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GOVERNMENT OF INDIA

जल क्रान्ति अभियान

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DRAFT POLICY ON SEDIMENT MANAGEMENT

MINISTRY OF WATER RESOURCES,
RIVER DEVELOPMENT AND
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CONTENTS

DRAFT

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POLICY ON SEDIMENT MANAGEMENT

1. PREAMBLE

Sediment transport, bank erosion and associated channel mobility represent key physical processes of rivers, and their understanding is of crucial importance for defining river restoration and management strategies. Most alluvial rivers have experienced increased sedimentation or bedload deficit, both due to natural processes and series of human interventions in the river catchment or on river itself. Rapid urbanization in flood plains, encroachment of river beds, changes due to human activity, grazing by animals and deforestation in catchment area of rivers are causing sedimentation in rivers. Problem of sedimentation is somewhat moderated by trapping sediment in reservoirs, dams. However, it results in loss of reservoir storage thereby reducing its benefits and reduced serviceable life**.** Common practices carried out by river management agencies demonstrate that sediment management has rarely been based upon best practices developed on scientific knowledge. For these reasons, a different approach to sediment management is desirable, incorporating: (i) knowledge and management of sediments at the basin scale; (ii) a wider application of available scientific knowledge.

While keeping the rivers in pristine condition is the ultimate goal, development of civilization has always been on the banks of the rivers, to utilise the blessings of the rivers and their waters. Dams and barrages have to be constructed across river courses in order to enable the society, slightly away from the rivers (thereby reducing the population pressure near the banks of the rivers) to utilise the water resources for their sustenance and share common sediment load. Therefore, sediment issues in dams, barrages and rivers cannot be dealt separately. For sensible and sustainable sediment management in rivers and reservoirs, it is necessary to adopt a silt management policy.

1.1 INTRODUCTION

Rivers are natural channels to drain water from highlands to lowlands/seas. Erosion and aggradations are the most important geological processes which have brought down large amounts of sediments from the higher elevations to the plains and have formed large fertile plains, which were adopted by the hominoid races for their development and sustenance. Big towns were located on the banks of rivers to meet needs of water and navigation. Over the time, the high lands of an area get worn down.

The material thus eroded is utilized further downstream to build banks and flood plains. As the river flows from high gradient to low gradient, momentum of the flow is reduced progressively by consumption of the kinetic energy in overcoming the flow resistance and consequently reducing its capacity to carry the sediments by tractive forces along the bed and suspension of coarser particles through turbulence, inducing thereby silt deposition en route. In general, there is erosion in the upper reach and deposition and erosion in the lower reach because of which morphological changes are manifest in middle and lower reaches of a river. Siltation process is subjected to several factors including physiography, geology, meteorology, hydrology and flow characteristics of the particular reach along with river stage (childhood, youth, mature stage, old age). When the bed slopes are high and consequently the energy gradient is more than available bed slope, the river has a tendency to erode the bed. When the flow velocities get reduced, the energy gradient becomes flatter and the river has a tendency to shed the sediment. To find the stable bed slope, the river path increases by meandering within the banks, depositing the sediment near the ends of the deep channel. Any development work creating human interference in flow of river has to take care of this phenomena and needs to restore the balance within a limited reach of the river on either side of the structure. A well designed structure has to take care of obstruction induced silting and proportionate withdrawal of silt with water so as not to affect the river regime beyond a controlled area upstream or downstream. Similarly, other human interferences such as removal of bed and bank materials through mining, dredging for removal of silt near outlets or for maintaining a specified depth of channel for navigation etc, should also conform to river regime. The river training works to protect or repel the erosion of a bank in high flood or induce silting near the bank by constructing velocity breaker obstruction such as porcupines to reclaim the eroded banks should also be largely confirming the regime and should create a manageable impact on the same bank or other bank outside the control area. In this context, need was felt to have a sedimentation policy for the rivers based on scientific studies and empirical evidences.

The ever rising population continue to encroach upon the flood plains on one hand and indulge in unorganised sand mining on the other. Silting of rivers has assumed serious proportions due to encroachment of flood plains. As of now there is also a notion that flood problems are on rise. Rising trend of flooding is generally ascribed to reduced carrying capacity of rivers on account of silt deposition in river beds.

1.2 INPUTS FOR POLICY

Although considerable research has been done in India on siltation and sedimentation, considerable new challenges have come up with continued developments and have to be continually addressed through additional research and development. Silt management has become a big issue with varied repercussions on

river health, flooding, navigation etc. To tackle this problem, the Hon'ble Minister (WR, RD & GR) desired to take steps towards formulation of an appropriate policy in this regard.

To this end, the Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR, RD & GR), Government of India organised a One-Day Conference on 'Sediment Management in Indian Rivers' on March 17, 2017 at Central Soil & Materials Research Station (CSMRS), Hauz Khas, New Delhi, under the guidance of Hon'ble Minister (WR, RD & GR) Sushri Uma Bharti with the objective to comprehensively deliberate issues related to sedimentation of Indian rivers with all the stake-holders and develop an appropriate policy.

Several top professionals in the field of water resources management participated in this event. The conference was attended by organizations under the MoWR, RD & GR, namely, Central Water Commission (CWC), Central Water & Power Research Station (CWPRS), National Institute of Hydrology (NIH), Central Soil & Materials Research Station (CSMRS), Ganga Flood Control Commission (GFCC), Brahmaputra Board (BB), Farakka Barrage Project (FBP), Central Ground Water Board (CGWB), National Project Construction Company (NPCC), Water & Power Consultancy Services India Ltd. (WAPCOS), etc.

This Conference also had widespread participation from various stakeholder groups, like Ministry of Environment & Forest and Climate Change, Ministry of Urban Development, Ministry of Agriculture & Farmers Welfare, Department of Science and Technology, Ministry of Earth Sciences etc. Various State Governments vulnerable to endemic flooding were represented, like Bihar, Jharkhand, West Bengal and Assam etc. The conference was attended by various leading academic institutions such as Indian Institute of Technology (IIT) Roorkee, IIT Delhi, TERI University. Non-Governmental Organizations working in the water resource sector also attended this Conference and participated in its deliberations.

Around 250 participants attended the Conference and took part in its deliberations, making it a very successful event.

1.2.1 CAUSES FOR SILTATION/ SEDIMENTATION

All rivers and streams flowing in the alluvial plains tend towards a stable flow condition maintaining a balance between the silt load carried and the volume and velocities achieved. This is generally called a stable sediment regime for the river. When underlying parameters of volume and velocities are disturbed, either due to lower

gradient (entering into plain reaches) or encroachment in flood plain, widening of the channel (braiding of river streams), suspended silt particles in the river water settle down. This is called siltation. This phenomenon is normally called sedimentation when it occurs in a reservoir. Hence, erosion of soil and rock particles by water from poorly maintained catchment during erosive phase of river regime and addition of extra sediment and silt load through human activity in flood plains disturb the natural sediment regime of the river and cause it to create unexpected deposition and erosive reaches. Siltation in rivers may or may not be accumulative; whereas sedimentation in reservoirs is generally accumulative. The sediment inflow rate into a particular reservoir is, in general, a function of the watershed characteristics such as drainage area, average land and channel slope, soil type, land management and use, and hydrology along with catchment health. Main factors responsible for the siltation / sedimentation are:

(i) Physical and hydrological characters of the catchment, such as slope, land use, land cover, urbanisation, agricultural practices, deforestation and forest degradation etc.,

(ii) Intensity of erosion in the catchment (sheet, rill, gully and stream channel erosion) including over-exploitation of minerals,

(iii) Quality, quantity and concentration of the sediment brought down by the river,

(iv) Size, shape and length of the reservoir and operation strategies impacting trap efficiency of the reservoir,

1.3 EFFECT OF INTERVENTIONS ON RIVER SEDIMENTS

1.3.1 EFFECT OF RIVER TRAINING WORKS ON RIVER SEDIMENTATION

River training works like embankments, groyne, spurs, dikes etc are various methods which have been adopted universally by all flood affected countries. Suitable methods are chosen along the river course to avoid unfavourable wandering of the main currents. River training works have played a remarkable role in ensuring the safety of people from floods. These are usually undertaken in response to a pre-existing problem of river instability and to arrest its erratic movement but can also have hydro geomorphic effects, as roughness of river section may change. This may cause aggradation at one place and degradation at other place in floodplain, erosion of riverbed, decrease of low and even mean water levels, loss of flood water conveyance capacity etc.

1.3.2 EFFECT OF CONSTRUCTION OF STRUCTURES LIKE DAMS, BARRAGES ETC. ON RIVER SEDIMENTATION

Dams / Barrages constructed on rivers alter the equilibrium of flow of water and sediment in alluvial channels. Construction of dams reduces the velocity of water in upstream thereby causing aggradation. Relatively silt free water released through the spillway, causes erosion/ degradation downstream of the spillway. Various technologies are available for ameliorating the effects of sediment trapping in the reservoirs of varying sizes. However, the specific situations encountered are generally unique and specific solutions have to be evolved in each case.

Though the storage reservoirs created due to dam construction tend to decrease the magnitude of flood flows by moderating them but due to encroachment of downstream floodplains by local population due to reduced risk of flood exposes them to higher risks of siltation and erosion.

1.3.3 EFFECT OF SAND MINING ON RIVER SEDIMENTATION

Mining of sand is proposed at an optimum level for removing excessive sediment deposit in rivers. However, unscientific sand mining depletes the mineral at rates at which the river system cannot replenish it. Excessive mining undermines the ability of riverbeds and riverbanks to support the infrastructure built on them, such as bridges, transmission towers, fertile agriculture land/ orchards and buildings, as it tends to create high overbanks with steep slopes, which are not stable due to limited shear strength of the constituent soil materials. Also, the continued collapse of such banks lead the river course to deviate towards developed lands and poses ever increasing threats to them. Often, the sand extraction is focused on reducing the haulage paths and ease of access. At present, while selecting a potential area for sand extraction, the attention is not being paid to the river regime and its sediment balance. Thus, there is a need to pursue the schemes with utmost care backed by scientific study, including simulations through mathematical and/or physical model study at appropriate scales and employing consistent formulations applicable to the given site conditions in identifying the rapid aggrading areas, suitable sites for mining, requirement of construction material, suitability of silt/sand to be mined for specific purpose and accordingly take corrective measures for controlled dredging in PPP mode. This will provide a ecologically and environmentally sustainable solution. A pilot project may be taken up in each river basin towards this.

2.0 DATA COLLECTION FOR AGGRADATION/DEGRADATION OF RIVERS

2.1 Systematic data collection and analysis needs to be carried out to study the aggradational and degradational behavior of rivers, especially in respect of rivers carrying large quantities of sediment load. In the existing projects necessary data on changes in river slope, bed material size and river cross sections be taken

periodically as this information is useful in improving methods of prediction of degradation/ aggradation.

2.2 Periodic monitoring of various morphological changes with space technology such as formation of shoals, meandering tendency of the river, effect of construction of hydraulic structures , damages to the bank, effect of afforestation/ deforestation and tectonic occurrences needs to be done. Critical reaches may be closely monitored pre and post monsoon. These could be supplemented with model studies as per the requirements, to take timely corrective measures to maintain its morphology and to check local erosion damages.

2.3 Results from research and developmental activities relating to river management being carried out in different institutes/organizations may be pooled together which could be used as a repository of knowledge for river management and share their findings on India WRIS portal.

2.4 Retrogression downstream of dams may be estimated using available methods and it shall be controlled using slope controlling structures and bank protection measures as necessary. Encroachment on river bed downstream of major reservoirs shall be monitored. Fresh encroachment to be completely stopped and existing to be gradually removed.

2.5 Studies related to basin geo-morphology on regional or sub-regional level needs to be carried out.

2.6 Impetus should be given to measurement of bed load in streams in hilly region.

2.7 Bathymetric survey of important reaches of rivers may be done at regular intervals.

2.8 Online reservoirs must have bathymetirc and topographical surveys to redefine Area Capacity along with deposition patterns in different zones every five years.

3.0 BASIC PRINCIPLES FOR SEDIMENT MANAGEMENT

The following basic principles should be followed for silt management of Indian rivers.

1. Sediment management should become a part of integrated river basin management plans.
2. Erosion, movement and deposition of sediment in a river are natural regulating functions of a river. The river stream has to complete its geo-morphological cycles from youth, maturity to old age. A stable river is able to constantly transport the flow of sediments produced by watershed such that its dimensions (width and depth) pattern and vertical profile are maintained without aggrading (building up) or degrading (scouring down).

3. Justification for removal or disturbance of silt must be evidence based. Where justified, silt management actions must follow best practice to minimize damage to the environment/river morphology.
4. Annual Silt requirement at fast developing infrastructure project may be estimated and critically aggrading river reaches and their sections in the vicinity may be analysed in their physical mode for supplementing. The same can be clubbed with silt removal as is given above wherever possible.

Thus, there is a need to pursue the schemes with utmost care backed by scientific study, mathematical model study and detailed physical model study in identifying the rapid aggrading areas, suitable sites for mining, requirement of construction material, suitability of silt/sand to be mined for specific purpose and accordingly take corrective measures for controlled dredging in PPP mode. This will provide an ecologically and environmentally sustainable solution. A pilot may be taken up in each river basin towards this.

4.0 PRACTICES ADOPTED FOR SILT MANAGEMENT

The method of minimizing siltation may be of two types - one that is required for the catchment and the other in the river itself.

(a) The method to be adopted in catchment may include-

An effective and permanent method of sediment control is soil conservation in the catchment, which includes the following practices;

i. Afforestation and forest management
ii. Regrading and grassland management
iii. Cultivation practices, such as crop rotation, increasing organic matter, mulching, seasonal cover crops, contour cultivation, strip cropping and terracing.
iv. Gully control and check dams- contour bunding and trenching.
v. Appropriate land use controls for protecting areas of importance.

(b) The method to be adopted in river itself-

vi. Storage reservoirs
vii. Desilting basins.
viii. River training works such as bank protection, spurs etc.
ix. River training works for local sediment control e.g. submerged vanes, bed bars, bundalling, etc.

x. Desilting- There are different methods of desilting such as flushing, slucing, siphoning, dozing, dredging etc.

xi. Supplementary building material requirement through scientifically identified reaches at aggrading reaches of river in near vicinity.

xii. Delineation of flood plains with different risks of flooding/ erosion and appropriate land use regulations and policies.

5.0 APPROACH OF SEDIMENT MANAGEMENTS OF RIVERS

5.1 Youthful stage-In this stage, the rivers have steep slopes and high sediment transport capacity.

In this stage following sediments management practices may be adopted-

a. Catchment Area Treatment- Catchment Area Treatment and Watershed Development works along with good agricultural practices and river bank protection/anti-erosion works are necessary to reduce silt inflow into the river system and must be undertaken in a comprehensive way.

b. Storage Reservoirs-The reservoirs are built to store water. Incidentally, these act as settling tanks for the sediment and trap the sediment carried by the river. Therefore the sediment concentration of the water released from the reservoir gets effectively reduced depending on the size of reservoir

c. Boulder/Gravel Mining- In this stage, boulder and gravels are deposited in the river. If these are mined at this stage and used for construction purpose, then a major portion of sediment can be reduced. Boulder/ Gravel mining can be done as per following guidelines-

(a) **The "Sustainable Sand Mining Management Guidelines – 2016" of MoEF&CC**

(b) **GSI Guidelines for** riverbed gravel/ sand mining

5.2 Mature stage-In this stage, the river enters and flows in plains, meandering mostly on bed of fine sand, has wide river bed and flood plain. Most importantly, modified through human interventions in terms of huge quantities of water diversion/abstraction and subjected to high degree of pollutant loads from domestic, industrial and agricultural activities.

In this stage, following sediments management practices may be adopted:-

a. **River training works such as bank protection, spurs etc** –River training works are used to control the erosion of river banks. Erosion control of riverbank reduces the sediments intake in river

b. **Sand Mining**- In this stage, sand is deposited in the river. If these are mined at this stage and used for construction purpose, then a major portion of sediment can be reduced. Sand mining can be done as per following guidelines:-

(a) **The "Sustainable Sand Mining Management Guidelines – 2016" of MoEF&CC**

(b) **GSI Guidelines for** riverbed gravel/ sand mining

c. **Desiltation/Dredging**- Desilting using sluicing and flushing near water resources infrastructure is very effective in increasing their serviceability. However, mechanical desilting in large reservoirs may not be techno-economically feasible. However, there exists some locations such as congestion at the mouth of tidal rivers, confluence points and the likes which can be tackled by desilting after thorough examination. For navigation purpose also the river reaches in the waterway path can be dredged, to have minimum draft for plying vessels. Desilting also improves the hydraulic efficiency if done near outlets and intakes.

When the meander loop extends substantially in the lateral direction, the friction loss over the meander length generates a head loss thereby resulting in a rise in the flood levels. Over the course of time, when the water path around a meander lengthens, arising to a critical level, a natural cut-off takes place. Making artificial cut-offs (cunnette) can be utilized as a method for flood control.

It is necessary to appreciate that the desilting does not always lead to the reduction of flood levels as the levels in the river are essentially controlled by the hydraulic conditions obtained at the cross sections forming upstream and downstream boundaries of the reach. The lowering of the bed level within the reach may not have influence on them consequently leading back to drainage problems within the season or within a few years. On the other hand, unsystematic dredging may have effects of banks destabilisation.

Before taking any desiltation/dredging work, the following guidelines should be followed-

(i) A study of the river reach selected for desiltation/ dredging by appropriate mathematical and/ or physical model studies by employing consistent practices. Historical river behaviour may also be kept in view.

(ii) Dredging for desilting of Indian rivers may be adopted only in exceptional circumstances or when no other sustainable alternative is available.

(iii) The de-silting of any river reach needs to be justified bringing out clearly the flooding caused due to siltation along with technical comparisons of the alternative flood mitigation measures with “do nothing” or “proposed de-silting/ dredging” being other options. It should invariably be associated with sediment flux studies and morphological studies to confirm no significant adverse effect on downstream or upstream reach of the river including the safety and effectiveness of river crossings, water intakes, existing river bank / flood protection measures etc. Post dredging, sediment flux studies should also be carried out to quantify the amount of silt likely to be deposited in future i.e. Sediment modelling studies for the river may be done before taking up any such project.

(iv) Negative impact on ecology and environment due to desilting may also be studied along with other studies and should be invariably made part of DPR.

(v) The quantity of sediments needed to be removed from rivers is usually very high. Since it is very difficult to find lands for silt disposal therefore it should be ensured that all silt removed from river should be utilized in some works.

(vi) The proposal for desiltation/ dredging work should also contain environmentally acceptable, practically possible silt disposal plan. River gravels/sands/silts are valuable resource and could be used gainfully in construction works, including housing, roads, embankment and reclamation works. Since it is very difficult to find lands for silt disposal therefore it should be ensured that all silt removed from river is utilized in some works.

(vii) Under no circumstances, disposal should create any contamination of water bodies, harmful to the flora and fauna existing adjacent to the disposal sites or disposed material should come back into the river again.

(viii) Desilted material should not be used for filling up of wetlands and water bodies including oxbow lakes, as these are important for recharging the ground water and providing base flow in rivers during lean season.

(ix) The modus operandi for silt disposal should be finalized before carrying out dredging. No project should be executed before formulating a suitable and sustainable action plan for silt disposal and be preceded by EIA Study, to avoid damage to ecology. The methodology to be adopted (say use of dredgers etc.) should be clearly laid down in the proposal so that its co-relation with the environmental hazards can be made.

(x) Normally, the funds required for dredging projects are enormous. Before embarking on a major desilting operation in any of the rivers, the financial implications may be discussed in detail.

(xi) The dredging/de-siltation/mining activities thereby disturbing the river regime may result into some adverse impacts, i.e., (a) River bed degradation; (b) Bank erosion; (c) Channel widening; (d) Lowering of water surface elevations in the river channel; (e) Lowering of water table elevations adjacent to the river; (f) Reduction in the structural integrity of bridges, pipelines, jetties, barrages, weirs, foundations supporting high tension lines, existing bank protection works and other manmade structures; and (g) Loss of environmental values resulting from (a) through (e). Restrictions as presented in ***Appendix I*** need to be enforced before planning and executing any dredging/ desilting / mining activities. These restrictions may be modified only after proper study and monitoring the effects of dredging / de-silting / mining.

5.3 Old stage-In this stage, the river experiences considerable changes in the sediment transport and deposition, causes wide spread flooding, undergoes frequent changes in the channel path/ delta formation.

In this stage following sediments management practices may be adopted:-

(a) **Desiltation/ Dredging**- In this stage, generally delta formation occurs due to heaving siltation, which leads to drainage congestion. Generally, the mouth of river gets choked. In these areas dredging/ desilting works may be carried out to maintain the flow continuity and sediments transportation to sea.

5.4 Lateral Connectivity for Sediment Management- Construction of embankment has resulted in breaking the lateral connectivity of river with its flood plain. Therefore, the silt carried by the river is being deposited in river bed only leaving the flood plains devoid of sediments. This has resulted in rising of river bed and causing bank erosion at high flood levels. In order to provide lateral connectivity to the river with its flood plains, sluice gates may be provided at appropriate places in the embankment to allow controlled flooding in flood plains. This will allow silt carried by the river to be deposited in its flood plains in thin layers distributed over vast areas and will ultimately result in reduction of silt loads in rivers and will make the agriculture fields in flood plains fertile. This will benefit in multiple ways-

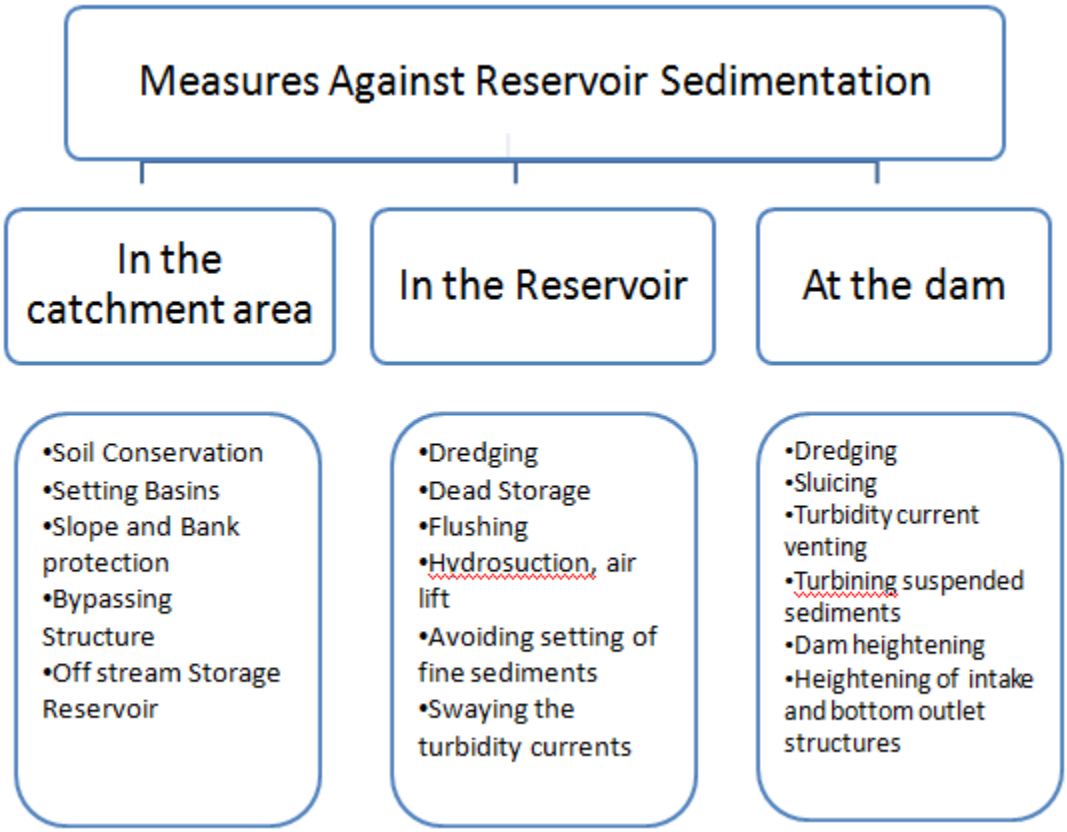
(a) Reduced high flood levels in downstream.
(b) Increased fertility of flood plains. Thus reducing the dependency of farmers on chemical fertilizers.
(c) Recharge of ground water.
(d) Rejuvenation of the water bodies etc.

Here, it may be mentioned that the sluice gates which allow incoming of flood waters in country side will be used for discharging extra water in river again when flood levels in rivers go down. Such sluice gates will also reduce drainage congestion on country side, if any.

5.5 Quantity of desiltation/ dredging- Urbanisation and infrastructure development works like buildings, roads, embankments etc. require large amount of silt and sand and the location and part of the river from where the silt is removed. Thus, the river silt is a valuable resource. The quantities of silt removed from the river shall be limited to the extent to which it does not harm the ecology of river or gainfully utilized in developmental works, whichever is less. Exploitable quantities should be determined "a-priori" and the reach should be monitored for excessive exploitative practices. Also, the safety and stability of the structures around such sites should also be monitored for adverse conditions. Quantities approved can be reduced/ increased depending on the concurrent observations.

6.0 RESERVOIR SEDIMENTATION MANAGEMENT:

The measures that can be adopted for reservoir sediment management are listed in Figure below-



6.1 **Land Management and Soil Conservation Techniques** – Check dams, settling basins, vegetation covers, agricultural practices, etc. may be adopted to control sedimentation.

6.2 Bedload management - Bedload relocation (dredging) and artificial bedload supply, etc. Flood Control Programs - Detention basins (holding ponds), energy dissipaters in channels (culvert outlet controls, forced hydraulic jumps, drop structures, stilling wells, etc. Land use controls: these are used to reduce storm runoff), Embankments/dyke/levee construction, Periodic flushing of rivers, etc may be used to control the sediments.

6.3 Reservoir Operation -Reservoirs particularly in upper reaches, should be operated in such a manner that first floods, having high silt load, are allowed to pass through without storage and river flows in later phases of the monsoon are only stored for use during non-monsoon season. This would require quantitative long term forecast with decision support system to be established for optimum reservoir operations.

6.4 Silt Flushing - It has been observed that major part of silt is trapped in reservoirs made on any river. In absence of silt, rivers downstream of such reservoirs become degrading. Therefore, appropriate silt flushing arrangements are required to provide sufficient sediment to the river downstream of reservoir. It will also increase useful life of reservoir.

7.0 SILT MANAGEMENT UPSTREAM OF BRIDGES, BARRAGES AND WEIRS-

Shoal formation upstream of barrages/bridges in the pond area is a natural phenomenon. Reduced velocities of water in upstream of barrage leads to deposit of silt, but sometime after construction, this attains equilibrium and the incoming silt is washed away through the under sluices and during the flood season when all gates of the barrage are open.

7.1 Upstream reaches of construction works, like barrages/bridges, etc., tend to get silted leading to wandering of river. As the waterway provided for design flood condition is much larger than actual waterway required in normal condition, there is a tendency for shoal formation upstream of barrages. Possibly, proper operation of gates verified on the basis of physical or mathematical modelling, river training, cut-off developments and provision of extra water way near the constrictions could be tried after proper assessment without impacting the morphology of river elsewhere. The area freed from the development in the form of oxbow lakes should be used for flood moderation rather than reclaiming it for other purposes.

7.2 Sediment sluicing may be incorporated to maintain sediment continuity from upstream to downstream reaches after carrying out necessary studies.

8.0 FLOOD PLAIN MANAGEMENT

River tends to achieve equilibrium on its own given the hydrology, sediment and natural bed and bank disposition. It is necessary to provide the river sufficient flood plain areas and lakes along the river to moderate the flood level. Any encroachment of flood plain, reclamation of lakes or disconnection of lakes from river should be avoided. Rather, adjoining lakes/depressions may be de-silted to increase their storage capacities. The de-silting of lakes, etc., should be in such a manner that the sediment continuity is maintained and should not lead to head cut that creates safety issues for the river crossings, water intakes or river training works locally or upstream.

8.1 To maintain the hydrological and ecological balance, regulation and prohibition of different activities in the river bed and different zones of flood plain is essential. The River Regulation Zoning for demarcating necessary zones should be implemented as early as possible. Central Water Commission in 1975 has already prepared a draft Flood Plain Zoning Bill in this regard.

8.2 The people, who have encroached the flood plains, may be educated to live with flood after making them aware of the zone in which they are located and the risks associated with it.

9.0 SOLID WASTE MANAGEMENT

Solid waste from community including garbage, rubbish, agricultural waste, toxic Industrial discharge, construction debris, landfills in the catchment area etc. all contributes to pollution in rivers which damages highly sensitive and fragile river ecosystem. Such anthropogenic activities cause aggradations and morphological changes in the river. The disposal of solid waste needs to be controlled by the local municipal bodies and government bodies.

Special care should be taken for solid waste generated out of industrial processes. Many times, the same contains toxic materials and intermixing with other silt may render the same unusable for food chain use. Such waste should not be allowed to be dumped in the river.

10.0 RIVER REJUVENATION/ ENVIRONMENTAL FLOW

There is need to construct storages with sufficient flood cushion. The stored water needs to be released during the non monsoon period in such a way that silt carrying capacity of river may be maintained. This will also improve the ecology of river.

11.0. EVALUATION OF SEDIMENTATION MANAGEMENT PROJECTS.

11.1 The economics and efficacy of Watershed Management programme needs to be examined considering existing catchment conditions.

11.2 Dredging/ desilting projects and their techno economic performances need to be evaluated.

12.0. INSTITUTIONAL ARRANGEMENTS

There is need to establish River Basin Authority for all basins as per recommendation of Doabia Committee. Clearances from CWC or from River Basin Authority of the concerned basin need to be made necessary for any desilting work of more than one lakh cubic meter on any inter-state/ international river apart from other clearances.

13.0. RESEARCH AND DEVELOPMENT NEEDS

In this field, the R&D efforts need to be carried out mainly on the following:-

i. Increased research into the erosion and sedimentation processes specially through the development of a unified system of erosion and sedimentation in selected reaches. Increased emphasis on the practical evaluation of water erosion control methodologies with emphasis on the communication of practical information to policy makers.

ii. Even though some efforts have been made to develop stable-channel design procedure taking into account the sediment load as one of the factors, the method still needs modification. Method of design of channels flowing through cohesive material and transporting large quantities of fine material needs to be developed also.

iii. At present, devices like sediment excluders and extractors are designed using thumb rules and model studies which give only qualitative information. As a result, even though some excluders and extractors are working satisfactorily, the performance of others is unsatisfactory. Hence, there is need for rationalizing their design procedures taking into account the theory of sediment transport. Some attempts have been made in this regard in India and abroad; however, much more needs to be done in this respect.

iv. If excessive scour takes place, the safety of structure is endangered and in the extreme case the structure may fall. Therefore, one must be able to anticipate the extent of maximum scour that can take place and provide measures to control it. Several relationships for scour have been developed from laboratory studies and few field data but there is need to collect reliable field data to verify these relations. Very little work is done in developing protective measures. The age old methods of rip-rap and launching apron provision are still the best methods available.

v. Generally, it is assumed that the plan form is not changed. However, if banks are easily erodible, plan form viz., straight, meandering or braided - can change. The analysis then becomes somewhat more complicated. While methods are available for quantitative prediction of changes in slope due to changed conditions, at present it is not possible to predict the plan form changes very accurately, even qualitatively.

vi. Knowledge of the sediment load, carried by a stream is necessary for the solution of practically all problems associated with rivers. Ever since, the pioneering work of Du Boys in 1879, many empirical and semi-empirical methods have been put forward for the calculation of bed load transport rates. But the accuracy of calculation of bed load transport rates by using the available methods is far from satisfactory.

vii. In recent years, denudation of catchment through human activity by way of agriculture, deforestation, extensive grazing etc. has been progressively accelerating soil erosion and disturbing solid liquid equilibrium in the rivers. Unusual sedimentation on the river beds as also in the storage reservoirs and irrigation channels have resulted in drainage congestion and reduction in the efficiency of canals and storage capacity of reservoirs. Excessive sedimentation in rivers is also responsible for higher flood levels besides posing problems in navigation channels. Regular sediment survey in rivers has, therefore, assumed great importance. Periodic sediment transport data of a stream provides vital information on the rate of soil erosion and changing land use pattern in the catchment and therefore forms the basis of planning, designing and maintaining water resources projects in a river basin as well as for preservation of the catchment ecosystem.

viii. Silt load data collection is of prime importance. It is necessary to use depth integrating samplers and time integrating samplers in place of bottle type sampler which will measure the actual concentration of the sediment in a given vertical.

Automatic type sampling instruments are of recent origin. It is necessary to use such instruments at some of the stations of vital importance.

ix. In hilly areas where it is problematic to measure the suspended sediment concentration accurately, it would be appropriate to adopt tracer techniques in the near future.

x. Analysis of bed material samples using electronic sedimentation balance shall be resorted to get a reliable and accurate particle size distribution curves of bed material samples.

xi. Presently methods are available either analytical or numerical to compute transport bed profiles in alluvial stream under simplifying conditions. These can be used to make engineering predictions needed in the management of alluvial rivers as a consequence of man-made interference in the river regime.

xii. The effective solution to desilting is erosion control in the upstream watersheds. It is important to remember that as far as water erosion is concerned, prevention is always easier and better than cure.

xiii. No single solution will be appropriate for every location. The approach to flood damage reduction that is likely to yield the most benefit at the lowest cost in many parts of any basin is one that retains water on the landscape rather than transferring it quickly downstream. The approach requires the restoration of some of the pre-settlement characteristics of watershed, such as permanent vegetative cover, an abundance of wetlands and soils with high organic contents that help reduce the flood peaks and contribute to stream flows during dry seasons.

xiv. Feasibility of introducing an arrangement need to be studied to pass the incoming sediment safely to downstream of the dams/ barrage structures to maintain the sediment equilibrium. It shall also be ensured that the concentrated sediment flux passed downstream will not create any major morphological changes on the downstream reaches.

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Appendix I

DREDGING/DE-SILTING/ MINING RESTRICTIONS FOR RIVER

The dredging/ de-silting/ mining restrictions are intended to limit the adverse impacts associated with it. The restrictions are intended to limit those impacts to a level which will have only minor effect on the morphology and ecology of the river.

1.0 Restriction on River Bed Degradation

The magnitude of dredging-induced river bed degradation is a key factor influencing the degree of instability of the river channel. Degradation of the riverbed results in secondary impacts such as bank erosion, channel widening, lowering of water surface elevations adjacent to the river, alteration of aquatic and terrestrial habitat, and a reduction in the structural integrity of manmade structures. Since secondary impacts increase as riverbed degradation increases, the degree of dredging/ de-silting/ mining induced river channel instability can be limited by controlling the amount of dredging related degradation. The dredging /de-silting / mining of the river reach shall be altered or terminated if the average river bed degradation over a 10 km reach length is more than a meter. A reach of river which has been dredged / de-silted /mined out and closed for further dredging will not be reopened until sufficient materials have accumulated to support renewed dredging activities for a reasonable period of time.

2.0 Restrictions Concerning Manmade Structures

2.1 Barrage or weirs or jetties

The barrages or weirs act as a river bed control structures across river. If they fail, it could induce severe riverbed degradation, bank erosion and channel widening. To safeguard the structural integrity of the barrage or a weir, following restrictions shall apply:-

a) Dredging/ de-silting/ mining activity upstream of structure will not be allowed within approximately 200 m.

b) Dredging/de-silting/ mining activities downstream of the structures will not be allowed within a distance of 800 m.

c) Maximum volume of extraction on downstream shall be decided by proper monitoring so that it will not have any effect on the integrity of the structure.

2.2 Water Intake Structures

No dredging will be allowed within 150 m distance from the intake structures for safeguarding structural integrity. However, this can be relaxed, if the water flow to the intake structures has been obstructed by excessive sedimentation. The dredging activity shall be restricted so that the water level reduction will not lead to functional difficulties in diverting water in to the intakes.

2.3 Bridges

No dredging will be allowed within 150 m of any bridge crossing to safeguard the structural integrity of the bridge. This shall not be applied where water way has been obstructed by excessive sediment deposit and is causing flooding of upstream reaches.

2.4 Pipelines

Pipelines buried in the riverbed have a high potential to be adversely impacted by dredging activities. If degradation of the riverbed exposes pipelines, damage could occur through sagging, buoyancy or displacement of the line downstream due to an accumulation of debris. The following restrictions will limit the potential for dredging/ de-silting/ mining induced localized degradation to expose buried pipelines:

a) No dredging will be allowed within 60 m of any pipelines that is buried 3 m or below the river bed.

b) No dredging will be allowed within 150 m from any pipeline that is buried less than 3 m below the river bed. Additional restrictions may be required for any pipeline located on or above the river bed. Such restrictions could be developed on a case by case basis.

2.5 Bank Stabilization Structures

No dredging will be allowed within 60 m of the most upstream and downstream point of the bank stabilization structure. Similarly, dredging/ de-silting/ mining restrictions as shown in Figure 1 shall apply for the bank stabilization structures. Levees or embankments will also be treated as in this case and accordingly the same restrictions shall apply.

2.6 Other structures

The support structure for high tension lines passing over the river shall also be treated as bridge piers and relevant restrictions as provided in clause.2.3 shall apply. Restrictions regarding other manmade structures not identified in this section may be determined on a case to case basis.

3.0 Restrictions Concerning Natural Formations

3.1 Natural Rock or Hard Deposits in River Channel

Natural rock or hard deposits located on or in the riverbed may act as riverbed controls and/or may increase aquatic habitat diversity. The importance of rock or hard deposit is dependent upon extent of its area, its thickness and other relevant factors. Based on these hard deposits, river is restrained to flow along a predefined alignment. Dredging/ de-silting/ mining shall not dislodge such hard deposits or dredging of collected silt upstream or downstream of such hard stratum shall not in turn displace it, whereby the river loses its control. Therefore, restrictions concerning natural rock deposits will have to be dealt case by case basis. River Ganga flows along the important ghats of Varanasi or elsewhere also, where it is worshipped by the people. It is held to flow along these ghats due to peculiar alignment formed by the rock or hard strata and silt deposits together. Hence, dredging / de-silting / mining shall be avoided at these places entirely along the width and at least 5 km upstream and downstream of such places.

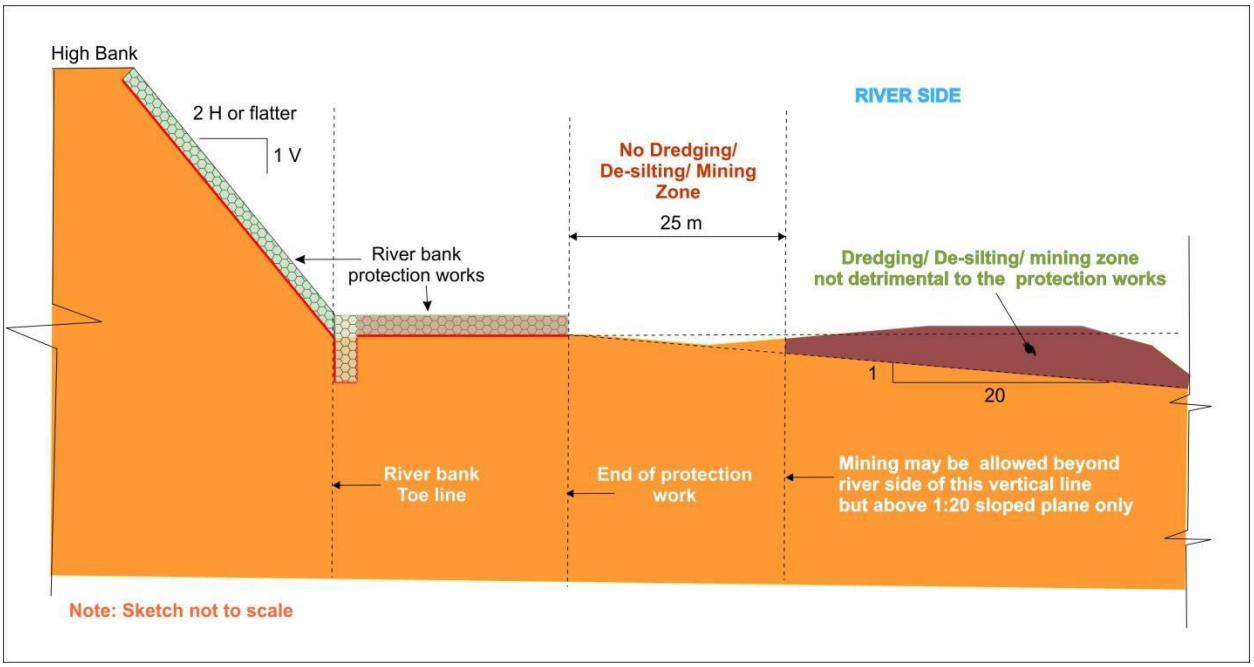

Figure 1: Dredging / De-silting / Mining Restrictions for protecting river bank/ embankment protection works

3.2 River Banks

Dredging/ desilting / mining close to riverbanks have a high potential to adversely impact the stability of those banks, especially when dredging/ de-silting/ mining occurs near the outside of sharp river bends. Bank erosion induced by such dredging can result in the loss of land, damages to man-made structures, and adverse impact to environmental resources. Therefore, the following restrictions are imposed to limit the potential for dredging/ de-silting/ mining induced local bed degradation which adversely impact the river bank stability:-

a) No dredging will be allowed within 60 m of the most upstream and downstream point of such banks.

b) Dredging/ de-silting/ mining restrictions as shown in Figure 2 shall apply for the bank considered to be important.

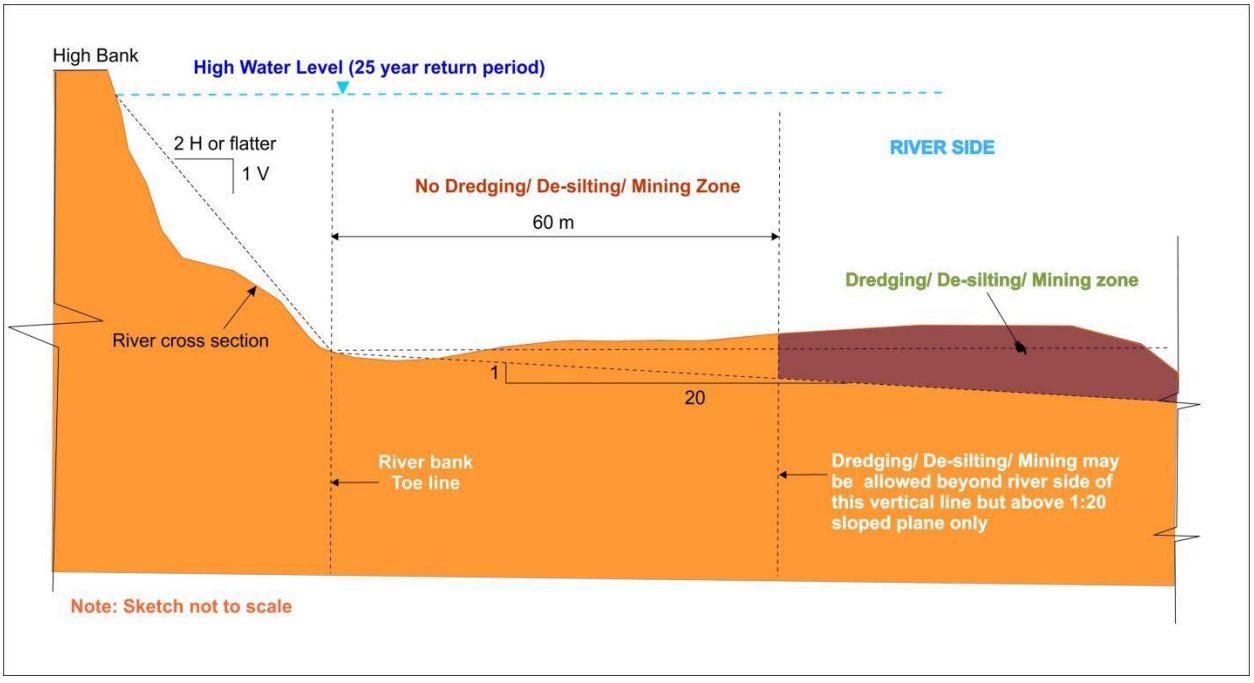

Figure 2: Dredging / De-silting / Mining Restrictions for protecting river banks