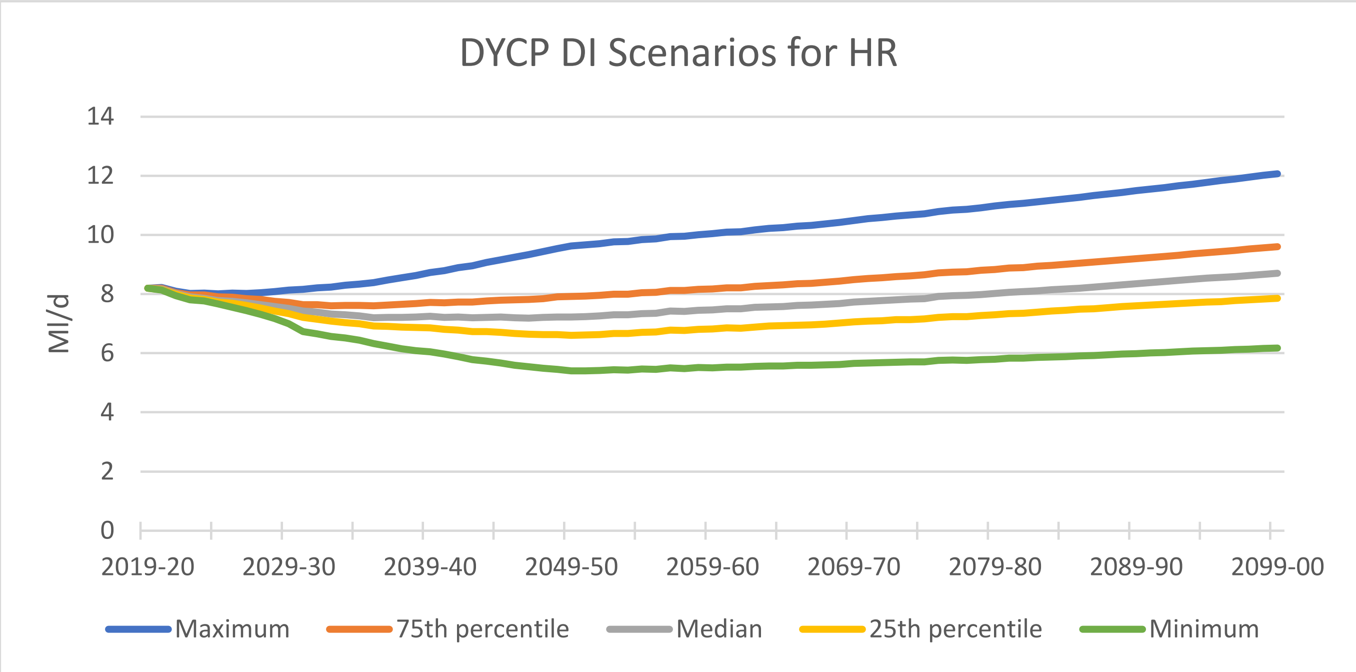


Figure 36: Range of DYMDO Distribution Input results

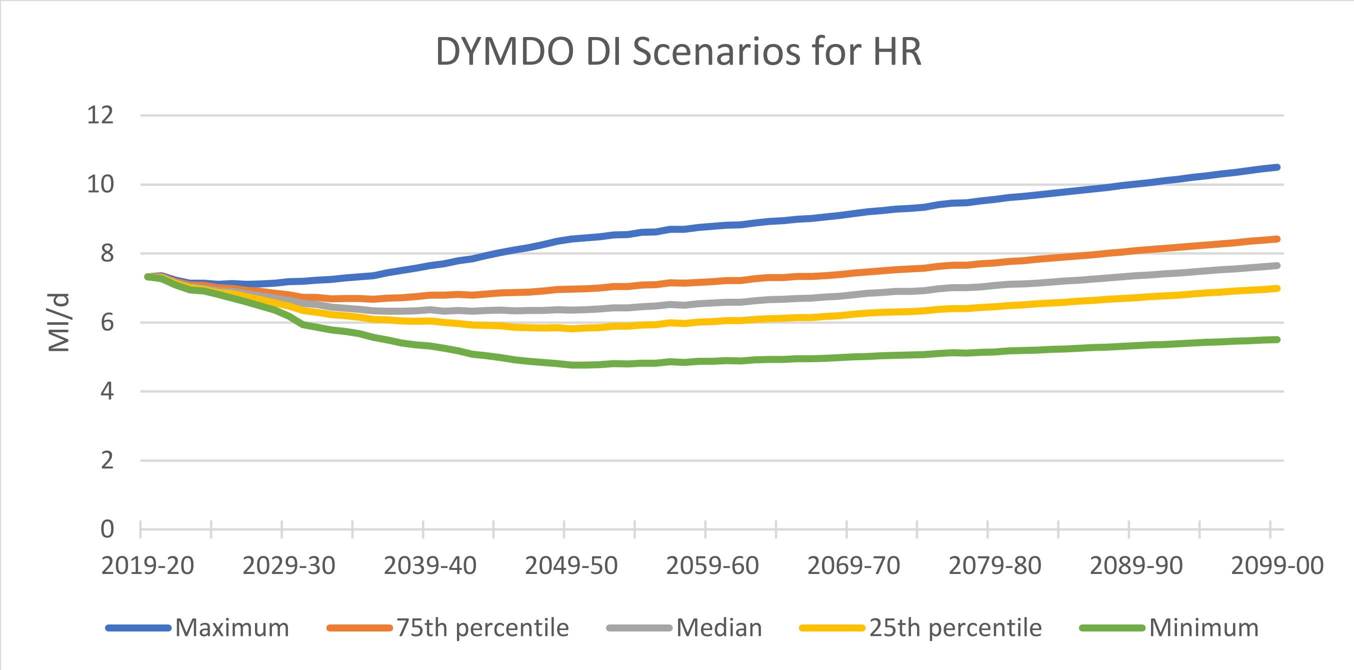


Figure 37: Range of NYAA PCC results

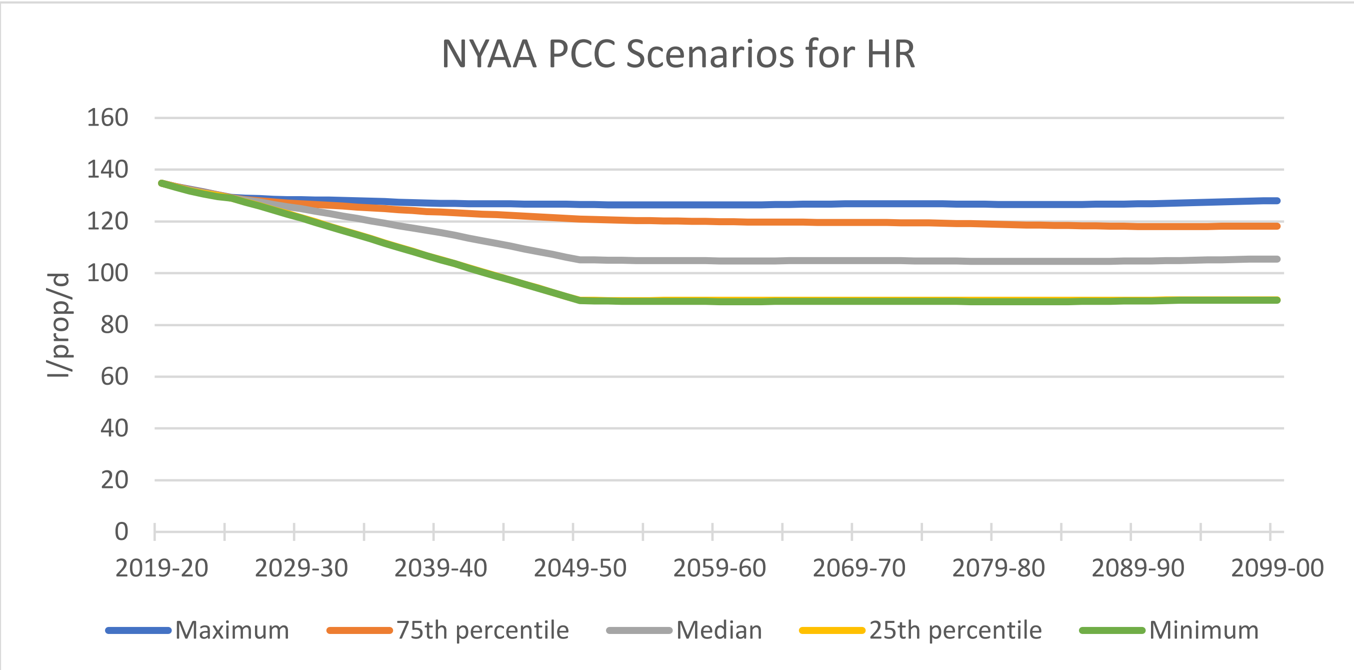


Figure 38: Range of DYAA PCC results

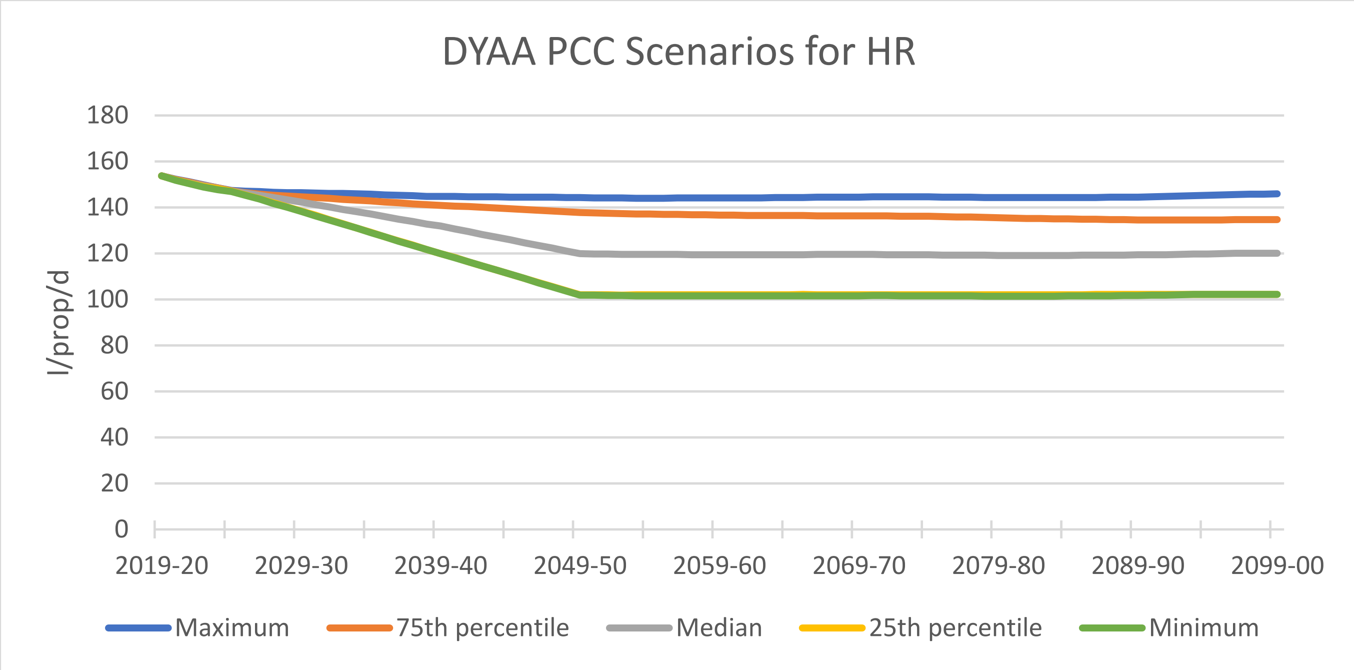


Figure 39: Range of DYCP PCC results

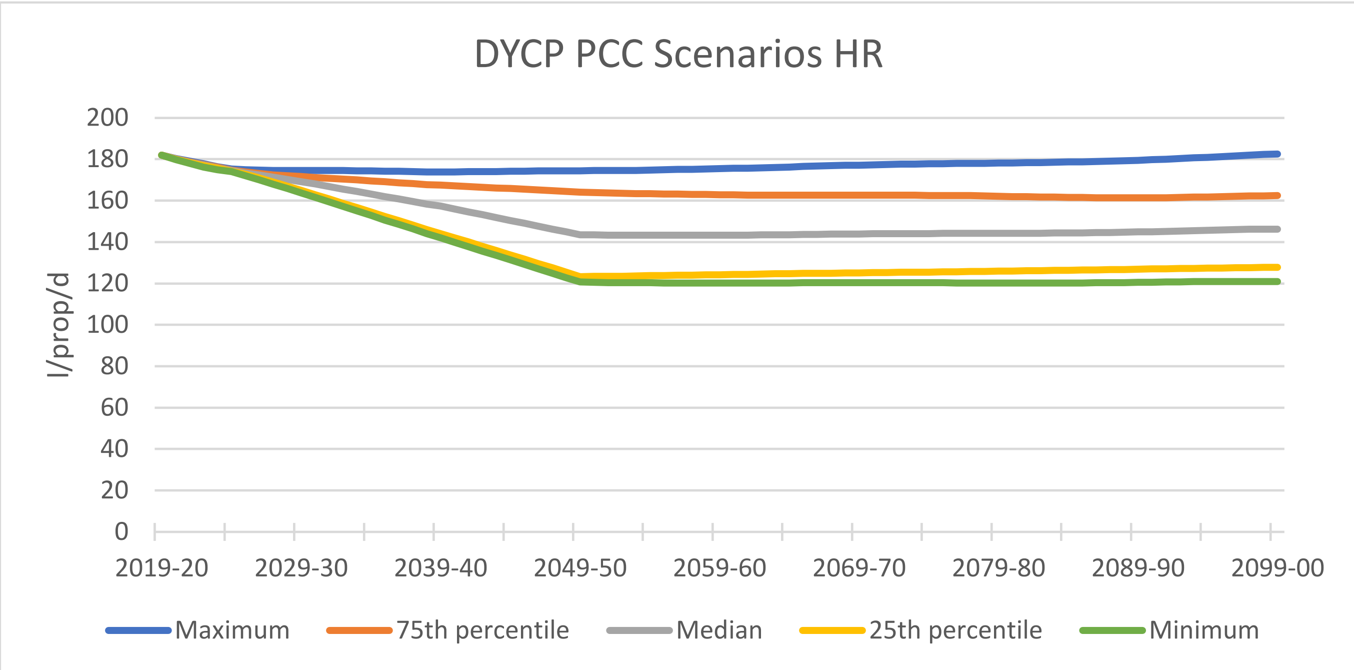
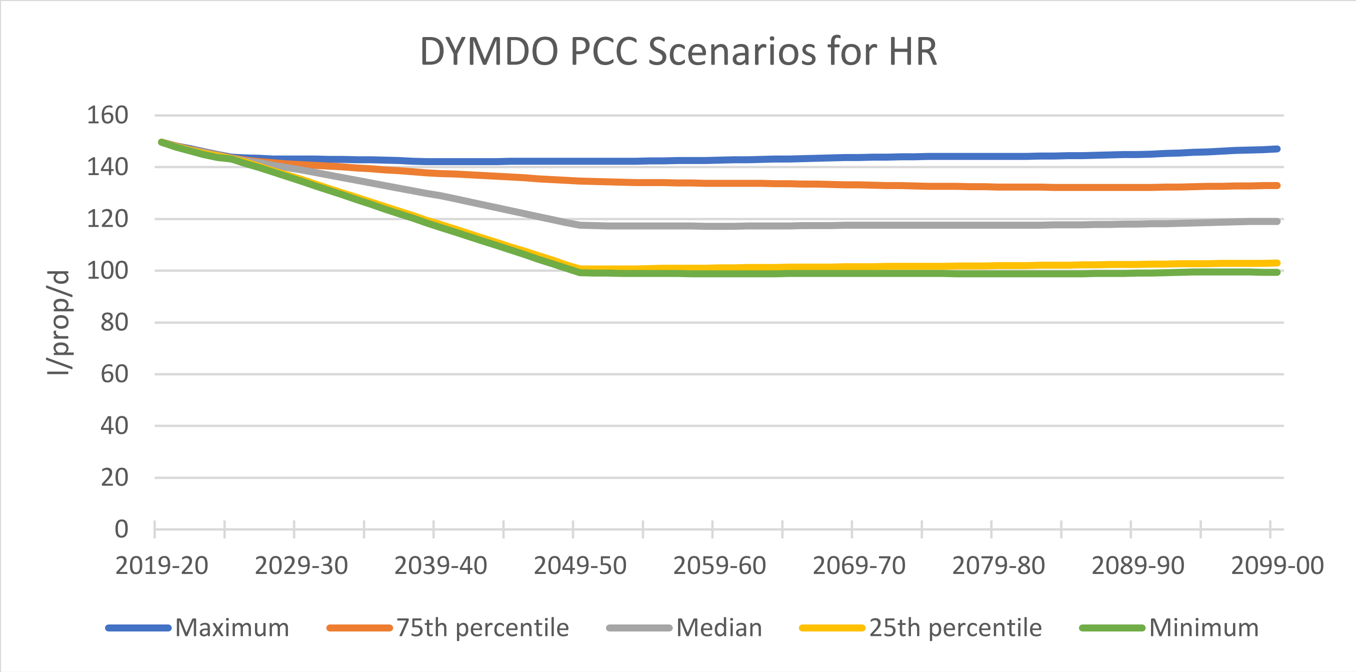


Figure 40: Range of DYMDO PCC results



B.5. Hampshire Southampton East (HSE)

Figure 41: Range of NYAA Distribution Input results

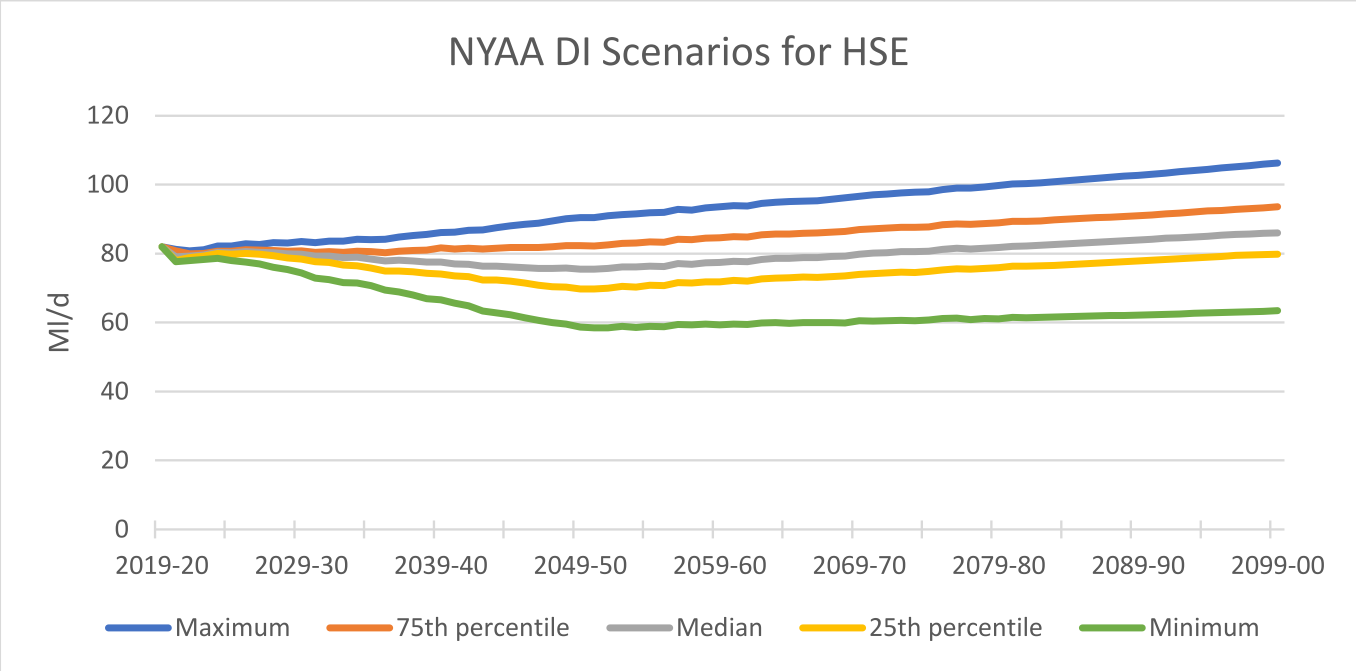


Figure 42: Range of DYAA Distribution Input results

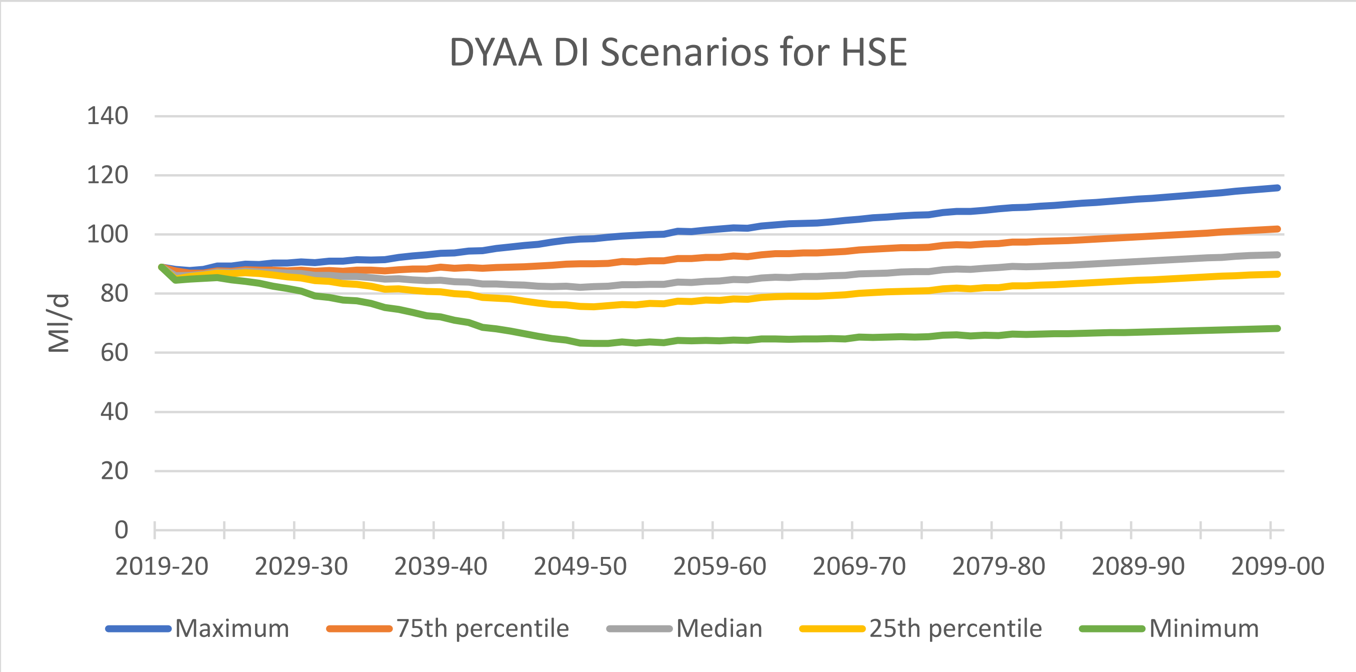


Figure 43: Range of DYCP Distribution Input results

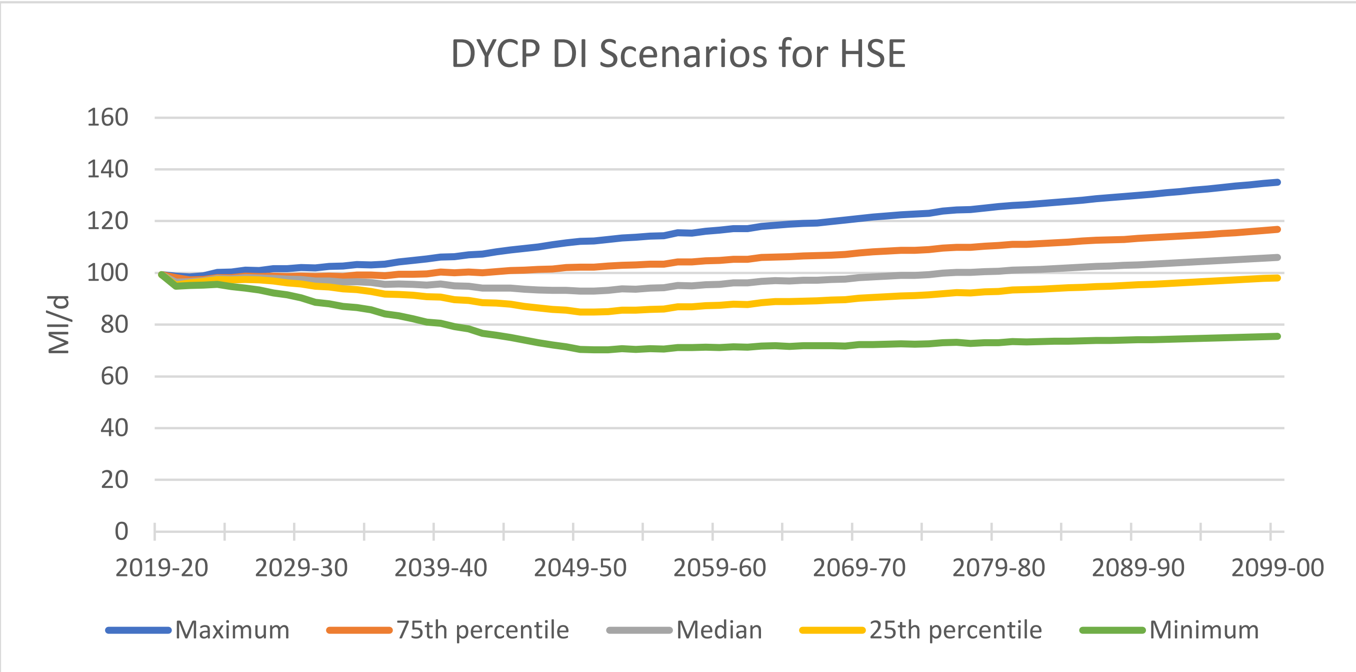


Figure 44: Range of DYMDO Distribution Input results

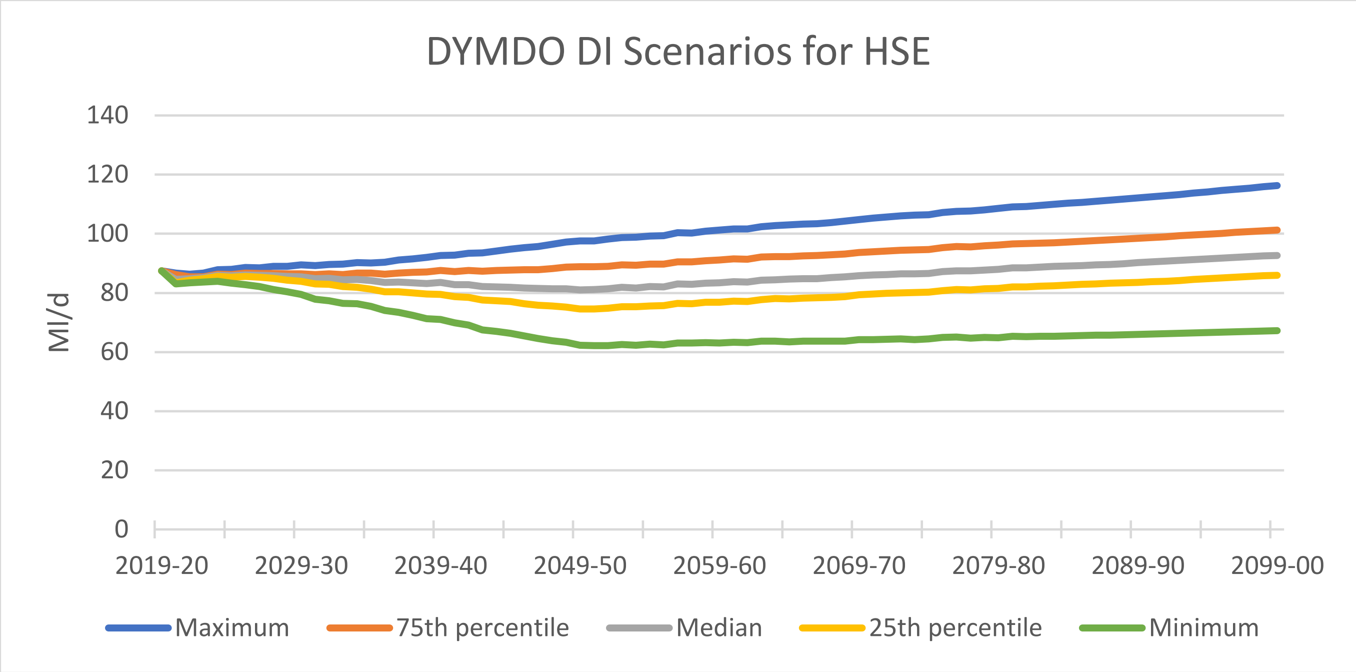


Figure 45: Range of NYAA PCC results

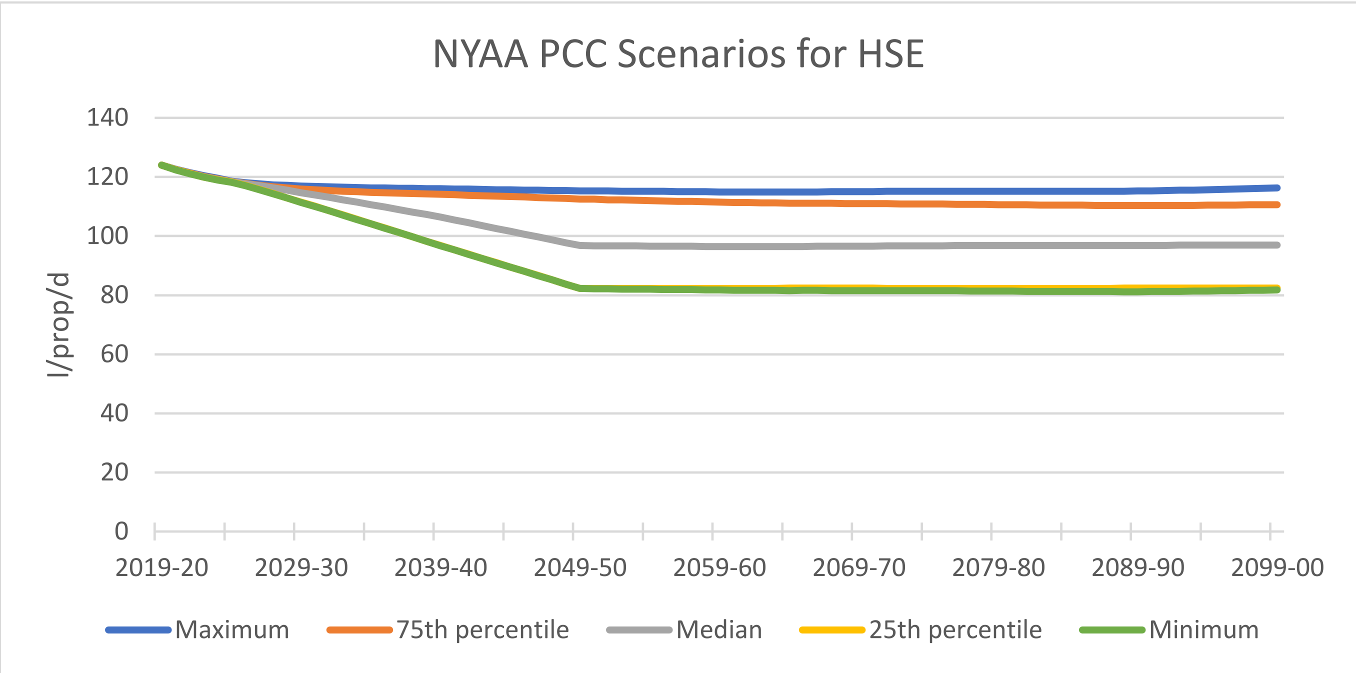


Figure 46: Range of DYAA PCC results

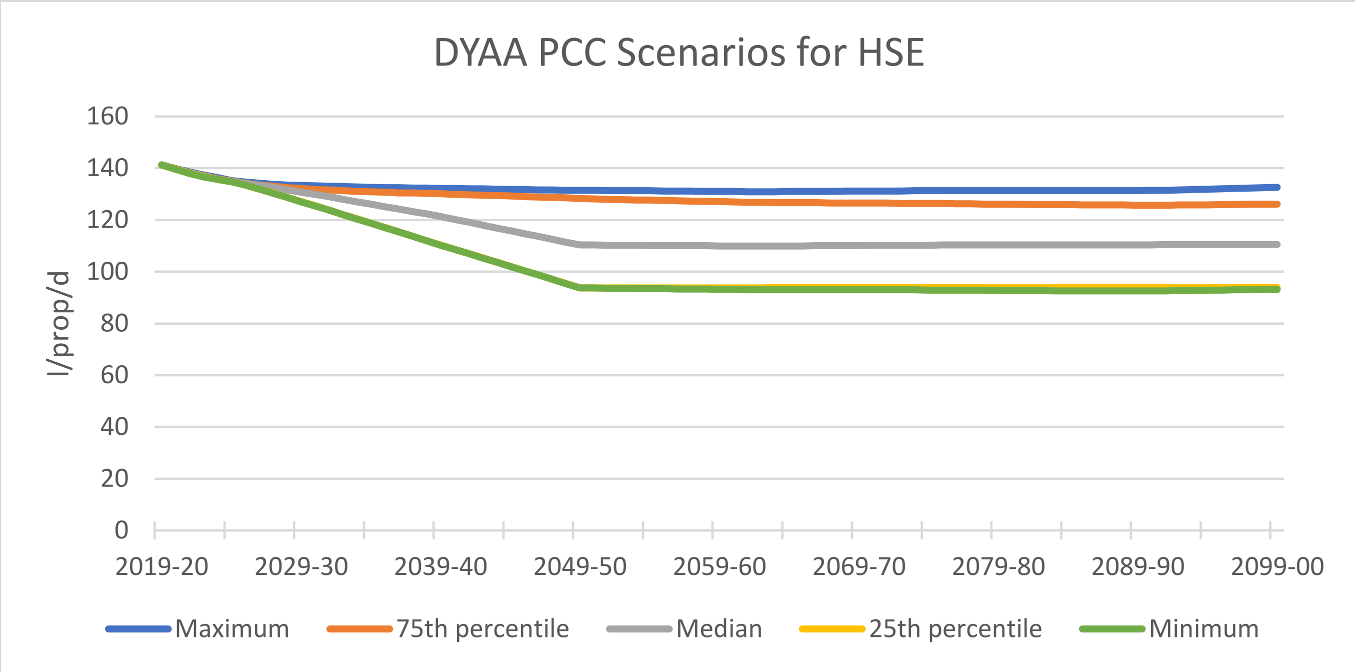


Figure 47: Range of DYCP PCC results

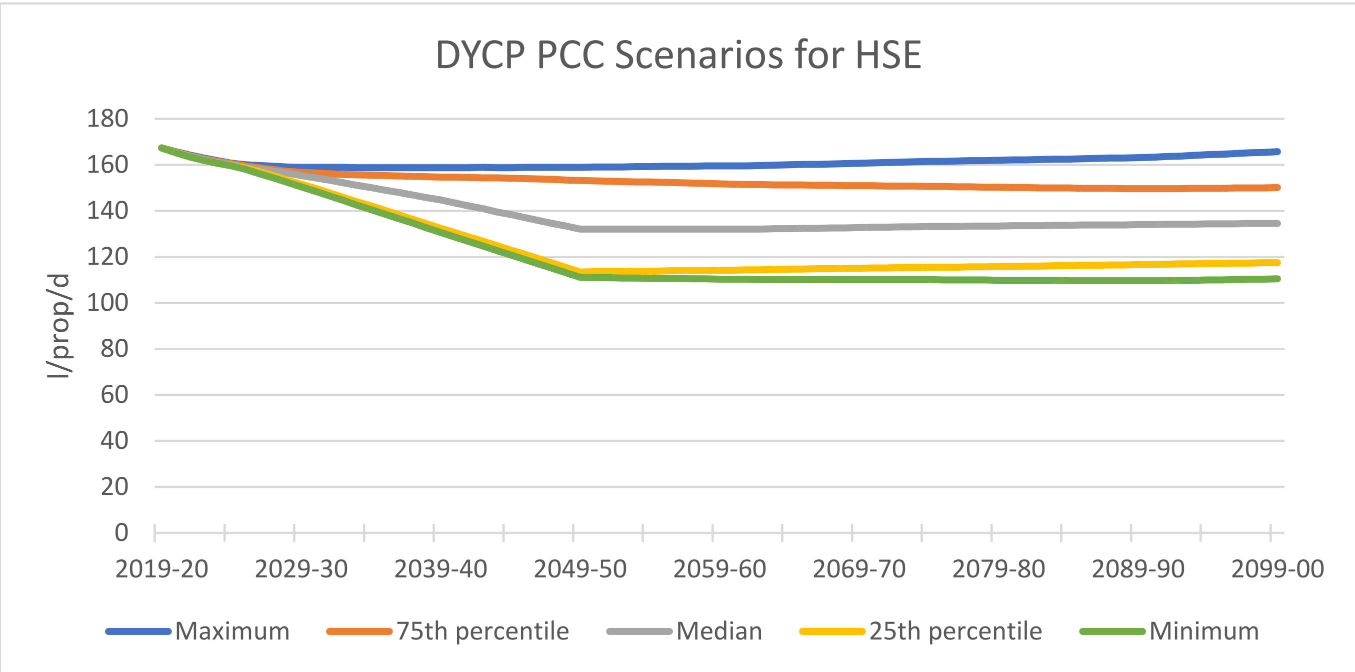
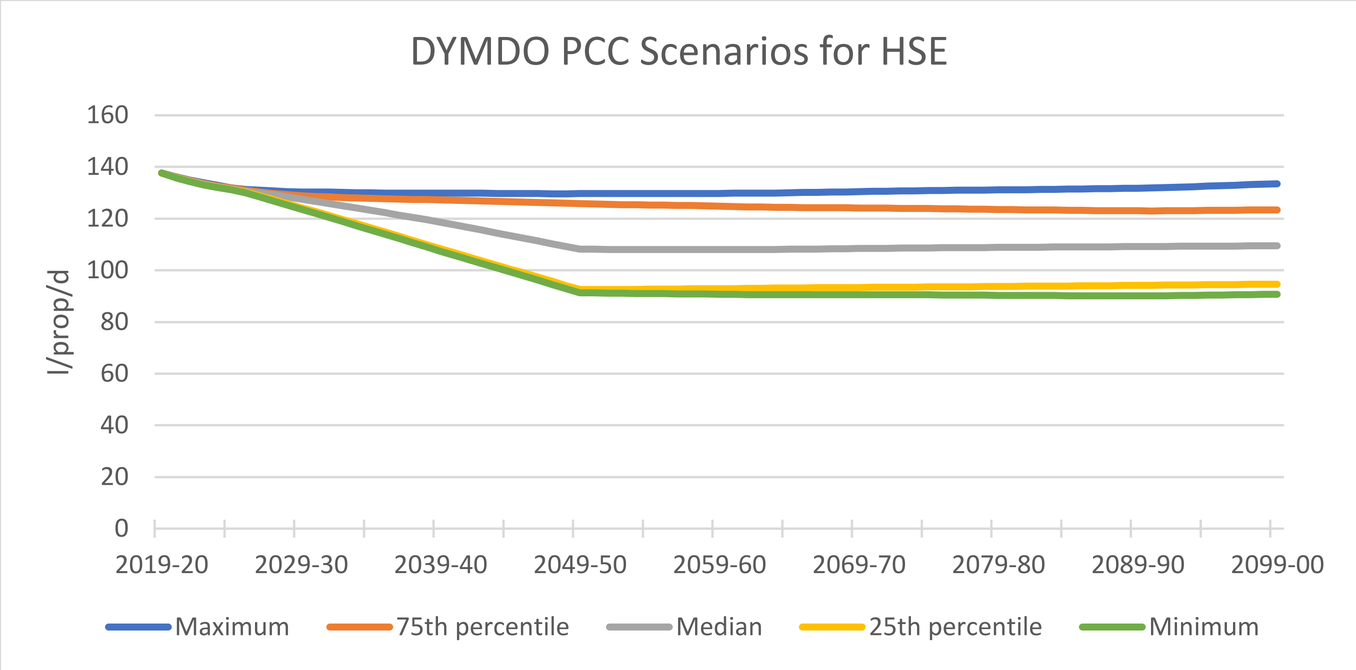


Figure 48: Range of DYMDO PCC results



B.6. Hampshire Southampton West (HSW)

Figure 49: Range of NYAA Distribution Input results

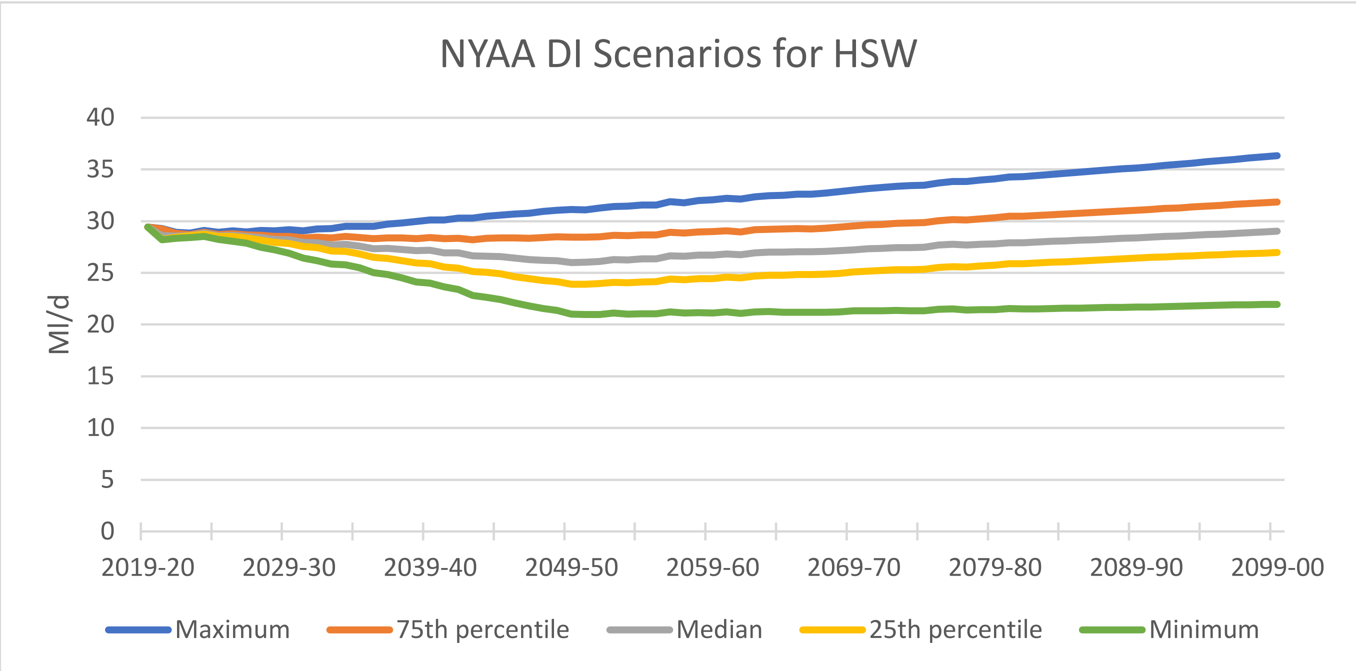


Figure 50: Range of DYAA Distribution Input results

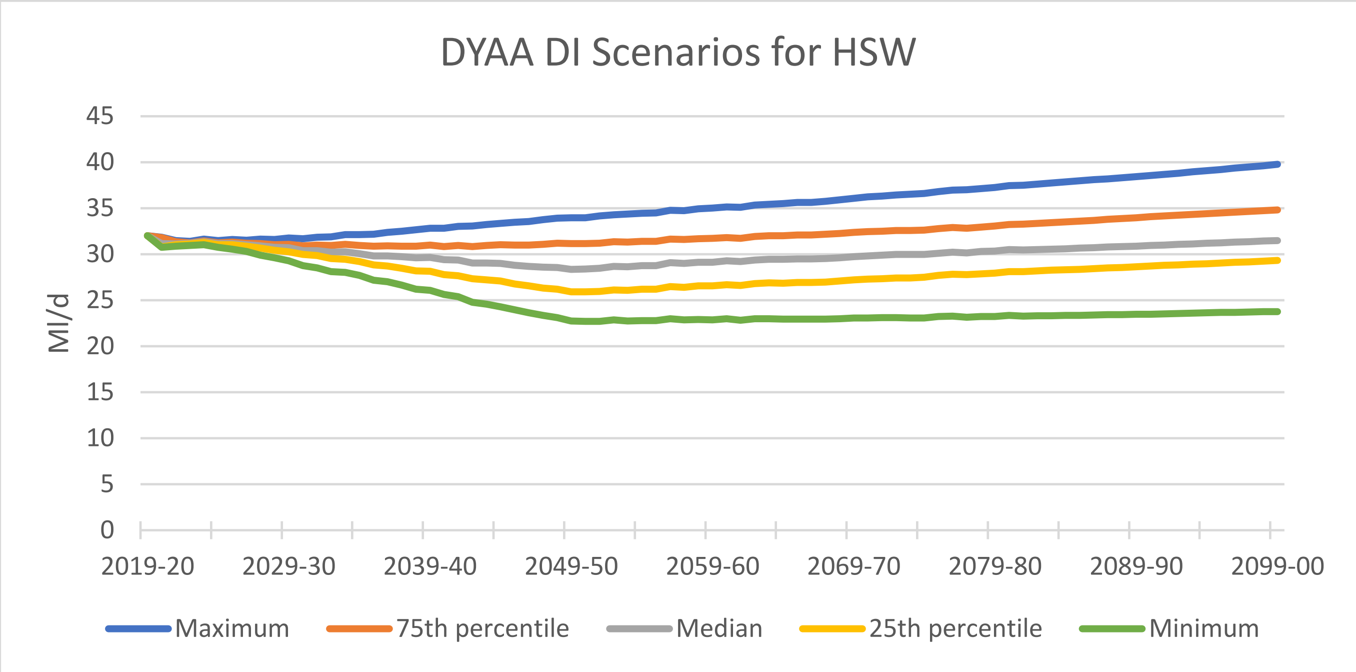


Figure 51: Range of DYCP Distribution Input results

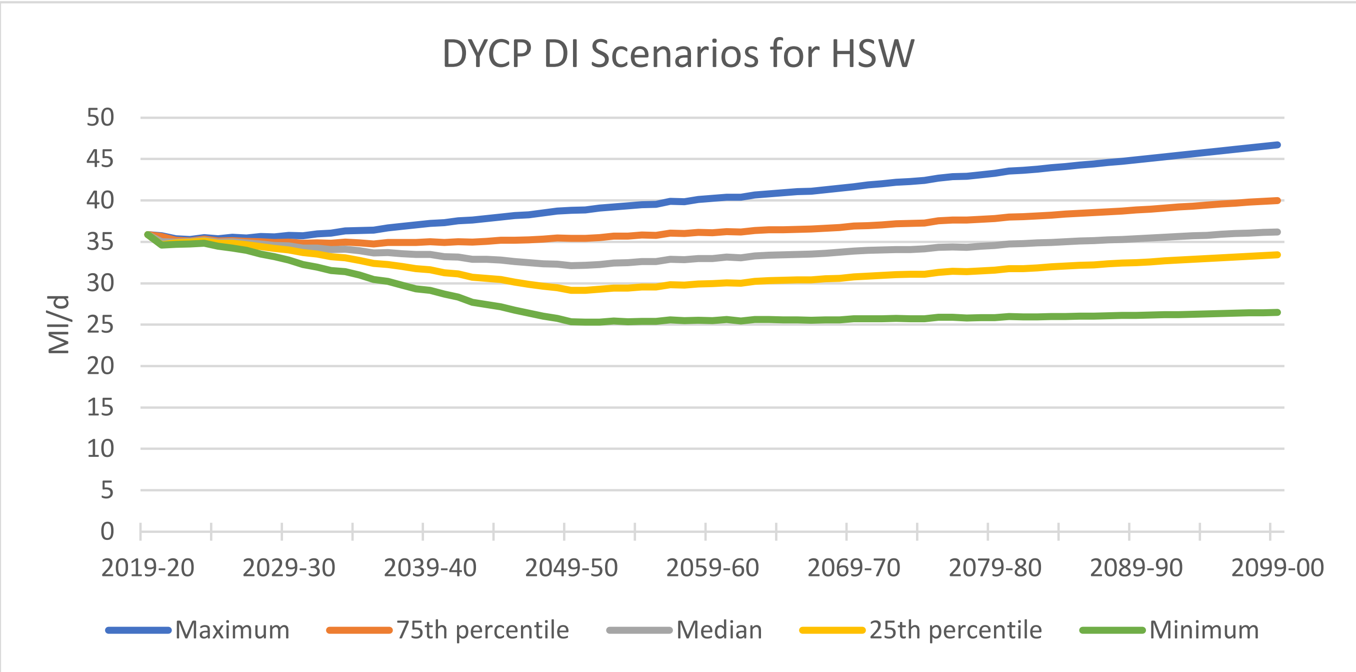


Figure 52: Range of DYMDO Distribution Input results

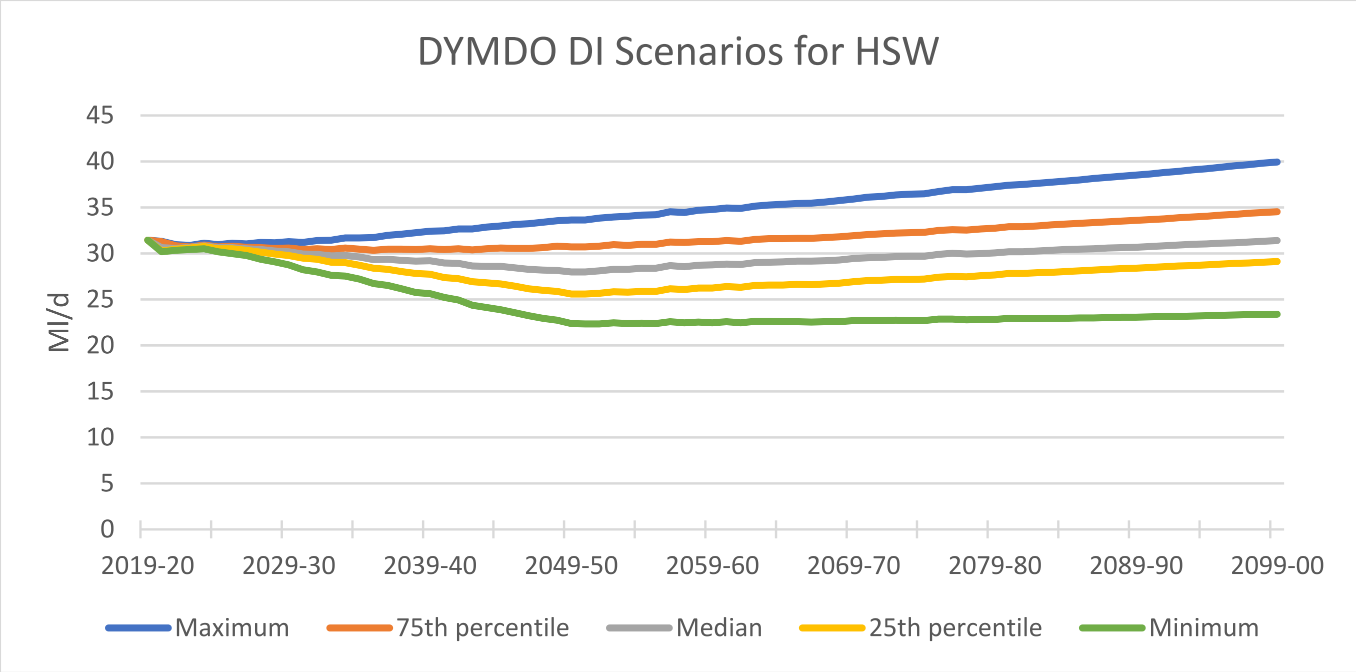


Figure 53: Range of NYAA PCC results

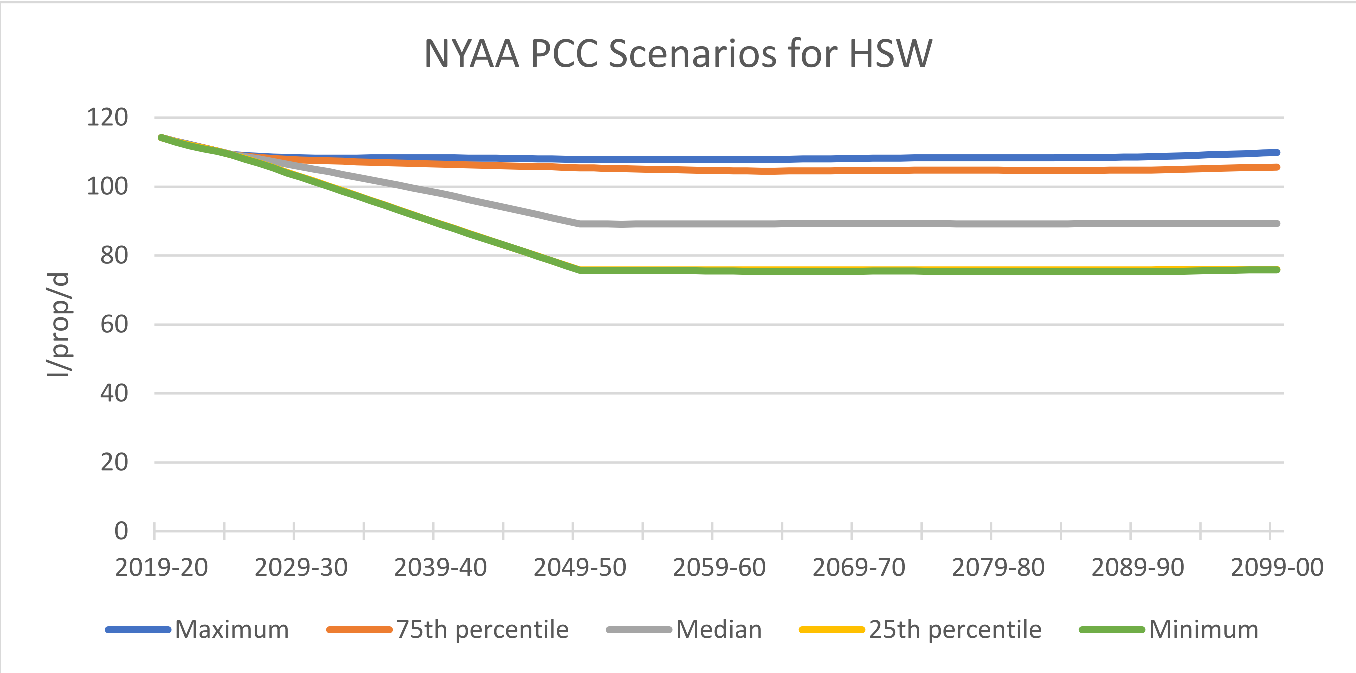


Figure 54: Range of DYAA PCC results

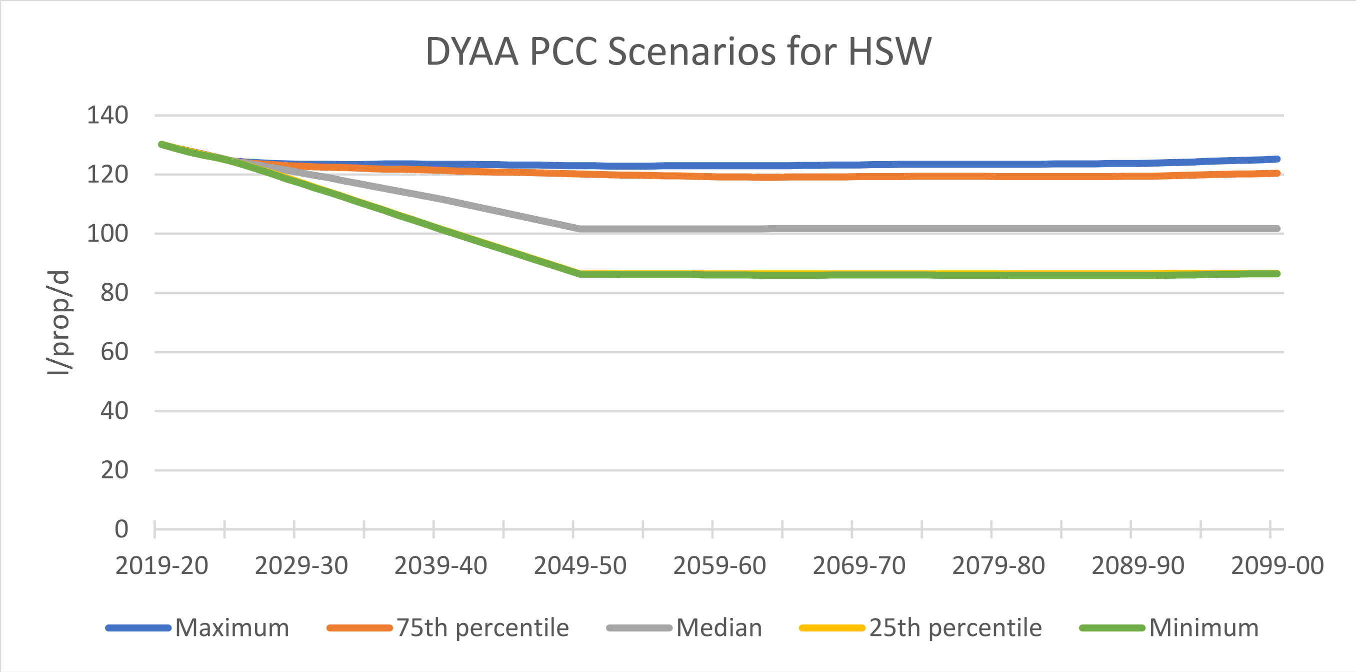


Figure 55: Range of DYCP PCC results

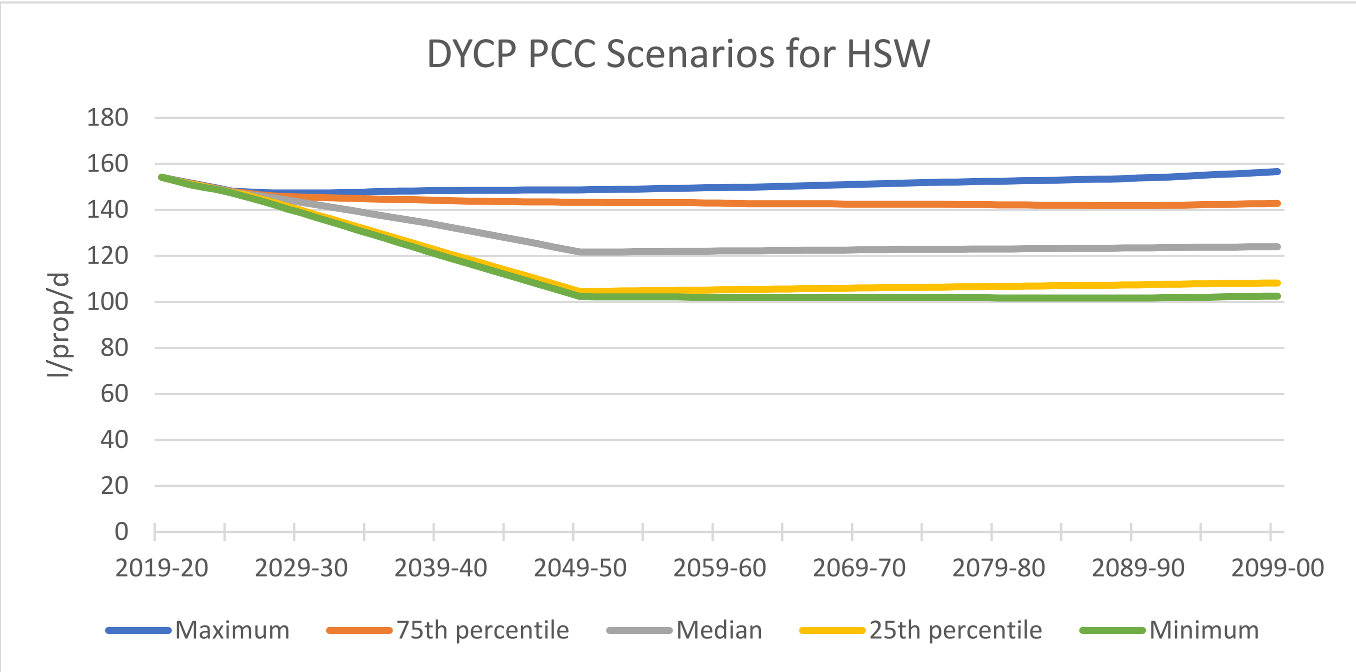
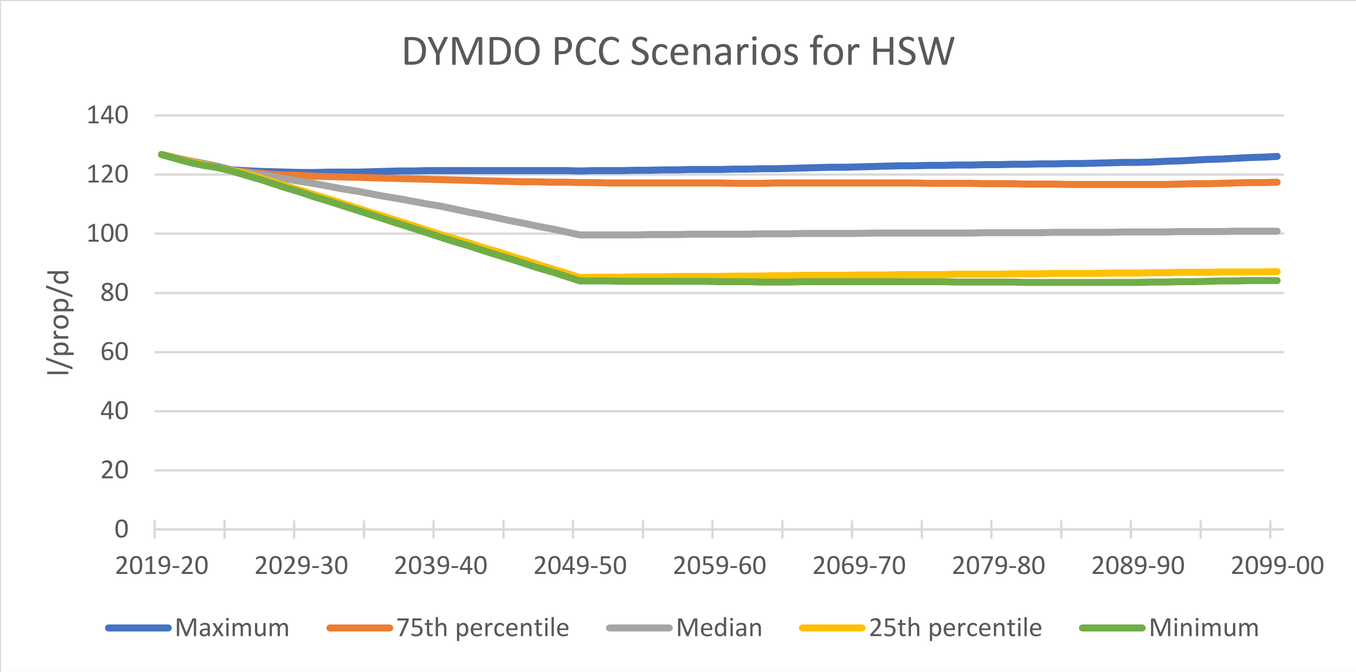


Figure 56: Range of DYMDO PCC results



B.7. Isle of Wight (IOW)

Figure 57: Range of NYAA Distribution Input results

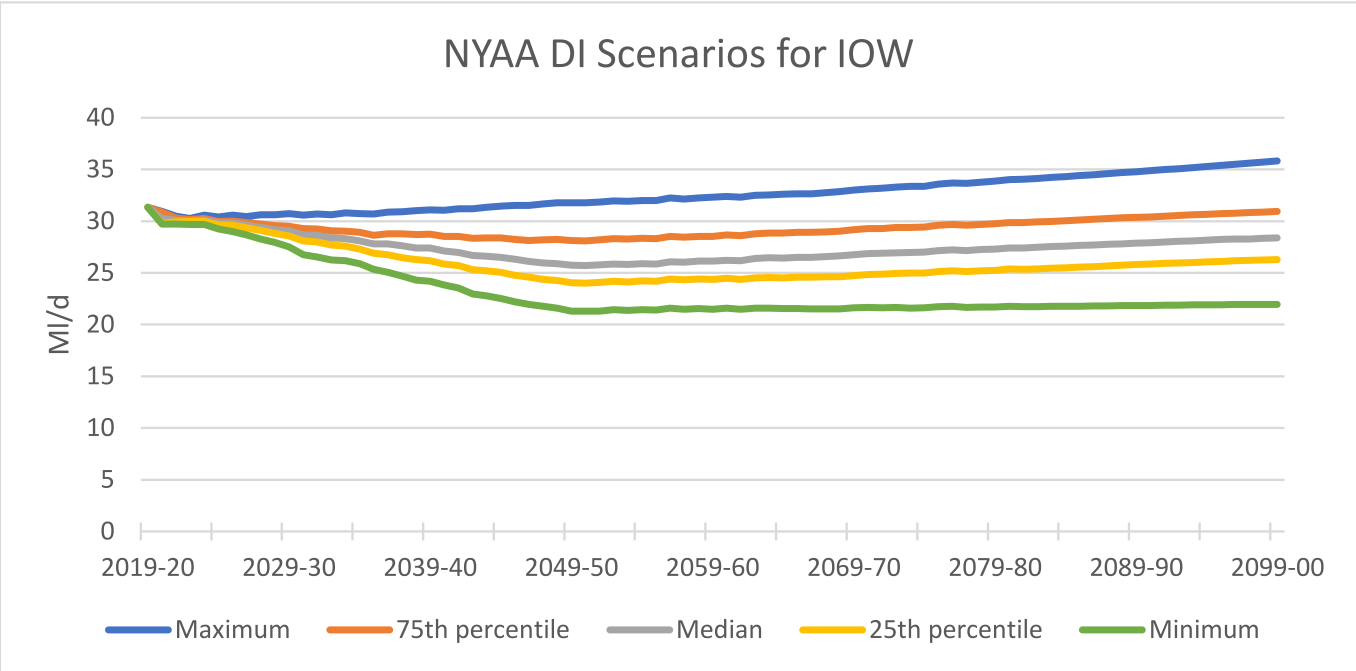


Figure 58: Range of DYAA Distribution Input results

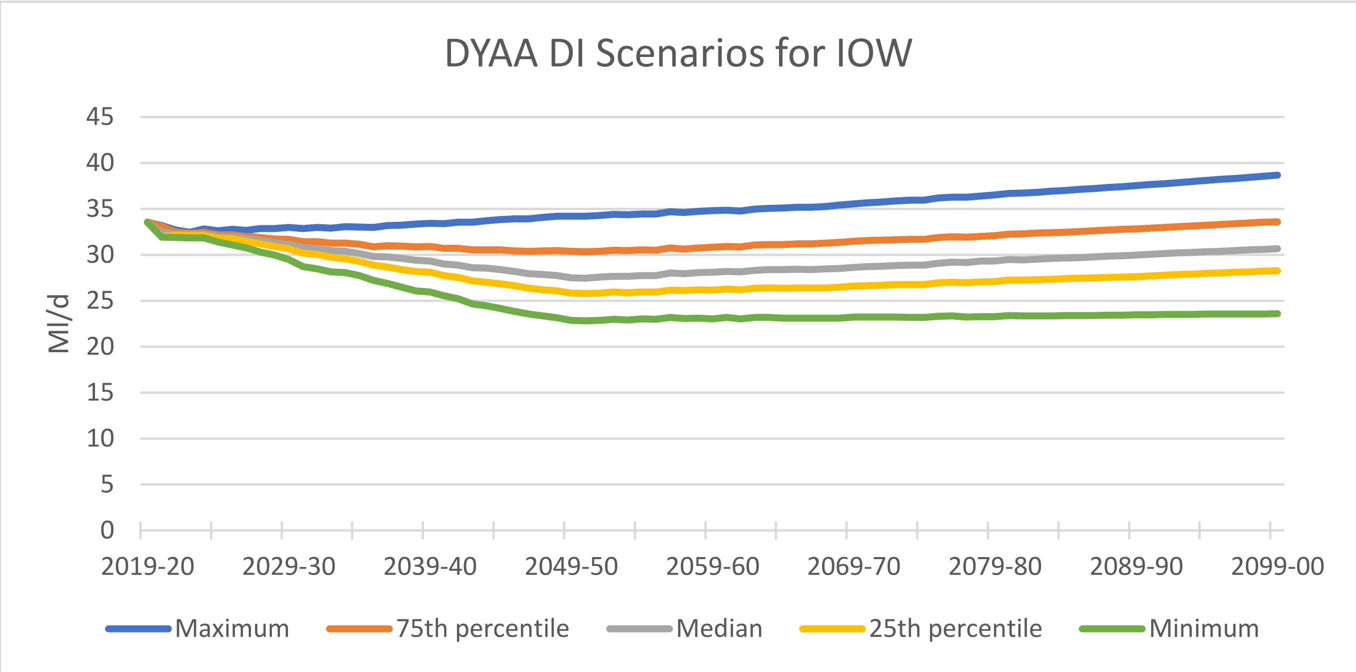


Figure 59: Range of DYCP Distribution Input results

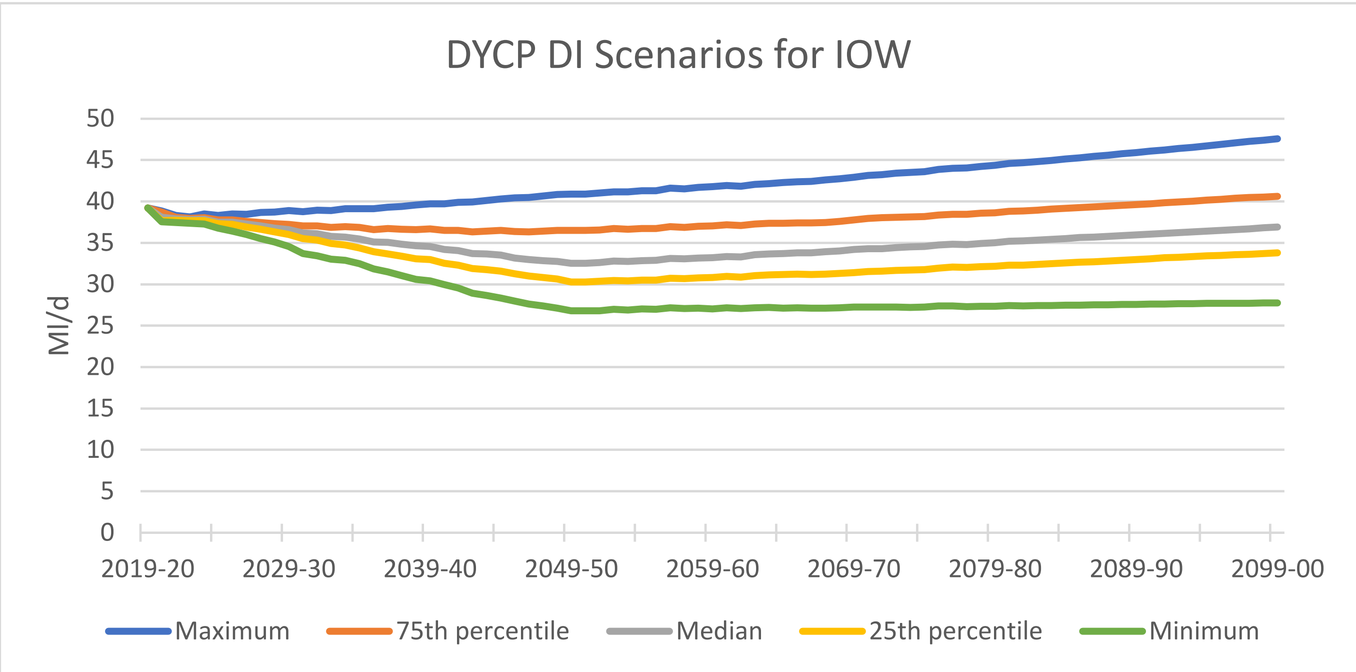


Figure 60: Range of DYMDO Distribution Input results

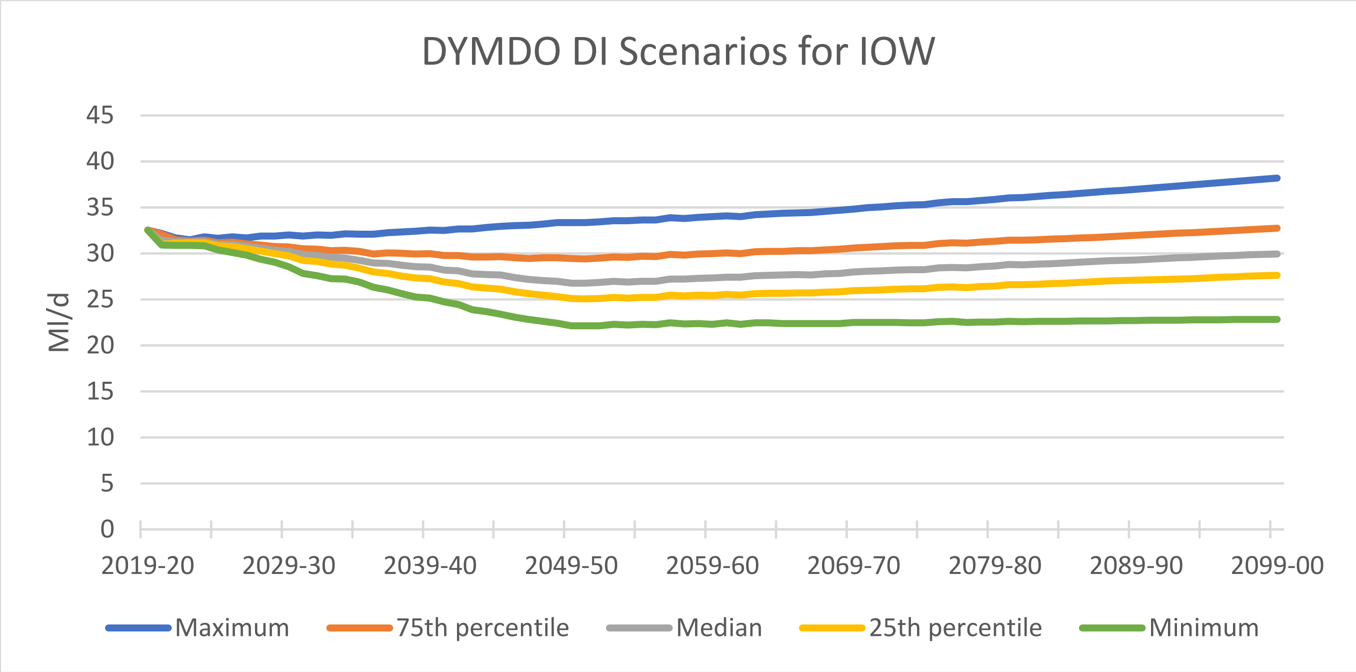


Figure 61: Range of NYAA PCC results

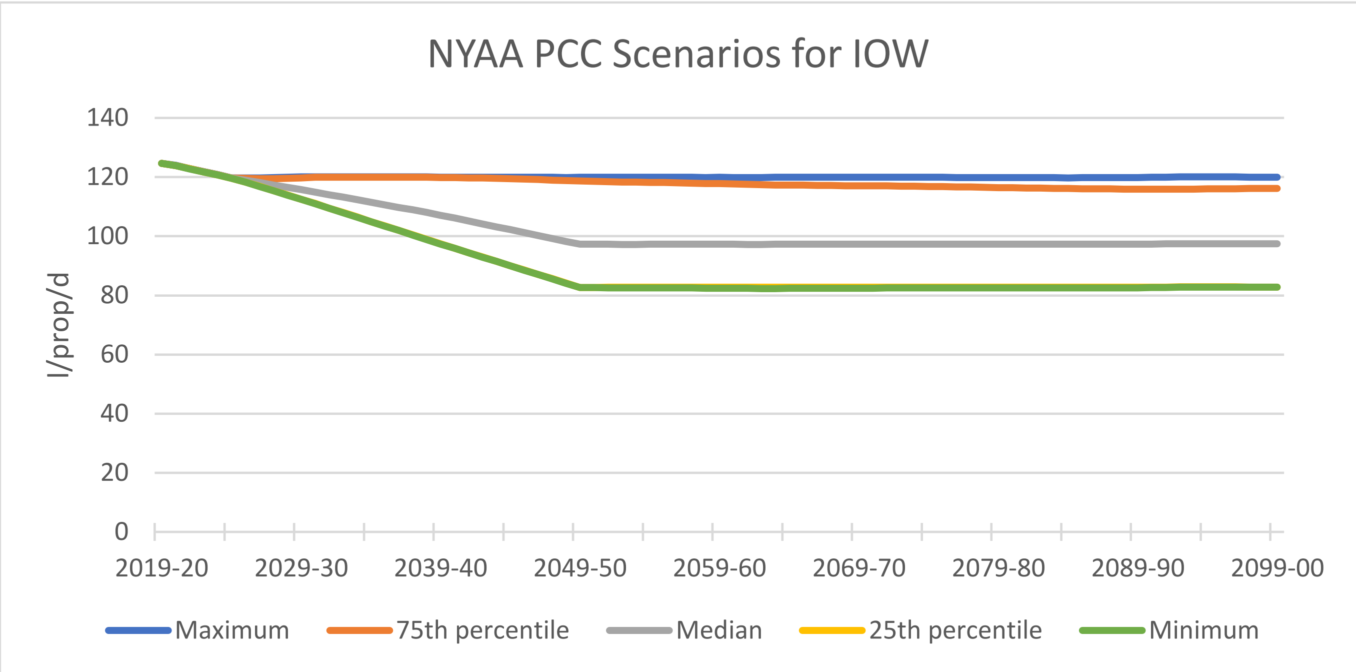


Figure 62: Range of DYAA PCC results

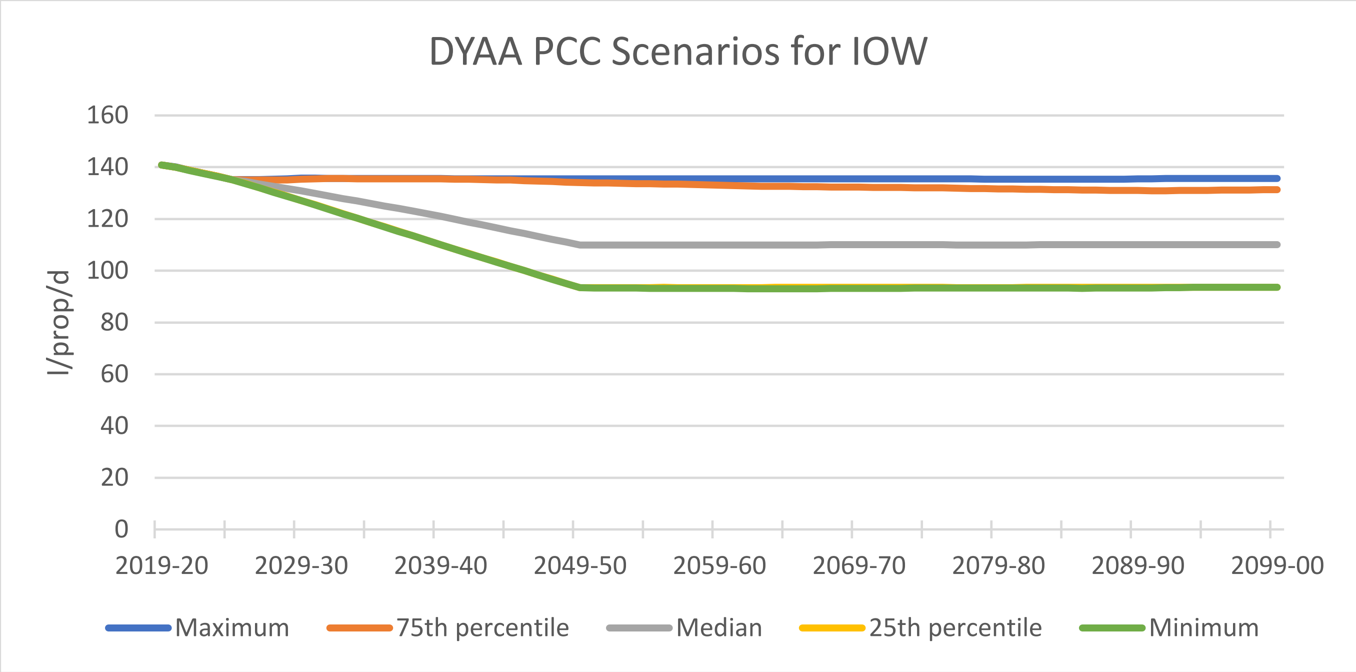


Figure 63: Range of DYCP PCC results

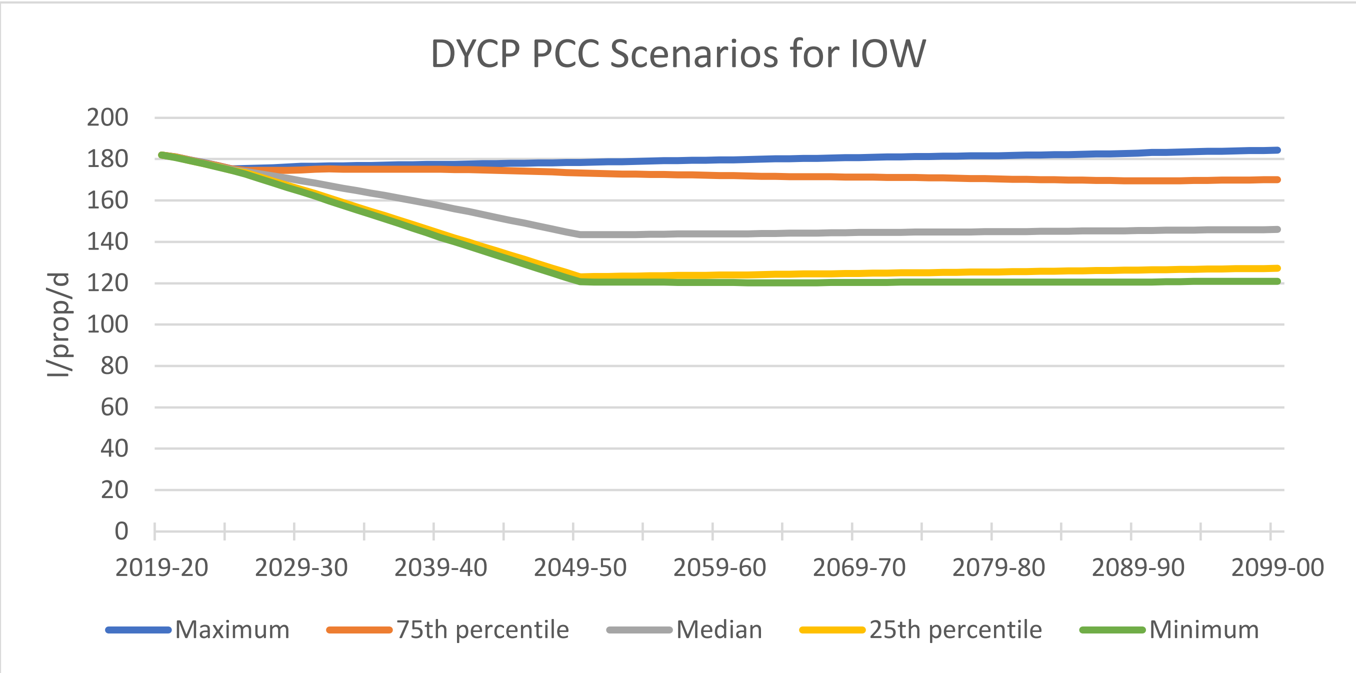
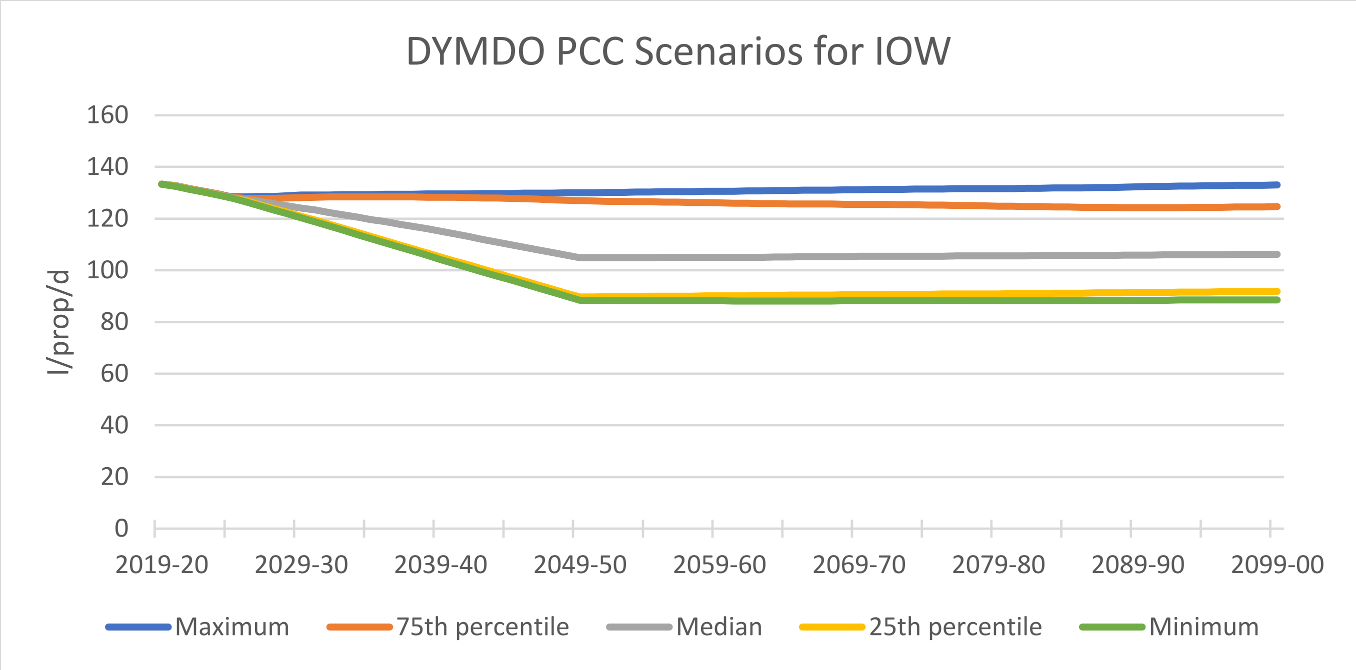


Figure 64: Range of DYMDO PCC results



B.8. Sussex North (SN)

Figure 65: Range of NYAA Distribution Input results

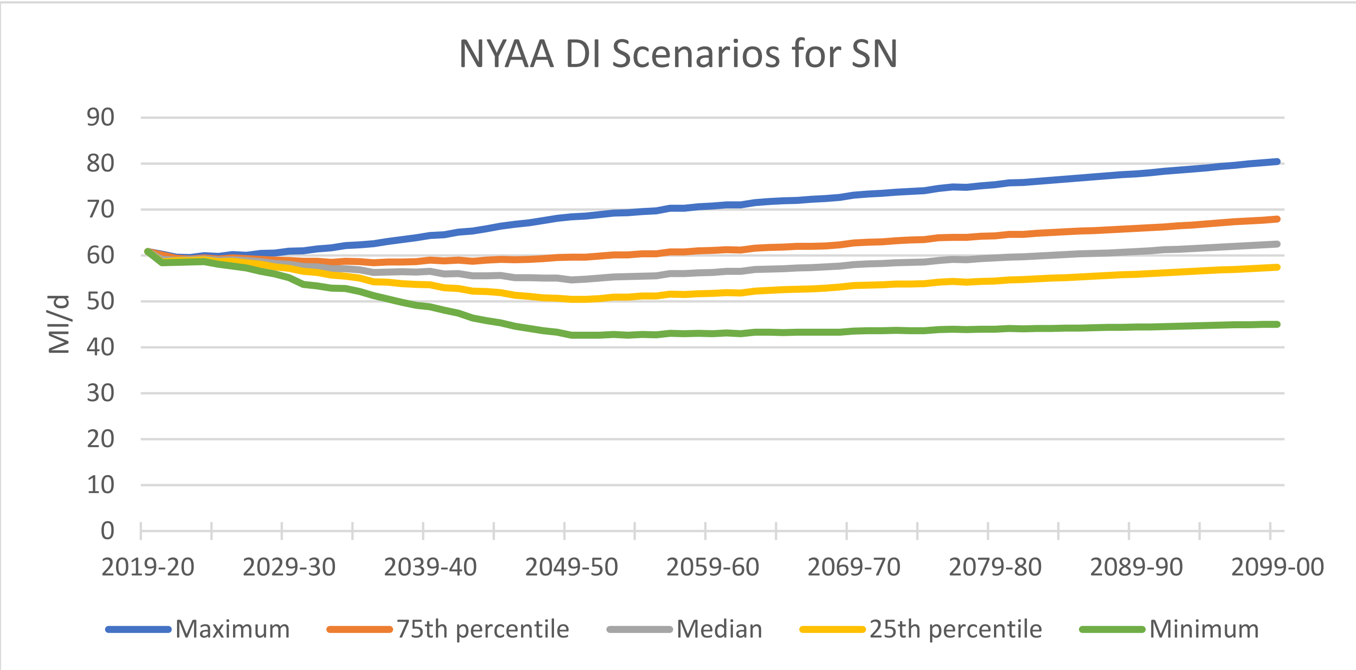


Figure 66: Range of DYAA Distribution Input results

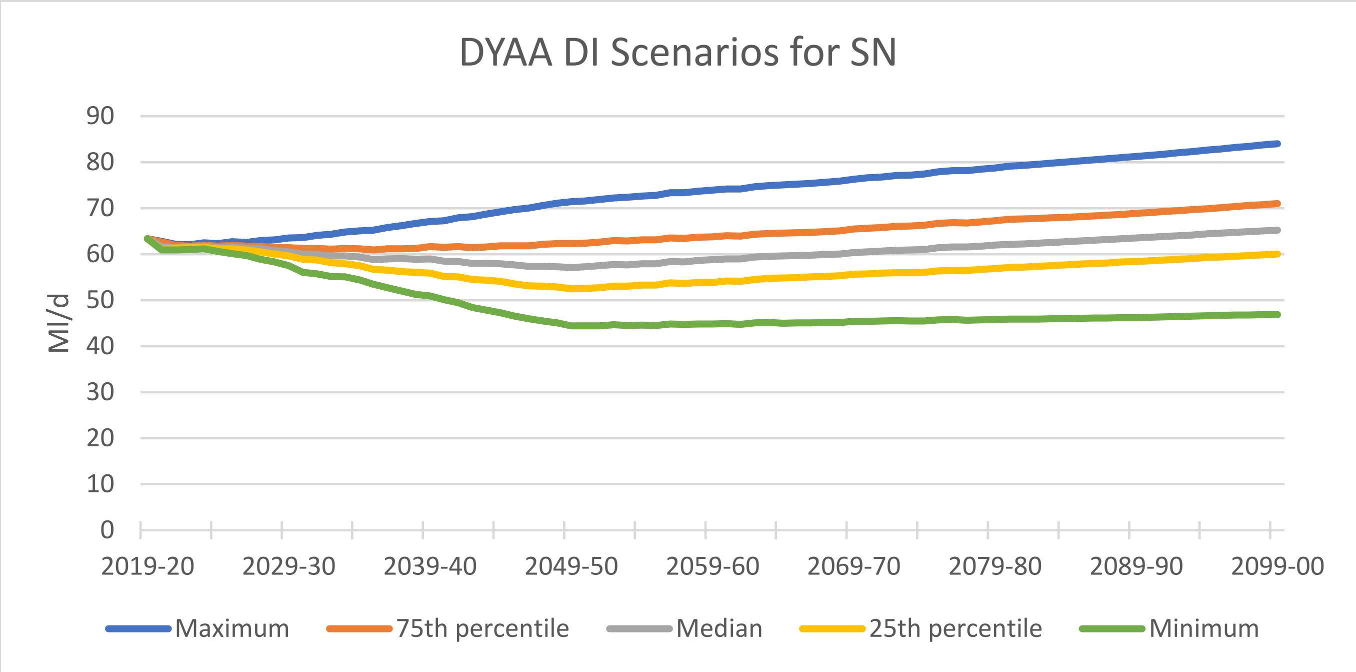


Figure 67: Range of DYCP Distribution Input results

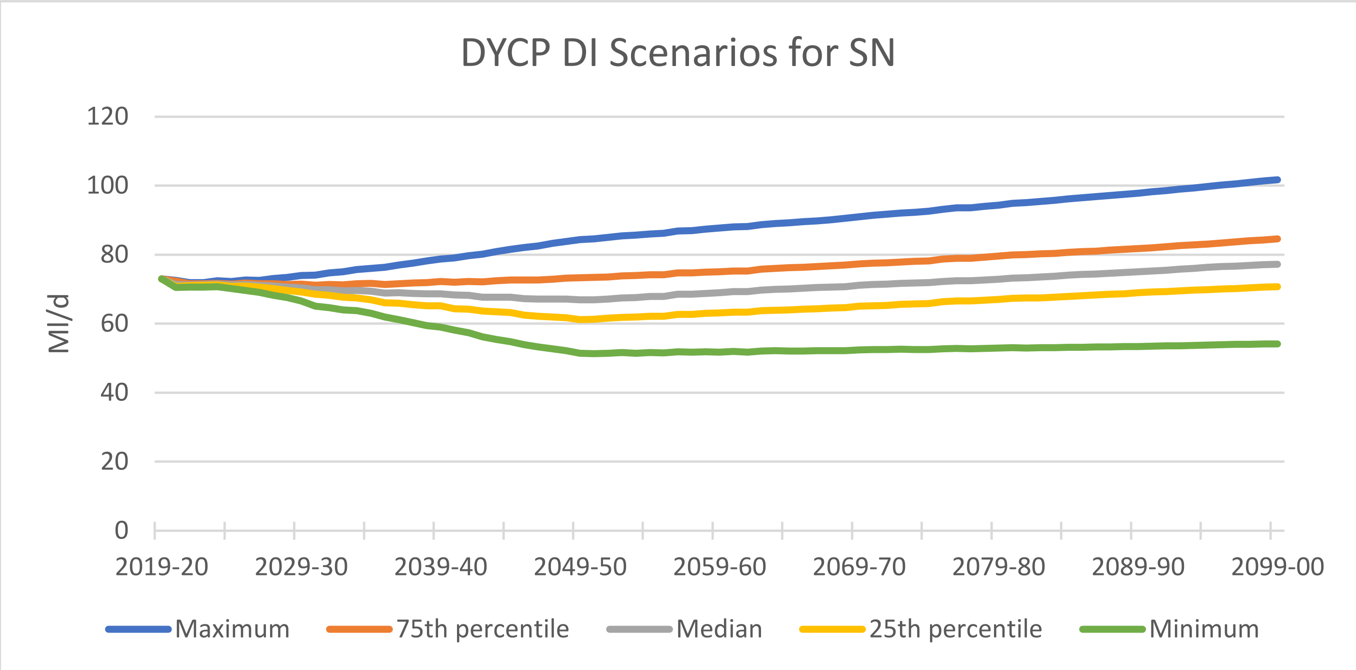


Figure 68: Range of DYMDO Distribution Input results

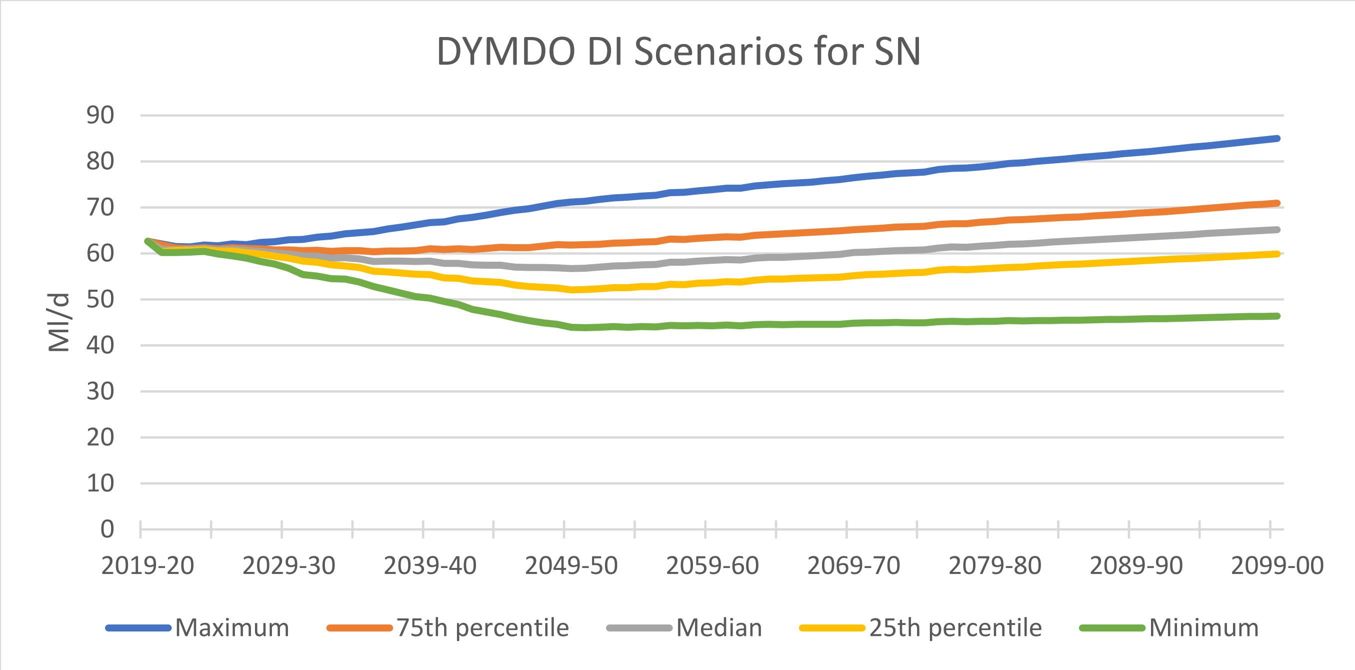


Figure 69: Range of NYAA PCC results

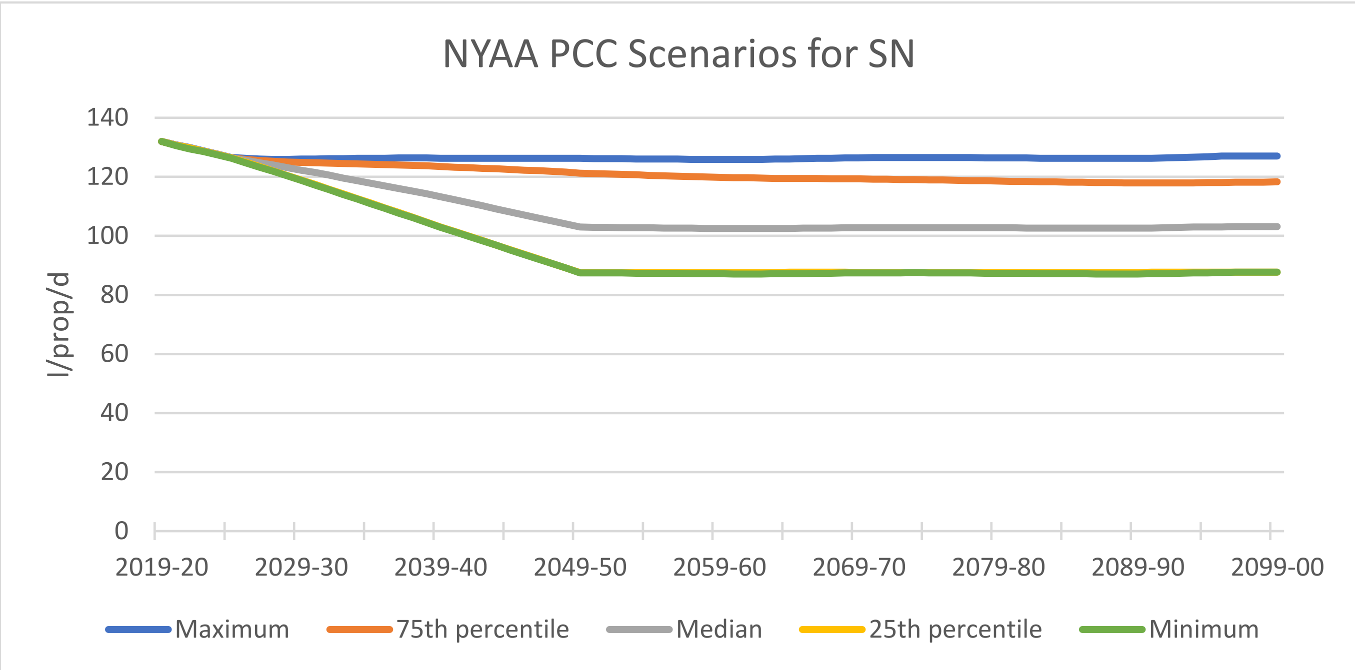


Figure 70: Range of DYAA PCC results

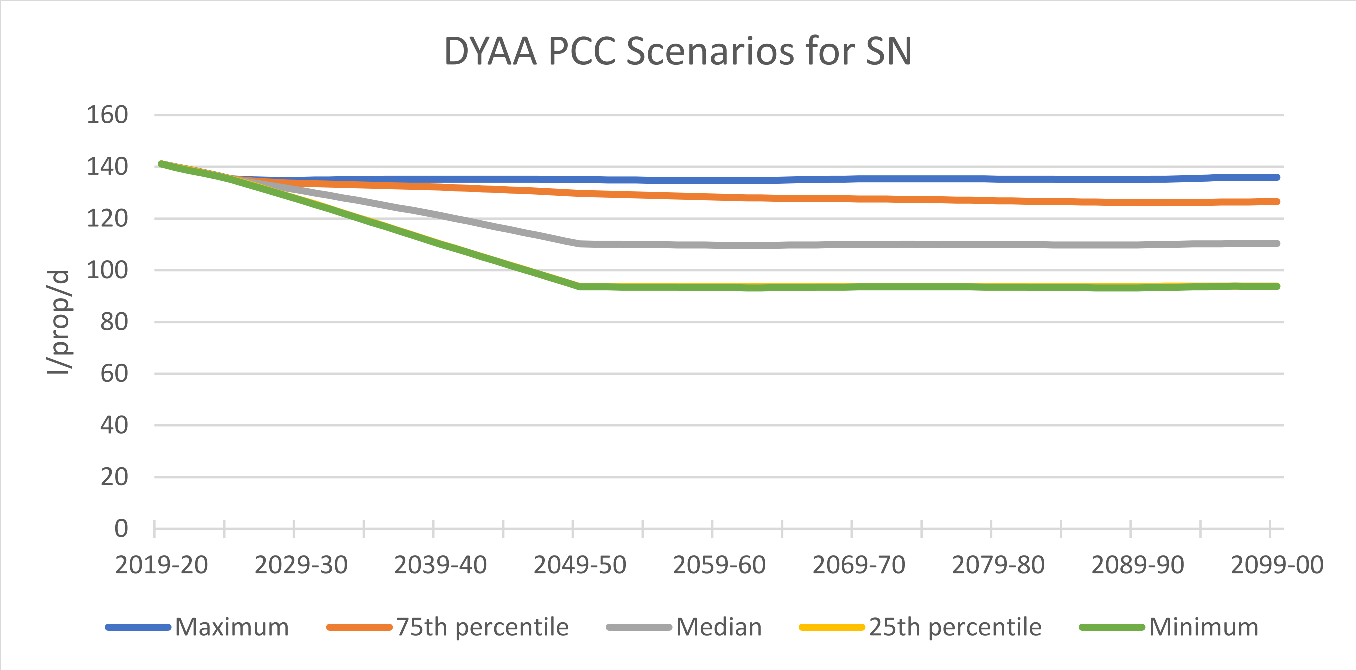


Figure 71: Range of DYCP PCC results

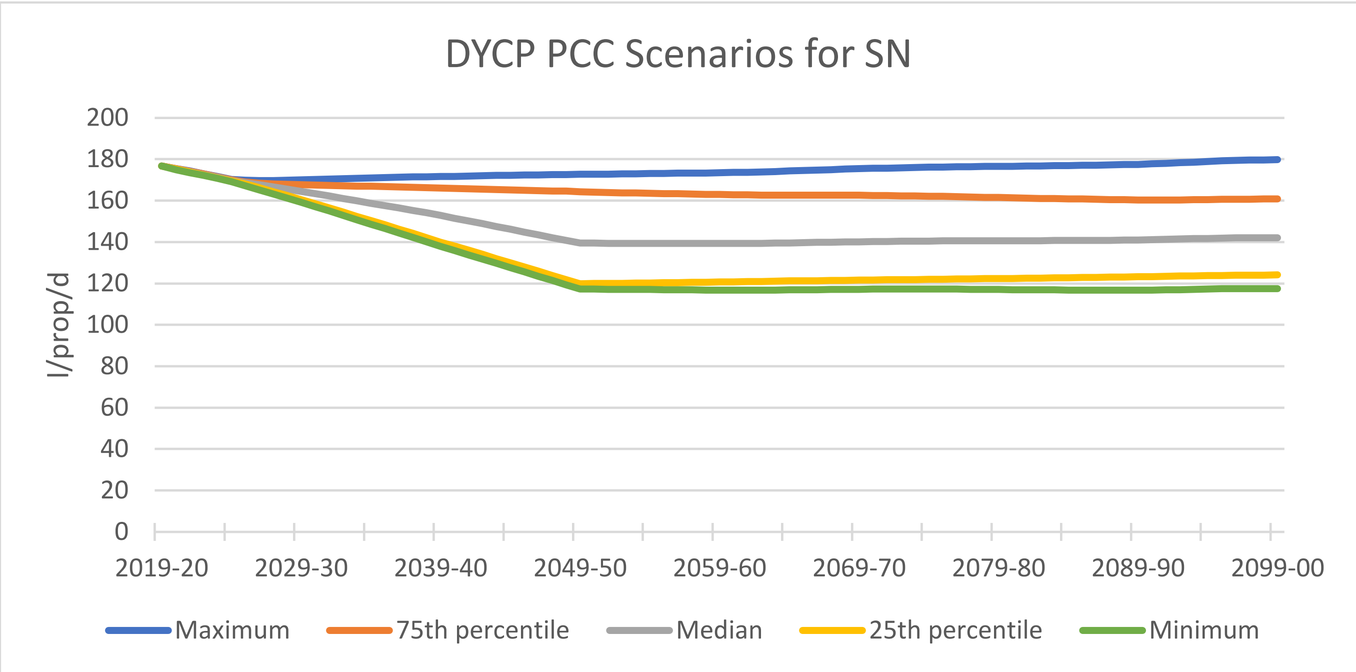
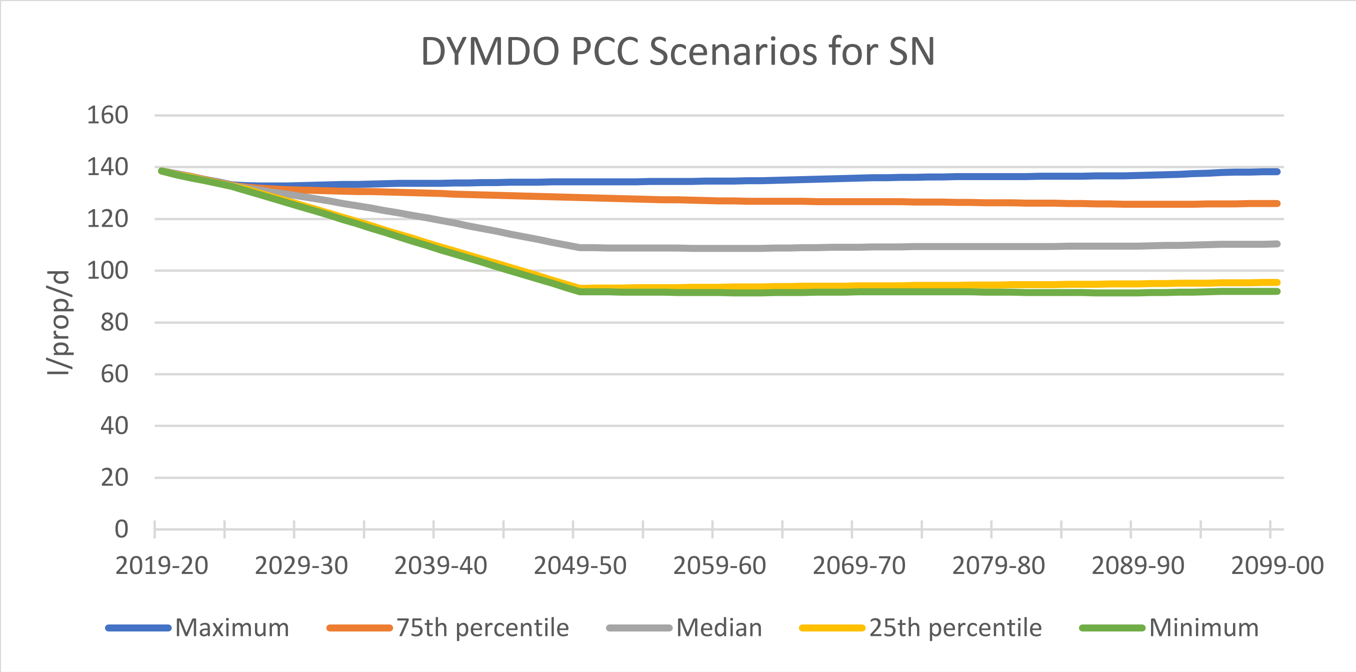


Figure 72: Range of DYMDO PCC results



B.9. Sussex Worthing (SW)

Figure 73: Range of NYAA Distribution Input results

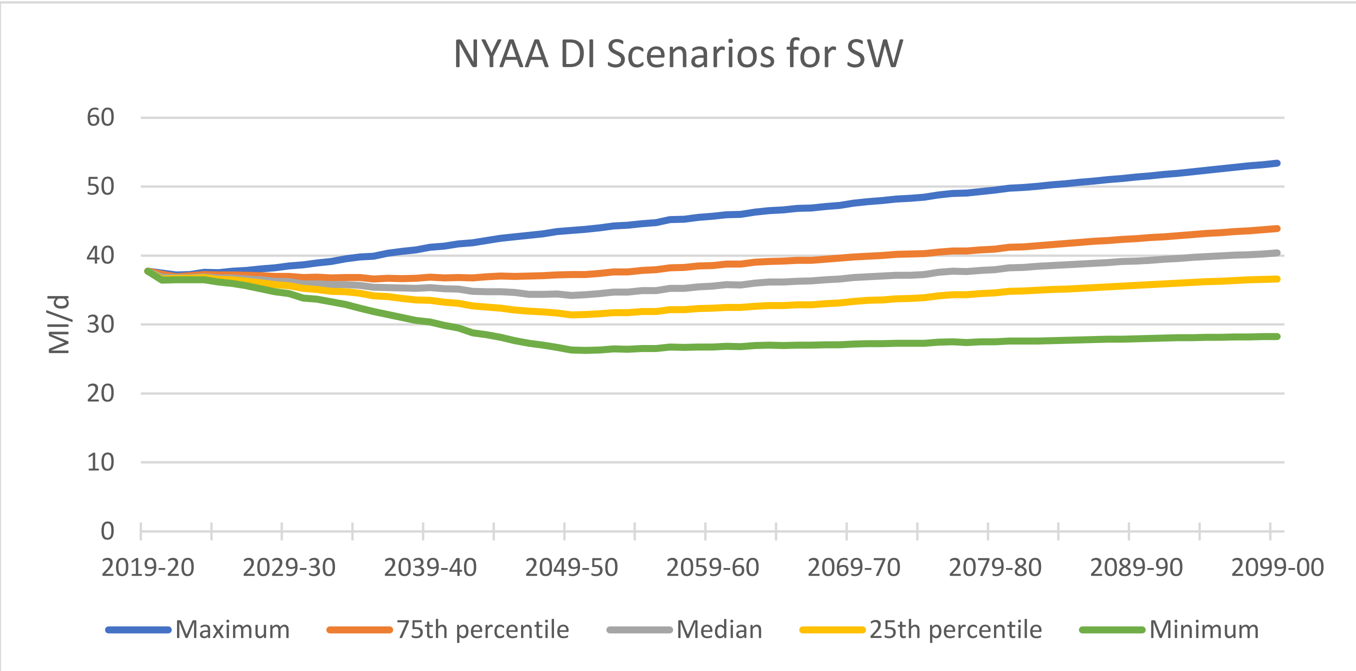


Figure 74: Range of DYAA Distribution Input results

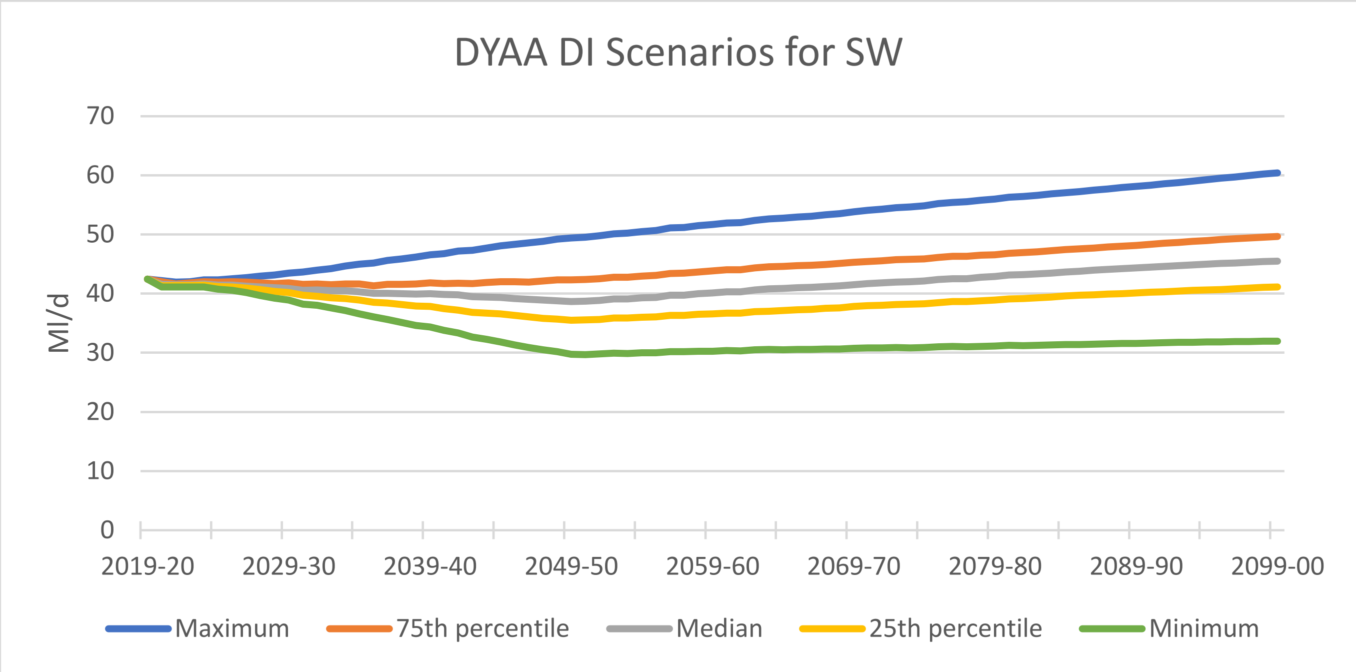


Figure 75: Range of DYCP Distribution Input results

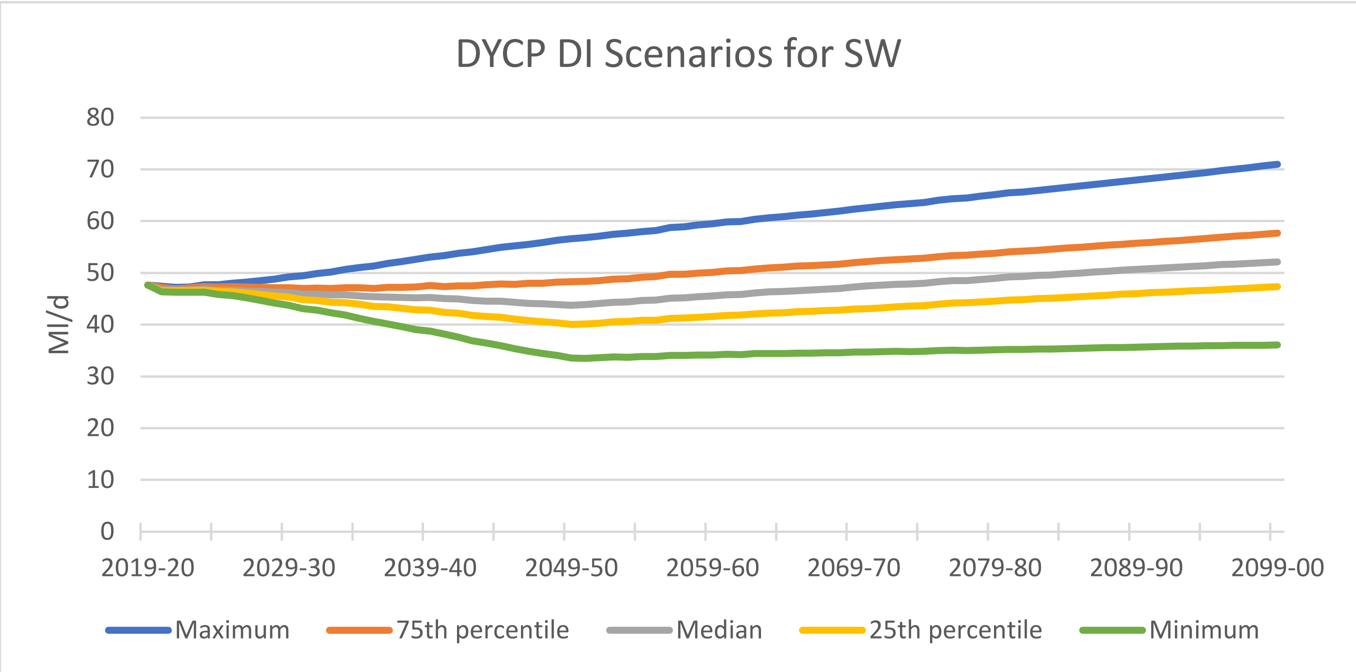


Figure 76: Range of DYMDO Distribution Input results

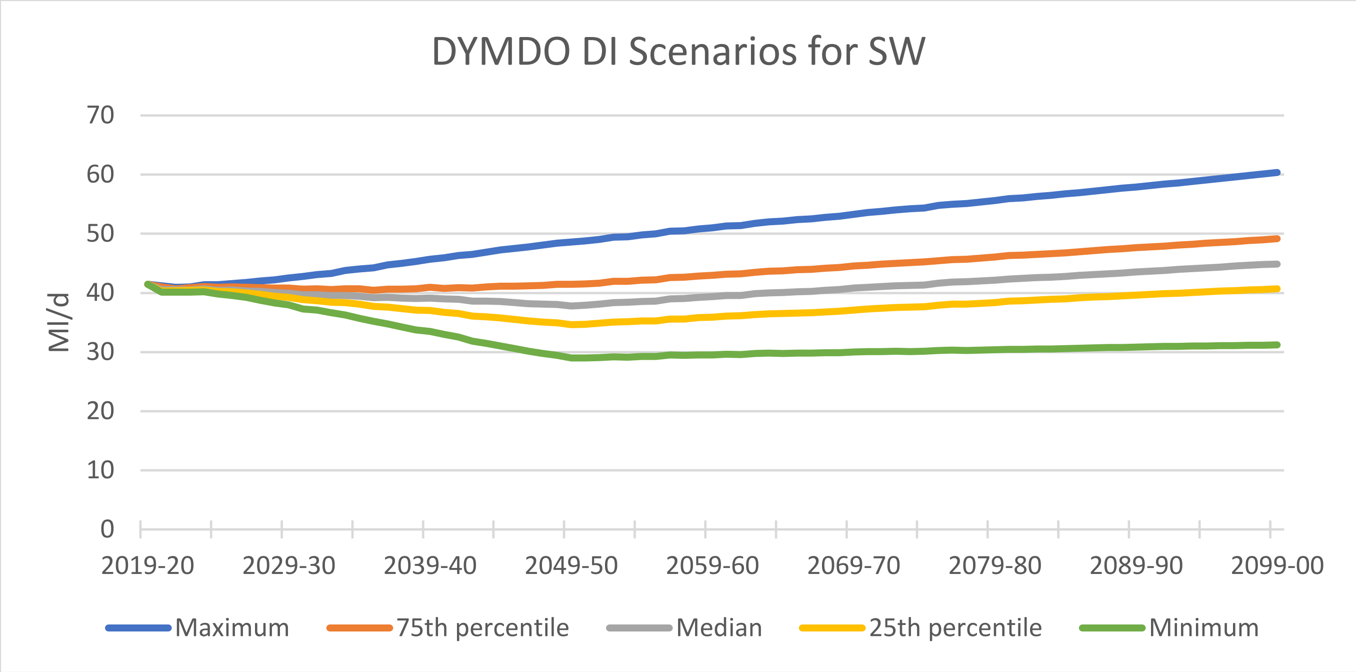


Figure 77: Range of NYAA PCC results

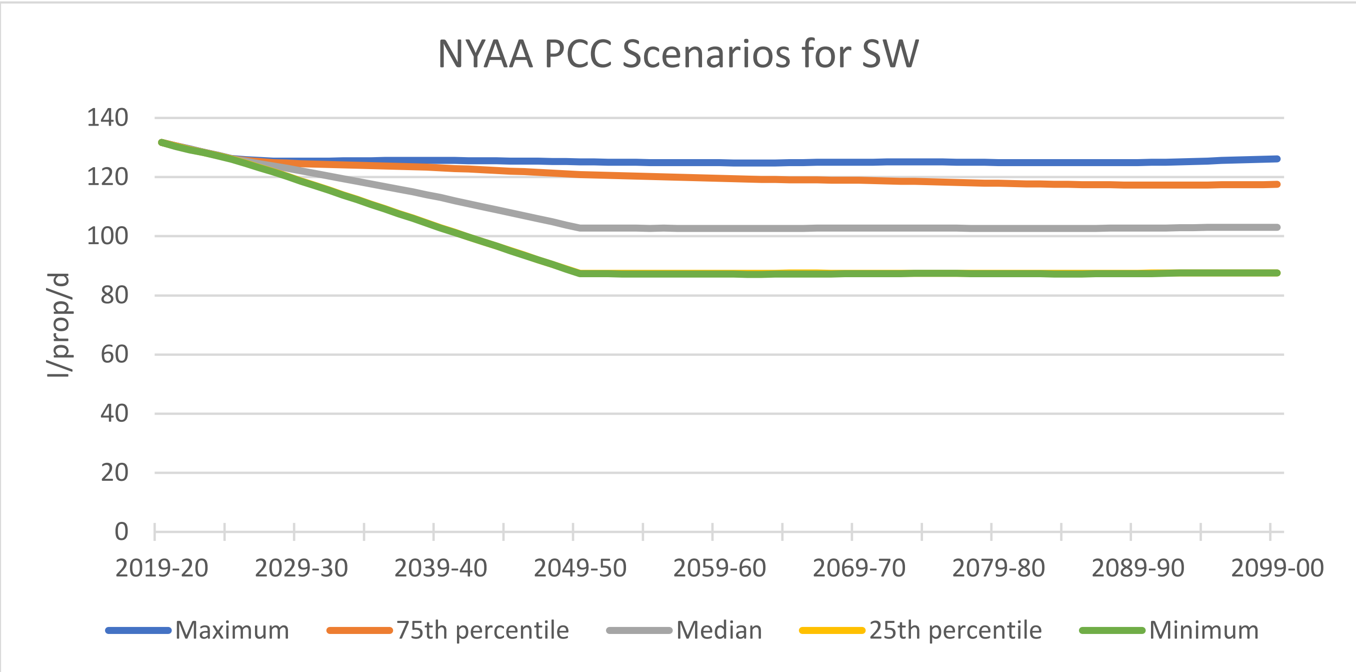


Figure 78: Range of DYAA PCC results

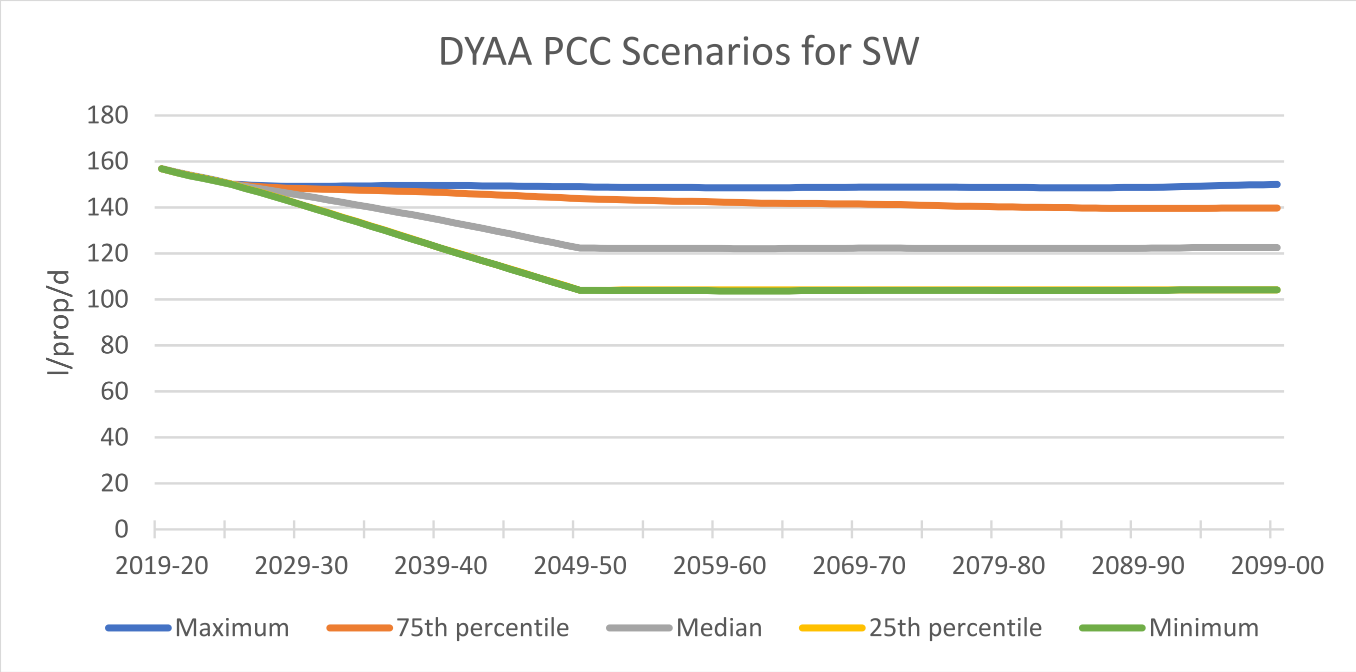


Figure 79: Range of DYCP PCC results

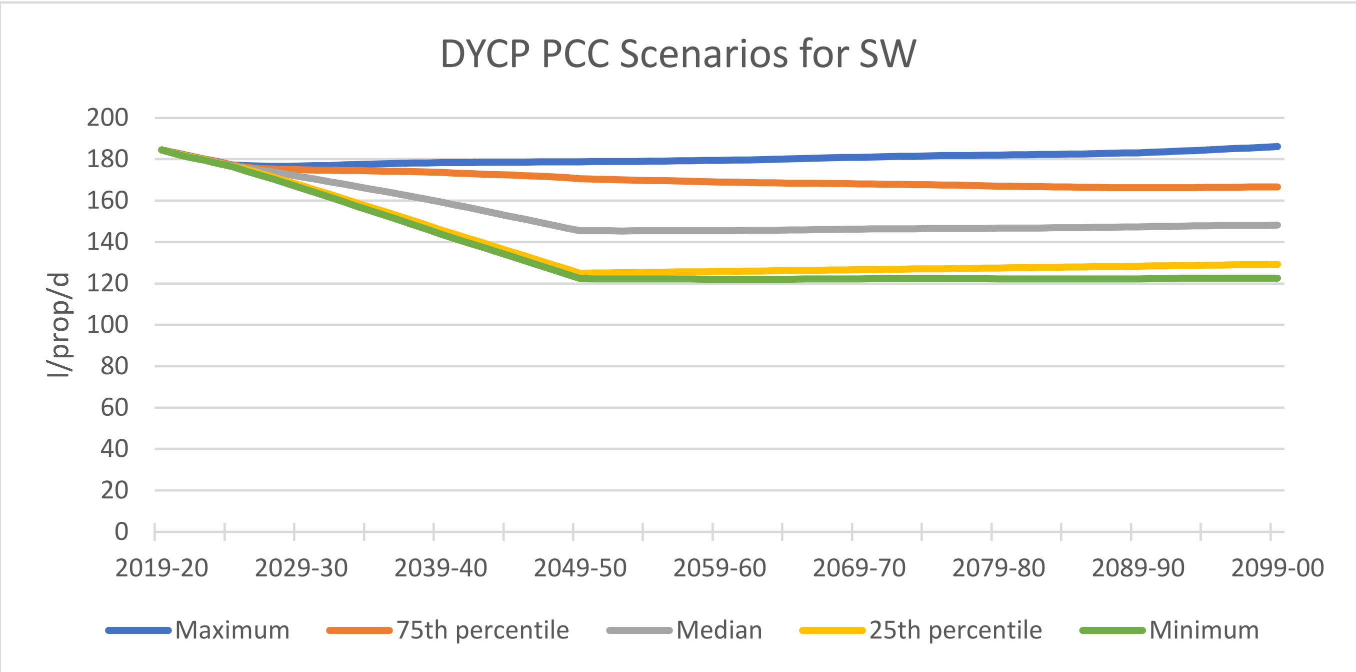
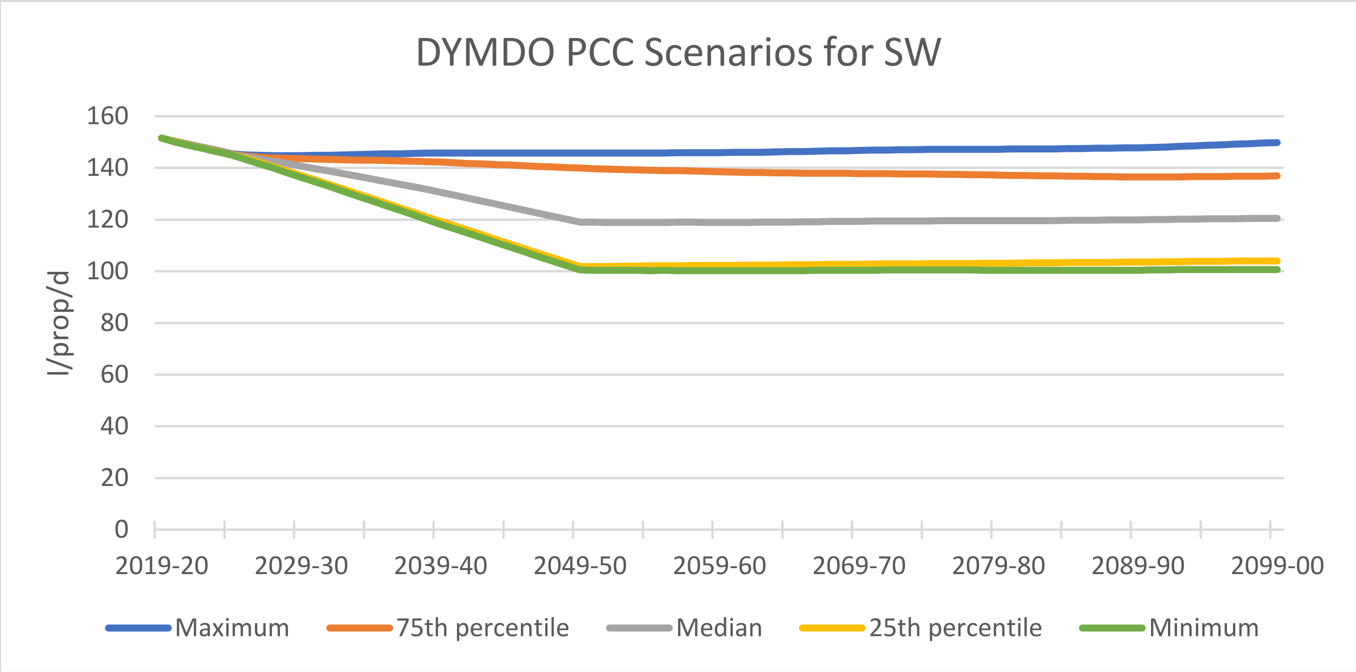


Figure 80: Range of DYMDO PCC results



B.10. Sussex Brighton (SB)

Figure 81: Range of NYAA Distribution Input results

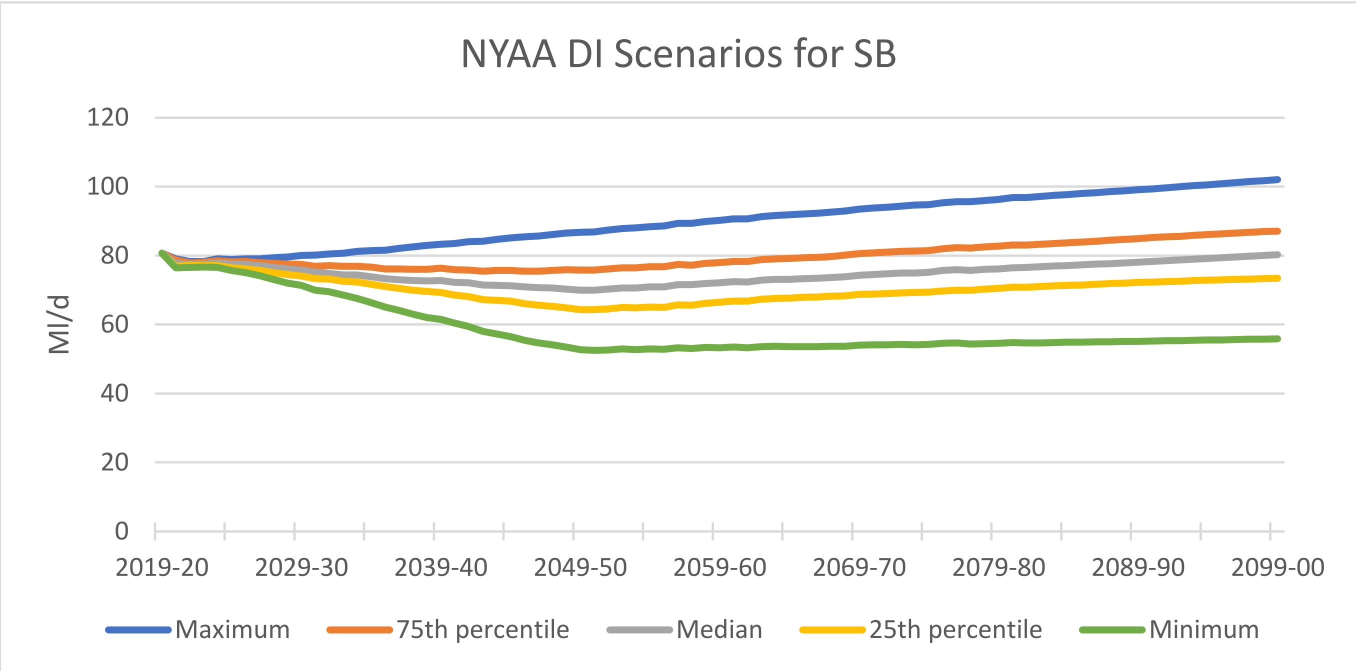


Figure 82: Range of DYAA Distribution Input results

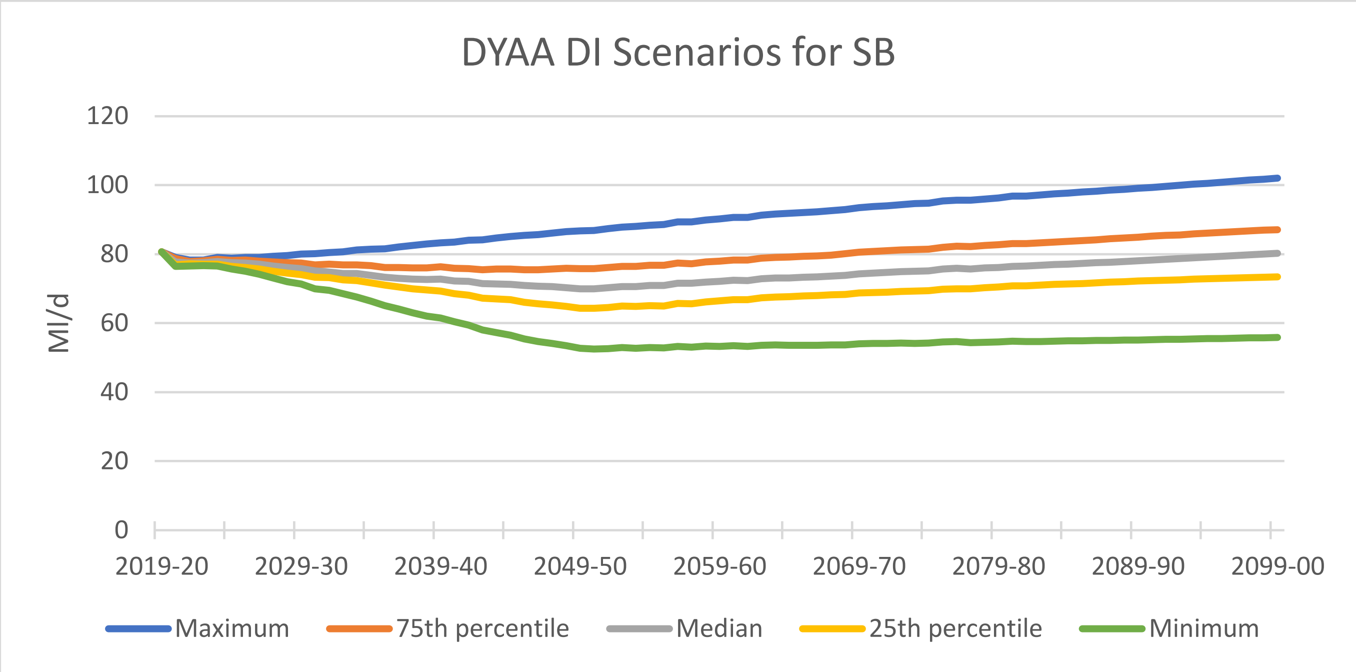


Figure 83: Range of DYCP Distribution Input results

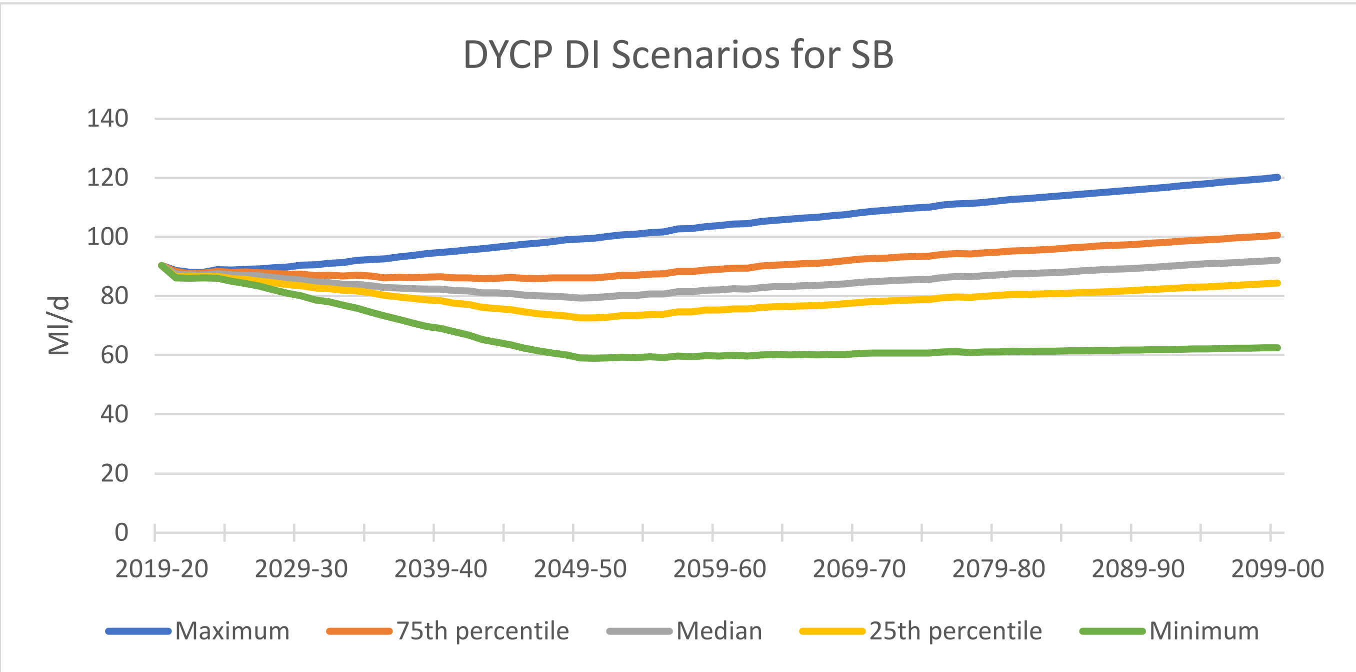


Figure 84: Range of DYMDO Distribution Input results

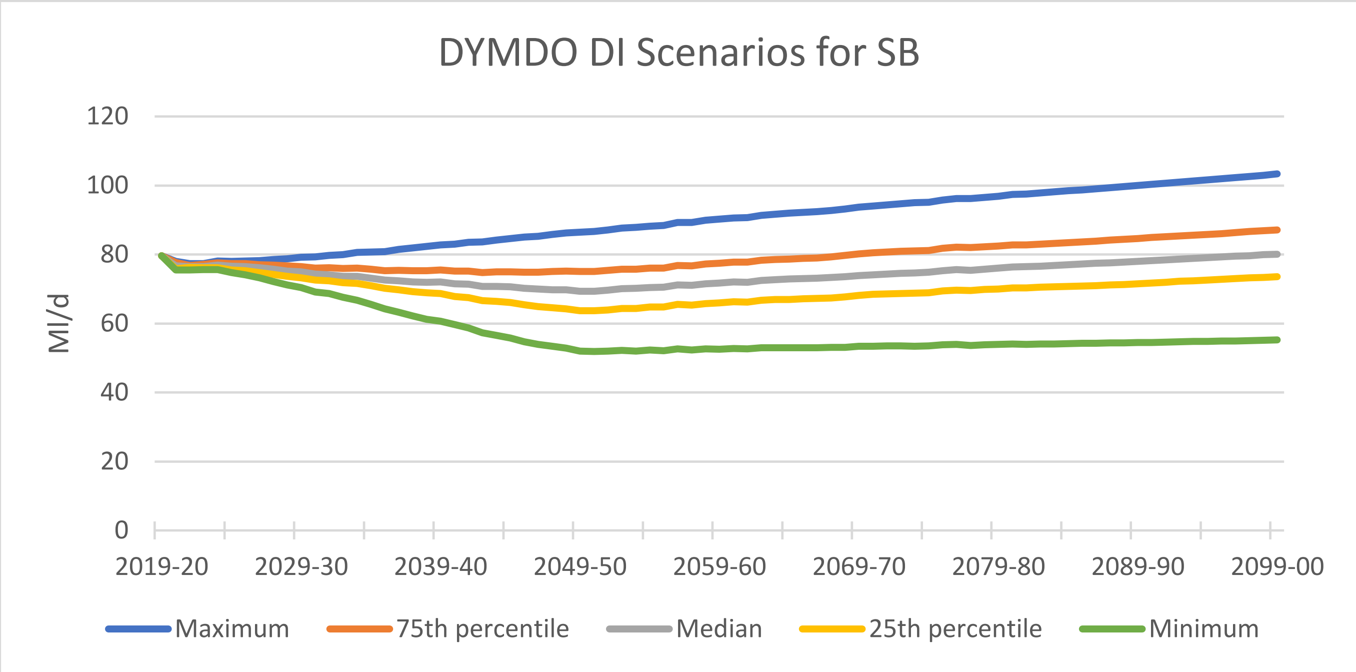


Figure 85: Range of NYAA PCC results

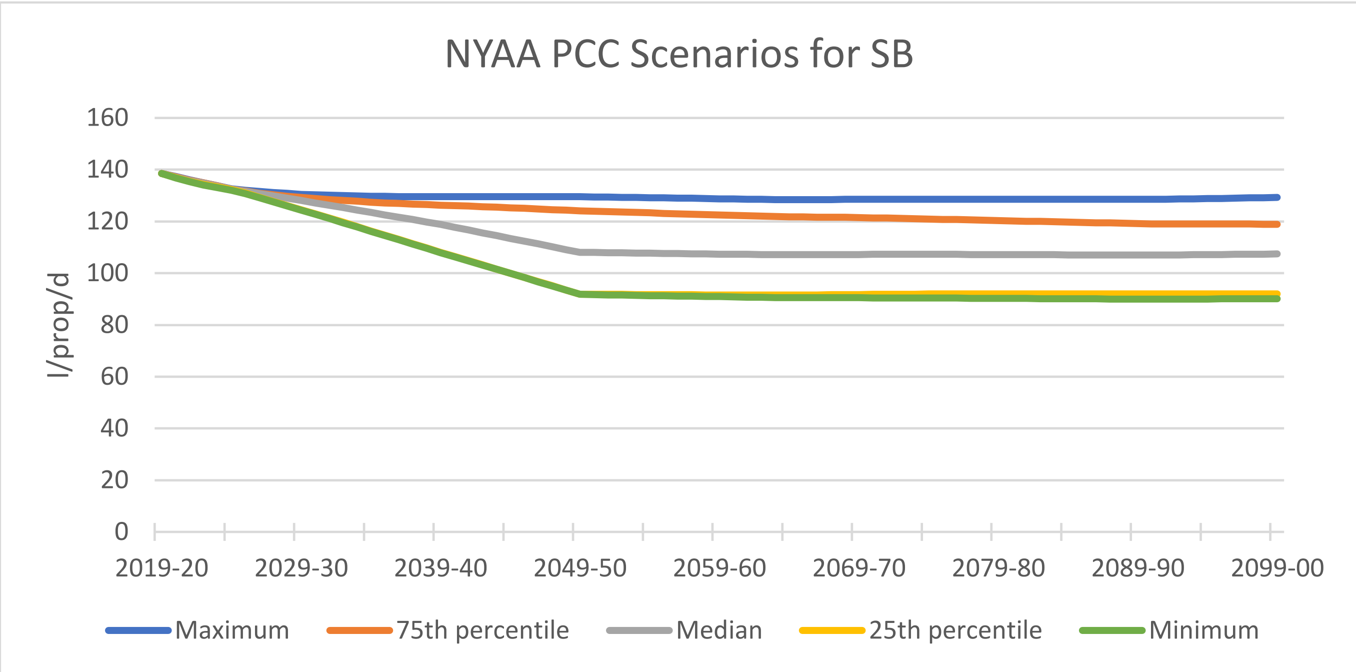


Figure 86: Range of DYAA PCC results

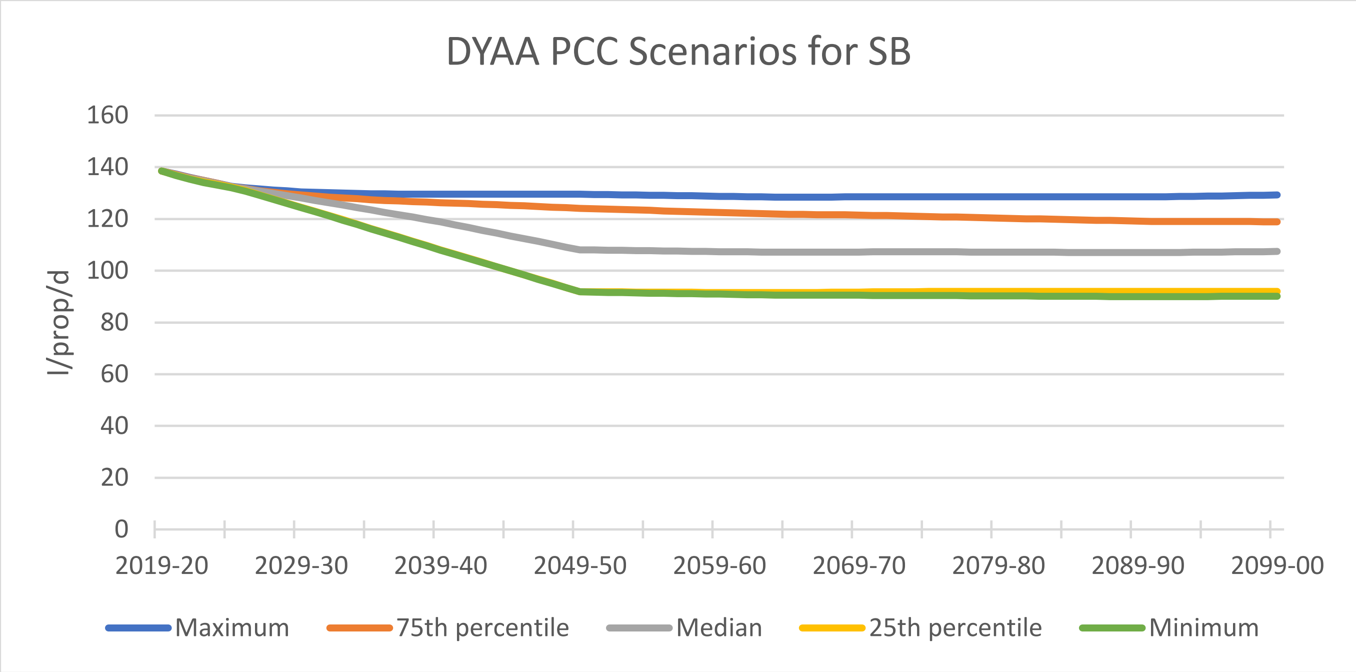


Figure 87: Range of DYCP PCC results

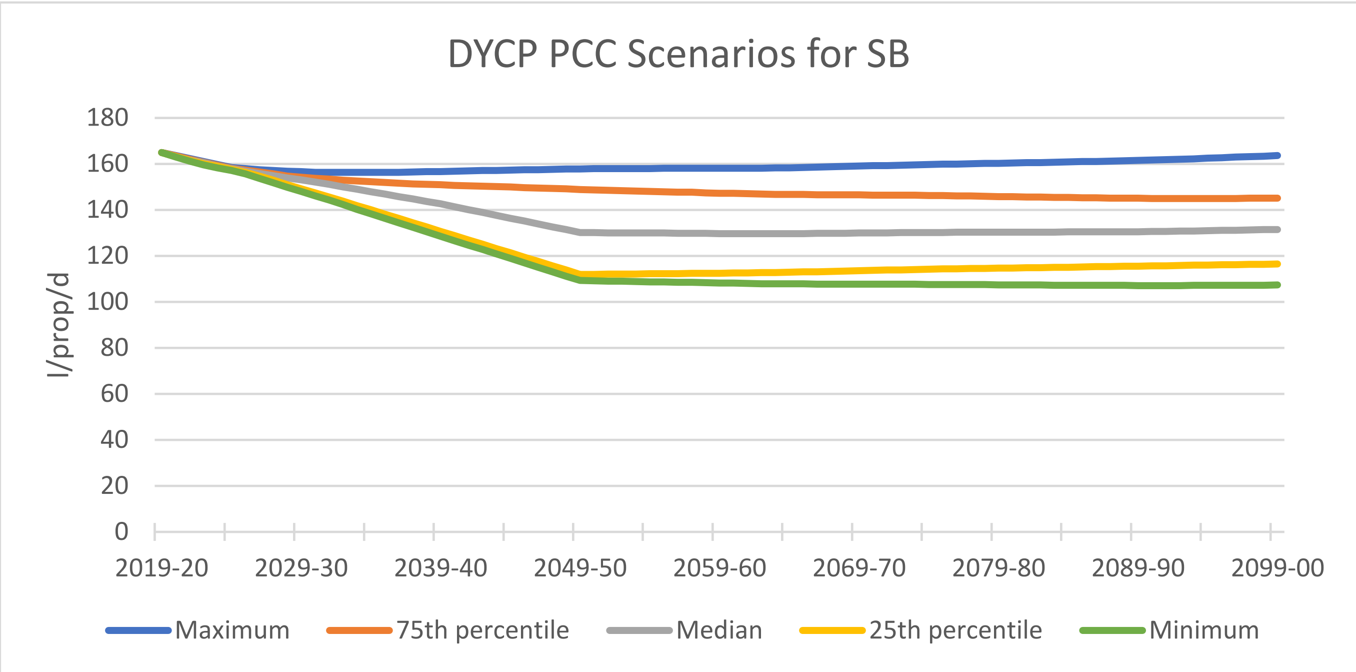
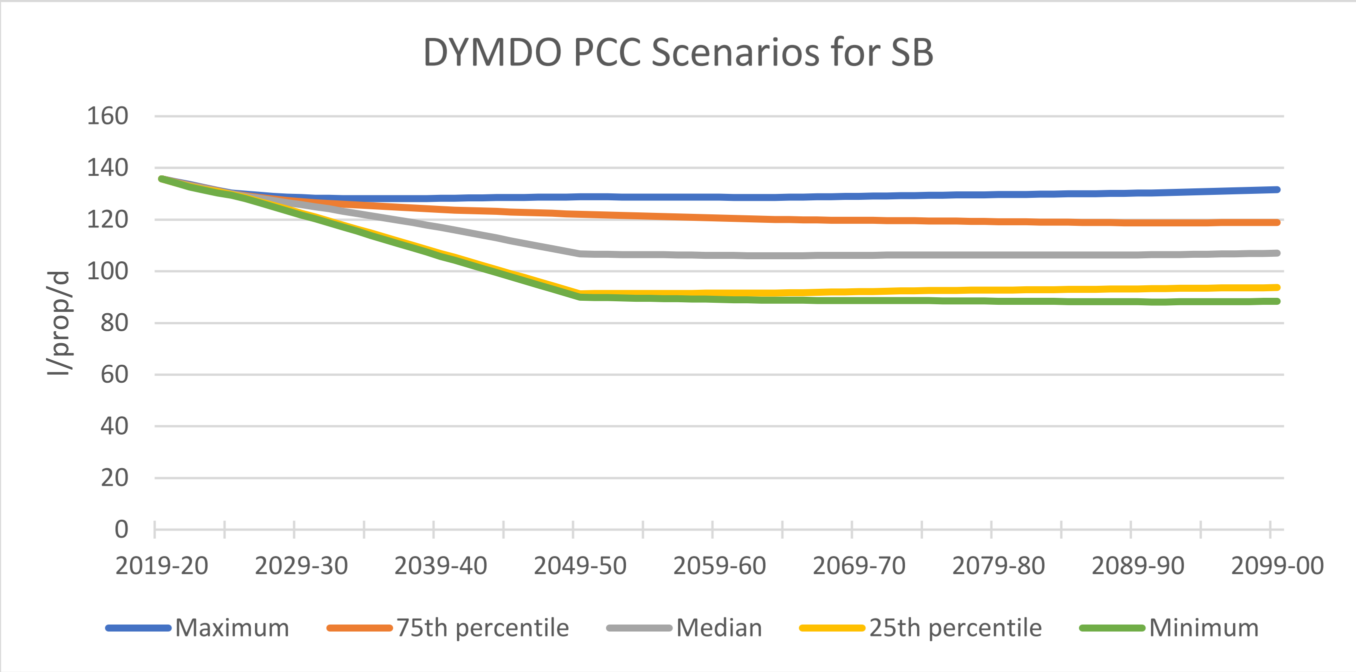


Figure 88: Range of DYMDO PCC results



B.11. Kent Medway East (KME)

Figure 89: Range of NYAA Distribution Input results

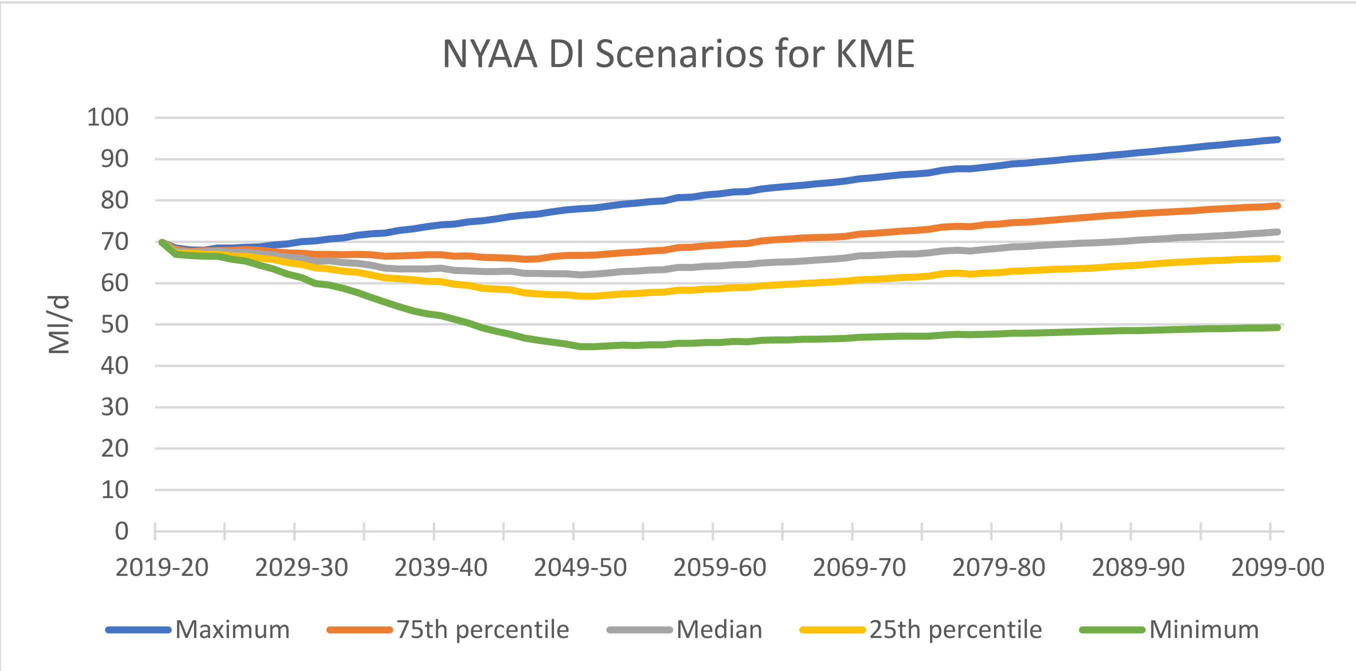


Figure 90: Range of DYAA Distribution Input results

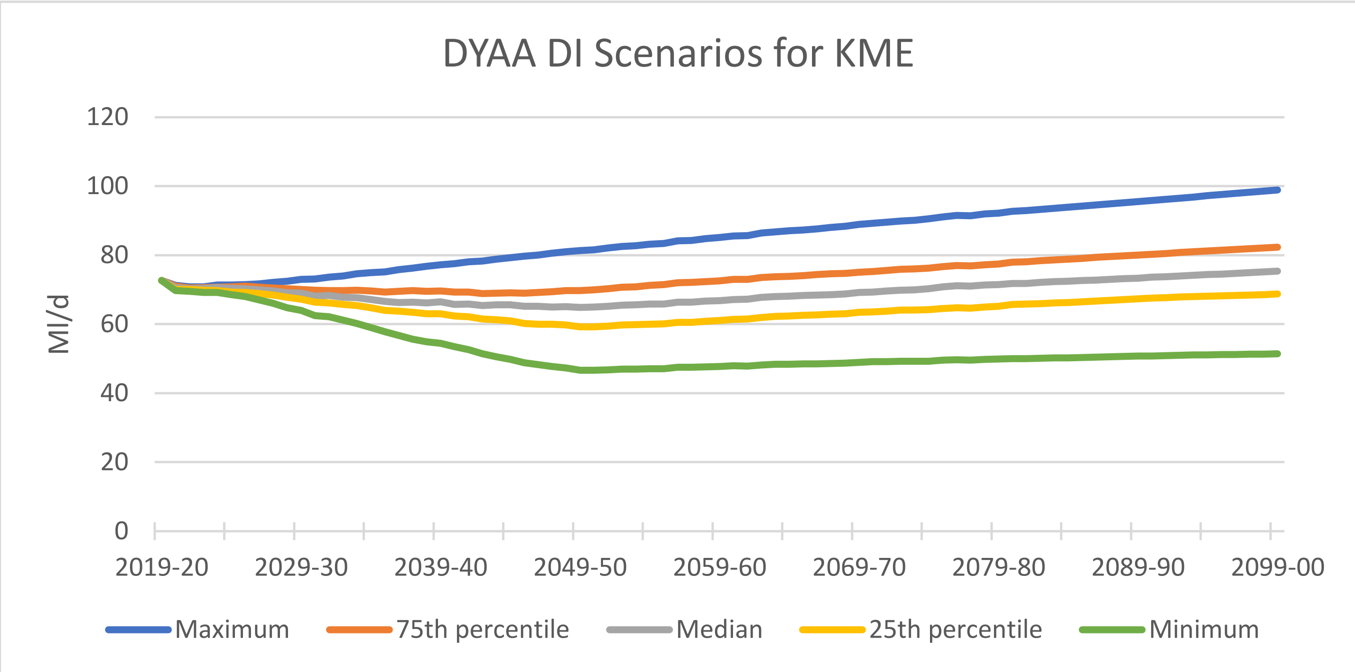


Figure 91: Range of DYCP Distribution Input results

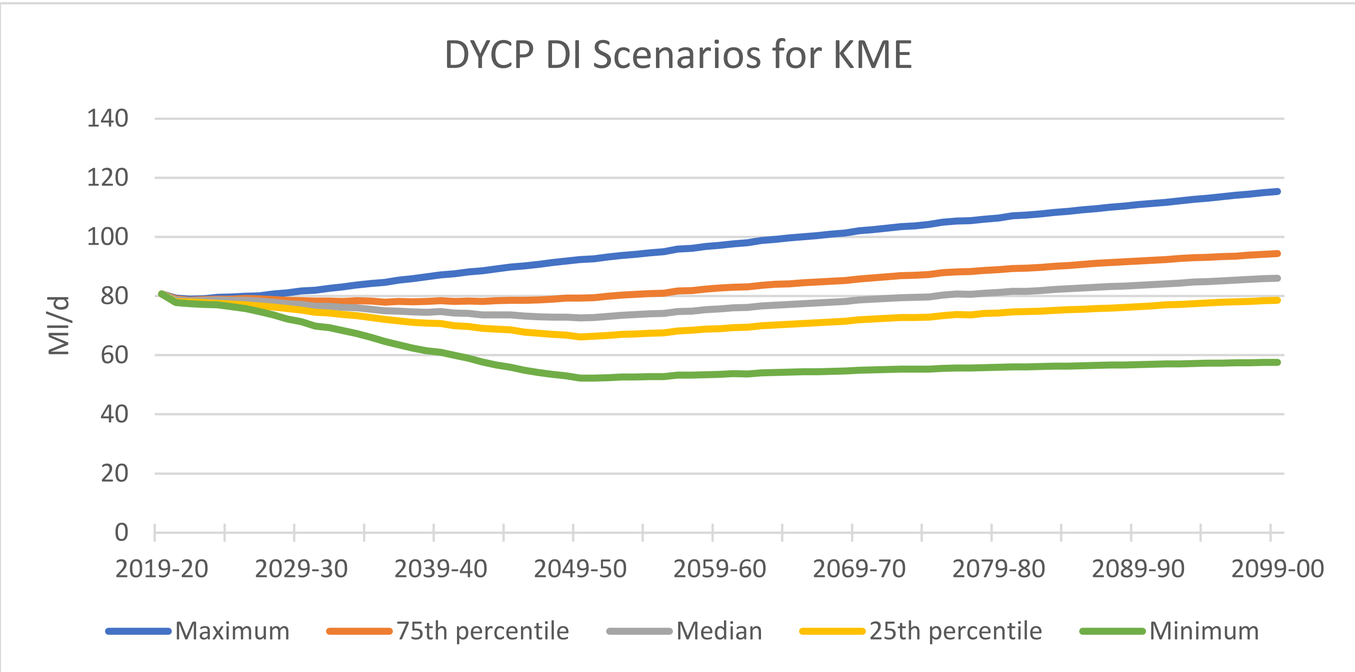


Figure 92: Range of DYMDO Distribution Input results

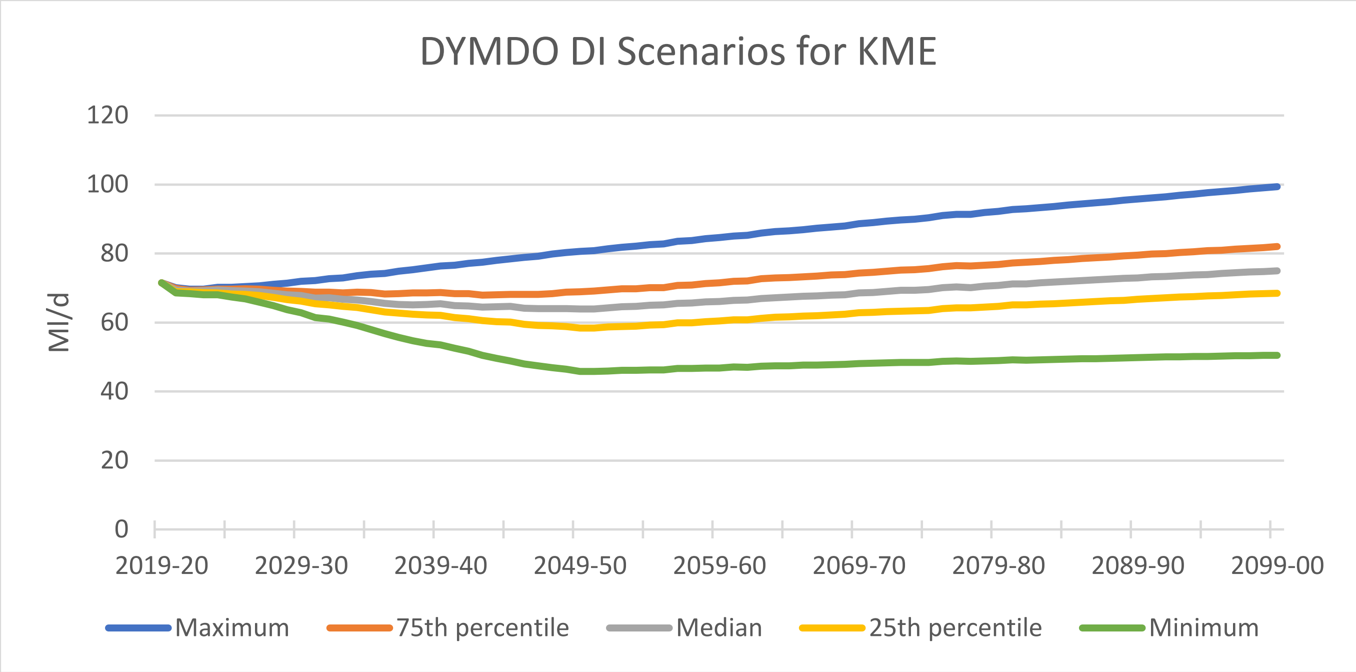


Figure 93: Range of NYAA PCC results

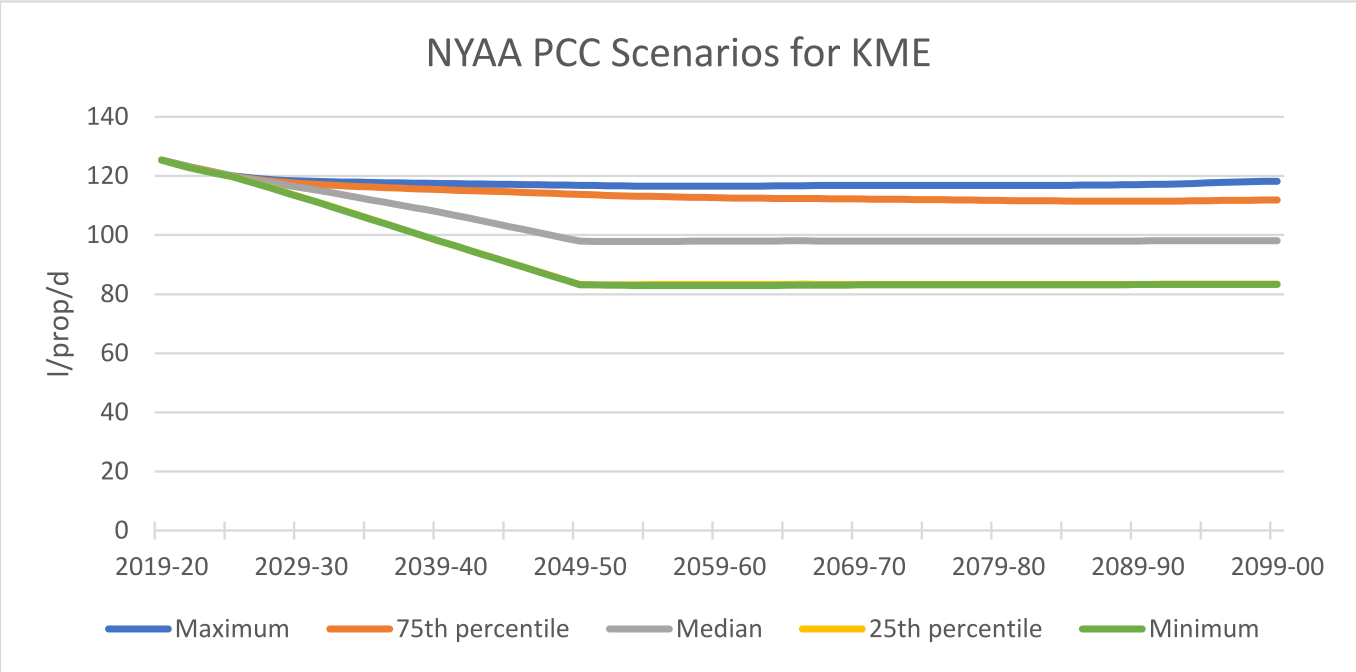


Figure 94: Range of DYAA PCC results

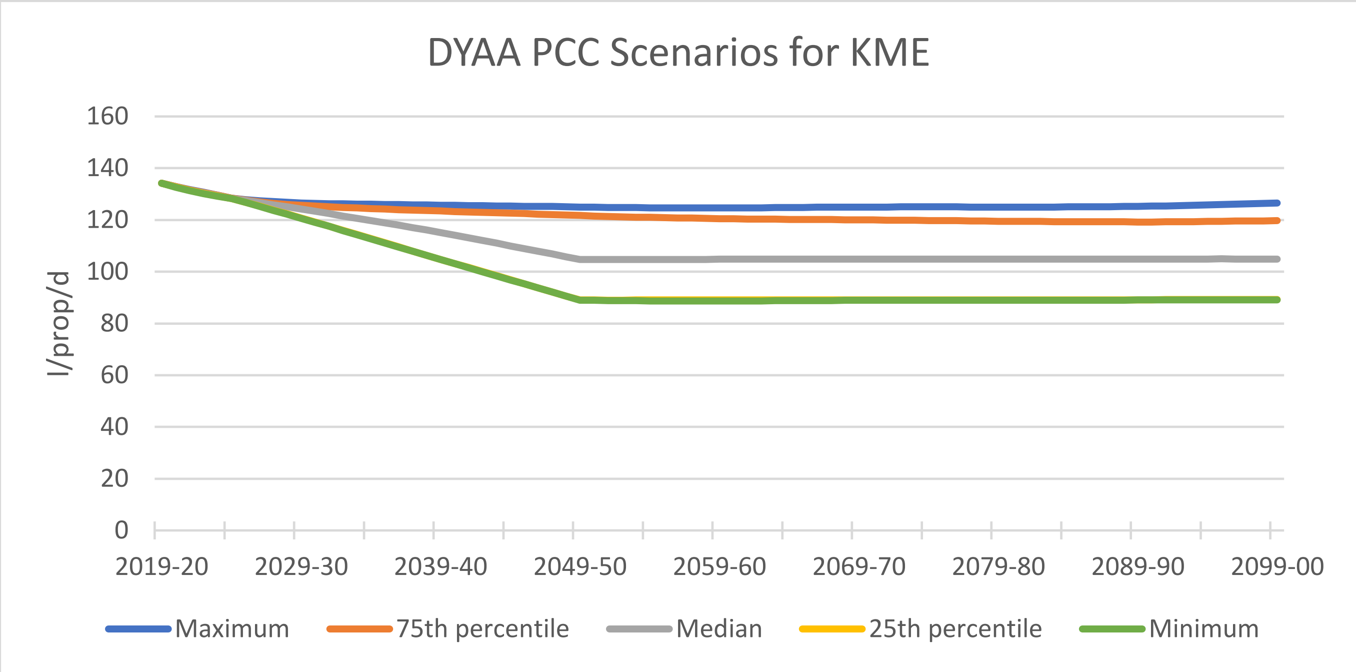


Figure 95: Range of DYCP PCC results

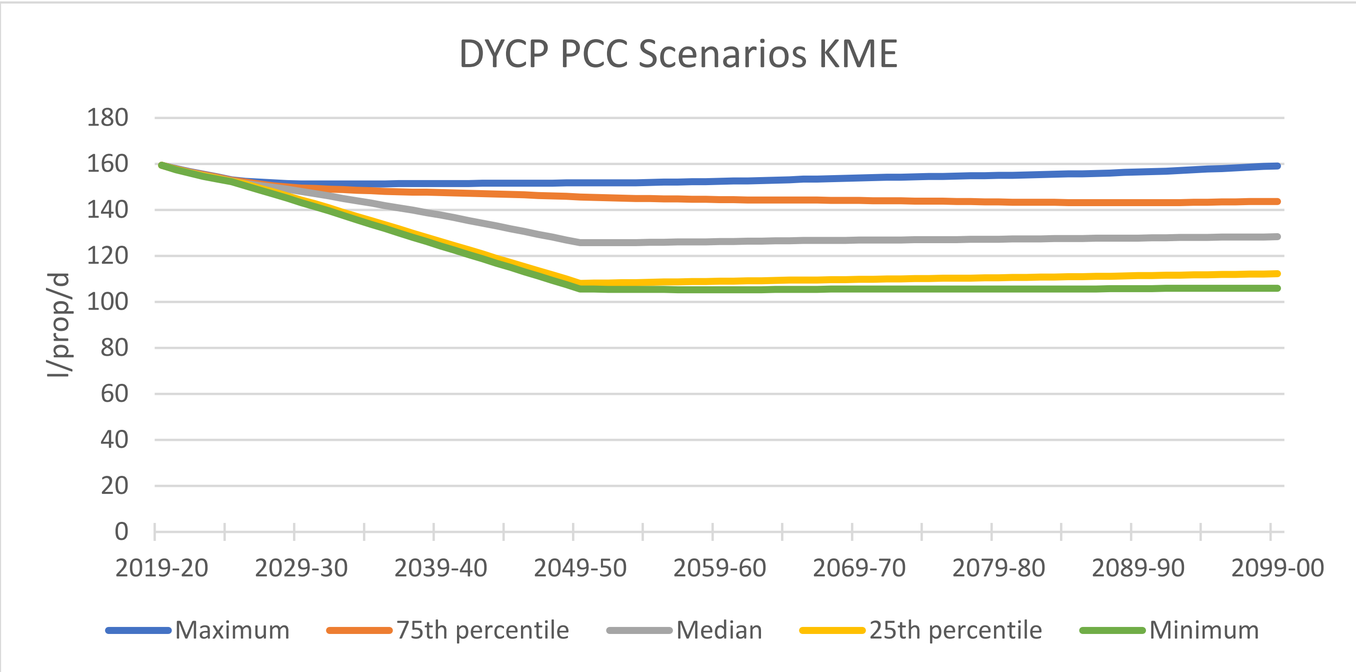
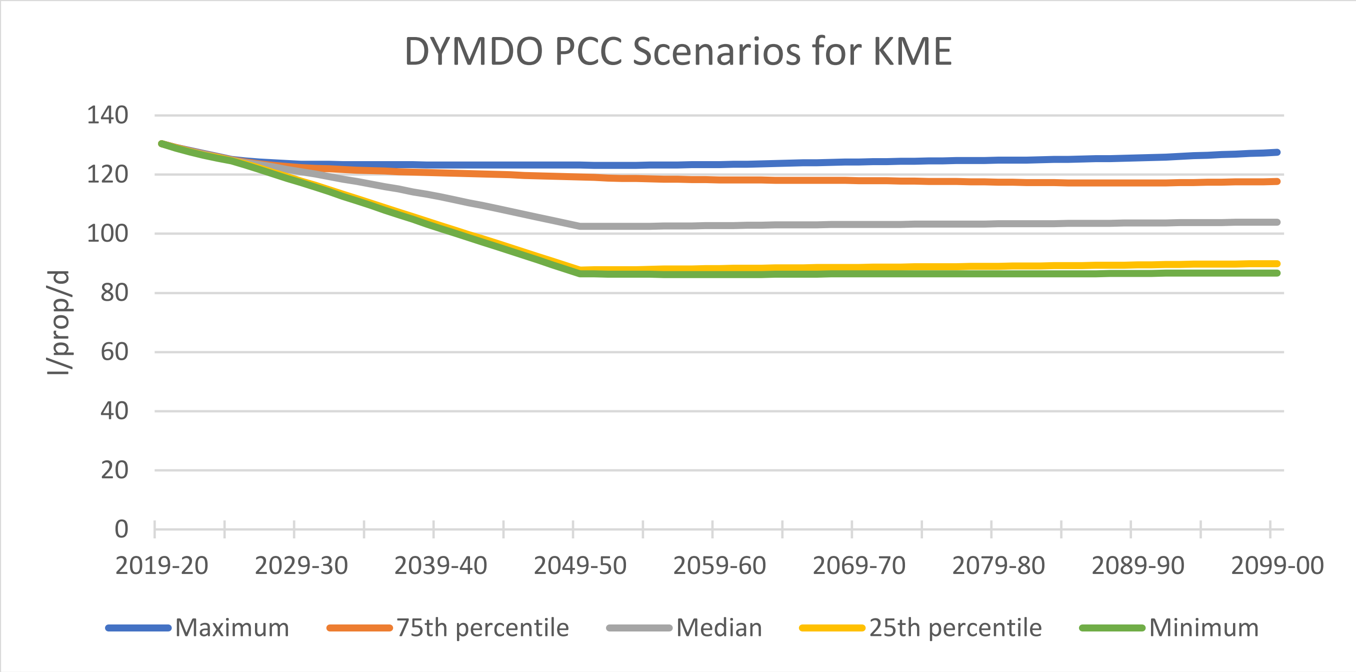


Figure 96: Range of DYMDO PCC results



B.12. Kent Medway West (KMW)

Figure 97: Range of NYAA Distribution Input results

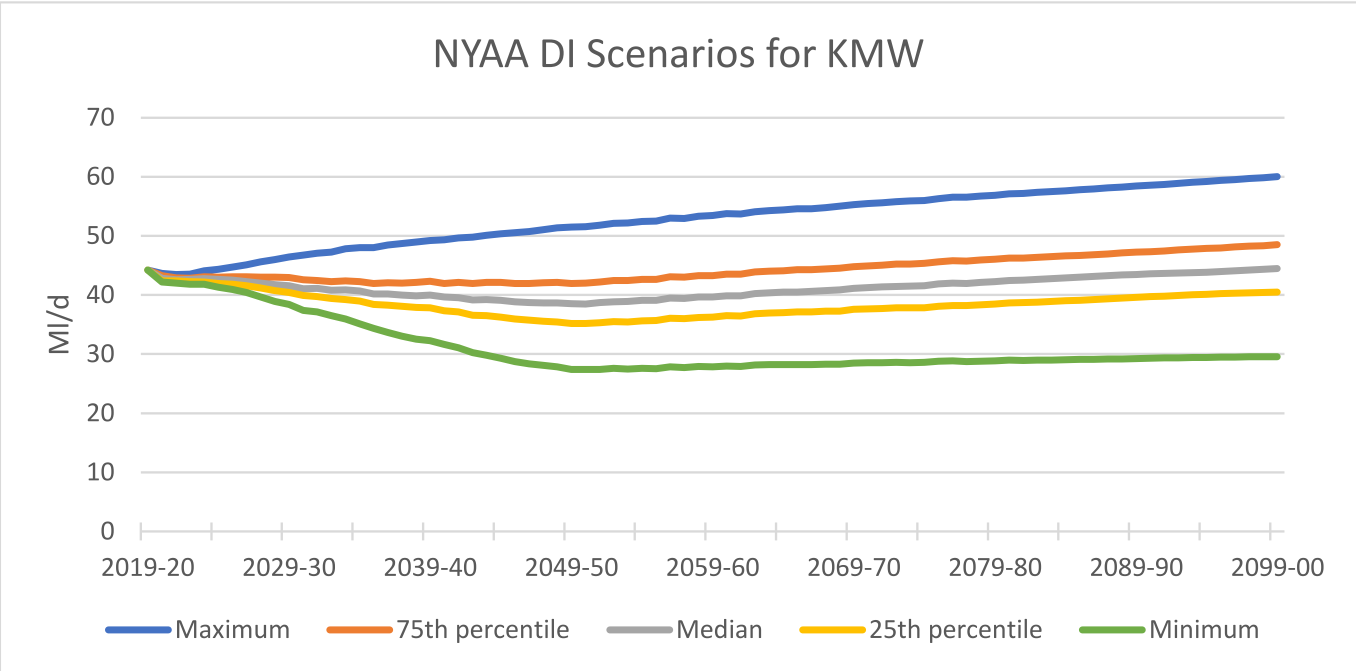


Figure 98: Range of DYAA Distribution Input results

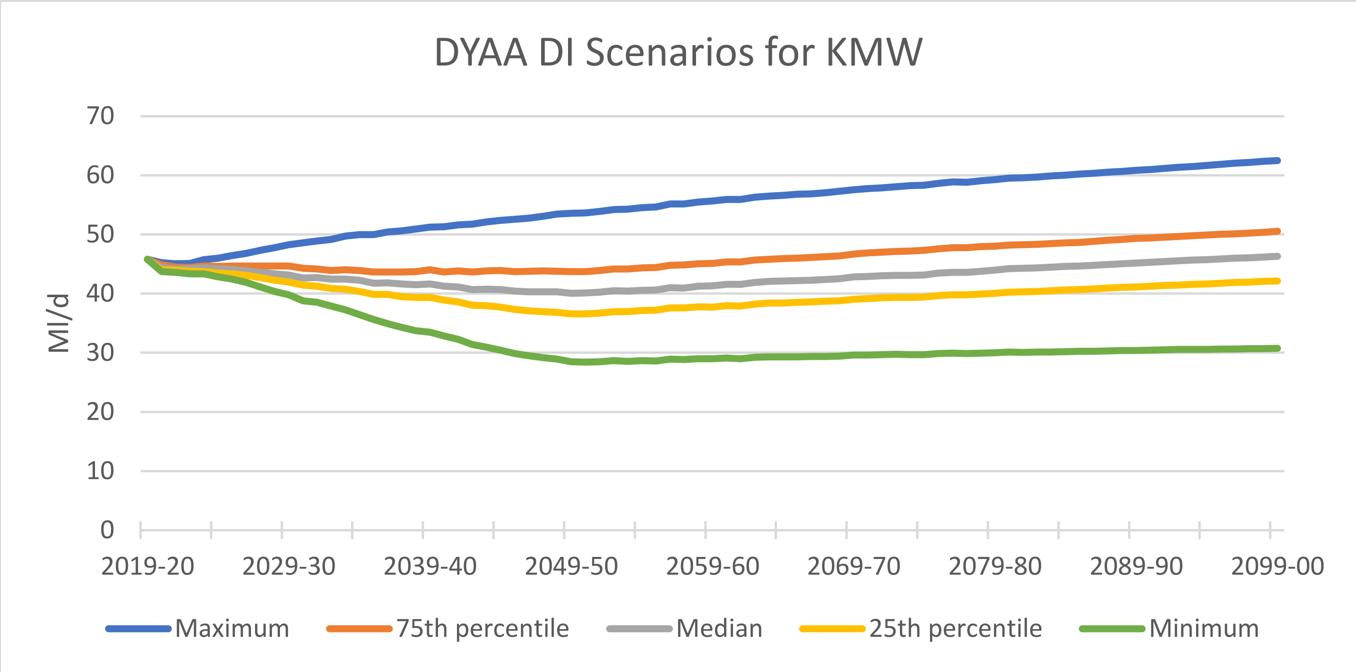


Figure 99: Range of DYCP Distribution Input results

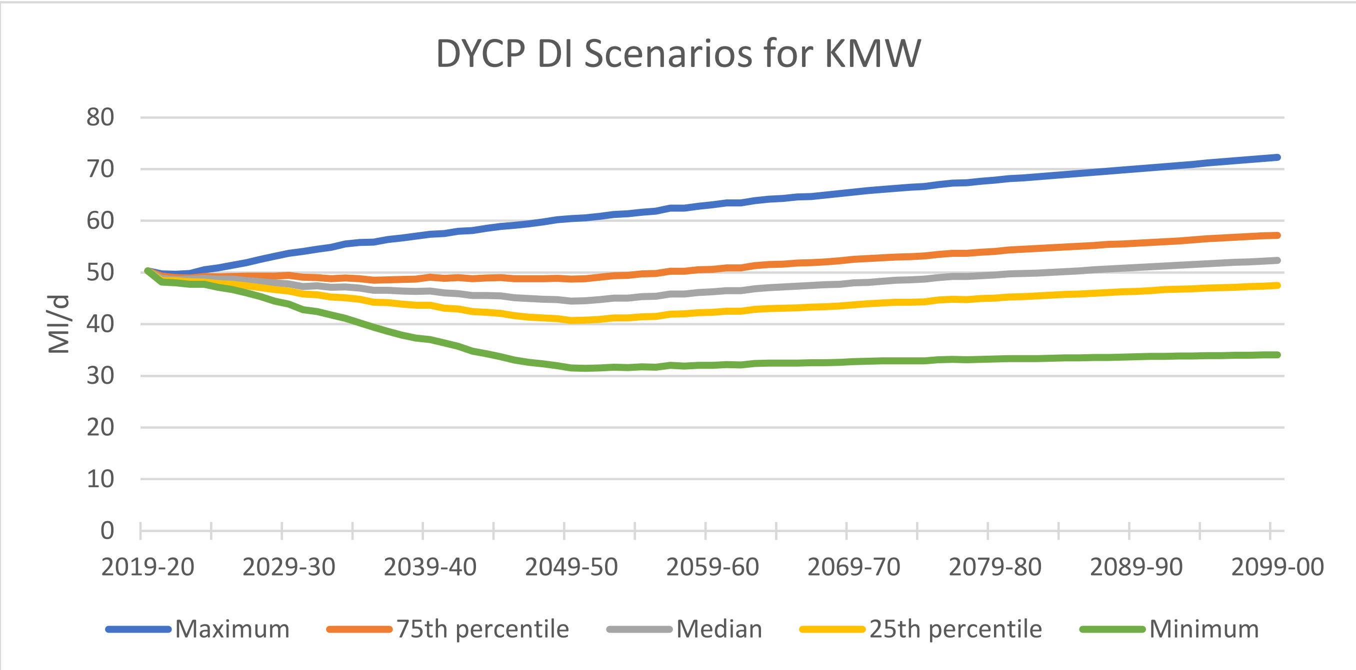


Figure 100: Range of DYMDO Distribution Input results

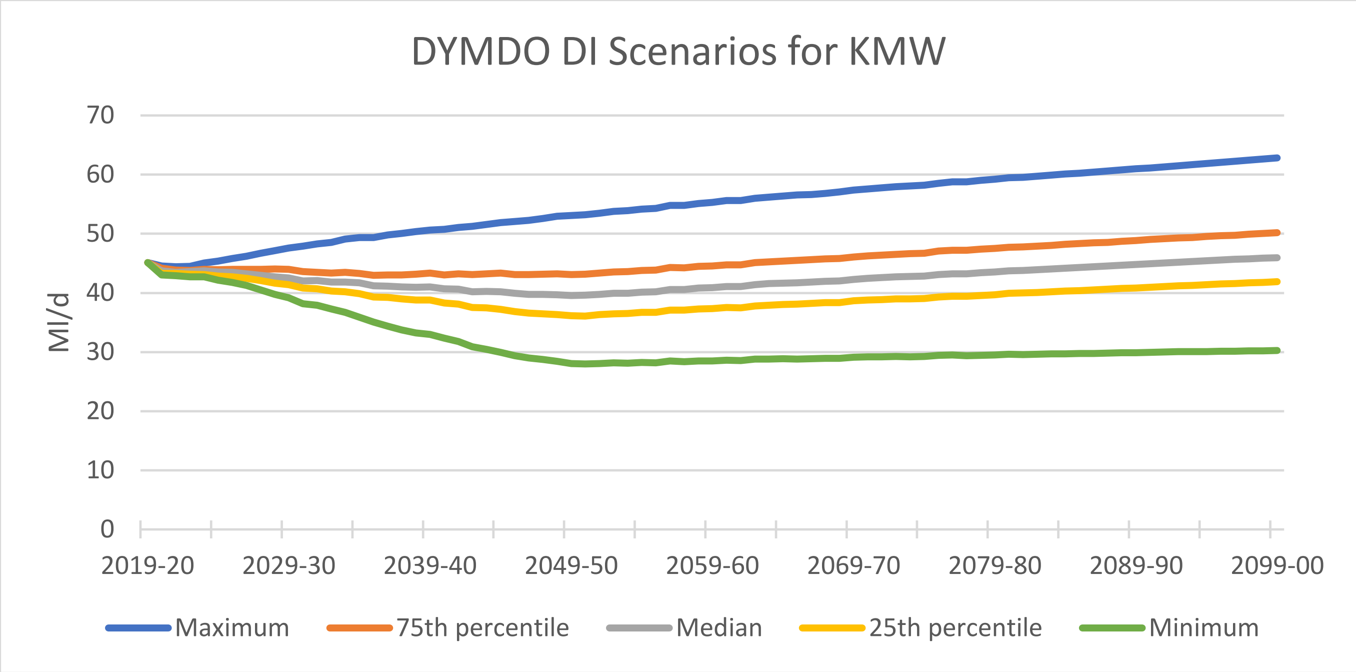


Figure 101: Range of NYAA PCC results

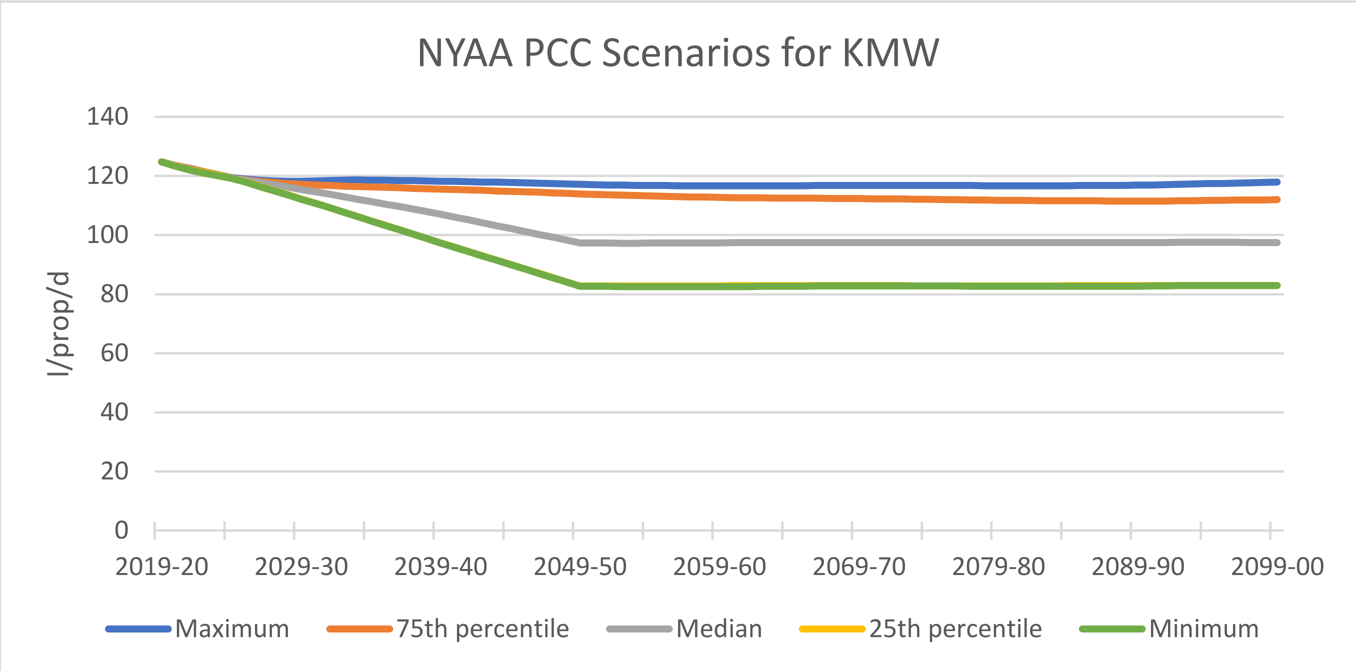


Figure 102: Range of DYAA PCC results

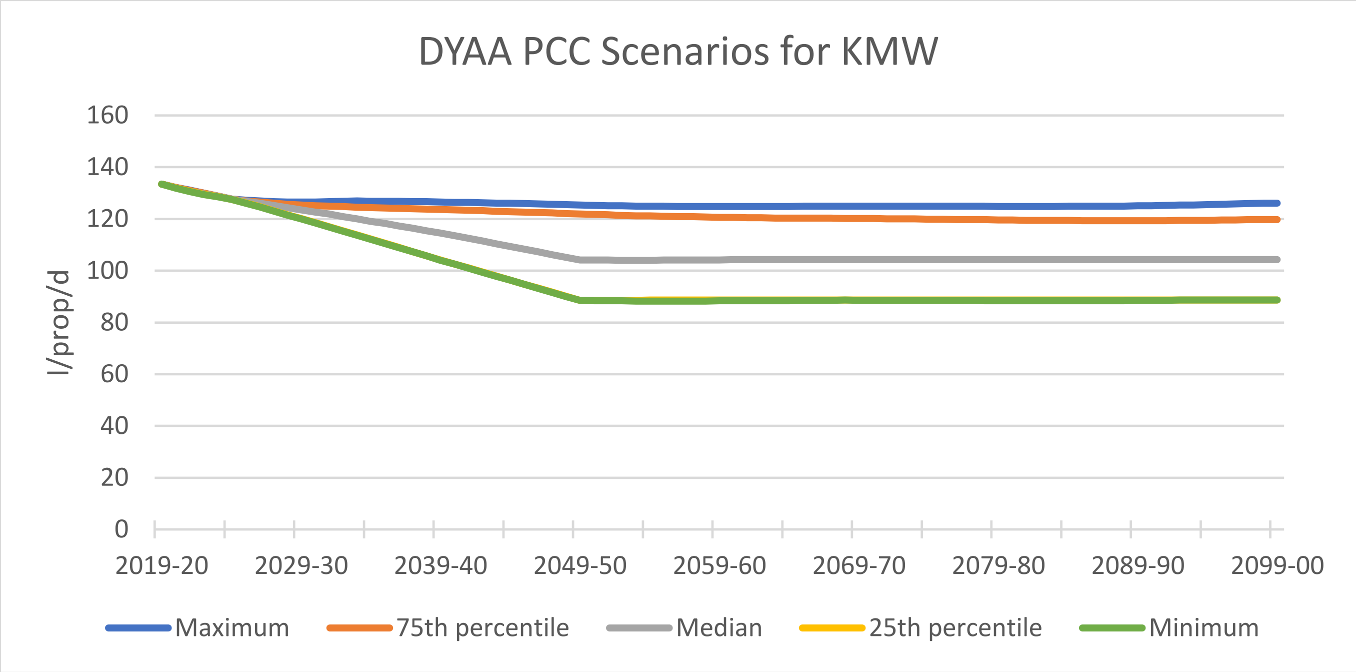


Figure 103: Range of DYCP PCC results

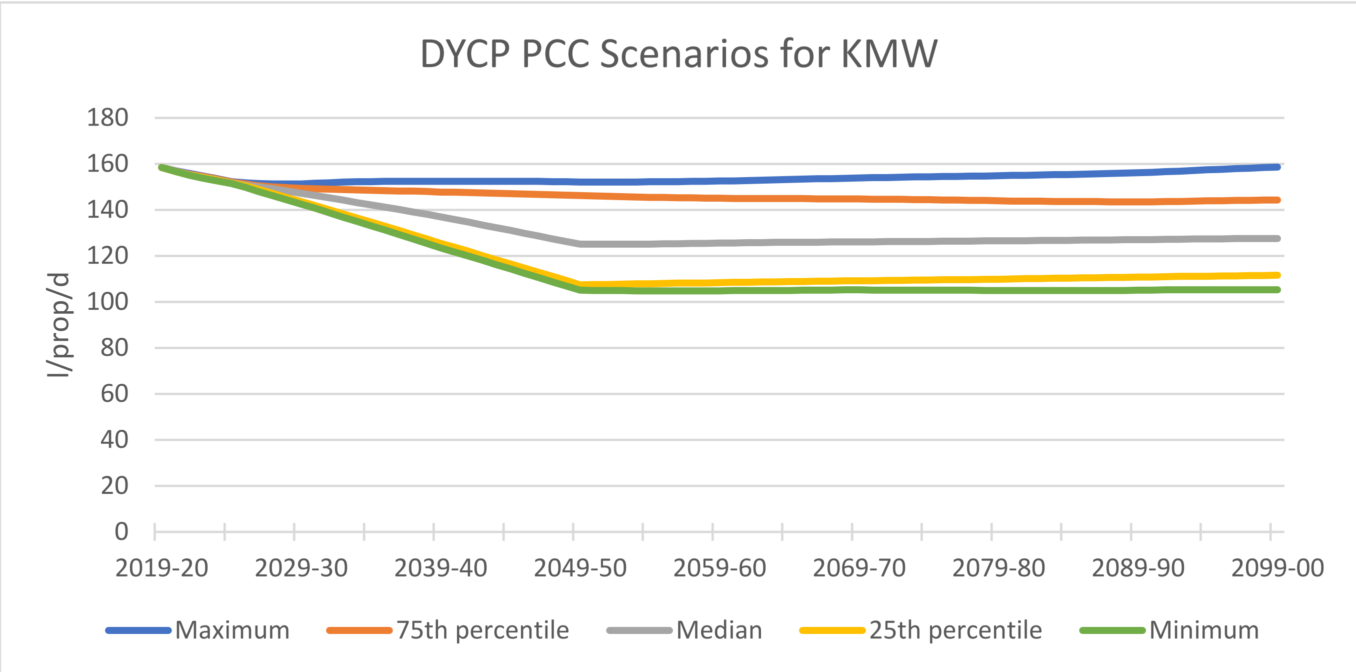
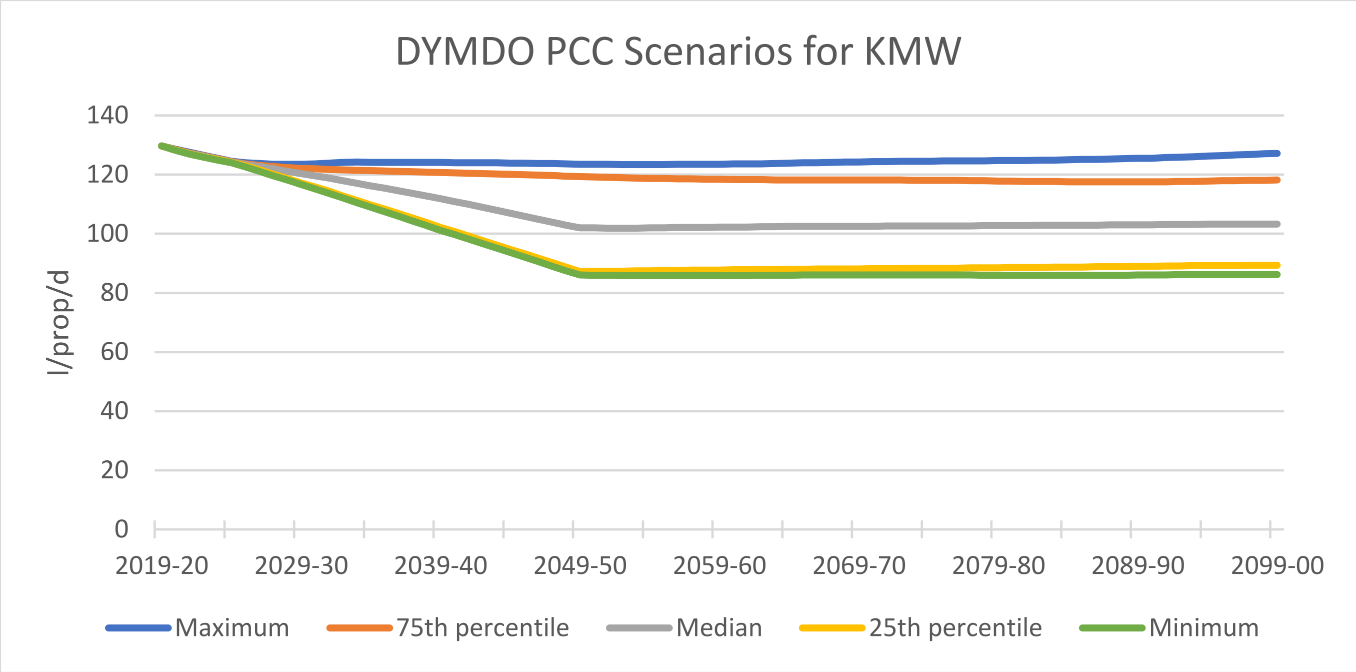


Figure 104: Range of DYMDO PCC results



B.13. Kent Thanet (KT)

Figure 105: Range of NYAA Distribution Input results

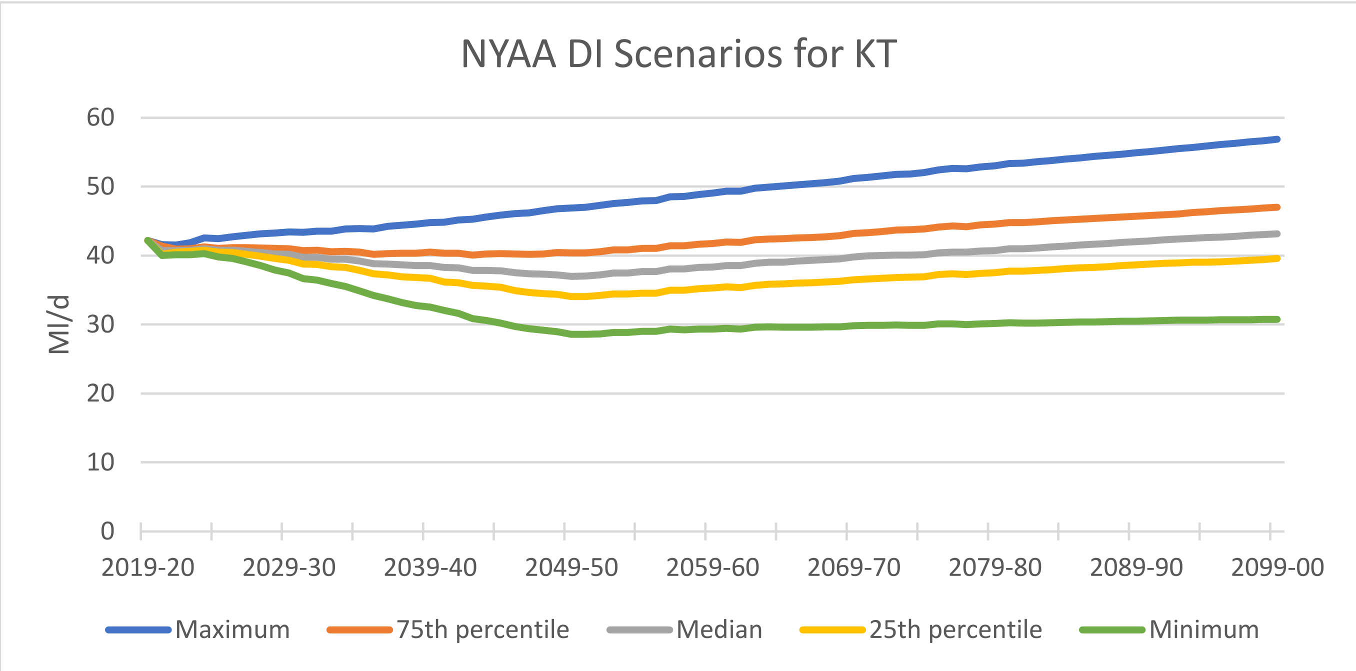


Figure 106: Range of DYAA Distribution Input results

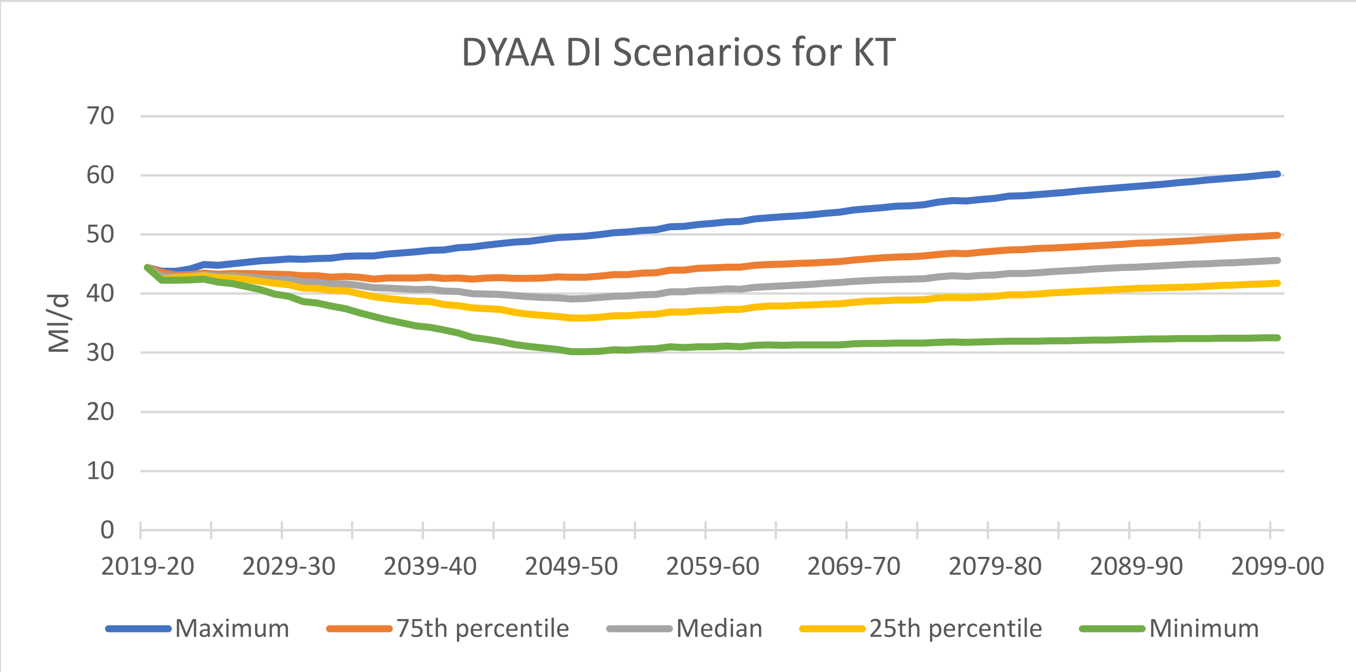


Figure 107: Range of DYCP Distribution Input results

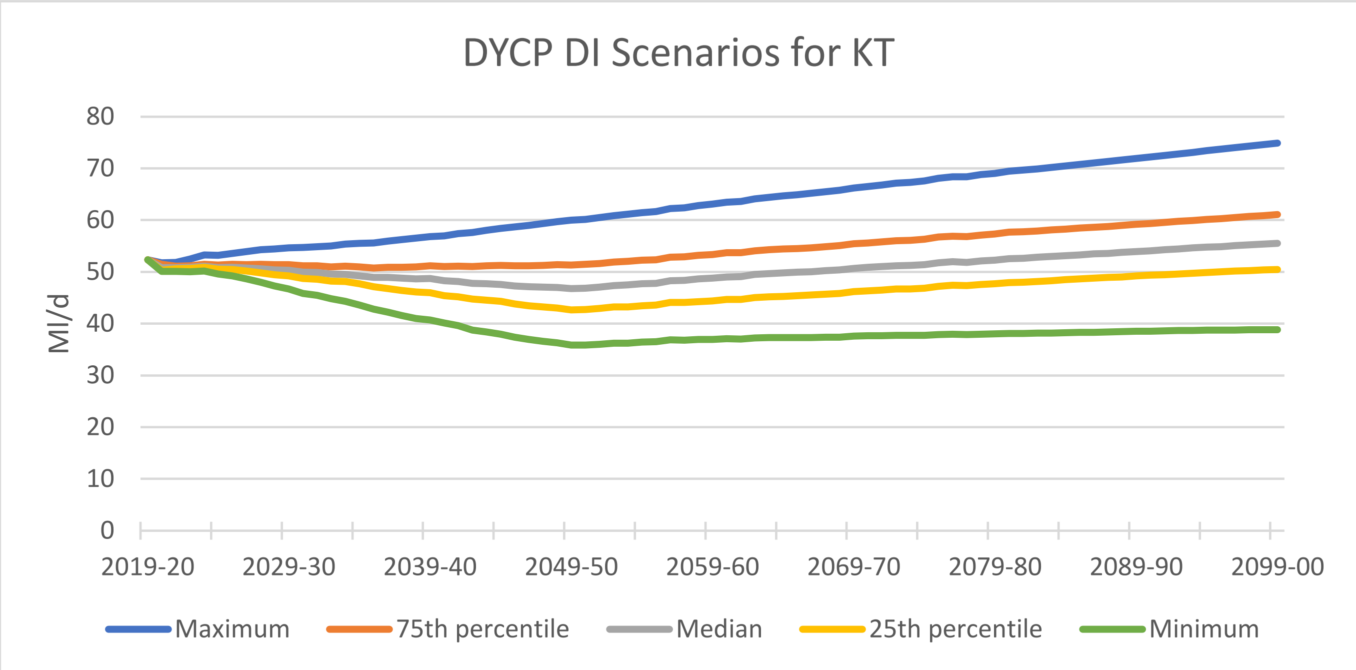


Figure 108: Range of DYMDO Distribution Input results

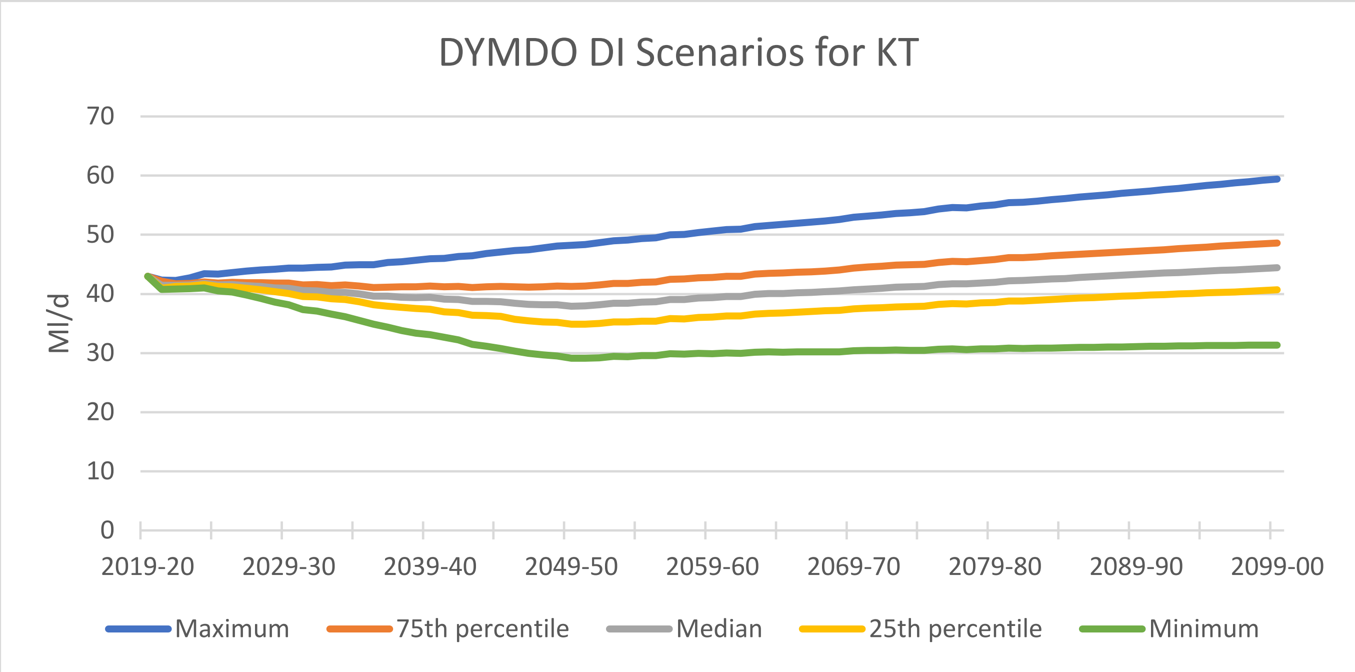


Figure 109: Range of NYAA PCC results

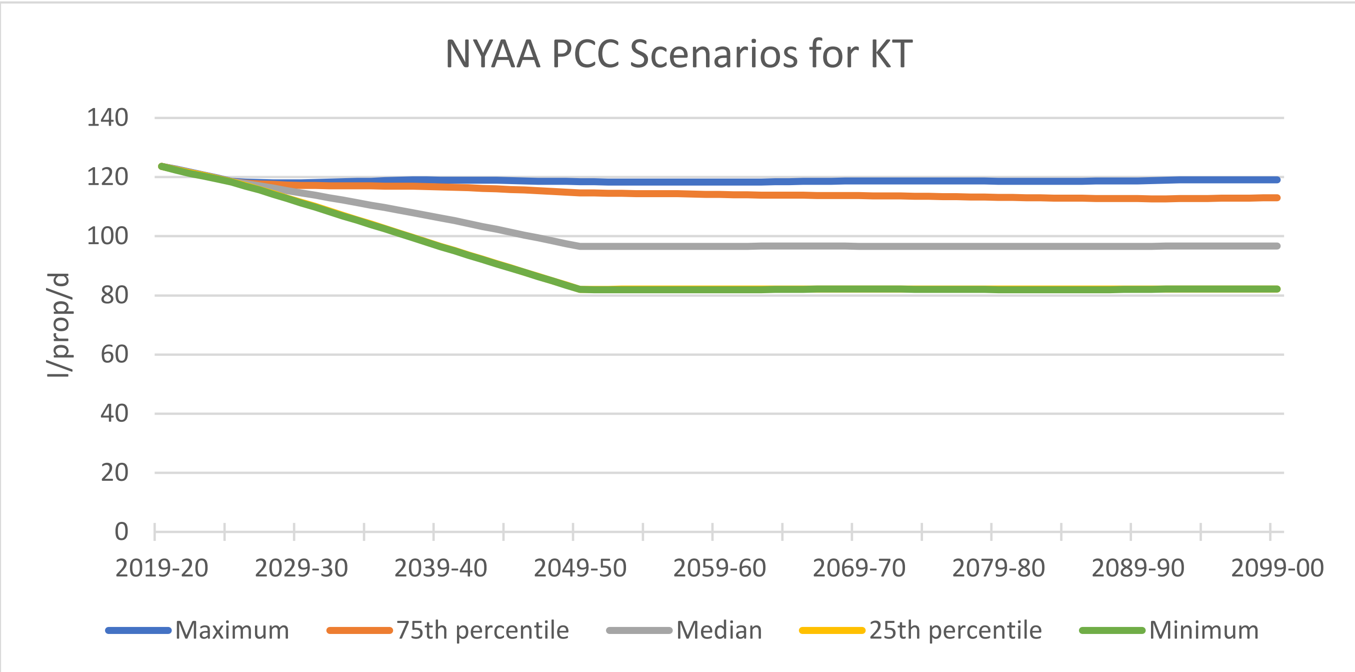


Figure 110: Range of DYAA PCC results

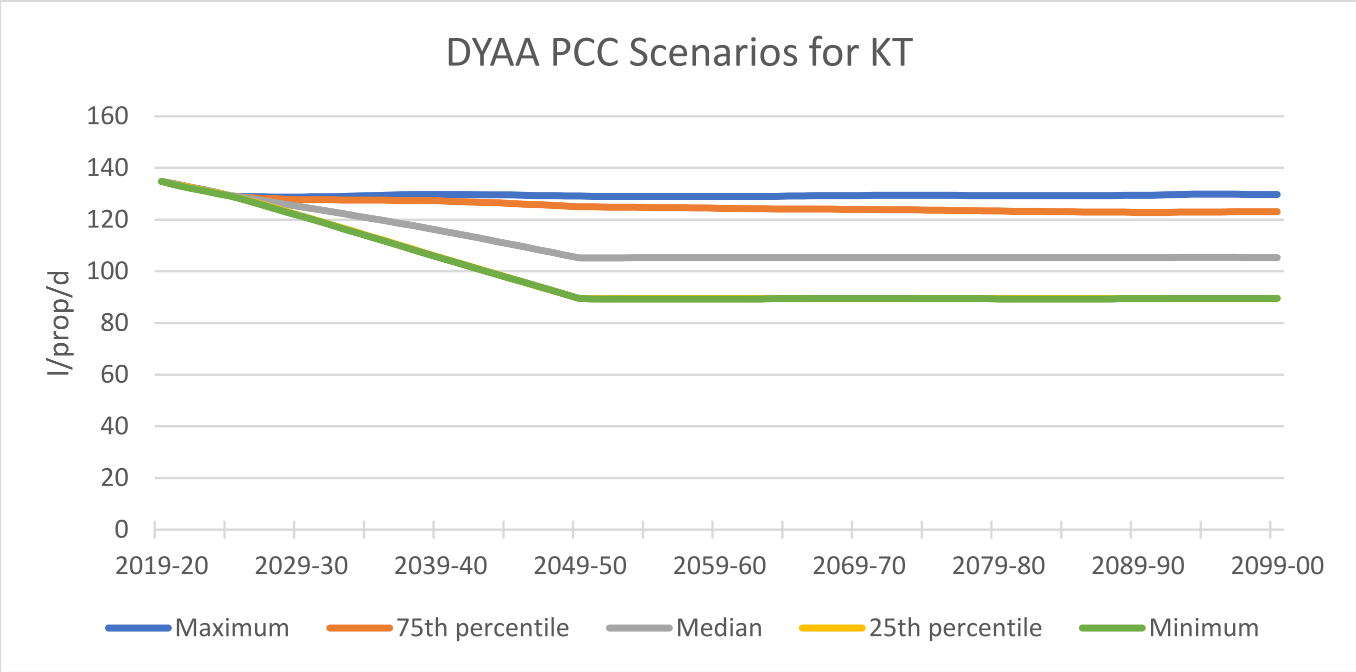


Figure 111: Range of DYCP PCC results

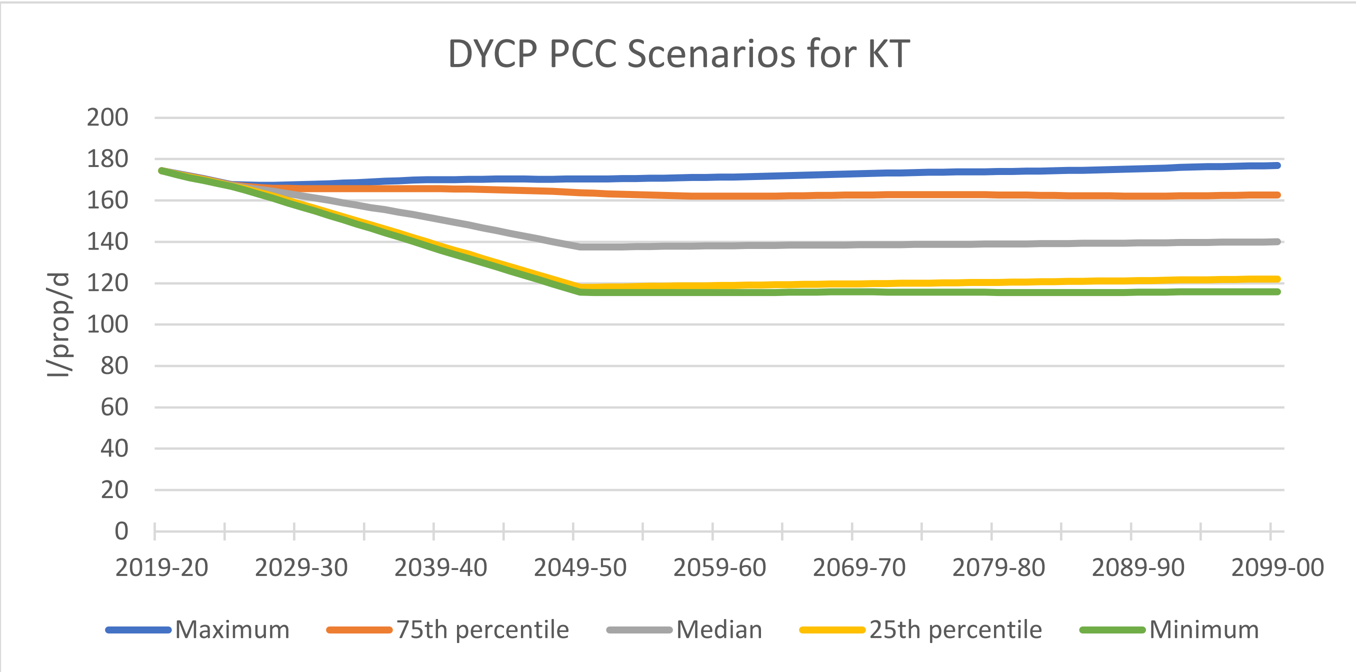
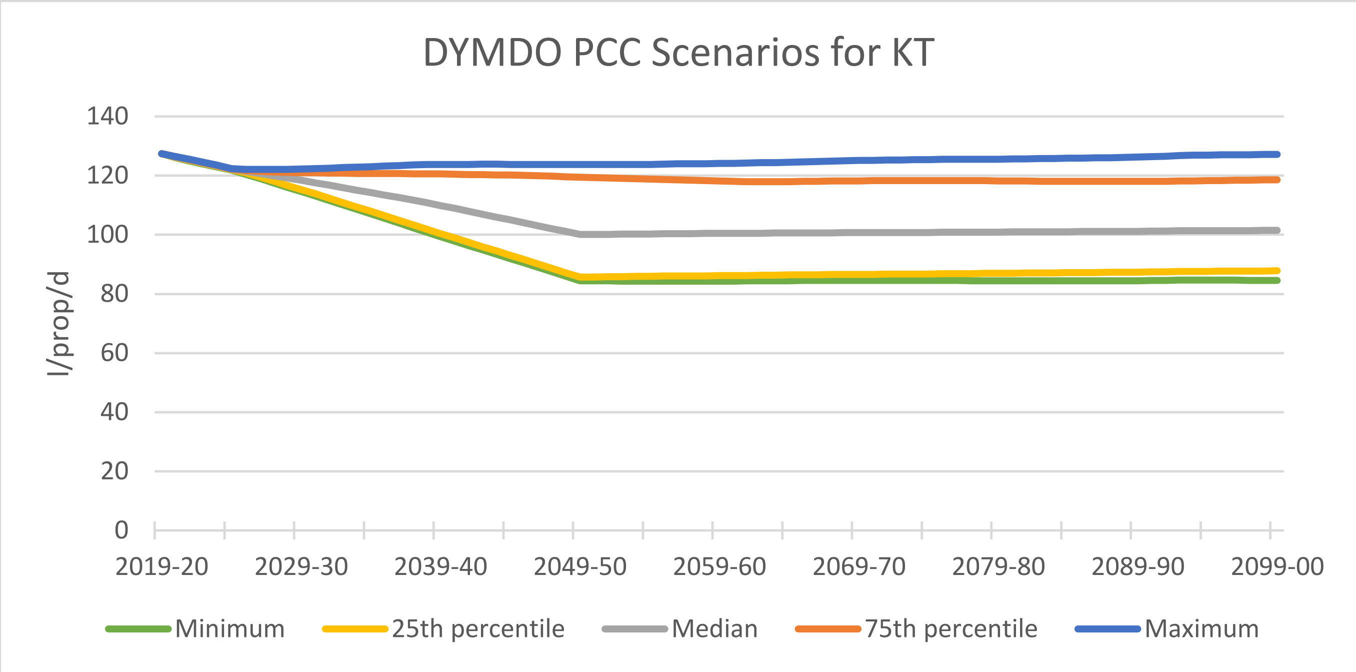


Figure 112: Range of DYMDO PCC results



B.14. Sussex Hastings (SH)

Figure 113: Range of NYAA Distribution Input results

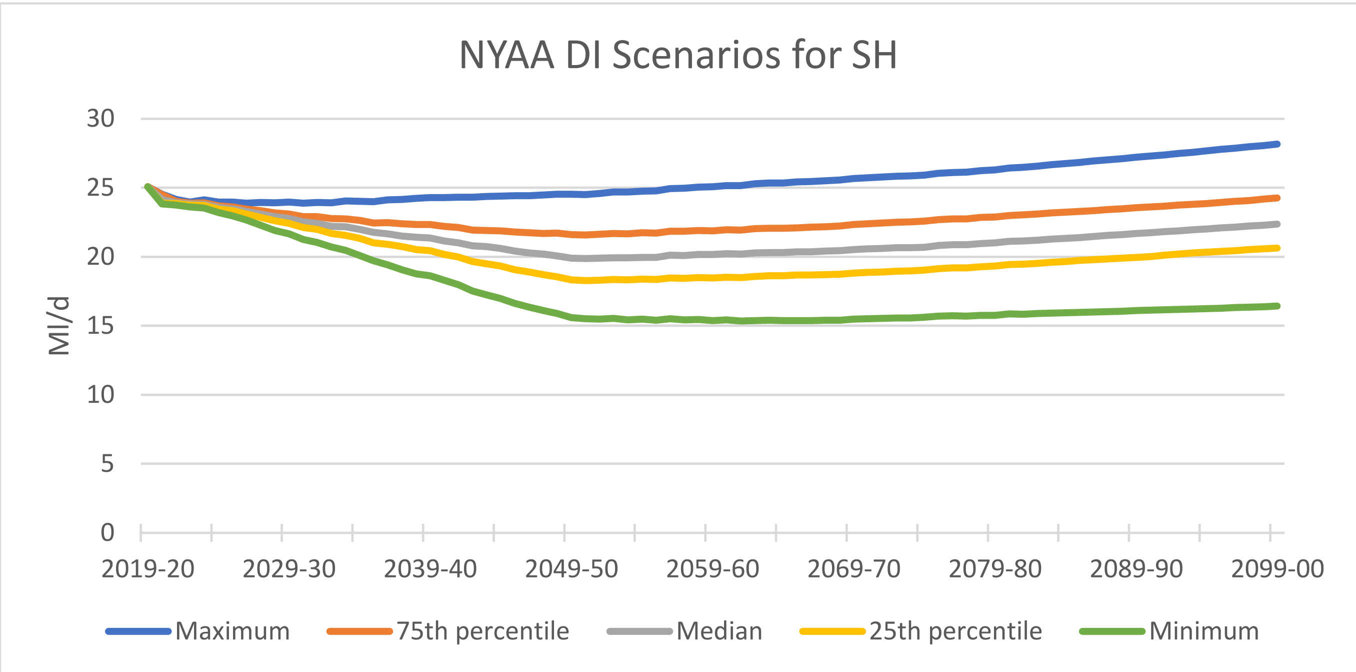


Figure 114: Range of DYAA Distribution Input results

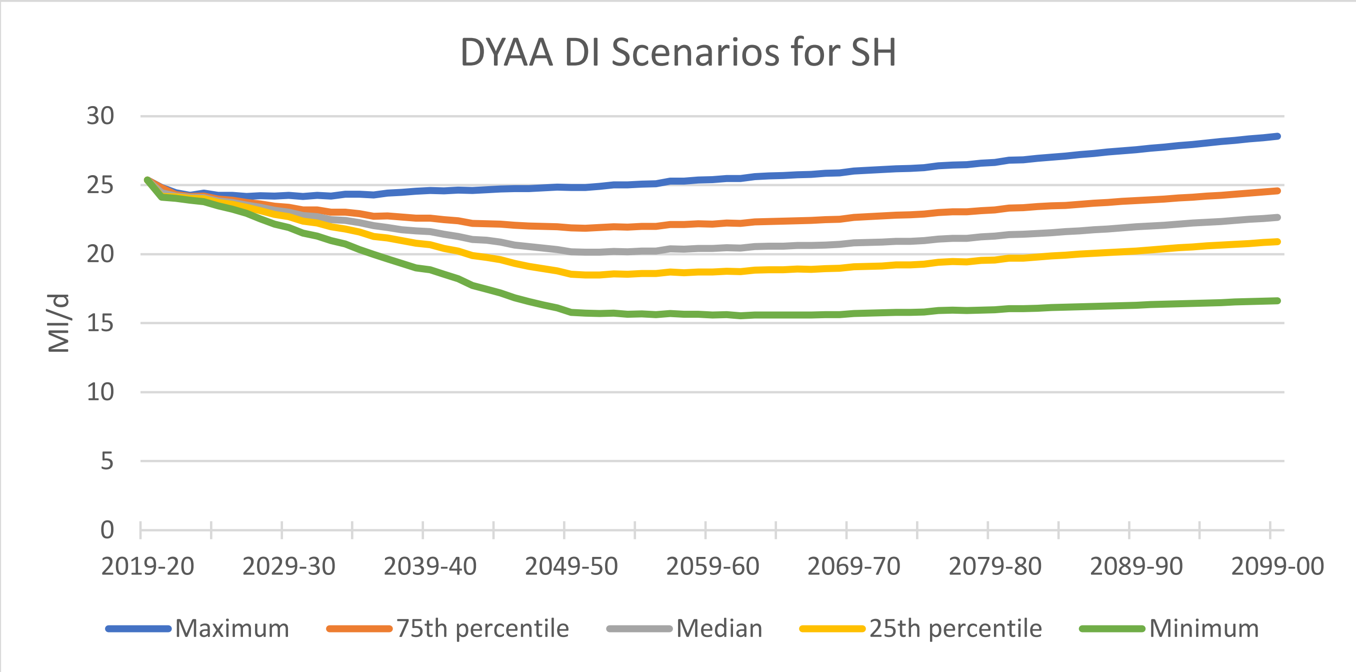


Figure 115: Range of DYCP Distribution Input results

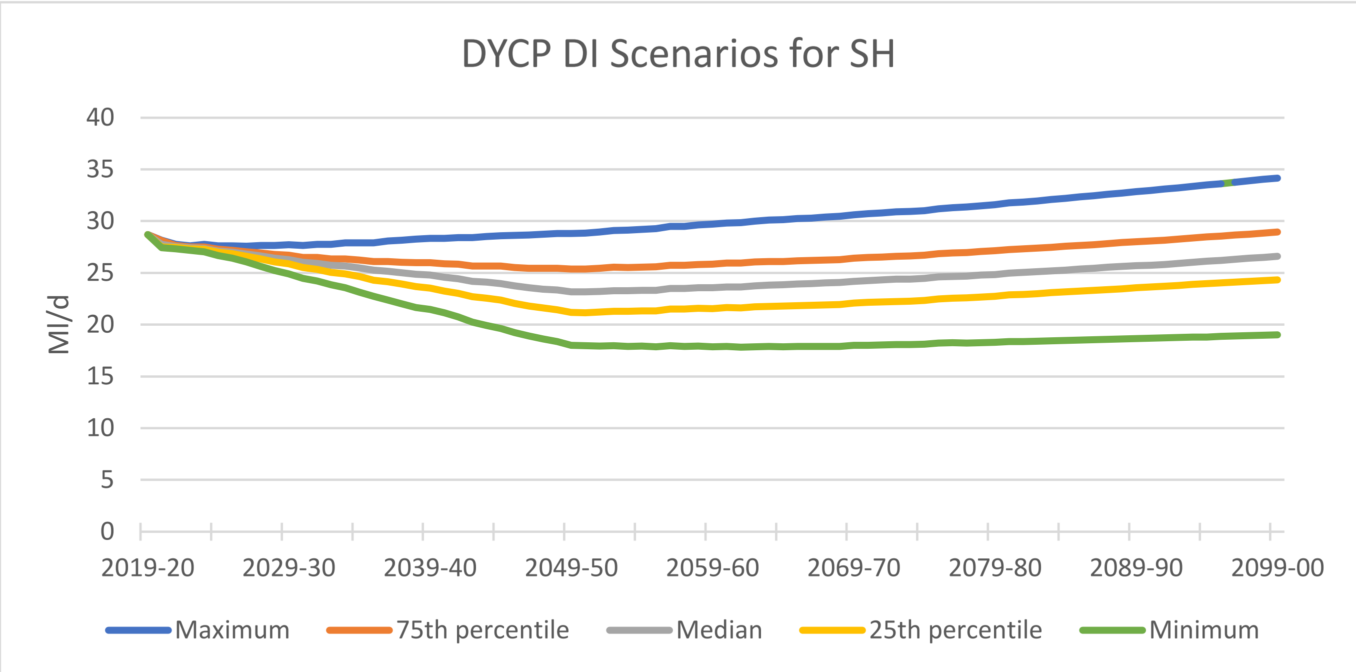


Figure 116: Range of DYMDO Distribution Input results

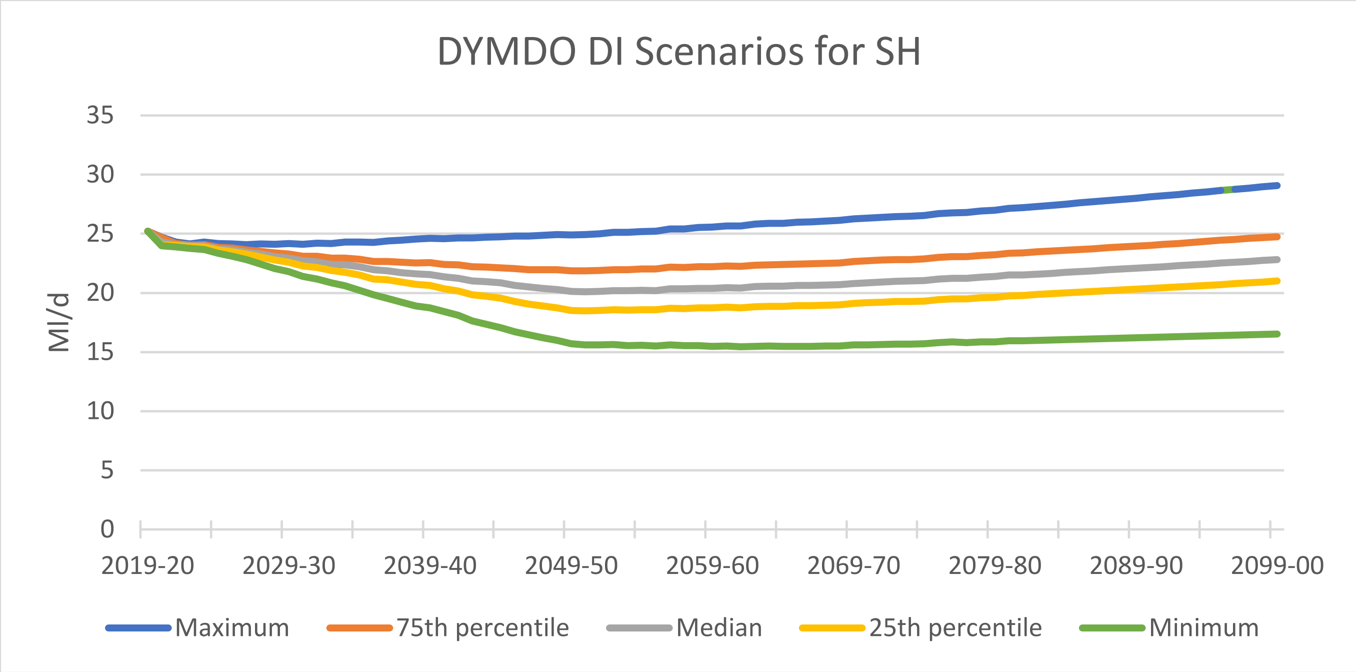


Figure 117: Range of NYAA PCC results

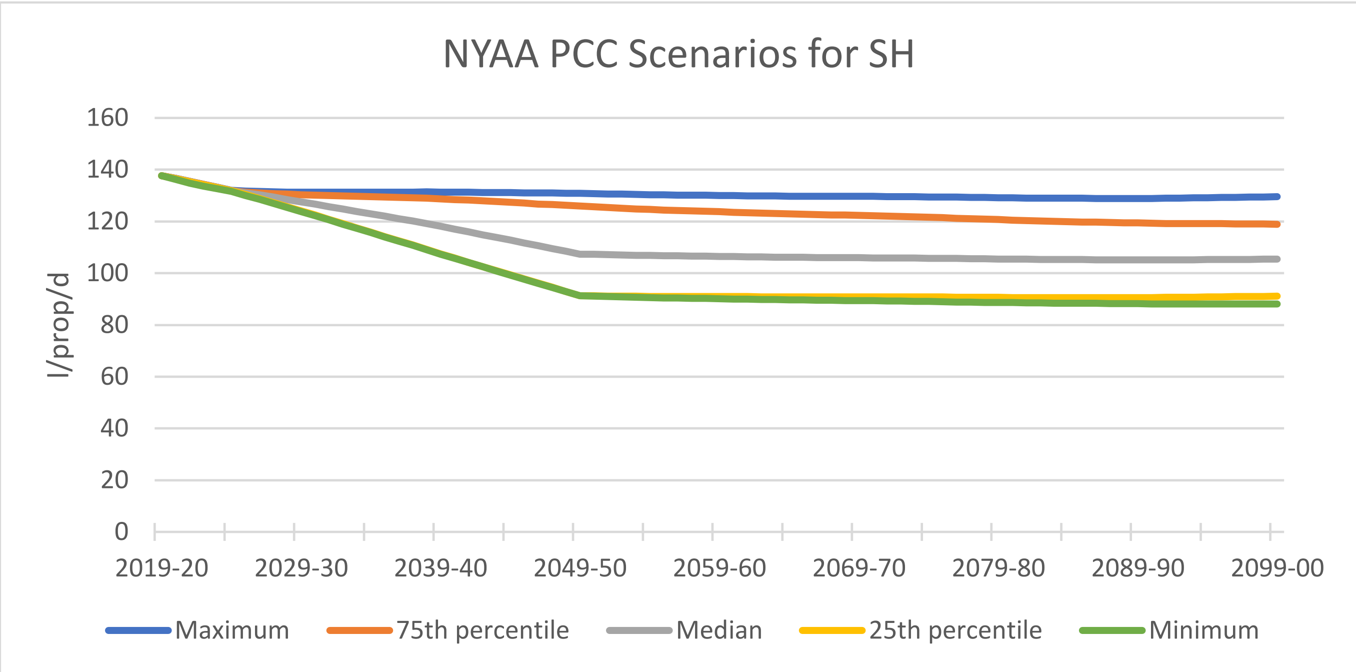


Figure 118: Range of DYAA PCC results

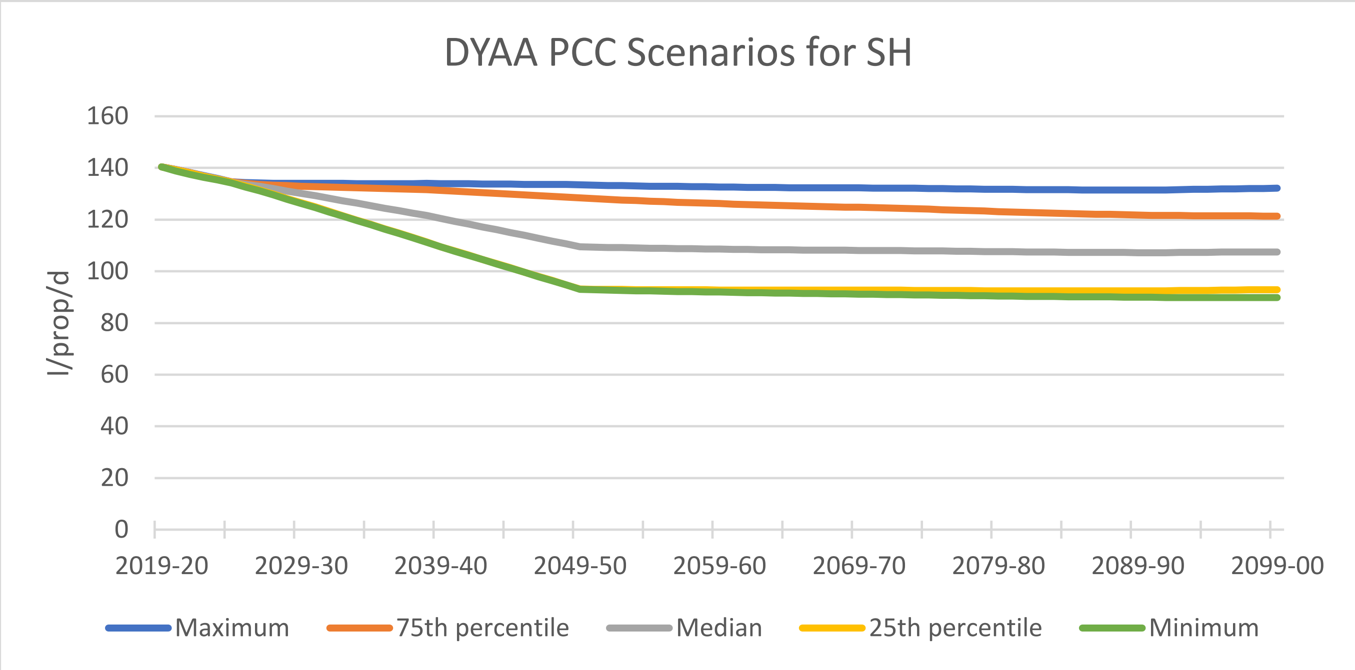


Figure 119: Range of DYCP PCC results

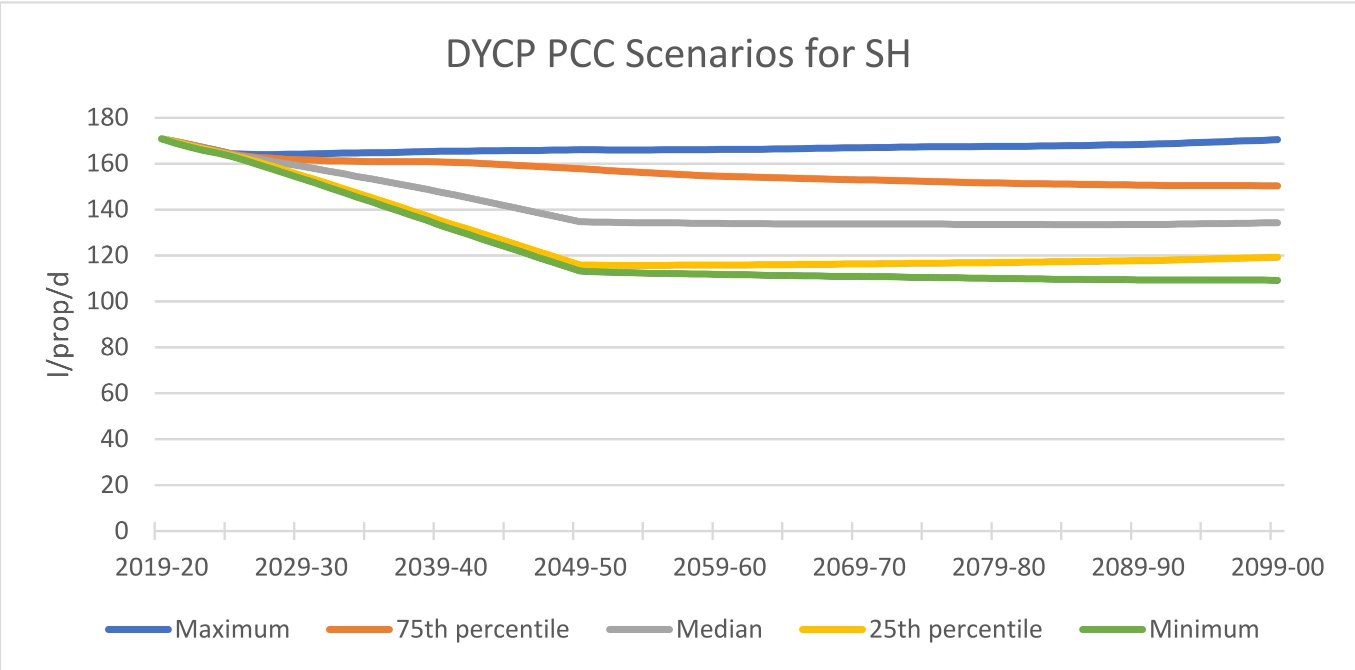
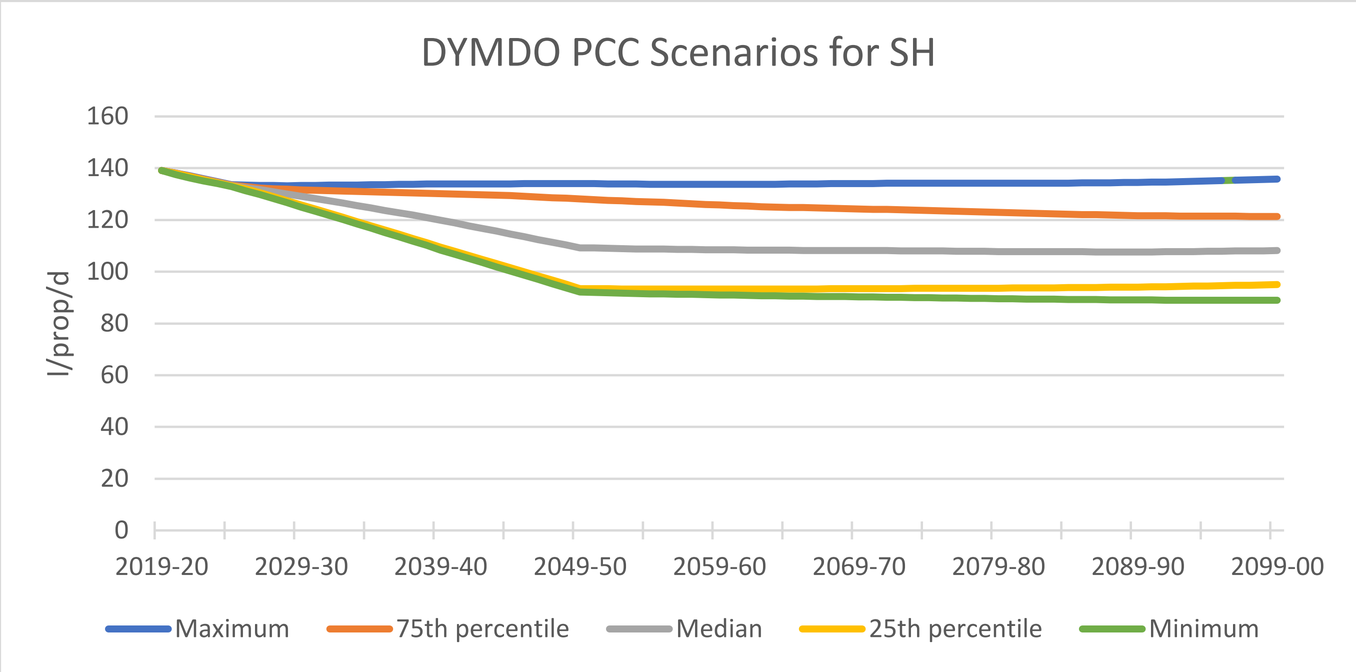


Figure 120: Range of DYMDO PCC results



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