WATER APPROPRIATION STUDY

FOR THE

BEL AIR WATER SUPPLY SYSTEM

Prepared for

MARYLAND AMERICAN WATER COMPANY

Contract Task Order No. MD-15-GF-1

Prepared by

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1.0 Background and Objectives

Gannett Fleming was authorized by Maryland American Water Company to evaluate an off-stream storage impoundment along Winters Run to serve as an emergency water supply for the existing water system serving the Town of Bel Air, Maryland. This concept will ensure a reliable source of raw water for the system during periods of drought.

The Bel Air water system serves primarily the town of Bel Air in Harford County, Maryland. The system is operated by the Maryland American Water Company (MAWC). The water system consists of the Winters Run Water Treatment Plant (WTP) that primarily treats raw water from Winters Run. Two existing groundwater wells, the Winters Run Well and the Bynum Well, also provide raw water to the distribution system.

In addition to the raw water supply, the Bel Air system has a finished water supply available from the Harford County water system. MAWC constructed a metered connection to the County system on MacPhail Road and has purchased a supply capacity for up to 0.5 MGD. The County bills the Town for the actual water used at a bulk water rate. This supply is used to supplement the supply from the WTP and the wells.

The primary water supply for the system is Winters Run, which is currently permitted for a 1.4 MGD annual average withdrawal and a 1.7 MGD maximum daily withdrawal. The current withdrawal permit also includes a restriction that only allows MAWC to withdraw from the stream if the passing flow is 6.07 MGD or greater. Thus, during periods of low stream flow, the primary raw water supply to the system is either restricted or unavailable.

During such periods, the Bel Air system has historically relied on the wells and the Harford County supply to meet the system demand. This has required more than the contractual 0.5 MGD of supply from the County. With recent changes in water supply planning for the region, Harford County has identified long-term water supply shortfalls, and so the availability of surplus County water in excess of the contracted supply is no longer a reliable supply option for the Bel Air system.

To address these concerns, MAWC is constructing an off-stream raw water storage impoundment which will provide a reliable raw water supply source when water from Winters Run, the wells, and the County is not sufficient to meet demand. The objective of this memorandum is to identify the recommended water allocation and flowby condition in Winters Run that will allow successful operation of the off-stream impoundment while minimizing impacts to the downstream users and ecosystem.

2.0 Methodology and Assumptions

2.1 Study Approach

In order to simulate daily operation of an off-line impoundment at Bel Air over an extensive period of record, a custom computer model of the impoundment and supply system was programmed using Microsoft Visual Basic Express software. The purpose of this model was to simulate the operation of the proposed impoundment and supply system for an extended period of record to estimate water availability during drought events under proposed conditions.

The safe yield of a water system is defined as the maximum quantity of water that can be continuously supplied during the most severe drought of record without exhausting the supply storage. It is assumed that the impoundment is full at the beginning of the simulation period. The safe yield of the system is reached when the specified demand can no longer be satisfied by the system without encroaching on dead storage.

The safe yield is considered sufficient when a constant daily demand can be met by the system. The projected water demand for this system is the highest in 2017 with a maximum monthly demand of 1.62 MGD. To simulate higher demands which typically occur during the summer season coincident with drought events, this maximum monthly demand estimate was used as the constant daily demand throughout the entire modeling period, including during severe drought events.

To determine the storage volume needed in the impoundment, the study first evaluated historic stream flow data to establish the design duration of the withdrawal restrictions period and the corresponding volume of raw water required to meet the system needs during the worst drought of record. To minimize impacts to the downstream users and ecosystem, various water allocations and minimum flowby requirements downstream were also considered and compared.

2.2 Assumed Mode of System Operation

The current Bel Air water system consists of two wells, Winters Run Well and Bynum Well. The system also receives 0.5 MGD from the Harford County Interconnection. The safe yield computer model assumes that the wells and the county supplies provide constant supply of 0.644 MGD. The remaining demand is met from the permitted withdrawal from the stream when the flow is above the minimum flowby requirement. Residual water from the permitted stream withdrawal is used to fill the impoundment as needed. During periods of drought when streamflow in Winters Run is below the minimum flowby requirement, storage in the impoundment is used to continue to meet the demand.

2.3 Hydraulic and Hydrologic Inputs

To calculate water availability, storage, and consumption, the model accepts multiple user-defined inputs. These inputs allow the user to define various aspects of the impoundment and intake system, such as normal pool elevation, minimum flowby requirements, dead storage elevation, and stage-storage relationships. Hydraulic and hydrologic data including daily river flows, monthly net evaporation rates, and water from other sources are also required as model input. As water balance is tracked over the period of record, the model also creates output data files that can be used for further analysis.

The accuracy of analysis is dependent on the use of representative model inputs and sound assumptions. Hydrologic data and system specific data help define both the natural and physical limitations of the water supply system. The following sections describe various components of the Bel Air water supply system and the modeling assumptions associated with them.

2.3.1 Wells and Harford County Interconnection

Both the Winters Run Well and the Bynum Well is capable of supplying 100 gpm or 0.144 MGD. This provides a total of 0.288 MGD when both wells are in operation. In order to increase the reliability of the system, it was assumed that one of the wells would be out of service for the duration of the drought of record. The Harford County Interconnection is assumed to provide a constant 0.5 MGD throughout the modeled period.

2.3.2 Streamflow at Winters Run Intake

The U.S. Geological Survey (USGS) has collected daily streamflow values over long periods of record at selected gage sites. These streamflow records are a valuable source of hydrologic information. The primary stream gage used in the analysis is located on Winters Run approximately 0.4 miles upstream of the intake for the Bel Air water treatment plant. The data from this gage extends 47 years between 1967 and 2014. Regulatory flowby requirements for the Bel Air water supply system are based on a stream gage located at the intake. The drainage area between the Winters Run gage and the gage at the intake increases by 2.0 square miles. To account for the added drainage area, the stream discharge values from the USGS gage were linearly transposed to the intake location based on the ratio of the drainage areas.

In order to analyze system operation over an even longer duration, the period of record was extended using stream data from a nearby watershed. Seven additional stream gages were analyzed within a 31-mile radius of the Winters Run gage for potential use in this analysis. The criteria considered in selecting an appropriate gage included the distance from the Winters Run gage, the average unit watershed runoff, and the available period of record. Based upon these criteria, the Deer Creek gage at Rocks, MD (USGS No. 01580000) was selected as a source of supplemental streamflow data. The gage is located 7.8 miles from the Winters Run stream gage and has a drainage area of 94.4 square miles. The average runoff per square mile of drainage area is slightly lower than that of Winters Run which provides a more conservative streamflow estimate. By transposing the flows measured at the Deer Creek gage to the site, a continuous record of daily streamflows at the intake's gage was developed from 1926 to 2014.

2.3.3 Net Evaporation

Evaporative losses and direct rainfall inputs from reservoirs can be substantial and are especially important in accurately simulating a water system during times of drought. Net evaporation is gross evaporation minus precipitation on the surface area of the impoundment.

Monthly evaporation rates are available from published sources. Monthly gross evaporation in the vicinity were estimated based on the publication *Evaporation from Lakes and Reservoirs* by Adolph F. Meyer of the National Resources Planning Board (1942).

To compute the net evaporation, precipitation over the impoundment surface must also be estimated. Due to spatial variation in precipitation, it is best to use the climatological stations that are closest to the site. The National Climatic Data Center (NCDC) maintains records of monthly precipitation in the United States. Seven NCDC precipitation gages within a thirty mile radius of the dam site were analyzed. Four gages were selected due to their close proximity to the site and periods of record. One additional gage was used as a supplemental source.

The Fallston, MD gage (USC00183050) provided data for the study from 1926 to 1954. The Benson Police Barrac, MD gage (USC00180732) provided the majority of precipitation data from 1954 through 1997. The Conowingo Dam, MD gage (USW00013701) provided data from 1997 to 2007, and the Bel Air 1.7 W, MD gage (US1MDHR0011) provided data from 2007 to 2014. The Aberdeen Phillips Field, MD gage (USW00013777) was used to supplement data for all gages which were missing small sections of data. These gages provided an acceptable representation of the monthly precipitation over the proposed Bel Air impoundment site from 1926 to 2014, the same period of record as the daily streamflow data.

Daily net evaporation was computed by subtracting the monthly precipitation from the monthly gross evaporation and dividing the result by the number of days in each month. The daily net evaporation is an input to the computer program model for each day of the simulation.

2.3.4 Impoundment Characteristics

Within the model, the user is able to provide the stage-storage-surface area relationship of the impoundment. The surface area is used to calculate the total gains or losses due to net evaporation during each time step of the model. The user also defines the normal pool and dead storage elevations. For the purpose of maintaining aquatic habitat within the impoundment, dead storage was assumed to be 10 percent of the total impounded storage. An additional 2 percent of the total storage was assumed to be unusable to account for any sedimentation that may occur within the impoundment. Because this will be an upland impoundment with no substantial contributing drainage area, natural inflows were assumed to be negligible. Direct rainfall on the surface of the reservoir is accounted for by the net evaporation inputs. Figures 1 and 2 show the stage-storage and stage-surface area relationships, respectively. These relationships are based on preliminary design drawings which will be refined in subsequent design phases.

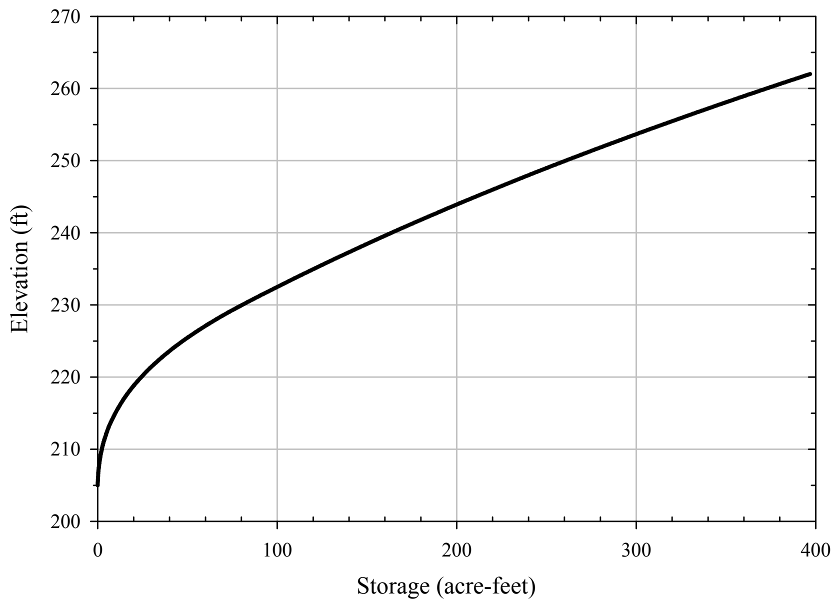


Figure 1. Stage-Storage Relationship of the Proposed Bel Air Impoundment

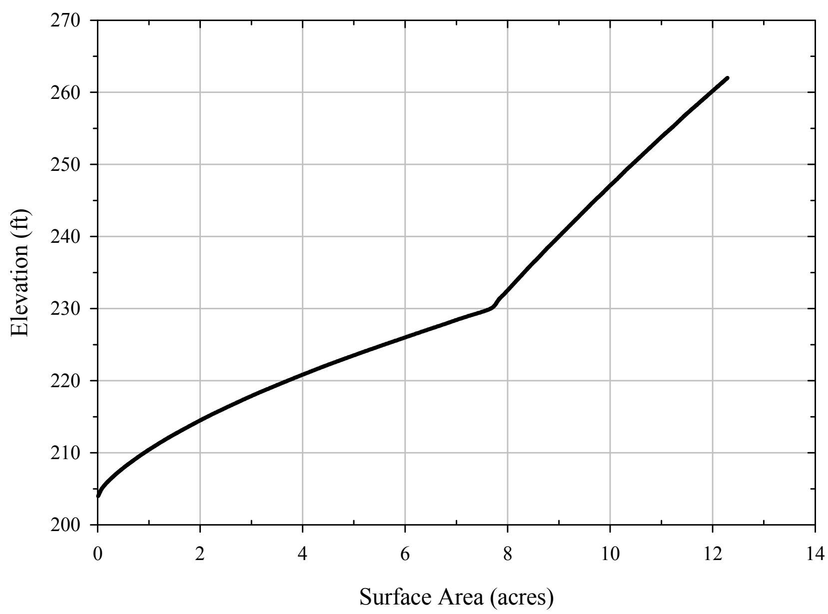


Figure 2. Stage-Surface Area Relationship of the Proposed Bel Air Impoundment

2.4 Downstream Water Users

As identified by Maryland Department of the Environment, there are three water users located downstream of the Bel Air water system which could be impacted by withdrawals from Winters Run to fill the proposed impoundment. These users are Jazpal LLC (Mountain Branch Golf Course), Van Bibber Water Treatment Plant (Aberdeen Proving Ground), and Jones Produce Farm. The withdrawal location for Jazpal LLC is approximately 0.7 miles downstream of Atkisson Reservoir, or about 5.0 miles downstream from the Bel Air WTP on Winters Run. The withdrawal appropriations and flowby requirements for the APG Van Bibber WTP and Jones Produce Farm are both based on the Otter Point Creek Stream Gage (USGS No. 01581757) located an additional 2.8 miles downstream. The permitted withdrawals and flowby requirements for each downstream user is summarized in Table 1.

Table 1. Existing Appropriations of MAWC and Downstream Water Users

Permittee	Effective Months	Ave. Daily Withdrawal (MGD)	Max. Daily Withdrawal (MGD)	Min. Flowby Requirement (MGD)	Drainage Area (sq. mi.)
MAWC Bel Air WTP	Year Round	1.40	1.70	6.07	36.8
Jazpal LLC (Mountain Branch Golf Course)	June-Nov	0.075	0.30	16.74	48.4
	Dec-May			31.86	
APG Van Bibber WTP	Year Round	2.10	4.00	10.21	55.6
Jones Produce Farm	Year Round	0.0144	0.136	10.21	55.6

3.0 Analysis Results and Recommendations

3.1 Recommended Water Appropriation

A range of potential daily withdrawal limits, flowby requirements, and impoundment storage volumes were analyzed in an effort to identify and minimize impacts to the downstream users and ecosystem. It is recommended that the current average daily withdrawal for the Winters Run WTP be increased from 1.4 MGD to 1.7 MGD, and that the maximum daily withdrawal be increased from 1.7 MGD to 8.4 MGD.

The 0.3 MGD increase in average daily withdrawal would allow the Bel Air WTP to maintain existing operations (1.4 MGD average daily withdrawal) and also fill the ~90 MG off-stream impoundment in any given year (90 MG divided by 365 days is approximately 0.3 MGD). During most years, the increase in average daily withdrawal will not be necessary. It is anticipated that this increase will only be required during exceptional events such as the first filling of the impoundment or when filling the impoundment following a drought event spans multiple calendar years.

In order to identify the optimal maximum daily withdrawal, a sensitivity analysis of this variable ranging from 1.7 MGD to 11.4 MGD was performed. Increasing the maximum daily withdrawal generally results in a reduction in the required impoundment storage as well as reduced filling times for the impoundment. Operation of an off-stream impoundment to meet drought demands was determined to be impractical under current permit limitations (1.7 MGD maximum daily withdrawal) due to extensive filling times and significant increases in the required storage volume. Conversely, reductions in the required storage are greatly diminished once the maximum daily withdrawal surpasses the recommended 8.4 MGD limitation. This means that the only benefit to increasing this limitation above 8.4 MGD would be a decrease in the number of days required to fill the impoundment. If the maximum daily withdrawal is less than 8.4 MGD, then the required storage volume and the number of days the stream is impacted during refilling events are increased. For example, a maximum daily withdrawal of 3.4 MGD would necessitate increasing the impoundment storage by about 15 percent and would increase the number of days required to fill the impoundment from about two weeks (at a maximum daily withdrawal of 8.4 MGD) to more than six weeks.

In order to minimize downstream impacts, the increase in maximum withdrawal would follow a staged flowby requirement with the existing maximum withdrawal of 1.7 MGD at a flowby of 6.07 MGD in Winters Run remaining unchanged. Any withdrawal in excess of 1.7 MGD up to the maximum withdrawal of 8.4 MGD would be subject to a higher flowby requirement. The higher flowby was calculated using the Maryland Most Common Flow Method.

The Maryland Most Common Flow Method was devised by the Water Resources Administration and used to establish flowby protection for the aquatic environment. The method assumes that the most common flow occurring in a specified period of time is within the tolerance limits of any natural organisms adapted to the stream's conditions. The method requires that an exceedance probability curve be created using mean monthly flow data from the stream gage. The flowby is then defined as the flow equal to the 85 percent exceedance value (i.e. the flow that is equaled or exceeded 85 percent of the time).

An exceedance curve of Winters Run flow was developed for every month of the year using data spanning from 1967 to 2014 from the Winters Run stream gage. The mean monthly flows were linearly transposed to the site of interest based upon the ratio of the respective drainage areas. The 85 percent exceedance probability flows were calculated for each month. In order to maintain a constant flowby requirement throughout the year, MDE's Water Supply Program recommended taking the average of the exceedance values for the months of July through October. This corresponds to the season with the lowest average flow rates in Winters Run. The flowby calculated using this method is 11.47 MGD.

The combination of allowable withdrawals and flowby requirements is illustrated in Figure 3. By operating under these recommended regulatory requirements, the Bel Air water supply system and proposed impoundment would be able to meet projected demands of the water system through the drought of record. Furthermore, the proposed requirements would eliminate any impacts to the Van Bibber WTP and Jones Produce Farm and minimize impacts to the Mountain Branch Golf Course and the aquatic environment.

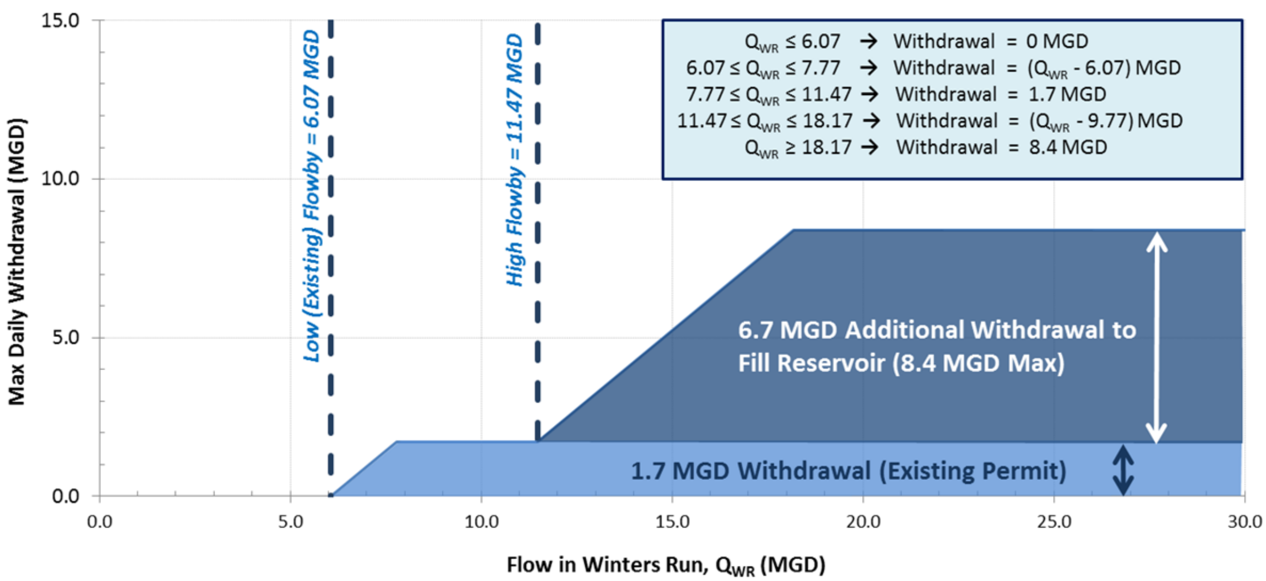


Figure 3. Recommended Allowable Withdrawal and Flowby Requirements

3.3 Impoundment Size and Frequency of Use

While the Based on the recommended water appropriation and flowby requirements described in Section 3.1, the total storage of the proposed impoundment will be equal to 90 million gallons (276 acre-feet). This includes a 10 percent dead storage volume for the purpose of maintaining aquatic habitat within the impoundment during extreme droughts and an additional 2 percent sediment storage volume. It also assumes that during the drought of record, the water system intake would be able to capture 75 percent of allowable withdrawals from Winters Run when flows in the stream intermittently spike above the permitted flowby requirement.

Per the model analysis, supplemental water supply from the impoundment to meet demand and subsequent pumping from Winters Run to fill the impoundment other than to top off the impoundment from evaporation losses, was simulated to be needed approximately 29 years out of the 88-year period of record. Therefore, for the assumed operating conditions, no impoundment withdrawals would be required to meet water supply demands during 59 of the 88 years of simulation. A plot showing streamflow at the intake, water released from the impoundment for water supply, pumped water from Winters Run to refill the impoundment, and changes in the impoundment volume for the 88-year period of simulation (1926 to 2014) are presented in Attachment A.

Out of these 29 years where impoundment water is needed for water supply, the demand from the impoundment for 12 of the years was relatively insignificant and resulted in negligible water being pumped from Winters Run to refill the impoundment. The simulation shows that long continuous periods are likely to occur when no supplemental water from the impoundment will be needed. For example, the simulation shows that the longest period when no water was needed from the impoundment was the 12-year period from 1942 to 1954. During this period the average daily flow from Winters Run never fell below 6.07 MGD.

Over the 88-year period of simulation, use of stored water for water supply was required approximately 8.4 days per year (about 2.3 percent of the time) with a total average yearly use of 6.2 MG. Over this same period, water withdrawn from Winters Run to fill the impoundment, other than nominal amounts to refill for evaporation losses, was simulated to occur on average 3.7 days per year or about 1.0 percent of the time. The total stored water used during the drought of record (2002) was 86 MG. The drought spanned a period of approximately 98 days. During the drought of record, there were 12 days when the flow in Winters Run exceeded the 6.07 MGD flowby and a total of 9.6 MG was withdrawn to meet daily water supply demands. Over this same period, the flow in Winters Run also allowed refilling of the reservoir for 5 days for a total volume of 15.6 MG. For the final sizing of the reservoir, it was assumed that only 75% of these available withdrawals from Winters Run would be captured during the drought.

3.4 Impacts to Downstream Water Users

As described in Section 3.1, the higher flowby was established using the Maryland Most Common Flow Method to provide protection for the aquatic environment. The flowby of 11.47 MGD was also analyzed to evaluate the effects the new water allocation would have on downstream users. This was done by estimating the magnitude that the higher flowby would need to be at the Bel Air intake in order to meet the current maximum permitted withdrawals and flowby requirements of the Bel Air water supply, the Van Bibber WTP, and Jones Produce Farm. This was calculated assuming flow is proportional to the contributing drainage area of both the Bel Air Intake (36.8 square miles) and the Otter Point Creek Stream Gage (55.6 square miles).

Analysis of available daily flow data from the Otter Point Creek Stream Gage indicates an average annual runoff of 1.59 cfs per square mile (cfsm) from 2004 to the present. Over the same period, the average annual runoff at the Winters Run gage was 1.51 cfsm, indicating that the watershed area downstream of the Bel Air intake produces a greater amount of runoff than the area upstream of the intake even after existing withdrawals occur at the Bel Air WTP. The assumption that flow within the watershed is proportional to the contributing drainage area is, therefore, conservative for the purpose of quantifying impacts to downstream users.

In order to eliminate any additional impacts to the Van Bibber WTP and Jones Produce Farm, it was determined that the higher flowby must be equal to or greater than 10.62 MGD. Assuming flows within the watershed are linearly proportional, when a flow 10.62 MGD is occurring at Winters Run, the corresponding natural flow at Otter Point Creek is 16.05 MGD. However, the existing permit allows a 1.7 MGD withdrawal at the Bel Air WTP for this condition, and so the flow at the downstream Otter Point Creek must also be decreased by this withdrawal amount. <u>The resultant flow at Otter Point Creek is 14.35 MGD when a flow of 10.62 MGD is occurring at the Winters Run gage.</u>

At present, the Van Bibber WTP and Jones Produce Farm have a combined maximum daily allocation of 4.14 MGD (4.0 MGD for Van Bibber WTP; 0.136 MGD for Jones Produce Farm). Both of these withdrawals are contingent on the same minimum flowby requirement of 10.21 MGD at the Otter Point Gage. This means that in order for both water users to fully withdraw their permitted allocation, the discharge at the Otter Point Creek stream gage must be equal to the minimum flowby plus the maximum daily withdrawal, or 14.35 MGD. <u>For any flow condition in excess of 14.35 MGD at the Otter Point Creek gage, both the Van Bibber WTP and Jones Produce Farm should be able to withdraw their full allocation.</u>

Based upon this calculation, it was determined that using a higher flowby equal to or greater than 10.62 MGD at the Winters Run Stream Gage would allow the filling of the Bel Air impoundment at a withdrawal rate higher than the currently permitted 1.7 MGD maximum daily withdrawal without impacting the Van Bibber WTP and Jones Produce Farm. Because the recommended flowby of 11.47 MGD (based on the Maryland Most Common Flow Method) is higher than 10.62 MGD, it can be concluded that the proposed stream withdrawals at the Bel Air intake will not have any adverse impacts on the Van Bibber WTP or Jones Produce Farm. This conclusion was confirmed within the safe yield computer model.

Given the much higher flowby requirement and purpose of water use of the Mountain Branch Golf Course (Jazpal LLC), it was judged that avoiding all impacts to the existing withdrawal at this facility was impractical and unnecessary. Over the 88-year period of record, the proposed allowable withdrawal and flowby requirements would result in an average total impact of 0.04 MG per year. This impact is judged to be negligible considering that the golf course has a daily allocation of 0.3 MG. The maximum annual impact was 0.61 MG over 3 non-consecutive days during the year. Table 2 summarizes the impacts that the revised permit conditions would have on the Mountain Branch Golf Course.

Table 2. Summary of Impacts to the Mountain Branch Golf Course (Jazpal LLC)

Scenario	Duration of Impact (days/year)	Duration of Impact (%)	Total Annual Impact (MG/year)
Average Annual Impact	0.7	0.2	0.04
Maximum Annual Impact	3.0	0.8	0.61
Minimum Annual Impact	0.0	0.0	0.00

3.5 Impacts to the Downstream Aquatic Environment

It is proposed that the existing flowby requirement at the Winters Run intake remain unchanged and that a significantly higher flowby be adopted for the relatively infrequent periods when the impoundment is refilled. The existing flowby (6.07 MGD) is based on a statistical estimate of the lowest average flow that would be experienced in Winters Run during a consecutive 7-day period with an average recurrence interval of ten years ($Q_{7,10}$). The $Q_{7,10}$ is a flowby threshold commonly used by regulatory agencies to protect aquatic resources and maintain water quality downstream of points of withdrawal. The proposed higher flowby of 11.47 MGD based from calculations of the Maryland Most Common Flow Method is 89 percent greater than the existing flowby estimate of the $Q_{7,10}$, thereby providing a greater level of protection to the downstream ecosystem than the current permit requirement.

Furthermore, the model simulation of the proposed system indicates that other than small withdrawals to replenish the reservoir due to evaporation losses, water would be withdrawn from Winters Run to fill the impoundment only one out of every three years. Withdrawals from

Winters Run to refill the impoundment would exceed an annual cumulative total of 7 MG only once every five years. The infrequency of withdrawals from Winters Run in excess of the existing permit limits is further illustrated by Figures 4 and 5.

Figure 4 shows the percent of time that a given percentage of the natural flow in Winters Run would be withdrawn for the existing and proposed permit scenarios. Significant divergence from the existing condition would occur less than one percent of the time under the recommended permit constraints. The greatest withdrawals would occur less than 0.2 percent of the time (or an average of less than one day per year).

Figure 5 displays a flow duration curve of regulated streamflow within Winters Run immediately downstream of the intake over the 88-year simulated period of record for the existing and proposed scenarios. Due to the infrequency of the required use and refilling of impoundment storage, the flow duration curves for the existing and proposed conditions are almost indistinguishable, representing the very limited impact the proposed withdrawal will have on downstream flows.

Given that the proposed higher flowby provides a greater level of protection to the downstream ecosystem than the current permit requirement and the infrequency of withdrawals to refill the impoundment in excess of current permitted withdrawals, it is judged that the impact to the downstream aquatic environment will be negligible.

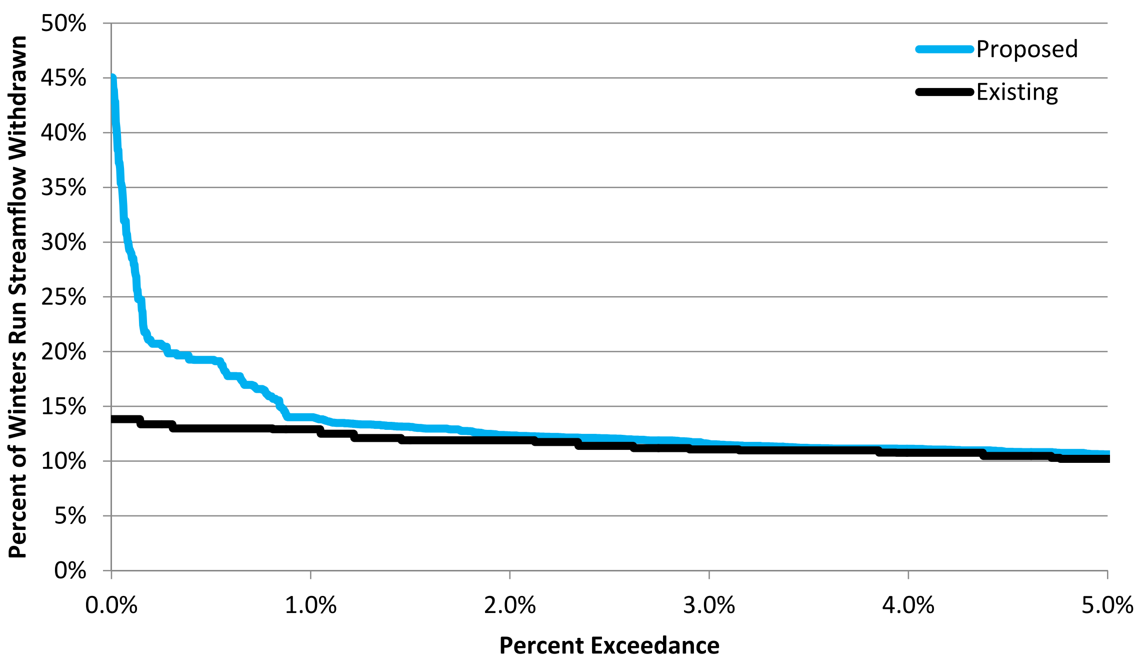


Figure 4. Exceedance Curve of Winters Run Withdrawals

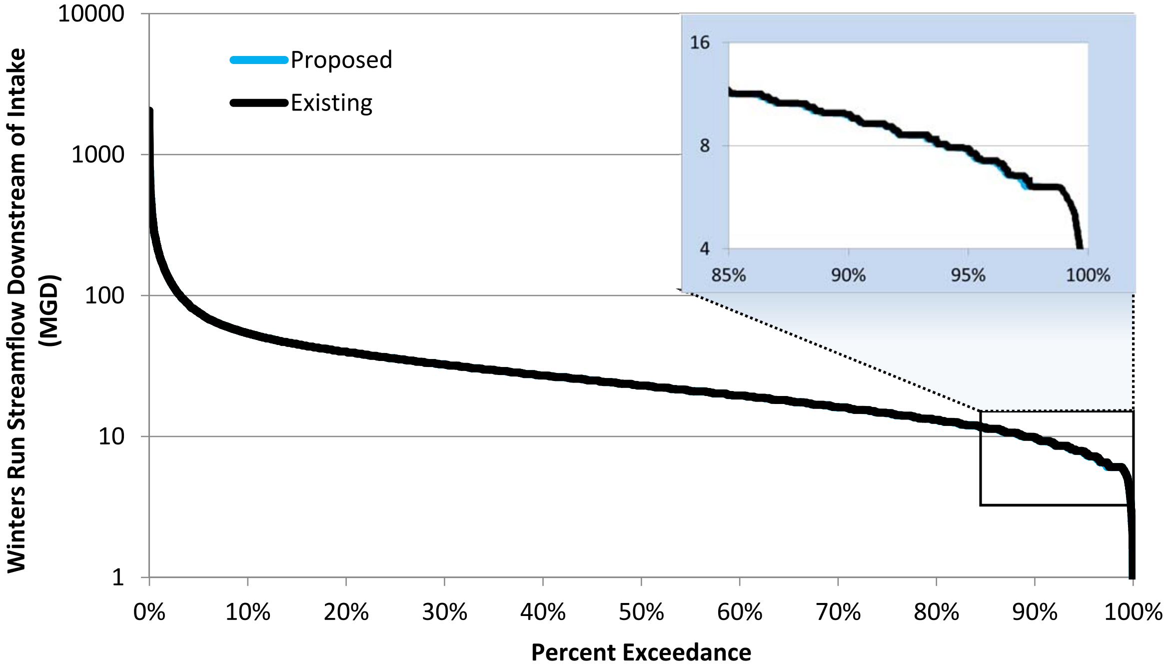


Figure 5. Regulated Streamflow Duration Curve Downstream of Bel Air Intake

4.0 Summary

MAWC is constructing an off-stream raw water storage impoundment which will provide a raw water supply when the water from the stream, wells, and the County is not sufficient to meet demand. The objective of this memorandum is to identify the recommended water allocation and flowby condition in Winters Run that will allow successful operation of the off-stream impoundment while minimizing impacts to the downstream users and ecosystem.

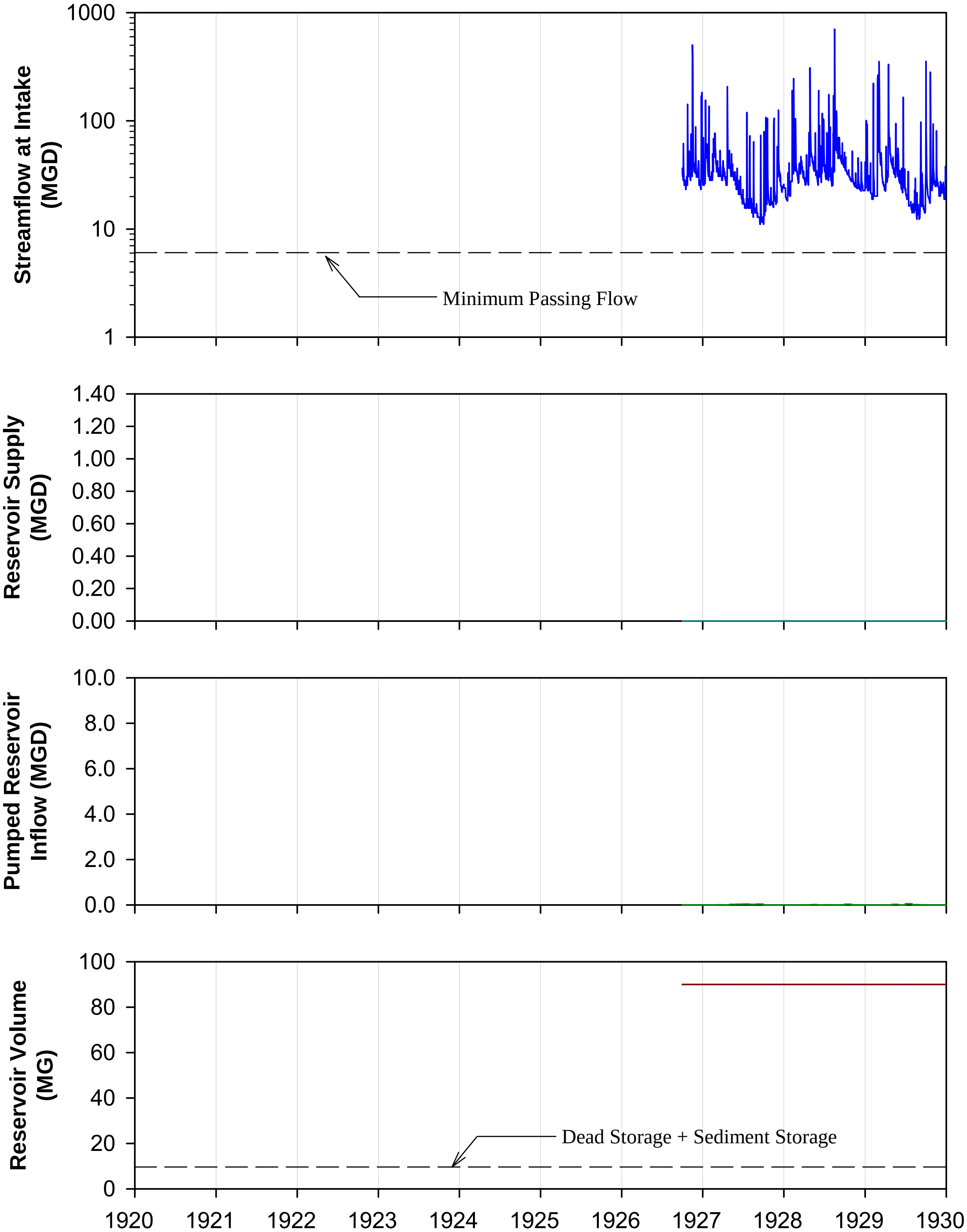
It is recommended that the current average daily withdrawal for the Bel Air WTP be increased from 1.4 MGD to 1.7 MGD, and that the maximum daily withdrawal be increased from 1.7 MGD to 8.4 MGD. The increase in average daily withdrawal would allow the Bel Air WTP to maintain existing water supply operations and also fill the proposed off stream impoundment in any given year. The increase in maximum withdrawal would follow a staged flowby requirement with the existing withdrawal of 1.7 MGD at a flowby of 6.07 MGD in Winters Run remaining intact and any withdrawal in excess of 1.7 MGD up to the maximum withdrawal of 8.4 MGD being subject to a higher flowby requirement. Using the Maryland Most Common Flow Method, a higher flowby of 11.47 MGD is recommended in order to minimize impacts to the downstream aquatic environment. This higher flowby was also proven to eliminate any impacts to the Van Bibber WTP and Jones Produce Farm and minimized impacts to the Mountain Branch Golf Course.

ATTACHMENT A

Decade Analysis Output for Impoundment

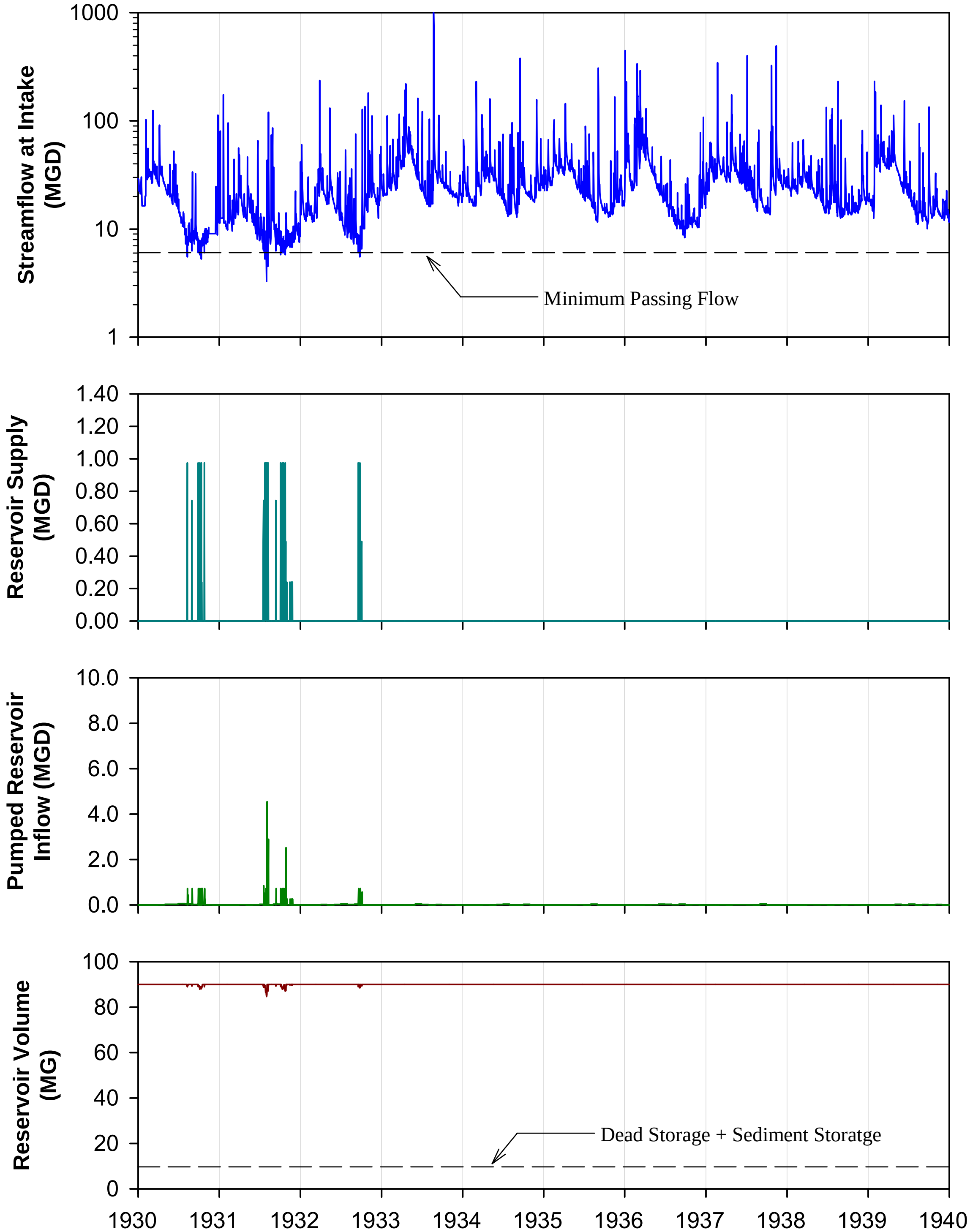
Summary of Impoundment Operations **1920 – 1930**

Constant Demand:	1.62 MGD	**Minimum Passing Flow:**	6.07 MGD
Normal Pool Elevation:	256.0 feet	**Permitted Daily Withdrawal:**	8.40 MGD



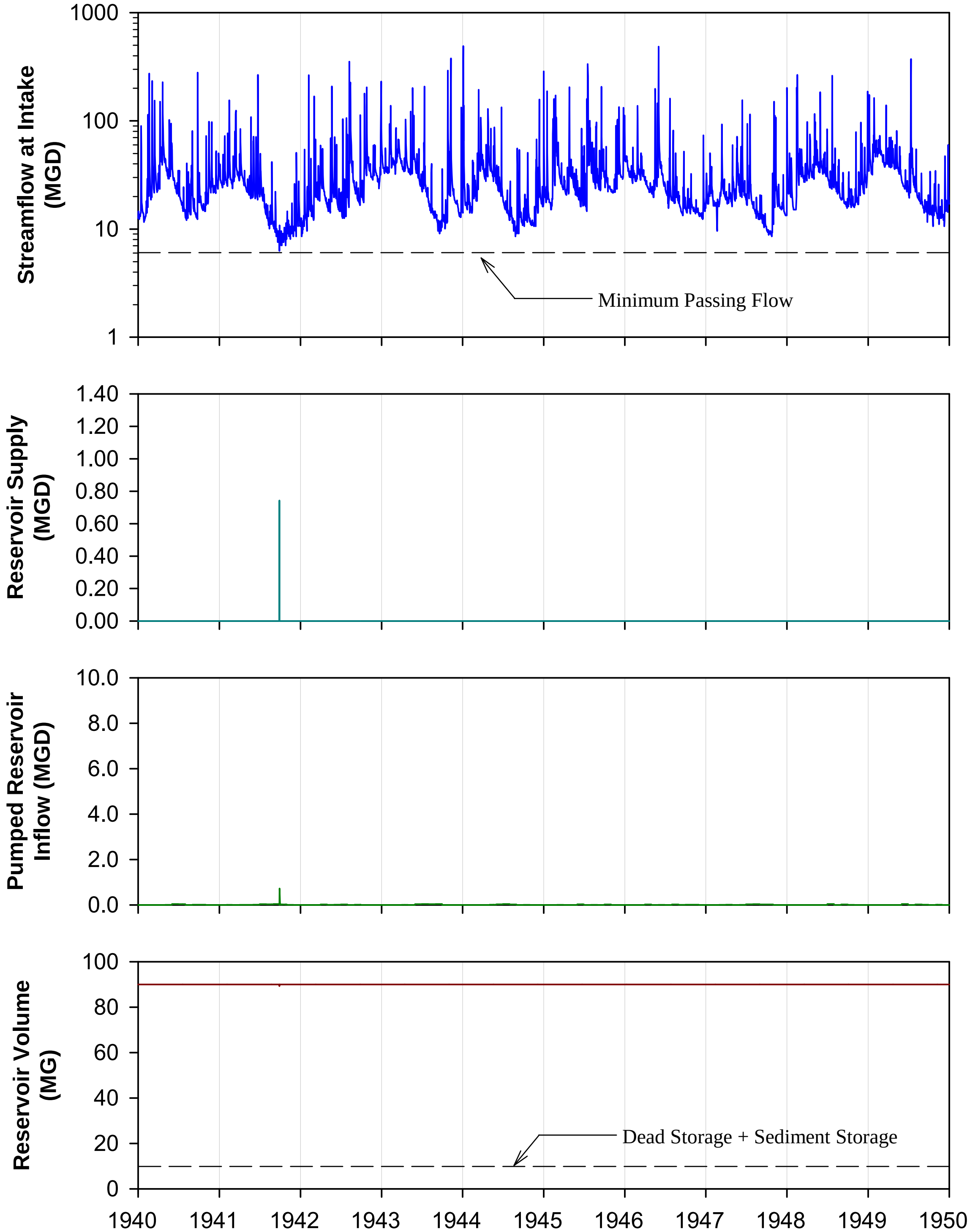
Summary of Impoundment Operations 1930 – 1940

Constant Demand: 1.62 MGD
Normal Pool Elevation: 256.0 feet
Minimum Passing Flow: 6.07 MGD
Permitted Daily Withdrawal: 8.40 MGD



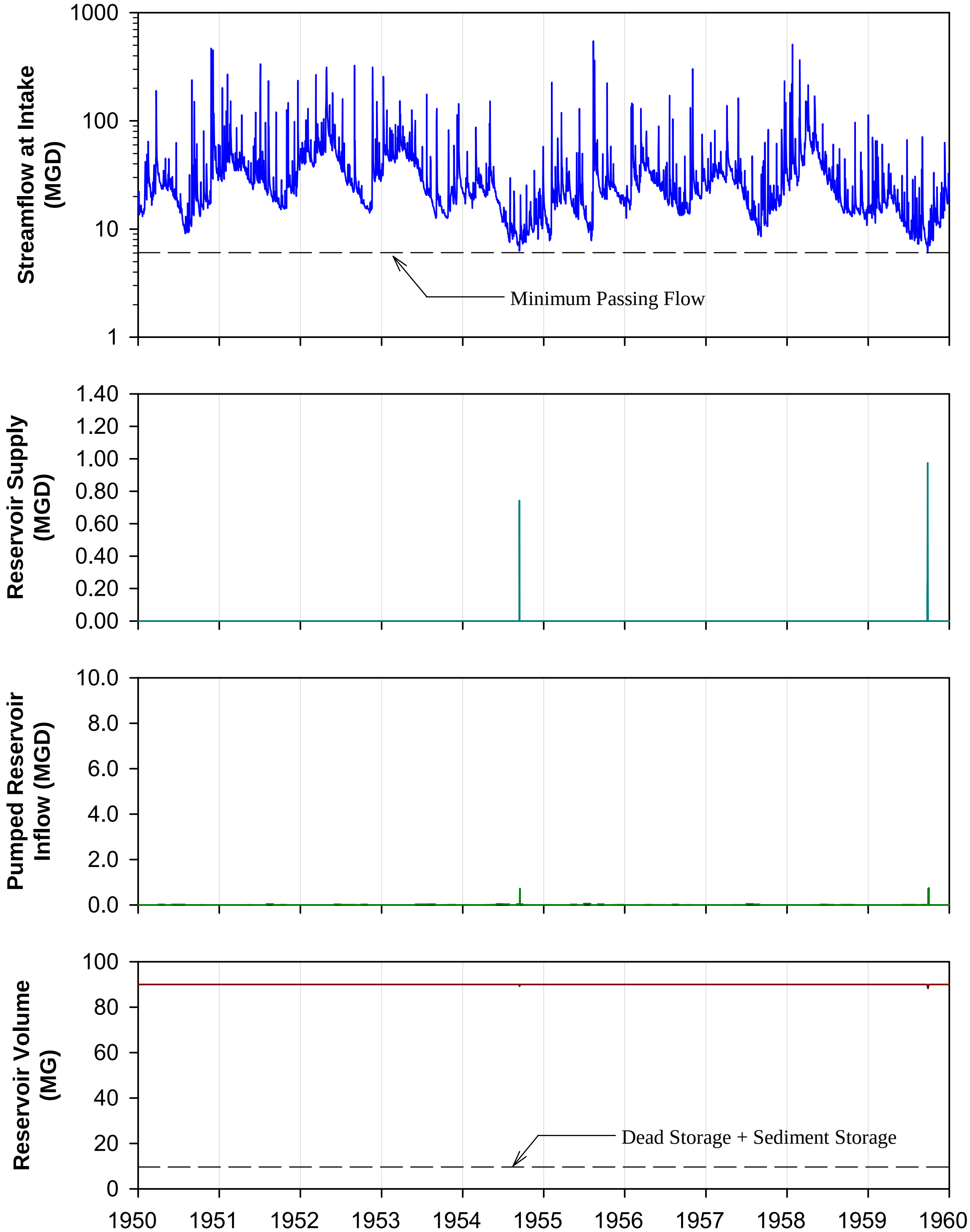
Summary of Impoundment Operations 1940 – 1950

Constant Demand:	1.62 MGD	**Minimum Passing Flow:**	6.07 MGD
Normal Pool Elevation:	256.0 feet	**Permitted Daily Withdrawal:**	8.40 MGD



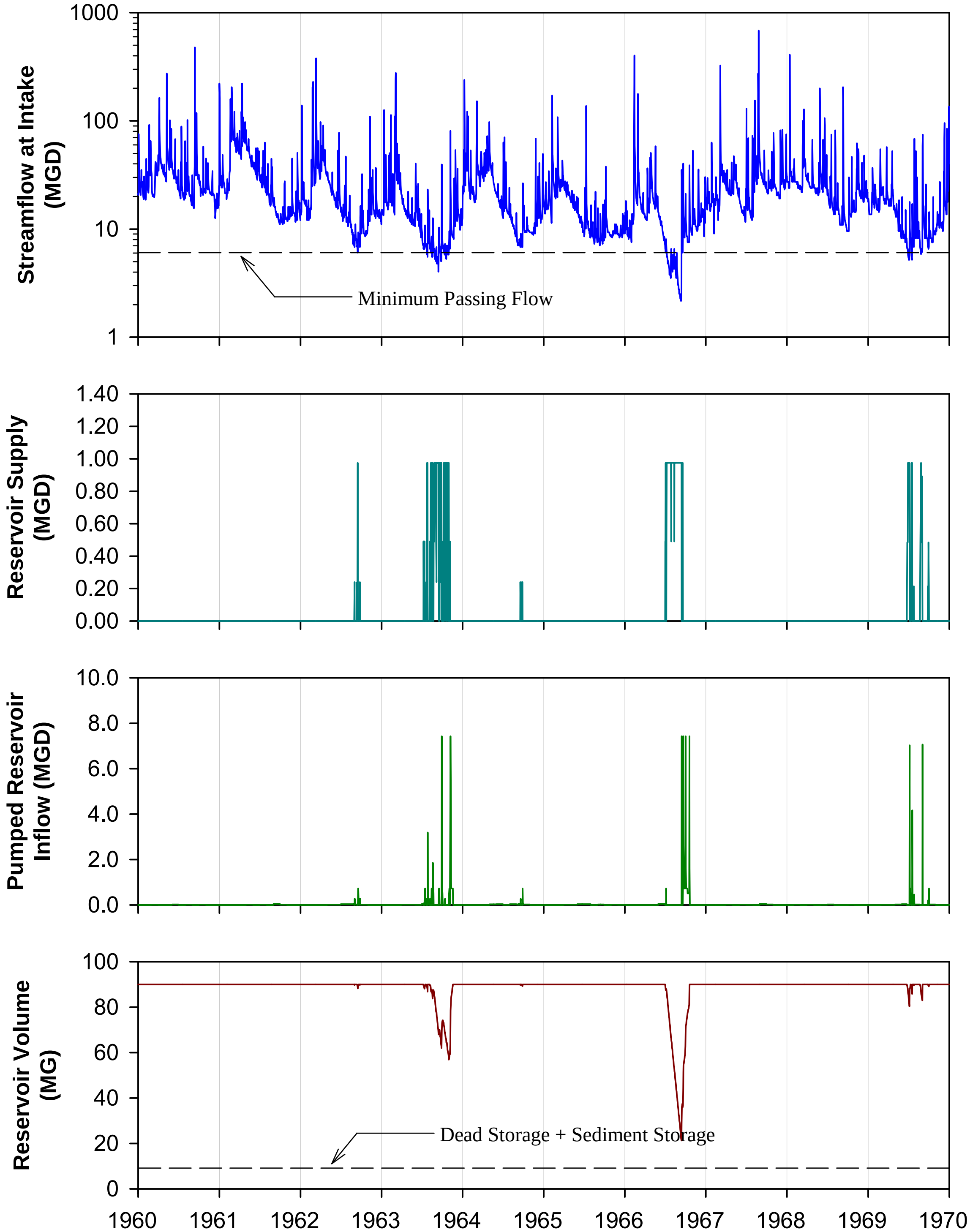
Summary of Impoundment Operations **1950 – 1960**

Constant Demand: 1.62 MGD **Minimum Passing Flow:** 6.07 MGD
Normal Pool Elevation: 256.0 feet **Permitted Daily Withdrawal:** 8.40 MGD



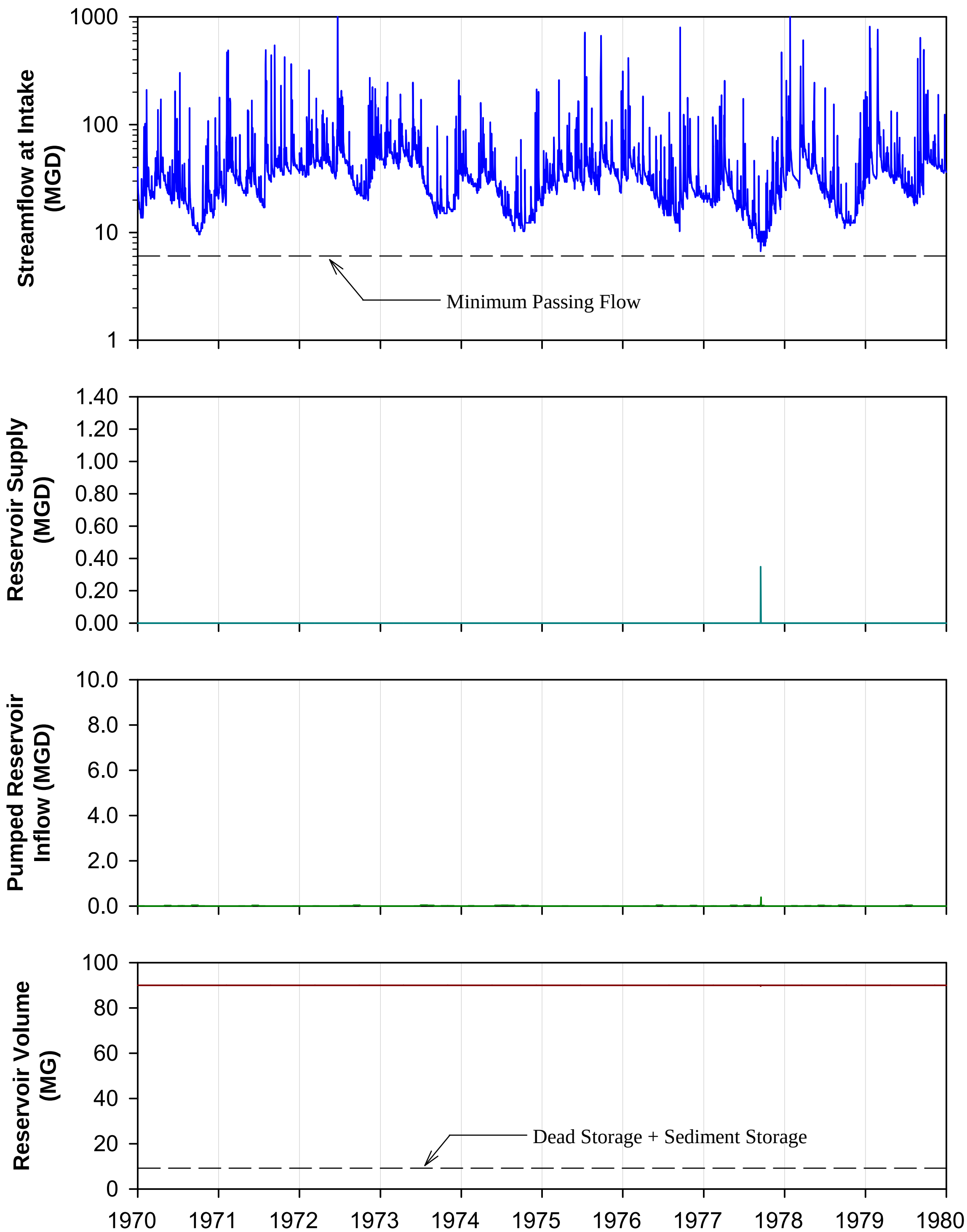
Summary of Impoundment Operations 1960 – 1970

Constant Demand: 1.62 MGD
Normal Pool Elevation: 256.0 feet
Minimum Passing Flow: 6.07 MGD
Permitted Daily Withdrawal: 8.40 MGD



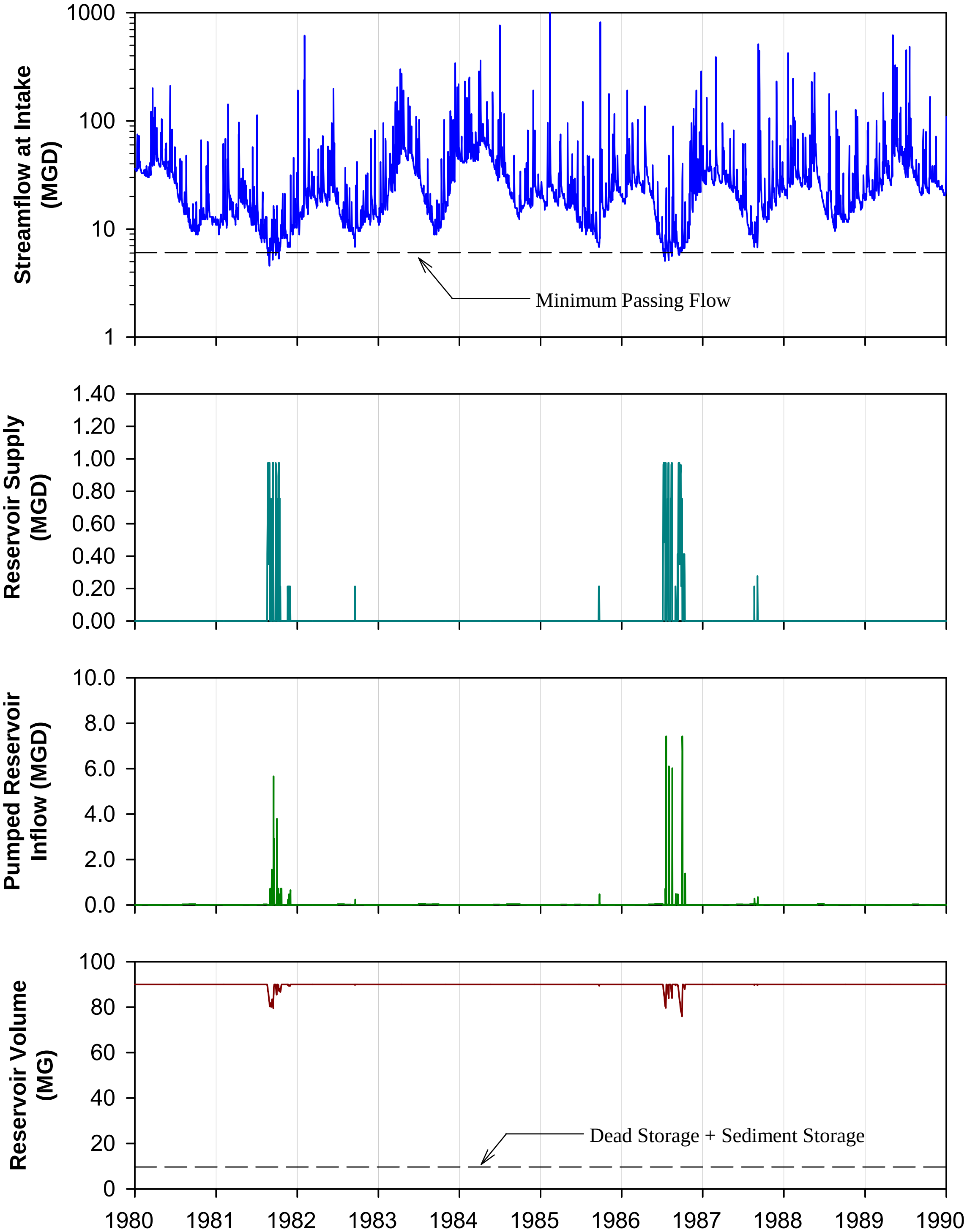
Summary of Impoundment Operations **1970 – 1980**

Constant Demand:	1.62 MGD	**Minimum Passing Flow:**	6.07 MGD
Normal Pool Elevation:	256.0 feet	**Permitted Daily Withdrawal:**	8.40 MGD



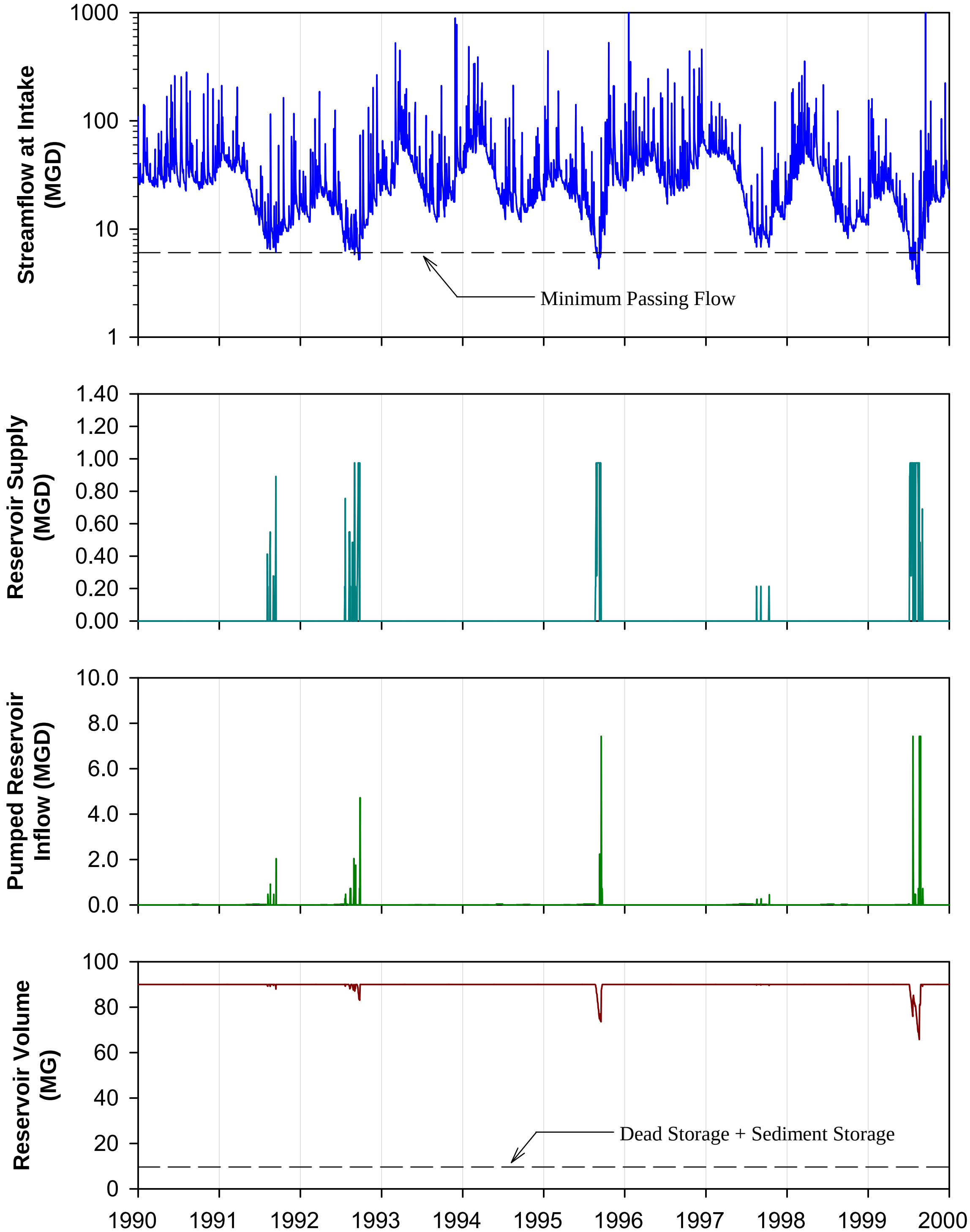
Summary of Impoundment Operations 1980 – 1990

Constant Demand: 1.62 MGD
Normal Pool Elevation: 256.0 feet
Minimum Passing Flow: 6.07 MGD
Permitted Daily Withdrawal: 8.40 MGD



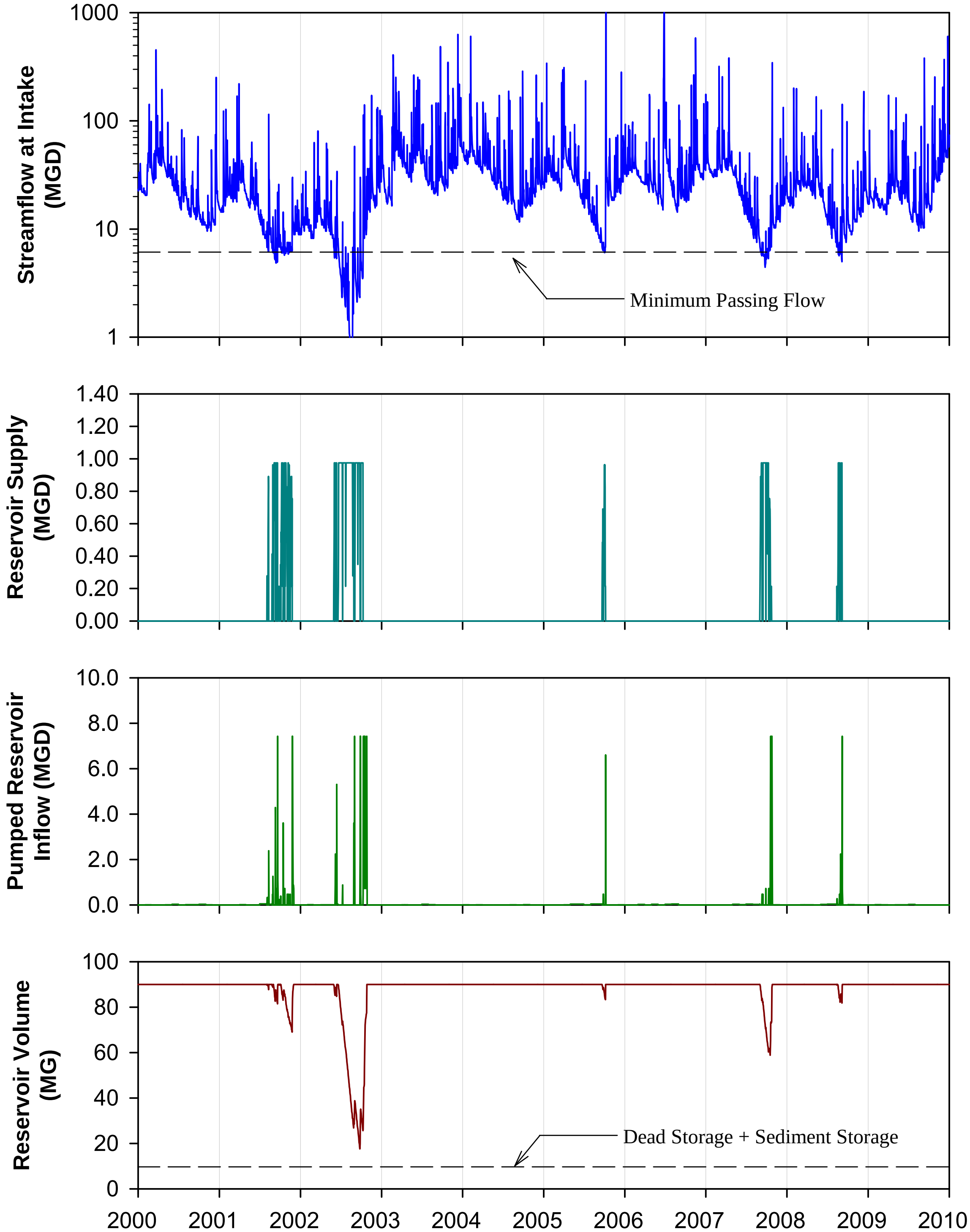
Summary of Impoundment Operations 1990 – 2000

Constant Demand: 1.62 MGD
Normal Pool Elevation: 256.0 feet
Minimum Passing Flow: 6.07 MGD
Permitted Daily Withdrawal: 8.40 MGD



Summary of Impoundment Operations **2000 – 2010**

Constant Demand:	1.62 MGD	**Minimum Passing Flow:**	6.07 MGD
Normal Pool Elevation:	256.0 feet	**Permitted Daily Withdrawal:**	8.40 MGD



Summary of Impoundment Operations 2010 – 2020

Constant Demand:	1.62 MGD	**Minimum Passing Flow:**	6.07 MGD
Normal Pool Elevation:	256.0 feet	**Permitted Daily Withdrawal:**	8.40 MGD