CONCLUSION & SUMMARY

1.0 Dhasan river is a moderate size southern sub-tributaries of the river Yamuna in which it pours through the river Betwa. Originating at the northern skirts of Raisen district (M.P.), the river flow essentially northward (or slightly to the NNE) for over three hundred kms to joint the Betwa river near Jigni town of U.P. It traverses over Sagar, Tikamgarh, Nowgown districts of Madhya Pradesh and Lalitpur, Jhansi, and Hamirpur districts of Uttar Pradesh. Madhya Pradesh shares almost ¾ of its expanse of over 11 thousand square kms, which extents from 23°30’N to 25°46’N latitude and 78°20’E to 79°51’E longitude. It is crossed by the National Highway No. 26, Jhansi to Lakhandon road, and Sagar to Bhopal road, Nowgong to Mauranipur road, as well as by the Katni–Bina and Jhansi–Manikpur Railway lines of the Central Railways.

2.0 The Dhasan river basin is mainly covered by five types of rocks namely, Bundelkhand Granite, Bijawar Series, Vindhyan Supergroup, Deccan Trap, and Alluvium and Laterite. Nearly two third of the Dhasan river basin is composed of the Bundelkhand Granite. Bundelkhand Granite and Gneiss, Grano-diorite and pegmatite cover extensive expanse of the middle basin. It is the most prominent formation and it is found as tors and mounds. The Bundelkhand gneissic country is traversed by pegmatite vein and well marked quartz reefs of varying dimensions. The basic igneous dykes traverse the gneiss, their general trend being towards NNW & NW. The second formation i.e., the Bijawar series covers middle south-east and some parts of south-western basin. Quartzites, Conglomerate, Ferruginous Sandstone etc. rocks comprise in Bijawar series. Southern i.e. the upper part of the basin is largely covered with the Deccan Trap and the Vindhyan Super group in a mixed way. There are two divisions in the Vindhyan, the lower Vindhyan, and the upper Vindhyan. The Semeri series constituting the lower Vindhyan comprises only sandstone and shale in this basin. The upper Vindhyan (Kaimur and Rewah series) consist largely of sandstone forming extensive plateaus and scarps. The fourth important litho-stratigraphic unit e.g. the Deccan Trap covers the entire southern part of the basin. The Deccan Trap comprises 10 or more flows of basaltic lava,
with an average thickness of about 50 feet. The fifth formation, e.g., the Alluvium and laterites covers some upper parts of the basin and much of the lower basin in the North.

3.0 The morphometric analysis of Dhasan river basin by using the Survey of India toposheets: 54/K, 54/L, 54/O, 54/P, and 55/I on the scale of 1:250,000 have been carried out by the Strahler’s (1957) scheme of stream ordering. The salient features of morphometric analysis are as follows:

(i) There are six orders i.e. I, II, III, IV, V, and VI, and Dhasan river being the VI order stream.

(ii) The total number of stream of all orders in accordance to Horton’s (1945) scheme is 1870. Out of these 1458 belong to I\textsuperscript{st} order, 329 to II\textsuperscript{nd} order, 68 to III\textsuperscript{rd} order, 10 to IV\textsuperscript{th} order, 4 to V\textsuperscript{th} order, and 1 belongs to VI\textsuperscript{th} order in Dhasan river basin. The graphical representation of number of stream on the corresponding order shows straight line and satisfies the Horton’s first law of stream number.

(iii) The total length of all 1870 streams in Dhasan river is 6795.75 kms. Of this, the length of I order, II order, III order, IV order, V order, and VI order stream are 4027.0 km (59.26%), 1502.75 km (22.11%), 692.0 km (10.18%), 356.0 km (5.24%), 123.75 km (1.82%), and 94.25 km (1.39%) respectively. The semilogarithmic plots of the total stream lengths are also linear and thus satisfy the revised law of stream lengths (Chorely 1957) which states that the total lengths of streams of each of the different stream orders in a drainage basin tend closely to approximate an inverse semilogarithmic series in which the first term is the total length of streams of the highest order.

(iv) Mean length of each order stream ranges from 2.76m of I order to 94.25m of VI order. The mean length shows approximately geometrical series from I order to VI order stream. The length ratio ranges from 0.16 to 0.91.

(v) Bifurcation Ratio: The straight-line plots satisfy Horton’s (1945) first law of stream numbers which states that the numbers of streams of different orders in a given drainage basin tend closely to approximate an inverse geometric series in which the first term is unity and the ratio is the bifurcation ratio. The bifurcation ratio, as defined by Horton is the ratio of

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the average number of branches or bifurcation of streams of a given order to that of stream of the next lower order.

It will be seen that, out of the twenty bifurcation ratios calculated for five the drainage basins, fifteen falls between 3 to 5. This seems to be the universal range for maturely dissected drainage basins. However, an unusually high ratio of 13 was obtained between the fourth and third order stream in the Dhasan (main). This is because there are only three fourth order stream even though there are as many as thirty-nine, third order streams. This is a drainage peculiarity, which, in the opinion of the author is due to the presence of more of the harder rocks in the Dhasan (main) basin, they having retarded a higher degree of integration of the third order streams.

The weighted mean Bifurcation ratios, calculated by taking into consideration the actual number of streams that are involved in the ratios, appear to be more meaningful. It is seen that the weighted mean ratio for the Dhasan (main), Bila (Kathin) Ur, Sukhnai and Lakheri is 4.75, 4.66, 4.11 5.42, and 4.38, and the ordinary mean ratio is 5.25, 4.01, 3.89, 4.65 and 3.65 for Dhasan (main), Bila (kathin), Ur, Sukhnai, and Lakheri as well as the ratios individually (1 to 13). Such a high degree of correspondence that is seen among the different types of the bifurcation ratio denotes a normal development of the Dhasan basin.

(vi) In all the five sub-basin of the region, surface flow becomes channelised after a laminar flow for 0.8 to 0.95km, which suggest a fairly high texture of drainage.

(vii) The length of basin ranges from 58.0 km to 356.5 km with perimeter being ranges from 158.75 km to 810.5 km, and the area ranges from 854.0 sq. km to 6204.0 sq. km for five drainage basin.

(viii) Shape of the basin is largely influenced by inherent rock types and processes in operation. The shape of Dhasan river basin has been determined by the ratios such as Form factor, Elongation ratio, and Circulatory ration, which are 0.162, 0.442, and 0.344 respectively. Based on these ratios, the Dhasan river basin would be slightly elongated and moderately compact shaped in nature. The shape of a drainage basin is significant since it affects the stream discharge characteristics (Strahler, 1968).
(ix) Analyzing the natural drainage system, it is noticed that the drainage frequency varies from 1 to 16 streams per 25 square kms. The topography, lithological, and structural features of the underlying rocks directly control the variation in stream frequency. Stream Frequency of Dhasan basin indicates that moderate to high-moderate drainage frequency about 73% of the total frequency. The percentage shares of low and high drainage frequency in total areas are 14.10% and 13.17 respectively. The distribution as such suggests the late youth to early mature stage of topography.

(x) The drainage density in the basin is 0.584 km/km². The drainage density map show that the major part of basin is characterized by medium to high drainage density.

(xi) According to Faniran (1968) the drainage intensity is defined as the ratio of stream Frequency to drainage density and based on this, it has been worked out to be 0.437. And the infiltration number is defined as the product of drainage density and stream Frequency, and based on this, it has been worked out to be 0.15.

(xii) The constant of channel maintenance indicates the relative size of landform units in a drainage basin and has a specific genetic connotation. The value of constant of channel maintenance is ranges from 1.58 to 1.88 for five drainage basins, and the average constant of channel maintenance is 1.712.

(xiii) There are four types of drainage patterns identified in the basin. In the Deccan Trap country, dendritic pattern is a common feature; the development of this drainage pattern depends on the resistance of rocks. The radial drainage pattern occurs in the central part of the basin in Bundelkhand granite rocks, this type of drainage pattern is developed due to presence of domes and hillocks in these areas. The rectangular drainage pattern is developed into joint and fault. The most helpful factor for the development of parallel pattern in the general slope, the entire streams descend the slope in parallel line. In most cases they flow along the joints & cracks of the rocks.

(xiv) Slope analysis of Dhasan river basin has been carried out by the method of Wentworth’s (1930). The average slope values have been grouped into six classes ranging from below 5⁰ to above 40⁰. The gentle, moderate,
moderate-steep, steep and very steep slope categories cover 57.86, 3.20, 22.95, 10.44 and 5.55 percent of the area respectively. The variation in slope is directly influenced by the topography and lithological structural characteristics of underlying rocks. The study of the hillside slope brings us to the conclusion that there is a radical difference in slope elements of the Vindhyan hills and the Deccan Trap hills. While in the Deccan Trap country the scarp (free face) is missing, in the Vindhyan all the four elements have been readily recognisable.

(xv) Sinuosity Index: The rivers having a sinuosity of 1.5 are called sinuous, and above 1.5 are called meandering (Wolman and Miller 1964, pp. 281). The standard sinuosity index (SSI) of Dhasan river and its major tributaries are 1.02 to 1.07, that is proved of all basin is sinuous.

(xvi) Hypsometric Curve: The areas below the curves stand for the volume of the landmass yet to be removed by erosion. These areas are 36.91 percent respectively in the basin, which indicates that the basin is in the mature stage. These figures are the most conclusive proof for the author's conclusion that the drainage basins under study have reached beyond late maturity in the erosion cycle. The hypsometric integral and erosion integral of Dhasan river basin is 36.91% and 63.09%.

(xvii) The superimposed profiles give a panoramic view of the morphology of the area. It has been drawn in south to north, and east to west direction, and the vertical exaggerated scale 87.50 times. The superimposed profiles represent the clustering of the majority of hilltops five different levels, which represent five erosion surface in the study area at the height groups of 150-210 m, 280-300m, 380-410m, 490-500m and 600-615metres.

4.0 Physical, chemical and biological weathering are active in the Dhasan river basin area. The most important factors which affect weatherings are climate, rock type and vegetation cover. Weathering in some specific rocks have been discussed. Mass wasting occurs in the areas of structural weakness and in intensely weathered zones wherever the gradient is high.

Weathering along does not produce any significant landforms through its products, like the soil, are of considerable importance. The most significant geomorphic effect of weathering on the basalts is the production of the black soils.
5.0 The climate of the Dhasan river basin as a whole, is semi arid and sub humid type. The climate of the region is generally pleasant, the air being generally dry except in the South-West monsoon season. The year may be divided into four seasons. The cool season starts from November to February, which is followed by the summer season from March to about Mid-June. The South-West monsoon season is from about the middle June to the end of September, October is the period of transition from the monsoon to the winter season. The winter season is normally cool while the summer season is hot and dry. The rainy season is quite pleasant with greenery. Generally, December and January months are the moderately coldest; May and June are the hottest months, whereas July and August are the wettest months of the year. The monthly average, maximum temperature of the study area varies from 23.63°C in January to 42.01°C in May and the minimum temperature varies from 26.47°C in the June to 7.28°C in the December. The maximum relative humidity varies from 65.0% in the morning and 46.4% in the evening in February, to a little more than 84.5% in the morning to 77.4% in the evening in August. The average annual rainfall of Dhasan river basin is 951.09 mm, and the rainfall is decrease from upper basin in south to lower basin in north. The residual mass curve of Sagar station registered improved groundwater recharging and infiltration condition from the year 1902 to 1961, 1965 to 1972, and 1988 to 1989.

6.0 The integrated study for ground water exploration has been carried out with emphasis on hydro geology coupled with remote sensing study, and favaurable area for further ground water development has been demarcated which is below 500 m amsl topographical contour in Dhasan river basin.

(i) The remote sensing techniques have been found applicable to different aspects. In the present study, the author has used this technique (LANDSAT-MSS, red band imagery, IRS-1D, LISS-III FCCs of green, red and near infra-red spectral bands, and IRS-1C, PAN data) in hydrogeomorphological mapping and lineament mapping. In hydrogeomorphological mapping, different geomorphic units of the area have considerable influence on the groundwater occurrence. The fractures
density of certain hydrogeomorphic unit such as alluvial plain, valley fills, pediment (sedimentary), Deccan plateau, buried pediplain (granite) are most favourable zones for groundwater exploration & development in the study area. Hence, these areas are marked as good to excellent favourable zones.

(ii) Two hundred twenty one lineaments in Dhasan river basin were identified from the satellite imageries and grouped into eight classes. It is observed that the lineaments mostly trend in NNE-SSW, NE-SW, NNW-SSE, N-S, and E-W direction in the area. However, the maximum numbers of lineaments trend in NNE-SSW.

(iii) The lineament density map shows three zones such as area without lineament, area between 0.3 to 0.8 km/sq. km, and area with more than 0.8 km/sq. km. The zones between 0.3 to 0.8 km/sq. km, and area with more than 0.8 km/sq. km are expected excellent potential zones for groundwater development except in the hilly area of the basin.

(iv) It is observed that the tube wells and dug wells are successful around Sihora, Semadhana, Rajauwa, Gugra, Jaruakheda, Bammorakala, Gulganj, Sejora, Palerahar, Mohara, Jevar, Baghera, Siya, and Dhanaura villages etc. due to high lineament density.

7.0 While sandstone, shale, and alluvium facilitated free of water, unweathered basalt, and unweathered granite are phratic formation, which may in places tend to confined condition.

(i) The important hydro-litho unit of the study area for ground water is alluvium, which comprises of silt, gravel, and clay particles the rocks of Vindhyan super group, consist of sedimentary rocks namely sandstone, shale, limestone, and highly weathered Basalt and Granite. The groundwater occurs under unconfined conditions in there formation. The water table maps reveal that the movement of groundwater is towards the main river courses. The water table contour pattern shows that the Dhasan, Bila (Kathin), Ur, Sukhnai, Lekhari rivers have influent and effluent pockets.

(ii) In the present hydrogeological studies, 121 groundwater dug wells were inventoried during Pre-monsoon and Post-monsoon season in the year of 1993 and 2002.
(iii) In general, the Pre-monsoon depth to water lever ranges from 4.60m bgl at Dargawan to 17.40m bgl at Jalandhar in 2002, and ranges from 3.00m bgl at Banda to 16.60m bgl at Jalandhar in 1993. The Post-monsoon depth to water lever ranges from 2.85m bgl at Bamhauri to 16.10m bgl at Harpalpur in 2002, and ranges from 1.20m bgl at Siaori to 13.05m bgl at Harpalpur in 1993.

(iv) The Pre-monsoon water table ranges from 587.17m amsl at Bhainsa to 158.82m amsl at Dhanaura in 2002 and ranges from 587.51m amsl at Bhainsa to 161.02m amsl at Dhanaura in 1993. The Post-monsoon water table ranges from 590.62m amsl at Bhainsa to 162.77m amsl at Dhanaura in 2002 and ranges from 591.77m amsl at Bhainsa to 164.12m amsl at Dhanaura in 1993.

(V) The water level fluctuation ranges from 0.00m at Harpalpur to 7.70m at Karrapur in 2002 and 0.10m at Bamhauri and Bharatpur to 9.80m at Baxwaha in 1993. The configuration of water table and topography may not be very congruous because the water table may be down on hilly area.

(vi) The comparison of hydrogeological data between 1993 and 2002 reveals that the depth to water lever and fluctuation of ground water level has increased during the one decade. It is apparent that in this one decade there has been immense development of ground water for the irrigation in the basin.

(vii) The Pre-monsoon depth to water level is mostly shallow to moderate except three patch of north basin around Bamhorikala, Jevar, and Lugase, and two patch of south basin around Jalandhar, and Karrapur in 2002; and except two patch of north basin around Bamhorikala, and Lugase, and one patch of south basin around Jalandhar in 1993, where water level is more than 15m bgl. Only one deep patch has developed in Harpalpur during 2002 in comparison to 1993, which might be due to withdrawal of ground water in the summer season.

(viii) The Post-monsoon depth to water lever is mostly shallow to shallow-moderate except three patch of north basin around Bamhorikala, Harpalpur, and Salaiya, and two patch of south basin around Bamhorikala Salaiya in 2002; and except two patch of north basin around Harpalpur, and Salaiya in 1993, where water level is more than 12m bgl. Only one
deep patch developed in Bamhorikala during 2002 in comparison to 1993, which indicates heavy pumping of ground water through dug wells and tube wells.

(ix) The annual water level fluctuation ranges between 0 and 8m in the Dhasan river basin. The high water level fluctuation were in the NW, middle, and SE part around Jaisinagar, Karhad, Jalandhar, Karrapur, Hirapur, Kakarwaha, Berorakhel in 2002, where water level fluctuated more than 6m, and the middle, and SE part around Jaisinagar, Jalandhar, Karrapur, Pedarwa, Baxwaha, Kharoo, Dhajraj, Chendeyra, and Siaori in 1993, where water level fluctuation more than 8m. Some pocket are developed for high fluctuated around Karhad, Hirapur, Berorakhet, and Kakarwaha, and some pocket are disappeared around Baxwaha, Dhajraj, Chendeyra, siaori, Kharoo, Majna, and Jaiharpur during 2002 in comparison to 1993.

(x) The water table map shows that the water table almost follows topography of the Dhasan river basin in many areas. The water table ranges between 591.77m amsl (Post-monsoon, 1993) near village Bhainsa in the upper basin, and 158.82m amsl (Pre-monsoon, 2002) Dhanaura in the lower basin. The maximum difference in water table is 432.95m.

(xi) The pre-monsoon water level change ranges from +1.70m at Ranital to –6.80m at Karrapur in 2002, in comparison to 1993. The post-monsoon water level change ranges from +1.70m at Sagar to –5.20m at Karrapur in 2002, in comparison to 1993.

- Flow lines represent the regional ground water flow and are towards north and following the general trend of surface water drainage.
- Water table contour are widely spaced in most of the area showing plain topography representing relatively more permeable area than hilly area which exhibits closely saved water table contour in the middle, and north part of Dhasan river basin.

8.0 The pumping tests carried out on twenty-six large diameter wells in Dhasan basin reveals that the value of transmissivity determined by Theis' Recovery method ranges from 35.789 m²/day at Tajpura to 109.262 m²/day at Garhpahra in different rock formations. The average transmissivity values in basalt, sandstone, and granite are 81.572; 83.928;
and 57.888 m²/day respectively. It is indicates that the sandstone is good aquifer in the study area. The transmissivity values are variations in the value of 'T' in the study area. It indicates that there is no homogeneity in the water bearing formation of the study area. It is also indicated from the pumping test analysis data that the Dhasan river basin has good to moderate groundwater potential in general. The fractured zone transmits the water to the well but the weathered zone is the chief but the source of stored water. The 'T' values indicate that the well yields are adequate for domestic and unto some extent for the irrigation purpose. The value of specific capacity determined by Slitcher's method ranges from 32.15 m³/day/m at Udka to 550.82 m³/day/m at Toda in different rock formations. The high value of specific capacity is represent good groundwater potential.

9.0 The annual groundwater increment in the area is 115038.51 hectare metres and the annual groundwater draft is 31683.79 hectare metres. Hence, the balance of the available groundwater for exploitation is works out to be 83354.72 hectare metres every year. Most of the groundwater gone is the effluent seepage during the summer through the Dhasan River and other effluent streams.

The future development of groundwater can be done by construction the new wells such as dug wells shallow tube wells, dug-cum-bore wells, deep tube wells, etc. The renovation of village ponds, the construction of stop dams, recharge shafts would be necessary to arrest the draining of surface water resources from the basins. The percolation tanks, sub-surface dykes and recharge shafts are especially constructed for the augmentation of groundwater resources. However, stop dams and village ponds may also function as recharge structure at some places in the area. In the Dhasan river basin, 310 gully plugs, 33 check dams, 6 masonry dams, 158 village ponds and Tanks 14 percolation tanks, 380 recharge dug wells and 16 sub surface dykes/dams have been proposed. The estimated quantum of recharge from the proposed structure would be order of 11.92 mcm.

10.0 The total recharge for Dhasan basin works out at 115038 hectare metres. Deducing 5%, which is usually regarded as natural
discharge during non-monsoon months, thus region as 109286.1 hectare meters as annual groundwater recharge. The current groundwater development works out at 29% of this stock, on which people of the region most depend for this various water needs. The WHO standard requiring per capita need of water are just untenable in the rather backward area like Dhasan basin in a developing country like India. Partly based on verbal enquiry with respondents, therefore the other has taken 30 liter per capita per day for urban areas and 15 liter per capita per day for rural area as the minimum need for domestic purpose. There are hardly any notable industries in the region consuming water in significant quantities. This leave only irrigation as the major non-domestic avenue of water consumption. Madhya Pradesh Irrigation Department worked out irrigation nod at 1m column of water per aerial unit irrigated. About half of cultivated area in Dhasan basin in under irrigation. By this logic Dhasan basin needs 2288MCM water for irrigation. Adding 500MCM for domestic and miscellaneous uses, one arrives at the total need of almost 2288MCM or 228800 hectare metres. The annual availability of developed capacity is only 29% of the total groundwater is potential. It clearly indicates the need as well as scope for further groundwater development.

Nevertheless, it will be start-range view to jump upon this course of action. In order to manage the groundwater resource on a sustainable basis, care most be taken to implement the groundwater augmentation structures as proposed, all along the strategy groundwater development.

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