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DETERMINATION OF STAGE-DISCHARGE RELATIONSHIP OF DAMAN GANGA RIVER, WESTERN INDIA

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Abstract: In the river, it is difficult to do continuous measurement of discharge and during the flood situation, it is impossible to conduct measurement of the river flow. In order to overcome this, gauging stations are keeping the record of stage and relating it with the discharge to compute the flow. The stage-discharge curve shows variation in water depth in terms of discharge, also known as stage-discharge rating curves. These curves are widely used in the research of flow patterns and the design of hydraulic structures and river channels. This study aims to determine the stage-discharge relationships in the Damanganga River Basin. For this purpose, two gauging stations are taken into consideration. The data has been procured for two gauging stations Ozerkheda and Nanipalsan for the year of 2018-19 from the Central Water Commission. The- values of the measured stage and corresponding discharge are plotted by the arithmetic scale and logarithmic scale to get the stage-discharge rating curve. The stage and discharge results are used to determine the rating curve equation for the Damanganga River at the two stations.

***IndexTerms* - Arithmetic scale, Flood, logarithmic scale, river section, stage-discharge curve**

I. INTRODUCTION

One of the most crucial parts for hydraulic engineers is the measurement of discharge through a river draining a catchment region. (Yadav, Singh, & Panda, 2017). For many hydrological applications, including water resource planning, reservoir operation, sediment handling, and hydrologic modelling, correct information about discharge and stage is crucial (Yadav, Singh, & Panda, 2017). A good rating curve at the gauging station is crucial for the accuracy of discharge data. Discharge is determined by the catchment area's rainfall, which is entirely stochastic. Due to stochastic nature of discharge, stage varies. Usually, a stage-discharge relationship, or so-called rating curve, is used to translate observed river stage values into river discharges. (Claps, 2011) (Khyati V. Mistry, 2018).

There are two ways to measure stream discharge: direct and indirect. In the direct approach, which is a time-consuming and expensive process, flow velocity and flow cross-sectional area are directly measured in the field (Yadav, Singh, & Panda, 2017). Therefore, at least in medium and large rivers, in most studies around the world, indirect method is preferred which is a two-step procedure: first, the stream discharge is plotted against the corresponding elevation of the water surface (called stage) through a series of careful measurements and in second step, the stage of the stream is observed routinely, and the discharge is estimated by using the previously established stage-discharge relationship.

1.1 Stage-discharge relationship

The relationship between the amount of water flowing at a given point in a river or stream and the corresponding stage is known as Stage-discharge relationship or Rating Curve. Stage is the height of stream level measured from an arbitrary datum (Carlos A. Ramírez, 2018). Depth is measured from the bottom of the channel. A plot of stage V/S discharge is made to obtain a Rating curve. The essence of the rating curve is that when the curve is established for a particular stream, subsequent determinations of discharges are obtained by dipping a measuring stick to measure the stage. The rating curve should be checked from time to time for accurate measurements. A major method used in discharge computation is the stage-discharge relationship. Regular measurements of stream discharge and the related water surface elevation or level are typically used to establish the link. Even under conditions of rigorous observation, the stage-discharge connection at a specific river cross-section is not necessarily unique since rivers are frequently influenced by forces that are neither always known nor simple to quantify. The stage-discharge relationship's inherent unpredictability is frequently made worse by significant inaccuracies that have human origins.

II. Study Area

The Daman Ganga also called Dawan River is a river in western India. The river's headwaters are on the western slope of the Western Ghats range, and it flows west into the Arabian Sea.Damanganga river drains total 2318 sq km.The river flows through Maharashtra and Gujarat states, as well as the Union territory of Dadra and Nagar Haveli and Daman and Diu.The district lies between the latitude

20°19′N and longitude72°50′E. The Daman Ganga rises in the Sahyadri hills close to Ambegaon village in Dindori taluka of Nasik district of Maharashtra State.Rain fall occurs during the monsoon months from June to September with an annual average rainfall incidence of approximately 2,200 millimetres (87 in) (maximum recorded is reported to be 3,780 millimetres (149 in). The soil conditions in the basin are categorized as "reddish brown soil, coarse shallow soil, deep black soil and Coastal alluvial soil". Silvassa, Vapi and Daman are the major towns on the banks of the river.In the present study, an attempt has been done on the cross-sections at the Wagh at Ozerkheda and Damanganga at Nanipalsan on the river of damanganga river, Western India (WRIS, 2021).

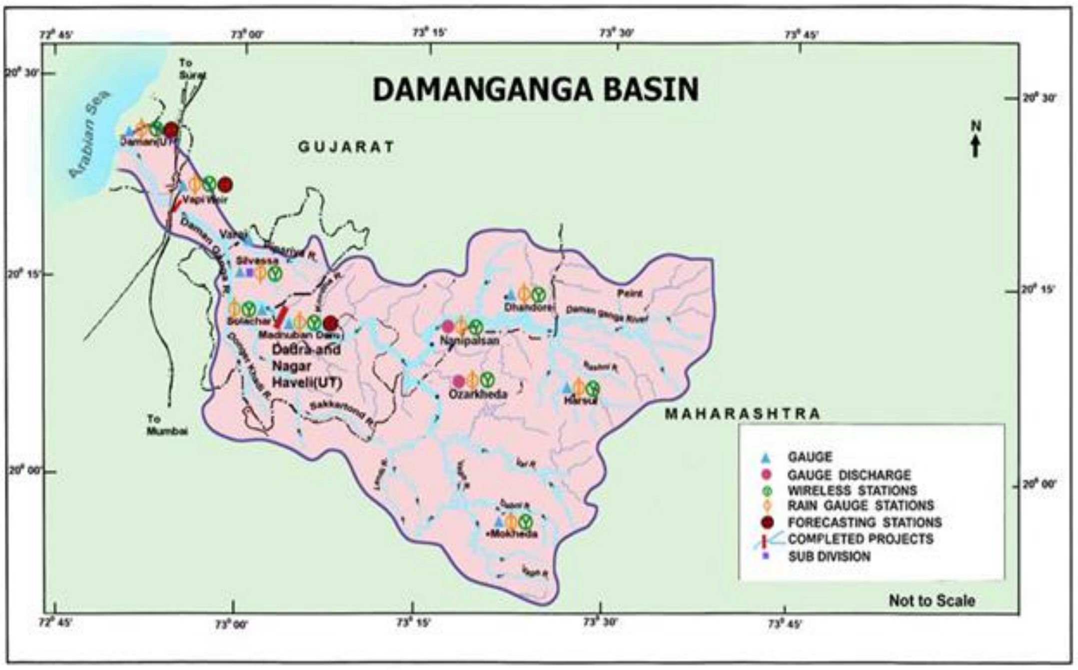

Figure 1. Damanganga river Basin (CWC, 2015)

III. Materials and Methods

3.1 Database

Stage-Discharge relationship of the Damanganga Basin was carried out by using AMS data. According, AMS data were procured from the water year book 2018-19 published by Central Water Commission, Mahi & Tapi basin organization Hydrological Observation Circle, Gandhinagar. The data were available for the Wagh River at Ozerkheda and Damanganga River at Nanipalsan gauging sites located in the damanganga basin.

3.2 Stage-Discharge rating Curve

Stages are easy to measure as compared to the measurement of discharge in rivers. Developing a rating curve entails two steps. The first step involves measuring stage and the corresponding discharges in the river and establishing a relationship. For the second stage, stage of river is measured and discharge is calculated by using the established relationship. Stage is measured by reading a gauge installed in the river. The measured values of the stages and the corresponding discharges plotted on arithmetic scales gives the required stage-discharge relationship that represents the integrated effect of a wide range of channel and flow parameters. Stage-discharge relationship is a single-valued relation that is expressed as: Q = a (h – ho)b where, Q = discharge (m3/s), h = stage (m),'a' and 'b' are rating curve constants, ho = stage corresponding to zero discharge (m) (Carlos A. Ramírez, 2018) (SEFE, 1996).
The 'ho' is instead a value that, when subtracted from the mean gauge heights of the discharge measurements, will cause the logarithmic rating curve to plot as a straight line. This is the reason why the 'ho' is sometimes referred to as the logarithmic scale offset. In the present study, the 'ho' is taken as the elevation of the lowest point in the river channel at the Wagh at Ozerkheda and Damanganga at Nanipalsan cross-section i.e. ho = 80.1 m and 95 m above MSL.
Log Q = log a + b × log (h – ho), A linear trend line equation between 'log Q' values (on Y-axis) and 'log (h – ho)' values (on X-axis) was fitted, the slope of the line gives 'b' and the Y intercept gives 'log a' (Subramanya, 1984).

IV. Result and Discussions

The data of river stage and corresponding flow discharge in the damanganga basin obtained from CWC. The measured stage (in m) is plotted in Microsoft Excel worksheet against the corresponding estimated flow discharge in an arithmetic plot with stage as ordinate and discharge as abscissa. After plotting the stage-discharge to the arithmetic scale, a smooth curve through the plotted points is drawn. To get the rating curve equation in its standard form, a linear trend line equation between 'log Q' (on Y-axis) and 'log (h – ho)' (on X-axis) is also plotted.For Wagh at Ozerkheda,Q = 35.823 (h – ho) 1.934 where, h = river stage (m), Q = flow discharge (m3 /s), and ho = 80.1 m above MSL.For Damanganga at Nanipalsan,Q = 42.984 (h – ho) 1.834 where, h = river stage (m),Q = flow discharge (m3 /s), and ho = 95 m above MSL.

Table 1: Stage-discharge calculation of June month at Ozerkheda gauging site

DAY	JUN		h= 80.1	35.823	1.934		
	WL	Q	h-ho	X= (log(h-ho))	Y= (log Qo)	Qc = K(H-h)m	log Q = log a + b × log (h – ho)
1	81.270	0.690	1.170	0.068	-0.161	48.533	1.68603341
2	81.270	0.690	1.170	0.068	-0.161	48.533	1.68603341
3	81.270	0.690	1.170	0.068	-0.161	48.533	1.68603341
4	81.270	0.690	1.170	0.068	-0.161	48.533	1.68603341
5	81.260	0.590	1.160	0.064	-0.229	47.734	1.678823704
6	81.260	0.590	1.160	0.064	-0.229	47.734	1.678823704
7	81.260	0.590	1.160	0.064	-0.229	47.734	1.678823704
8	81.250	0.500	1.150	0.061	-0.301	46.941	1.671551576
9	81.250	0.500	1.150	0.061	-0.301	46.941	1.671551576
10	81.250	0.500	1.150	0.061	-0.301	46.941	1.671551576
11	81.250	0.500	1.150	0.061	-0.301	46.941	1.671551576
12	81.250	0.500	1.150	0.061	-0.301	46.941	1.671551576
13	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
14	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
15	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
16	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
17	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
18	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
19	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
20	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
21	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
22	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
23	81.240	0.420	1.140	0.057	-0.377	46.155	1.664215936
24	81.420	3.050	1.320	0.121	0.484	61.285	1.787351936
25	81.680	10.88	1.580	0.199	1.037	86.769	1.938364759
26	82.380	54.30	2.280	0.358	1.735	176.363	2.246407947
27	82.650	79.49	2.550	0.407	1.900	218.983	2.340410662
28	81.760	14.21	1.660	0.220	1.153	95.466	1.979850995
29	81.480	4.450	1.380	0.140	0.648	66.786	1.824688106
30	81.220	0.270	1.120	0.049	-0.569	44.602	1.649349609

Table 2: Stage-discharge calculation for June month at Nanipalsan gauging site

DAY	JUN		h= 95	42.984	1.834		
	WL	Q	h-ho	X= (log(h-ho))	Y= (log Q)	Q = K(H-h)m	log Q = log a + b × log (h – ho)
1	96.370	0.000	1.370	0.136720567	infinity	76.56888937	1.884052348
2	96.370	0.000	1.370	0.136720567	infinity	76.56888937	1.884052348
3	96.360	0.000	1.360	0.133538908	infinity	75.54699348	1.878217186
4	96.360	0.000	1.360	0.133538908	infinity	75.54699348	1.878217186
5	96.360	0.000	1.360	0.133538908	infinity	75.54699348	1.878217186
6	96.360	0.000	1.360	0.133538908	infinity	75.54699348	1.878217186
7	96.360	0.000	1.360	0.133538908	infinity	75.54699348	1.878217186
8	96.360	0.000	1.360	0.133538908	infinity	75.54699348	1.878217186
9	96.360	0.000	1.360	0.133538908	infinity	75.54699348	1.878217186
10	96.360	0.000	1.360	0.133538908	infinity	75.54699348	1.878217186
11	96.360	0.000	1.360	0.133538908	infinity	75.54699348	1.878217186
12	96.350	0.000	1.350	0.130333768	infinity	74.53134506	1.872338959

13	96.350	0.000	1.350	0.130333768	infinity	74.53134506	1.872338959
14	96.350	0.000	1.350	0.130333768	infinity	74.53134506	1.872338959
15	96.350	0.000	1.350	0.130333768	infinity	74.53134506	1.872338959
16	96.350	0.000	1.350	0.130333768	infinity	74.53134506	1.872338959
17	96.350	0.000	1.350	0.130333768	infinity	74.53134506	1.872338959
18	96.350	0.000	1.350	0.130333768	infinity	74.53134506	1.872338959
19	96.340	0.000	1.340	0.127104798	infinity	73.52195179	1.866417028
20	96.340	0.000	1.340	0.127104798	infinity	73.52195179	1.866417028
21	96.340	0.000	1.340	0.127104798	infinity	73.52195179	1.866417028
22	96.340	0.000	1.340	0.127104798	infinity	73.52195179	1.866417028
23	96.340	0.000	1.340	0.127104798	infinity	73.52195179	1.866417028
24	96.330	0.000	1.330	0.123851641	infinity	72.51882139	1.860450737
25	96.460	0.000	1.460	0.164352856	infinity	86.04585713	1.934729965
26	96.860	5.020	1.860	0.269512944	0.700703717	134.1508928	2.127593567
27	96.850	4.720	1.850	0.267171728	0.673941999	132.8311025	2.123299777
28	96.800	3.380	1.800	0.255272505	0.5289167	126.3213045	2.101476602
29	96.750	2.250	1.750	0.243038049	0.352182518	119.9605944	2.079038609
30	96.750	2.250	1.750	0.243038049	0.352182518	119.9605944	2.079038609

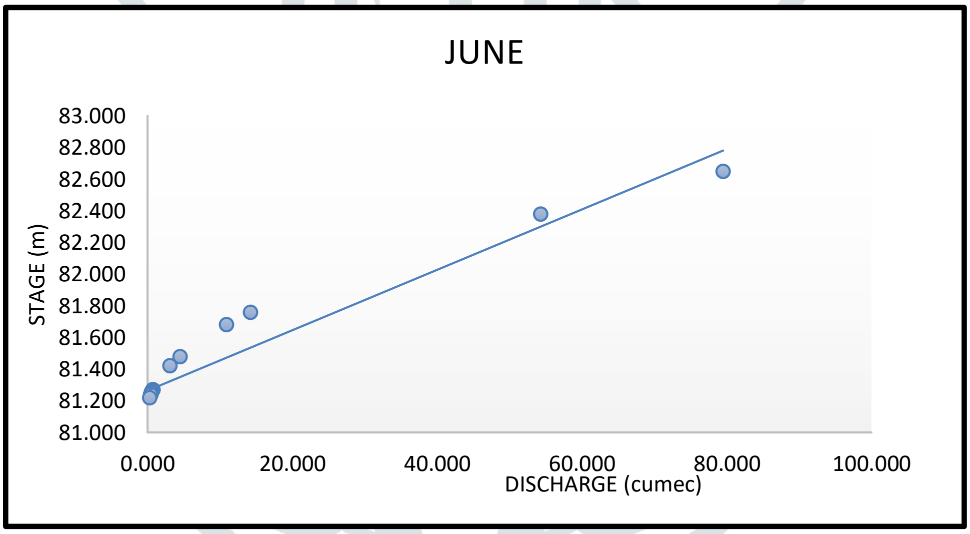

Figure 2. Stage-Discharge rating curve for Wagh River at ozerkheda (Arithmetic Scale)

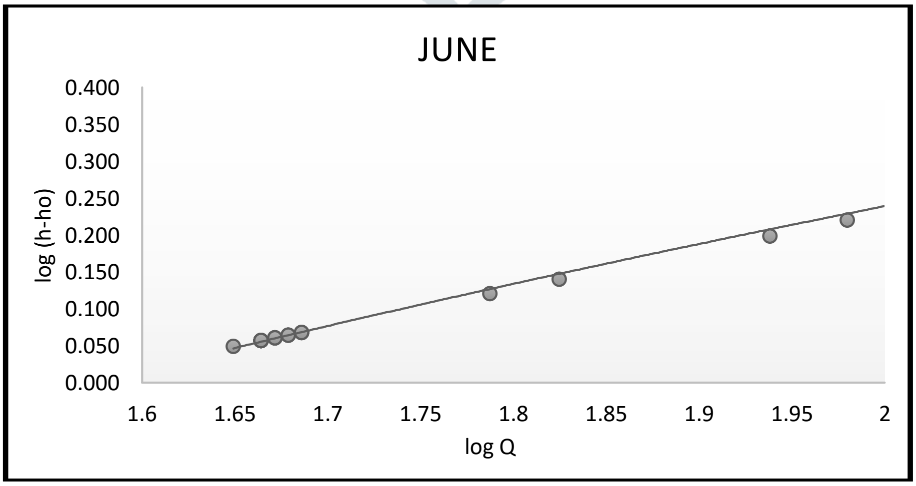

Figure 3. Stage-Discharge rating curve for wagh river at ozerkheda
(Logarithmic Scale)

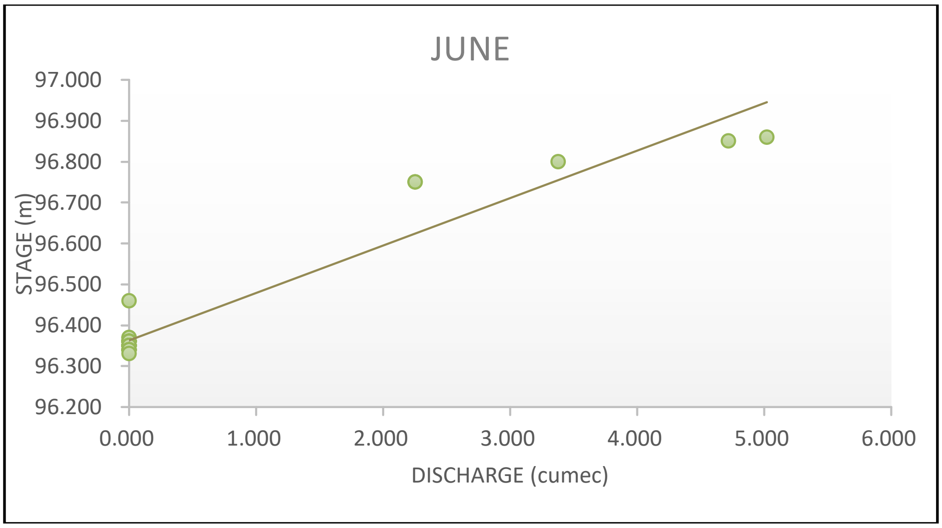

Figure 4. Stage-Discharge rating curve for Damanganga river at Nanipalsan (Arithmetic Scale)

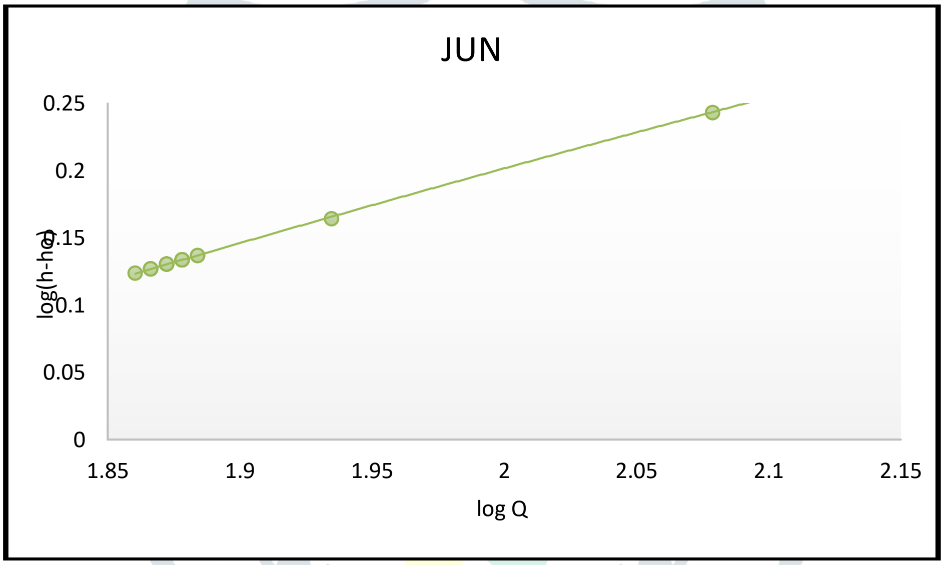

Figure 5. Stage-Discharge rating curve for Damanganga River at Nanipalsan (Logarithmic Scale)

V. Conclusion

In the present study, stage-discharge relationship is obtained using the data of discharge of two gauging station Ozerkheda and Nanipalsan. The obtained rating curve can be used to determine discharge in Damanganga River. From the stage-discharge curve, high values of stage can be used for the design of water harvesting structures, while low values of stage can be useful in study of environmental flow and water availability for irrigation during the low flow in the river.

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