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Analysis of mainstay discharge in the Way Batumerah Watershed for annual water allocation plans

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***Keywords*— Raw Water, Water Allocation, Mainstay Discharge, Maintenance Flow.**

***Abstract*—** *This water shortage has caused drought disasters whose impact is felt both in rural areas in decreasing food production and in urban areas experiencing raw water difficulties. In the implementation of the "Water Allocation Preparation" activity, several technical approaches will be carried out including: Data Collection; Data Analysis; Prioritization of water users; Calculation of water balance; Calculation of water allocation plan; and Implementation, Monitoring and Evaluation of the Implementation of the Annual Water Allocation Plan. In the watershed of Way Batumerah, the intake area has a watershed area of 6.97 Km^2 where the Batumerah Intake; Sedimentation occurs in the distribution pipe; There are two villages that are drained by intakes; There are community channels around the intake; and During the dry season, water is not enough to meet the needs of the community.The availability of water in the Batumerah River can be calculated in a period of half a month. In wet year conditions, the largest mainstay discharge (Q30%) of 1.83 m^3 /s occurred in October II. In normal year conditions, the largest mainstay discharge (Q50%) was obtained at 0.89 m^3/s in September II. In dry years, the largest mainstay discharge (Q80%) was obtained at 0.35 m^3/s in June I. The calculation of maintenance flow needs must follow KP 02/2013 which is 5% of the existing discharge in the relevant period or Q95 according to SE Director General of Natural Resources 05/2016.The water allocation unit and allocation limit for PDAMs in the Batumerah watershed are assumed to be in accordance with the value of PDAM's water needs for the dry condition half-month, which is 0.105 m^3/s. However, in certain months there is a deficit, so PDAM's water demand is the result of reducing water availability with minimum maintenance flow needs (0.001 m^3/s). Water use priority is a policy that regulates the order of water allocation based on applicable laws and regulations.*

I. INTRODUCTION

Water is the source of life for humans and other living things. The nature of water is very different compared to other resources, because water is a flowing resource, knows no administrative boundaries, and its needs depend on time, space, quantity and quality. Water problems can be broadly divided into three categories, namely: 1) Too much water, generally occurs in the rainy season, and often causes floods; 2) Too dirty water, that is, water pollution, occurs mostly due to industrial, household and agricultural waste; and 3) Too little water. This water shortage has caused drought disasters whose impact is felt both in rural areas in decreasing food production and in urban areas experiencing raw water difficulties. This also creates conflicts of interest between water users, as has often happened in the dry

season. With the increasing population and the development of socio-economic life of the community, it will also cause an increase in the need for water. This will cause water to increasingly become a scarce item at certain times for some locations that are prone to water shortages. This conflict of interest for water, which was originally only between individuals or community groups using water, with the spirit of decentralization and regional autonomy is feared to have the potential to escalate local conflicts into unwanted conflicts between districts / cities. Water allocation is a series of actions, which include: actions to regulate water rations/quotas in accordance with the type of water use, efforts to always be able to meet the amount and quality of water in accordance with the rights guaranteed by the state. The basic needs of daily life and people's agricultural business in the irrigation system are the top priority, as well as the rights of other water users obtained based on water use permits, where the amount / volume of water that can be taken from a network of water sources for business purposes has been determined. By allocating water, it is hoped that it can prevent violations that can result in interference with the human rights of other people or parties.

II. LITERATURE REVIEW

2.1 Water Allocation System

Effective water allocation requires an approach that can be applied to three key areas: 1) policies and regulations, 2) management strategies, and 3) institutional capacity. Policies and regulations constitute the legal framework for water allocation. Management strategies include plans, tools, methodologies, processes, and approaches to implement legal and policy frameworks. While institutional capacity is the ability of organizations and stakeholders in shaping policies and strategies (WWF, 2007). These three elements determine the functioning of the water allocation system and the protection of related resources in the watershed. If one of the three elements is inconsistent with the other two, then the implementation of the system will be dangerous. Without a policy level, there will be no clear legal understanding of water use. Without a good management strategy, the implementation of laws to achieve sustainable water allocation will experience obstacles. Without institutional capabilities, the implementation of water allocation will be weak. To be able to implement a fair and sustainable allocation of water requires intervention from one or more of the above aspects.

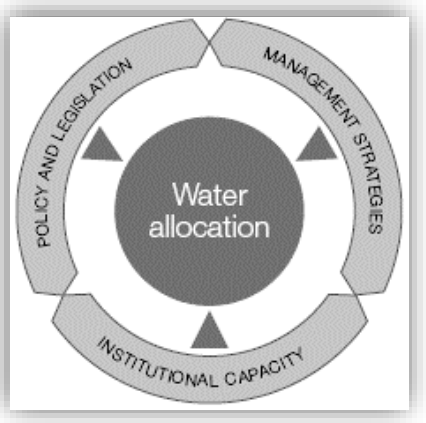

Fig.1 Water Allocation System according to WWF (2007)

2.2 Basic principles of Water Allocation

Water allocation is the process of rationing water for various types of uses whose amount is adjusted to the availability of water contained in a source / location, and in accordance with Law No.11/1974, article 11 paragraph 1. In accordance with the development of water allocation management, water allocation planning must be comprehensive from upstream to downstream and based on river basins (WS) or at least on a watershed scale, and with the basic principles of water allocation management must be based on PUPR Regulation No. 06 / PRT / M / 2015, article 9 namely in allocating water and water sources for water resources infrastructure operations must be carried out based on the principles of: a. prioritizing the allocation of water for the fulfillment of basic daily needs and irrigation for people's agriculture in the existing irrigation system; b. maintain the continuity of water allocation for other existing water users; c. pay attention to the allocation of water to meet basic daily needs for residents who live near water sources and / or around water-carrying networks.

Planning water allocation at the watershed level or watershed level is a comprehensive effort that

Based on policies that aim to uphold the following five principles:

1) Justice; i.e. allocating water fairly and proportionately among type groups use, justice between administrative regions, and justice between upstream and downstream regions.
2) Environmental protection; That is to allocate a certain amount of fresh water for needs ecosystem and including to accommodate the needs of sediment transport, water recharge soil, waste decomposition and ecosystem sustainability in estuaries.
3) Development priorities; allocate water to support development needs economic and social, among others,

to support strategic priorities and protect dependencies of existing needs.

4) Balance between water supply and demand; i.e. balancing the water supply with dynamic needs demands, especially to manage variability natural supply of water, and to avoid or prevent frequent water deficits.
5) Unexpected.Promote efficient use of water; i.e. promote continuously to water users so that they are moved and able to take initiatives to make efficiency in water use

2.3 Preparation for Water Allocation

Division of Government Affairs field of public works and spatial planning, sub affairs: Water Resources, then the authority in

The arrangement/management of water allocation activities is as follows:

1. Water sources located in river basins whose management authority is located
2. on Government implemented by the Directorate General of Water Resources of the Ministry Public Works and Public Housing through BBWS/BWS and/or Legal Entities.
3. Water sources located in river areas whose management authority is located in the Provincial Government is carried out by the BPSDA WS concerned.
4. Water sources located in river areas whose management authority is on: The Regency/City Government is implemented by SKPD formed by the Government The District/City concerned

2.4 Water Availability and Demand

Water availability basically consists of three forms, namely rainwater, surface water, and groundwater. The main water source in water allocation management is surface water sources in the form of water in rivers, channels, lakes, and other reservoirs. The use of groundwater is in fact very helpful in meeting the needs of raw water and irrigation water in areas that are difficult to get surface water, but its sustainability needs to be maintained with controlled intake under safe yield. In water allocation management, rainwater contributes to reducing the need for irrigation water, namely in the form of effective rain. In some areas with inadequate surface water quality, rain harvesting is carried out, where rainwater is collected into a source of water for domestic use.

To express water availability using only a number, the number is the average of existing discharge data. This method does not provide information about data variability. Presenting data as 12 numbers that express a monthly average provides more information about data variability in a year, but does not provide information about how reliable debits are. A number that shows the variability of water availability as well as shows how much reliable discharge is the mainstay discharge.

2.5 Mainstay Debit

A mainstay discharge is a discharge that can be relied upon for a certain level of reliability or reliability. For irrigation purposes, mainstay discharge with 80% reliability is usually used as stipulated in the Irrigation Planning Criteria (Directorate General of Irrigation, 1985). This means that with an 80% chance that the discharge that occurs is greater or equal to the discharge, or in other words the irrigation system can fail once in five years. For drinking water purposes and industry, higher reliability is required, which is around 90% to 95%. If river water is used for hydroelectric power generation, it requires very high reliability, which is between 95% to 99% (Goodman, 1984).

2.6 Household and Urban Water Needs

Household and urban water needs (domestic and municipal) are often referred to as raw water if the water has not been treated, and clean water or drinking water if the water has been treated using a Water Treatment Plant. This need is very important to always be met, because failure to meet household and urban water needs can cause disease outbreaks and public unrest. The amount of water demand depends on the population, consumption patterns that are in line with the increase in welfare levels, and the size of the city, or village which can be assumed to depend on the population.

2.7 Industrial Water Requirements

Industrial water requirements are generally constant relative to time. With the increase in industry, so does the need for industrial water. Industrial water demand surveys are needed to determine the average water use in certain types of industries. This index number can then be related to the size of the industry, for example through the number of products produced, or the number of labor. For industries located in an industrial area, a rough estimate of water needs per hectare can be used between 0.5 to 2 liters / s.

2.8 Agricultural Water Requirements

In water allocation management in river basins, irrigation water demand data can be obtained from river basin managers, such as the District/City Irrigation Public Works Office (DPUP), or the Provincial Water Resources Office, or River Basin Centers and Halls, as input for water allocation management. The amount of irrigation water demand in this field can be checked with the help of a computer model to calculate irrigation water needs, based on parameters that influence, including planting patterns and schedules, effective rainfall, percolation, efficiency,

groups, and so on based on KP01 irrigation network planning criteria from the Directorate General of Irrigation (1985). Water requirements in rice fields depend on factors: land preparation, consumptive use, percolation and seepage, water layer change, effective rainfall, and irrigation efficiency. Water needs in this rice field can be expressed in units of mm / day or liter / s / ha.

2.9 Water Requirements for Maintenance Flow

Based on Government Regulation Number 38 of 2011 concerning Rivers, the amount of river maintenance flow is the mainstay discharge of 95%. The amount of river maintenance flow is equivalent to 20 years of dry discharge, a relatively small number, but in river areas with maximum resource utilization is considered to cause conflicts of interest with other water users. The following discussion is about how river maintenance flows in various countries are calculated and applied.

III. METHODOLOGY

In the implementation of the "Water Allocation Preparation" activity, several technical approaches will be carried out including: Systematically the technical approach and activities to be carried out for the work of "Water Allocation Preparation", can be seen in the Work Implementation Flow Chart in **Figure 2**

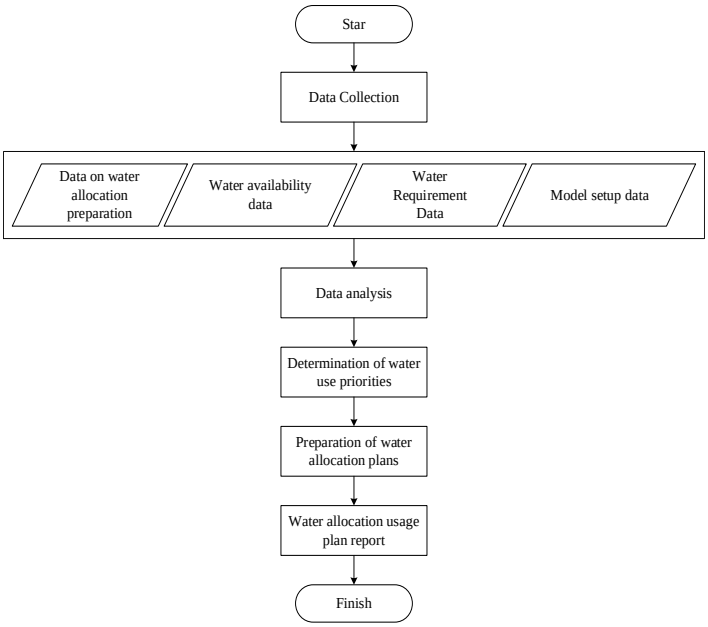

Fig.2 Research Flow Chart

IV. DISCUSSION OF RESULTS

4.1 Ambon-Seram WS Administrative Region

Water resources management in the Ambon-Seram River Basin is carried out within the administrative area of the Maluku Provincial government. Administratively, Ambon Seram River Basin is included in three regencies and one city, namely Central Maluku Regency, West Seram, East Seram and Ambon City.The topographic data used in this study was generated through digital data in the form of a Digital Elevation Map (DEM).

Data taken from SRTM (Shuttle Radar Topography Mission) satellite captures. which can be accessed openly through the USGS (*Unites States Geological Survey*) on https://earthexplorer.usgs.gov/ online site. DEM can be accessed in raster form in GeoTiff format with the accuracy of the data taken is 1 arc second or 30 m. In this study, the object of analysis is in the Way Batumerah watershed.

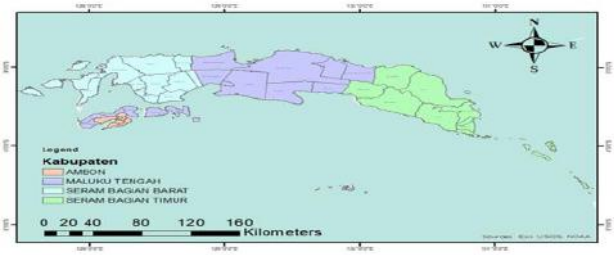

Fig.3 Ambon-Seram WS Administrative Region

4.2 Batumerah Watershed

The Batumerah watershed is located in Ambon City and covers Sirimau District. Geographically, Batumerah watershed is located at 3°42'21.204"S - 3°40'37.425"S and 128°10'57.66"E - 128°13'28.693"E. The total area of the watershed is 6.97 km^2. The Batumerah watershed area is shown on Figure 4.

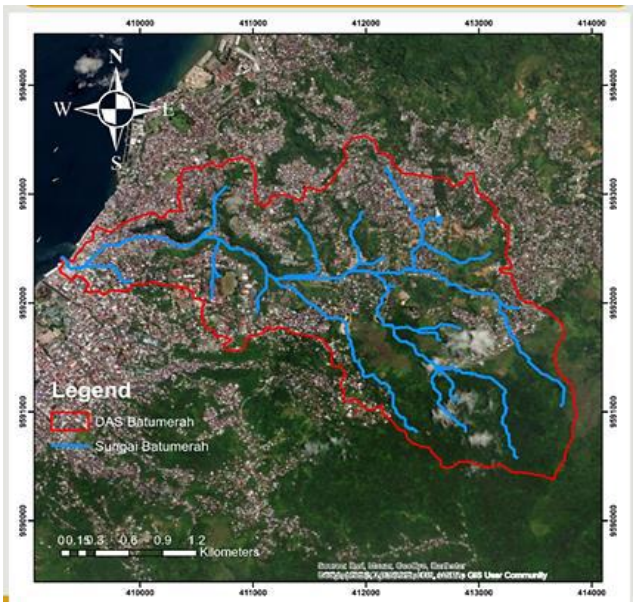

Fig.4 Batumerah watershed

4.3 Water Needs Retrieval Building

Human use of water can basically be divided into water extraction and on-site use. In the Way Batumerah watershed, the intake area has a watershed area of 6.97 km^2 where Batumerah Intake;

- Sedimentation occurs in the distribution pipe;
- There are two villages that are drained by intakes;
- There are community channels around the intake; and
- During the dry season, water is not enough to meet the needs of the community.

4.4 Water balance plan

In hydrological calculations, rain data is needed provided by rainfall posts around the study area. In the Batumerah watershed, there is one nearby rainfall post, namely the Telaga Kodok rainfall post and the IAIN Rainfall Post. Due to the lack of data on the rainfall post network in Maluku Province, the amount of hydrological and climatological data is very limited. Therefore, the data at the rainfall post is filled with satellite rainfall data Global Precipitation Mission (GPM) GPM is a satellite rainfall and snow calculation project by NASA and JAXA. Through GPM Core Observatory will be received from two types of satellites, namely GPM Microwave Imager (GMI) and Dual-frequency Precipitation Radar (DPR).

The availability of water in the Batumerah watershed is a discharge that can be provided by the Batumerah River to meet water needs in the Batumerah watershed. The calculation of water availability is carried out by hydrological calculations where rain will be simulated into surface flow. The rainfall data obtained is rain correction data from GPM satellites with a span of 11 years. Due to limited discharge data, a simulation of rain calculation into surface flow was carried out using the NRECA model. The calculation was carried out using daily rainfall data and climate data that had been obtained previously to calculate surface flow in the Batumerah River. The resulting discharge is calibrated with discharge data obtained from field research with the smallest error. Observation discharge in the study watershed and its surroundings is not available, so only two-day measurement data projected from the Ruapa watershed is used as calibration data.

Table 1 Batumerah Intake Calibration

Calibration					
Date	R	Qobs	Qsin	NSET	NSEB
4/11/2019	2.590	0.150	0.160	0.000	0.002
23/03/2021	0.390	0.070	0.070	0.000	0.002

Calibration	
NSE	1.00
Correl R:Qsin	78.57%

From the modeling results, daily discharge data in a span of 11 years is shown in Graph 5 comparison of the results of discharge modeling and rainfall data. From the comparison results, a fairly good correlation was obtained visually between rainfall and surface flow.

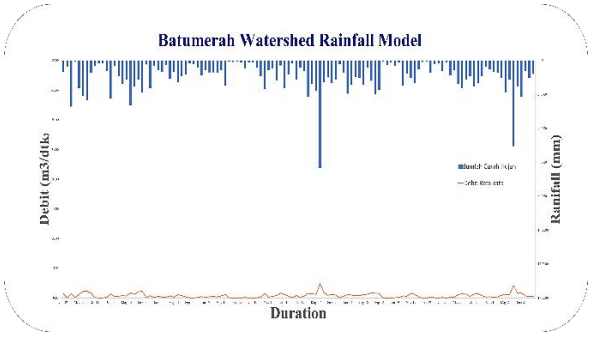

Fig.5 Comparison of Discharge and Rainfall in Batumerah Watershed

The availability of water in the Batumerah River can be calculated in a period of half a month as shown in Table 2 Half-Month Mainstay Discharge in Batumerah Watershed . In wet year conditions, the largest mainstay discharge (Q30%) of 1.83 m^3 / second occurred in October II. In normal year conditions, the largest mainstay discharge (Q50%) of 0.89 m was obtained^3/sec in September II. In dry years, the largest mainstay discharge (Q80%) of 0.35 m^3/s was obtained in June I. The graph of the mainstay discharge for the half-month period is shown in Figure 6.

Table 2 Half-Month Mainstay Discharge in Batumerah Watershed

Year	Month											
	Jan		Feb		Mar		Apr		May		Jun	
	1	2	1	2	1	2	1	2	1	2	1	2
	Jan		Feb		Mar		Apr		Mei		Jun	
Q30	0.298	0.262	0.21	0.346	0.397	0.29	0.454	0.386	0.583	0.836	0.795	1.446
Q50	0.18	0.131	0.084	0.195	0.229	0.165	0.282	0.26	0.386	0.441	0.543	0.838
Q80	0.07	0.031	0.016	0.052	0.11	0.056	0.085	0.109	0.162	0.194	0.275	0.265
Q95	0.011	0.006	0.003	0.005	0.052	0.019	0.01	0.034	0.044	0.103	0.063	0.051

Year	Month											
	Jul		Aug		Sep		Oct		Nov		Dec	
	1	2	1	2	1	2	1	2	1	2	1	2
	Jul		Agst		Sep		Oct		Nov		Dec	
Q30	1.128	1.734	0.703	0.37	0.598	0.315	0.276	0.19	0.133	0.204	0.226	0.348
Q50	0.592	0.561	0.398	0.169	0.267	0.192	0.133	0.102	0.083	0.056	0.105	0.186
Q80	0.185	0.038	0.018	0.041	0.022	0.009	0.016	0.015	0.028	0.006	0.008	0.047
Q95	0.054	0.008	0.002	0.002	2E-04	8E-06	0.003	6E-04	0.007	0.001	0.001	0.002

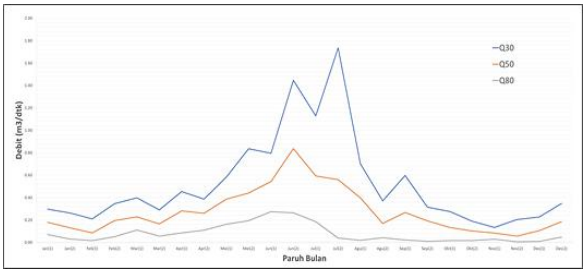

Fig.6 Half-Month Mainstay Discharge in Batumerah Watershed

4.5 Domestic and Non-domestic Water Needs

Domestic water demand is the amount of water needed by domestic consumers for household water purposes. Domestic water demand can be estimated by population, people's lifestyle, and socioeconomic conditions. Water sources in the Batumerah watershed come from river intakes and pumps. The water requirements of the Batumerah watershed from the river intakes are shown **Error! Reference source not found.**in figure 7.

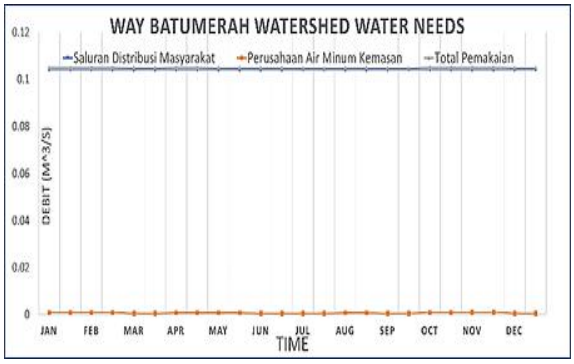

Fig.7 Water Needs of Batumerah Watershed

4.6 River Conservancy Water Needs

The calculation of maintenance flow needs must follow KP (*planning criteria*) 02/2013, which is 5% of the existing discharge in the relevant period or Q95 according to SE (*form letter*) Director General of Natural Resources 05/2016. So that the maintenance flow in the Batumerah watershed.

Table 3 Maintenance Flow Needs of the Batumerah Watershed Half-Month Maintenance

Year	Month											
	Jan		Feb		Mar		Apr		May		Jun	
	1	2	1	2	1	2	1	2	1	2	1	2
	Jan		Feb		Mar		Apr		Mei		Jun	
Q95	0.011	0.006	0.003	0.005	0.052	0.019	0.01	0.034	0.044	0.103	0.063	0.051

Year	Month											
	Jul		Aug		Sep		Oct		Nov		Dec	
	1	2	1	2	1	2	1	2	1	2	1	2
	Jul		Agst		Sep		Oct		Nov		Dec	
Q95	0.054	0.008	0.002	0.002	2E-04	8E-06	0.003	6E-04	0.007	0.001	0.001	0.002

4.7 Water Balance Calculation

The calculation of the water balance in the Batumerah watershed is carried out by finding the difference between the availability of water in the weir and the water demand in the Batumerah watershed. Water availability in the Batumerah

watershed can be predicted from the characteristic pattern of periodic rainfall in the dry, normal and wet year rain pattern groups so that the flow discharge of dry, normal and wet year conditions is obtained. Water requirements can be calculated based on irrigation, domestic, non-domestic water requirements and river maintenance.

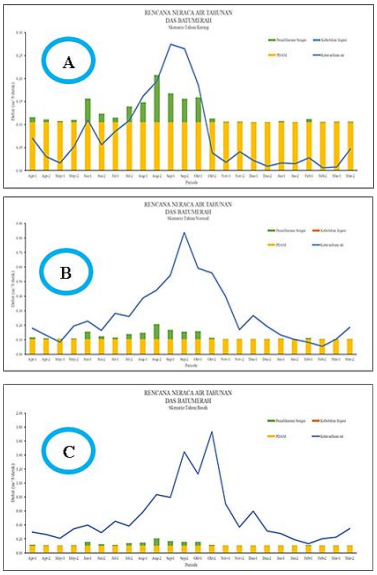

Fig.8. Water Balance of Batumerah Watershed Dry, Normal, Wet Year Pattern

V. CONCLUSION

1. The water allocation unit and allocation limit for PDAMs (*Local water company*) in the Batumerah watershed are assumed to be in accordance with the value of PDAM's water needs for the dry condition half-month, which is 0.105 m^3/sec. However, in certain months there is a deficit, so PDAM's water demand is the result of reducing water availability with minimum maintenance flow needs (0.001 m^3/sec).
2. Water use priority is a policy that regulates the order of water allocation based on applicable laws and regulations.

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