Restoration and Conservation of River Yamuna

Final Report

Submitted to the

National Green Tribunal

with reference to Main Application no. 06 of 2012

(Tribunal's order dated 24 September 2013)

Expert Committee constituted by the
Ministry of Environment and Forests, New Delhi
(Order no. K-1301/2/2013-NRCD Dated 13 September, 2013)

Prof. C. R. Babu (Delhi University, Delhi) – *Chairman*

Prof. A. K. Gosain (IIT-Delhi) - *Member*

Prof. Brij Gopal (Jaipur) – *Member*

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PREFACE

The river Yamuna is one of the sacred rivers of India. Besides Delhi, the Capital of India since Moghul period, two other major cities, Mathura and Agra, within its 200 km distance downstream of Delhi are of greatest historical and cultural importance. However, this very stretch of the river is also one of the most heavily polluted and degraded river stretches in the country. Although the flow of river Yamuna had been diverted at Tajewala (Haryana) more than a century ago, the lean season flows in the river have been totally eliminated downstream of Tajewala (now Hathnikund) over recent decades. Delhi receives its water requirements only upstream of Wazirabad barrage through a distributary of the Western Yamuna Canal, and no freshwater flow below the barrage. Rapid growth of Delhi has resulted in the generation of huge quantities of sewage and wastewater that are not treated fully before discharge into the river. The 52 km stretch of the river from Palla to Jaitpur in the NCT of Delhi has lost its life supporting potential. The 22 km stretch from Wazirabad to Okhla is the most polluted segment of the river as it receives outfall from 22 drains which contribute 80% of the pollution load of the river. The vast floodplains, which serve as a floodway and help recharge ground water, have also been gradually eliminated to a great extent and encroached upon by gradual reclamation by dumping solid wastes and construction of various buildings. This has reduced the flood carrying capacity, groundwater recharging capacity, and other biodiversity related ecological functions. The morphology of the river and the wetland functions are also altered by embankments, bunds, roads, flyovers, guide bunds and spurs, several bridges and three barrages.

The latest among the many PILs before the Courts, including the Supreme Court, is the case of Manoj Mishra Vs Union of India & Others (Application No. 6 of 2012) before the Hon'ble National Green Tribunal (NGT). The NGT directed the Ministry of Environment & Forests, Government of India to constitute an Expert Committee to examine various issues related to the dumping of solid wastes, the Riverfront Development Scheme of DDA and the restoration, preservation and beautification of the river Yamuna. The MoEF constituted a three-member Expert Committee comprising of the undersigned. We the members of the committee held 6 meetings, surveyed both banks of the river along the entire 52 km stretch from Palla to Jaitpur, held discussions with different stakeholders including the Applicant. We also critically examined the documented information available in Reports of the committees and authorities and Court Orders and decisions. The committee also generated

high resolution maps (1:1000) with different layers on GIS platform and delineated the river zone.

We present here in this Report an assessment of the current status of the river, our field observations, comments on the major issues and the approaches to restoration of the river and its floodplain. We have made a set of recommendations and suggested an institutional framework, and timelines for implementation of the recommendations.

Brij Gopal	**C. R. Babu**	**A. K. Gosain**
(Member)	(Chairman)	(Member)

ACKNOWLEDGEMENTS

The members of the Expert Committee would like to record their gratitude to the Secretary to the Government of India, Ministry of Environment and Forests, Shri Dr. V. Rajagopalan, for entrusting the task of preparing a Report on the rejuvenation of the river Yamuna in NCT of Delhi and the corresponding UP portion as directed by the Hon'ble National Green Tribunal.

The National River Conservation Directorate of the Ministry of Environment & Forests, Government of India has extended full support to the committee to discharge its functions. The Committee members express their sincere appreciation to the cooperation and guidance provided by the Advisor, Shri Brijesh Sikka, who is also the convenor for the committee. We also thank Dr A. Senthil Vel (former Director, NRCD), Shri Ravi Sinha (Director, NRCD), Shri Sandeep Gupta (Senior Monitoring Expert, YAP-III, NRCD) and Ms. Vandana Singh, (Monitoring Expert, YAP-III, NRCD) for their help in various ways.

We gratefully acknowledge the Delhi Development Authority for not only providing the financial assistance to GSDL for the generation of data sets and high resolution maps of 'O' zone with different layers but also for providing valuable available information. Thanks are due to the officers of Landscape Division and the Chief Engineers of concerned Divisions of DDA and officials of Irrigation and Flood Control Department of Uttar Pradesh for assisting the committee during field visits.

The Committee thanks Miss Anu Priya Goyal and Mr Jatin Anant of Professor Gosain's Lab at IIT, Delhi for their help on the various aspects of analysis of the geo-spatial data. Thanks are also due to Dr Rakesh Kumar and Shri Pankaj Kumar of the Centre of Excellence Programme of MoEF at Centre for Environmental Management of Degraded Ecosystems (CEMDE), University of Delhi for their assistance in finalization of the Report.

We would like to record our appreciation for all the stakeholders, particularly officers of DDA, Delhi Jal Board, Central Pollution Control Board, the Central Ground Water Board, the Central Water Commission, GSDL and ISRO who had interacted with members on more than one occasion. We also thank the Applicant, Shri Manoj Misra for the presentation of his vision on the river Yamuna before the Committee.

SUMMARY OF THE REPORT AND RECOMMENDATIONS

During the past two decades, the 22-km urban stretch of River Yamuna passing through the NCT of Delhi has undergone serious degradation in many respects. Despite several interventions by the Government, various high level committees and the courts at the highest level, the river remains critically polluted (except during the rainy season) and its space continues to be encroached upon for different purposes.

On the direction of the Hon'ble National Green Tribunal (NGT) in the present case of Mr Manoj Misra vs Union of India and Others (Application No. 6 of 2012), the Ministry of Environment & Forests (MoEF), Government of India, constituted a three member Expert Committee to examine the issues related to the large-scale dumping of solid wastes, the encroachment, the reclamation of river bed and the floodplains, the river front development scheme of DDA, and the restoration and conservation of the river Yamuna.

The MOEF constituted the Expert Committee (Order No. K-13011/2/2013-NRCD of 13 Sept 2013) with the following TOR:

(i) to critically analyse and examine the Yamuna River Front Development Plan of DDA,

(ii) to suggest steps for further improvement of the Yamuna River Front Development Plan keeping in view the environmental concerns of river Yamuna in the proposed stretch, and

(iii) to also take into account the observations of Hon'ble Supreme Court in the matter relating to 'Maily Yamuna' Writ Petition No.725 of 1993.

The Hon'ble NGT in its order of 24 September 2013, extended the mandate of the Expert Committee by stating that "the Report shall not only suggest the methodology and process required to be followed for restoration, preservation and beautification of the river beds but even state as to who should execute the work and the manner in which such work should be executed". The Hon'ble NGT also stated that "keeping in mind, the committee, even if it chooses to inspect the entire Yamuna and find out whether debris has been completely removed or not, it has to state with certainty the plan for restoration, preservation and

beautification which is to be carried out within a time frame to be prescribed by the Tribunal".

The committee had 6 meetings and conducted site visits. The Committee held six meetings to discuss with different stakeholders including the petitioner, different facets of the river and its degradation leading to its eclipse and possible ways and means to restore and conserve it. The members of the committee also extensively surveyed both the banks of the river in the entire 52 km stretch of River Yamuna through NCT of Delhi and its border with UP. The committee also critically evaluated the available information relating to rejuvenation, development and management of river Yamuna, particularly with respect to 52 km stretch of NCT of Delhi and UP portion, in the Reports and recommendations of different Authorities and Committees constituted, different projects undertaken by the Government agencies/institutions and court orders and decisions as well as the status of 'Maily Yamuna' case. The committee also generated 1:1000 resolution maps on GIS platform using 2010 data sets supplied by GSDL on different aspects of the river ecosystem, and flood zoning was also undertaken using digital model.

Based on the observations and critical assessment of available documented information presented in this Report, the Committee recommends the following:

Solid Wastes, Garbage Dumps and Encroachments

During field visits, the Committee observed large dumps of solid wastes and garbage in many places. In several cases, the solid wastes had been relocated to the edge of the floodplain, and dumped for widening the bunds and guide bunds, for constructing roads to cremation grounds / ghats / temples, nurseries and agricultural fields located within the active floodplain. Extensive areas of the floodplain (on the eastern side, in UP area) are being used by solid waste recycling units and their dumps. Similarly, floodplain areas are also encroached upon by the DMRC's prefabrication units. Further, encroachments have occurred for expansion of settlements such as Jaitpur extension, and at Badarpur Khadar.

Recommendations

1. All solid waste dumps including those used for roads and bunds within the active floodplain should be removed forthwith.

2. All solid waste recycling units, farm houses, cattle farms and nurseries must be relocated at the earliest.
3. Construction of new bunds, roads and guide bunds, widening of existing bunds, spurs and guide bunds within the active floodplains should be stopped and banned.
4. No filling of the floodplains / riverbed be allowed in the name of development and renovation of ghats. The floodplain under built up areas at Sur Ghat and Quidesia Ghat should be recovered. All recreational facilities for people visiting ghats should be created close to the embankments/roads where a channel taken out from the water course of the river can be brought for the purpose.
5. All settlements encroaching upon the floodplain (with the exceptions noted in the detailed report) should be relocated at the earliest.
6. Construction of new barrages and roads, railway and metro bridges, and embankments and bunds should not be permitted. In exceptional cases, a critical assessment of their potential impacts on flood aggravation and environmental clearances should be made mandatory.
7. There is a shortage of landfill sites in Delhi. Immediate action is required to identify additional landfill sites catering to the next 25 years of requirement. Action is also required to identify more sites for recycling of building material waste.

Responsible Organizations: (*Irrigation & Flood Control Departments of Delhi, Delhi Development Authority, Land Revenue Department of Delhi & Uttar Pradesh, concerned Municipal Corporation of Delhi & Uttar Pradesh)*

The River Zone

Rivers require a certain space to carry their peak flows and sediments, and for their ecological functions. This includes the river channel(s) and the floodplains which together are often designated as river corridor or floodways or simply the river zone. In case of river Yamuna, the embankments and numerous constructions on the floodplain, especially within the 22 km stretch through urban Delhi, have already constricted the river zone to a very narrow space,

and at many points, the channel flows along the embankment and hence, has no floodplain left.

Recommendations

1. The 'O' zone as defined in MPD 2021 and as delineated in the present Report, together with the corresponding part of the river and active floodplain within the embankments on the U.P. side on the east, should be designated as the river zone.
2. The River Zone so designated should be preserved and protected for the conservation and restoration of the river. No development activity should be permitted within the river zone that encroaches upon the active floodplain, obstructs the flow or pollutes the river (solid waste or wastewater).
3. The existing constructions/facilities/ within the river zone that are allowed as an exception (such as Akshardham temple and Commonwealth Games Village, settlements such as old Jaitpur, Sonia Vihar, Jagatpur, etc., Samadhis, Delhi Secretariat and Velodrome, Thermal Power Plants, etc.) should be treated as a Special Zone within the river zone. The Special Zone should have a regulatory regime which needs to be worked out separately keeping in view that these areas do not cause any impact whatsoever on the water quality or flow of the river.
4. The Committee notes that the Govt of NCT-Delhi has already agreed to relocate the Millennium Bus Depot (as per the affidavit filed in the High Court of Delhi).
5. Appropriate measures such as barbed wire fencing in highly vulnerable areas should be considered for preventing encroachments and waste dumping in future. The polluter-pays principle should be enforced for defaulters.

Responsible Organizations: *State Government of National Capital Territory of Delhi & Uttar Pradesh including their concerned Agencies such as Delhi Development Authority, Irrigation & Flood Control Department of Delhi & Uttar Pradesh, Land Revenue Department of Delhi & Uttar Pradesh.*

The Yamuna Riverfront Development (YRFD) Scheme of the DDA

The Yamuna River Front Development plan of the DDA is an "Integrated project of recreational areas along with biodiversity parks" in four of the subzones (of the O-zone). The area proposed for the implementation of Yamuna Riverfront Development (YRFD) scheme by DDA is the active floodplain which is frequently flooded by medium floods. The proposed activities such as construction of various recreational and public facilities by effecting topographic changes will reduce the flood carrying capacity and aggravate flooding, besides contributing to pollution.

Recommendations

1. The Yamuna Riverfront Development is untenable and should be stopped. It is noteworthy that the DDA itself admits on their proposed re-delineation of 'O'-zone (as per the Public Notice issued by DDA on 28 September 2013) that the riverfront refers to the area that lies outside the embankments. But the area of the proposed YRFD is within the active floodplain.

2. The Riverfront Development Scheme should be replaced by a plan for restoration of the river and its floodplain as suggested below and detailed in this report.

Restoration of River Yamuna

Restoration of a river to bring back its biophysical characteristics and ecological functions requires addressing the root causes of degradation. River Yamuna is severely affected by the elimination of its natural flow (except during the rainy season), destruction of its physical characteristics (elimination of floodplains by embankments and encroachments, and solid waste dumping and reclamation), habitat fragmentation (by barrages and guide bunds of bridges/flyovers), destruction of natural floodplain biodiversity, and excessive discharge of wastewaters (untreated or partly treated sewage, and stormwater). The Committee recognises that some of these changes are irreversible and it will not be possible to restore the river fully to its old glory, it is possible to rehabilitate the river for many of its functions, water quality and beauty.

Recommendations

1. Controlled dredging is required to remove the huge accumulation of sediments and sludge which has reduced the flood carrying capacity of the main channel, silted up wetlands and floodplain water bodies, and aggraded the floodplain (partly due to solid waste dumps).

2. Dredging of the river bed and pondage of Okhla barrage should be undertaken.
3. Many of the spurs have lost their original purpose because the flow in the river is highly reduced and regulated. In several places these are being extended right upto the current channel and being developed as parks. This extension and development must be stopped and the length of spurs should be restricted to allow a wider space for the river channel to meander and carry more water.
4. Existing wetlands and water bodies both upstream and downstream of Wazirabad reservoir should be deepened and enlarged.
5. Culverts must be constructed under the existing guide bunds of roads and flyovers, which have fragmented massive wetlands, so that flood waters flow without obstruction along the river course and into the floodplain wetlands. This will also help movement of aquatic biota (e.g., fish) and enhance the groundwater recharge.
6. A mosaic of wetlands and floodplain vegetation having native biodiversity should be developed. A cascade of treatment wetlands along the western and eastern banks (100-150 m belt) must be created and the outfall from all the major drains (after treatment in STPs) should pass through them before discharging into the river channel. These wetlands will help improve the water quality by reducing the BOD and nutrient levels through the action of the plants and animals therein. Wetlands should also be developed along the smaller drains before they discharge their contents into main drains. The outfall from Barapulla drain should be channelized through the cascade of wetlands already existing in the area.
7. A greenbelt/greenway should be developed on both sides of the embankment, for controlling erosion, reducing sediment load of the main channel, reduce pollution, and beautification. Nature trails may be provided across riparian areas for recreation to the public without losing the ecological functions of the floodplains.
8. The control of sewage pollution must be given highest priority. Besides the interceptor sewer system now being developed, the capacity of sewage treatment plants must be increased; their efficiency must be ensured and enhanced; sewerage facilities should extended to un-sewered areas, and the present sewerage systems be rehabilitated. Adoption of new technologies to reduce BOD levels from 20-30 mg/l to

below 10 mg/l, together with the use of treatment wetlands as noted above, would enhance the quality of water in the river.

9. Immediate action is required to ensure the provision of environmental flows throughout the river, and especially in the stretch downstream of Wazirabad. The sewage and stormwater generated from the city can help mitigate the flow requirement to some extent provided they are treated to an acceptable quality as per CPCB standards and then allowed to flow through wetland systems restored on the floodplain as recommended above.
10. To manage the waste water system in the NCT of Delhi, a comprehensive master plan for sewerage for complete Delhi should be prepared by DJB.
11. Agricultural activity on the floodplain should be regulated to totally prohibit the use of agrochemicals (fertilisers and pesticides) and should be restricted to areas beyond 100 m on either side of the river channel and other wetlands/water bodies.
12. Access to the river channel for social/cultural/religious functions and recreation should be allowed in a manner that it avoids construction of paved (pucca) paths and does not cause any kind of pollution.

Responsible Organizations: *State Government of National Capital Territory of Delhi & Uttar Pradesh and its agencies like Irrigation & Flood control department of Uttar Pradesh, Delhi Development Authority, Land & Revenue department of Uttar Pradesh Pollution Control Board / Delhi Pollution Control Committee, Ministry of Water Resources, Government of India.*

Institutional Arrangements

1. The River Zone of the river Yamuna within the NCT-Delhi (together with the corresponding areas of U.P.), as identified in this report, is highly vulnerable to several anthropogenic pressures in the absence of regulatory measures and legal protection. The ecological integrity of the river, particularly the functioning of floodplain ecosystems, cannot be sustained even after restoration unless adequate measures are taken for its protection. The Committee therefore recommends that the 52 km stretch of the river Yamuna in the NCT of

Delhi and UP should be declared as a **Conservation Zone** under section 3 of the Environmental Protection Act 1986 (29 of 1986) and appropriate rules be framed for the human activities to be permitted or prohibited.

Responsible Organizations: (*Ministry of Environment and Forests, Government of India)*

2. A High Powered Committee for Yamuna River Development chaired by the Lt. Governor, Delhi had been constituted by the Govt. of India in August, 2007. It is suggested that this Committee be expanded to include the Chief Secretary, U.P as well as five expert members in the field of Science and Engineering and its mandate to also include integrated management and coordination among various planning, execution, funding and regulatory agencies of the two states to be involved in the restoration and management of the river in the Delhi stretch. The HPC should also closely liaise with the NGRBA for better integration of their activities, since Yamuna is a sub-basin of the Ganga Basin.

Additional Recommendations

1. Successful restoration of the river for its ecological functions and their future sustainability will depend heavily on the provision for Environmental Flows through the entire 52-km stretch. Despite an earlier Supreme Court direction for providing 10 cumecs of freshwater flow downstream of Wazirabad, the desired flow has not yet been made available. The Committee recommends that the Environmental Flows requirements, particularly for the lean season, may be re-assessed for the entire 52-km stretch and the required flows be ensured at the earliest.

Responsible Organizations: (*Ministry of Water Resources, & Ministry of Environment and Forests, Government of India)*

2. A separate programme of promoting public awareness for the conservation of the river and for the community participation in the restoration, management and monitoring of the river should be prepared and implemented through a separate Society / Trust.

Responsible Organizations: (*Delhi Development Authority)*

3. To secure the ecological integrity of the river, to prevent encroachment and dumping of solid wastes and to prevent unauthorized constructions, river policing by a dedicated unit should be enforced by the respective states.

Responsible Organizations: (*State Government of National Capital Territory of Delhi & Uttar Pradesh)*

INTRODUCTION

Background

It is well established that the environmental and ecological degradation of the river Yamuna in the stretch passing through the NCT of Delhi due to anthropogenic factors has led to the loss and degradation of riparian ecosystems. The loss of life supporting potential of the river is the major concern to the public, the Government and the courts. For example: (i) the water quality in this stretch is characterised by 40 to 50 mg/l BOD and almost zero DO levels and extremely high coliform density (2,40,00,000/ml), (ii) the flowing water, the river bed, the floodplain forest and grassland ecosystems are locally extinct, and (ii) further, the floodplain is so restricted in some segments by encroachments using combinations of bunds roads, guide bunds and spurs (Figure 1) that not only reduced the recharging area for flood waters leading to the reduction in ground water recharge but also make the city highly vulnerable to floods resulting in ecological disasters as has been happened recently in Kosi (Bihar) and Ganga river basin (Uttarakhand).

Several PILs have been filed in the Supreme Court and many orders have been issued to the Central Government and the Government of NCT of Delhi which have constituted a number of committees for the improvement of the river. Earlier, the Delhi High Court had also constituted a Committee – the Usha Mehra committee – which suggested removal of encroachments and some of these were removed. However, the river continued to be further degraded and encroached upon.

Shri Manoj Mishra filed a petition (Application No. 06 of 2012) at National Green Tribunal against Union of India and others on the activities that are contributing to the eclipse of river. The issues are the large scale dumping of solid waste, the encroachment, the reclamation of river bed and the floodplains, the river front development scheme of DDA and the re-delineation of 'O' zone by DDA. The Hon'ble Tribunal directed the Secretary, Ministry of Environment and Forests (MoEF), Government of India to constitute a committee, under his Chairmanship, to oversee the removal of solid waste dumps and also prevent dumping of solid waste. It also directed MoEF to constitute an Expert Committee to examine the Riverfront Development Scheme proposed by DDA.

While constituting this Expert Committee, the MoEF took into consideration also the ongoing 'Maily Yamuna' case in the Hon'ble Supreme Court. The SC also directed the MoEF to constitute a committee, under the Chairmanship of its Secretary, and that committee constituted a Technical Committee under the chairmanship of the Member Secretary of CPCB. The Technical Committee asked IIT-Roorkee and IIT-Delhi, both of which were represented in the committee, to submit a joint proposal for pollution abatement in the urban stretch of NCT of Delhi. Both IITs have only recently submitted a proposal on "Formulation of study proposal for integrated management and control of water quality of river Yamuna".

TERMS OF REFERENCE

Following the directive of the Hon'ble Tribunal, the MoEF constituted the Expert Committee (Office Order No. K-13011/2/2013-NRCD of 13 September 2013), with following ToR (Annexure I):

(iv) to critically analyse and examine the Yamuna River Front Development Plan of DDA,

(v) to suggest steps for further improvement of the Yamuna River Front Development Plan keeping in view the environmental concerns of river Yamuna in the proposed stretch, and

(vi) to also take into account the observations of Hon'ble Supreme Court in the matter relating to 'Maily Yamuna' Writ Petition No.725 of 1993.

The Hon'ble NGT in its order of 24 September 2013 (Annexure II), extended the mandate of the Expert Committee by stating that "the Report shall not only suggest the methodology and process required to be followed for restoration, preservation and beautification of the river beds but even state as to who should execute the work and the manner in which such work should be executed".

The Hon'ble NGT also stated that "keeping in mind, the committee, even if it chooses to inspect the entire Yamuna and find out whether debris has been completely removed or not, it has to state with certainty the plan for restoration, preservation and beautification which is to be carried out within a time frame to be prescribed by the Tribunal.

APPROACHES FOLLOWED BY THE EXPERT COMMITTEE

The Expert Committee set forth the following approaches to address the issues mentioned in ToR through the suggested implementable action plan for restoration, preservation and beautification of river Yamuna:

(i) Interactions with the applicant and Government stakeholders, the data presented by them (Manoj Misra, Landscape Unit and GIS unit of DDA, Delhi Jal Board, 2013) were examined.

(ii) Study of voluminous data generated by different public and private agencies using geospatial techniques,

(iii) Analysis of legal judgements passed,

(iv) Critical evaluation of the recommendations/action plans made by different committees set up by the Central and State Governments,

(v) Intensive field surveys of the river zone, and

(vi) Analyses of high resolution maps of 1:1000 with different layers generated by the committee on GIS platform.

The Expert Committee held 6 meetings and undertook field surveys of both the banks in the entire 52 km stretch of the river from Palla to Jaitpur (Annexures 3-10).

Geospatial Data Analyses

The following are the details on Geospatial Data analysed:

The geospatial layers supplied by GSDL in the ArcGis format are given in Table 1.

The geographic data were organised in the form of Geospatial Database for information processing, geospatial analysis and subsequently composing different thematic maps for reporting.

Google satellite imageries (updated 2014) were used for cross verification of the geographic data.

The area under floodplain in UP was identified by demarcating the embankment line in UP using temporal satellite imagery from Google as base map.

The elevation values for UP area were interpolated from the elevation values of the cross-sectional profiles available along the stretch of Yamuna from the Department of Irrigation & Flood Control, Government of NCT of Delhi (GNCTD).

The entire floodplain stretch (composed of O-Zone and UP portion of floodplain) was cut into 8 sub zones (as described in Yamuna River Front Development Scheme formulated by DDA, Sep 2013) and furthermore the floodplain were classified into left and right banks along the Yamuna river flow for better depiction. The area under each segment has been described separately.

The built up area within the O-Zone was demarcated as polygon using satellite imagery from Google as base map.

The terrain for each subzone was extracted and overlaid with layers of various infrastructure and land use and land cover features to render 3D perspective on a geospatial platform.

Table 1: List of Data layers used in Geospatial Framework

Data Layer	**Data Format**	
Digital Elevation Model (DEM)	Raster (5x5 m)	DEM for Delhi merged with DEM for UP (constructed using the data on river cross-sections supplied by the Department of Irrigation & Flood Control)
Cross sections	Points	Cross sections every 250 m along the river longitudinal section
Boundary	Polygons	'O' Zone, 'O' zone + UP
River Boundary	Polygons	River main channel of 2010
Infrastructure	Lines	Roads
Infrastructure	Lines	Embankments, Bridges
Land Use / Land Cover	Polygons	Buildings, Cultivated Area, Plantations, Reserved Forest, Farms, Barren Land
Topographic Feature	Polygons	Marshy Swamp, Water Bodies

STATUS OF THE RIVER YAMUNA

Origin and Journey of the River

The river Yamuna is one of the sacred Himalayan rivers originating from Yamunotri glacier (near Saptarishi Kund at Bandar Poonch glacier peak at an elevation of 6387 m in Mussoorie range of lower Himalaya. The river travels over a distance of 1370 km across Uttarakhand, Himachal Pradesh, Haryana, Delhi, Rajasthan and Uttar Pradesh and finally joins Ganga at Allahabad (Prayag); its basin spreads over an area of 66,220 sq.km which constitutes 42.5% of the total Ganga River basin and has major four tributaries - Tons, Giri and Bata joins it from its right side and Asan joins it from its left side, all of which constitute basin (Head waters) of the river in Himalayan states. Tons constitute 60% of the flow of the river. In plains its tributaries are Hindon, Chambal, Sindh, Betwa and Ken. The upper Yamuna basin upto Okhla in Delhi represents less than 20% of its total basin (Martin et al, 2007; Agarwal & Krause, 2013).

According to Agarwal & Krause (2013) 17 hydroelectric projects were completed, one hydroelectric project is under construction and about 20 are proposed within Yamuna river basin. It enters into plains of north India after the river forms an interstate border for about 50 km between Uttarakhand and Himachal Pradesh. In the plains it forms an interstate border between Haryana and Uttar Pradesh for about 200 km distance and then it enters into Delhi. After traversing 45 km, it forms an interstate border between Delhi and UP and then forms interstate border between Haryana and UP and finally enters into UP, and runs parallel to Ganga before joining it at Allahabad. A total of 6 barrages were constricted across the river. In the hills one barrage on Yamuna at Dakpathar and another one on its major tributary Asan were constructed in Uttarakhand; in the upstream of Delhi, Hathnikund (Tajewala) barrage was constructed in Haryana and the water was diverted to Western Yamuna Canal (WYC) and Eastern Yamuna Canal (EYC). The tail end of WYC joins the river Yamuna near Palla and EYC also joins at Wazirabad reservoir. Further, the abstraction of water at Tajewala barrage which is about 2 km distance downstream from Hathnikund take place. The upstream of Wazirabad has also been deteriorating recently due to release of pollutant into Yamuna river from the towns of Karnal, Panipat, Sonipat and others. Consequently, there was no flow after Hathnikund barrage into rive Yamuna during dry season. Within NCT of Delhi three barrages were constructed across the river – the Wazirabad, the ITO and the Okhla barrages.

In UP, Gokul barrage was constructed to provide drinking water to Mathura and Agra. The river enters into NCT of Delhi at Palla in the north and exits at Jaitpur in the south.

River Course within NCT of Delhi

The river Yamuna within NCT of Delhi and the corresponding portion of UP traverses over a distance of 54 km. The stretch of 26 km in the upstream of Wazirabad reservoir receives water from a branch of Western Yamuna canal which joins the river at Palla and the Eastern Yamuna canal joins it at Wazirabad barrage; both the canals originate from Hathnikund barrage, the downstream of which there is no flow from barrage during lean period and whatever the flow is from the canals. This stretch of river has potable water and does not receive any sewage water. The water in the upstream of Wazirabad barrage has recently been deteriorating due to release of pollutants from towns of Haryana located in the upstream. **The urban stretch of the river of 22 km between Wazirabad barrage and Okhla barrage receives only sewage from 22 drains and fresh water from Wazirabad barrage during monsoon.** The upstream of Okhla barrage receives polluted water through Hindon cut canal from Hindon river (originates from Siwaliks), and water from Okhla barrage is drawn by Agra canal and Gurgaon canal. The Hindon river also receives waste water from Ghaziabad through Dhasana drain and finally discharge its contents into Yamuna after it crosses the NCT stretch. In other words, Hindon also contributes to the pollution load of Yamuna. The Shahadra drain carrying waste water from Trans Yamuna area discharges its content into river after Okhla barrage. **In other words, the NCT of Delhi constitutes less than 1% of the total catchment of Yamuna but contributes more than 50% of the total pollutant load in the river and this load of pollutants is discharged over the urban stretch of 22 km between Wazirabad and Okhla barrages.** Further, water from Okhla barrage is abstracted into Agra canal that carries share of Uttar Pradesh and Rajasthan.

The Delhi share of river water is received in the upstream of Wazirabad barrage to meet water treatment plants located at Wazirabad and Chandrawal. Further, Delhi also gets water from Satluj and Beas water through Narwana branch Karnal link which joins Yamuna canal at Karnal. The share of Delhi from Ravi-Beas is carried through this link upto Karnal and thereafter through Western Yamuna canal system upto Haiderpur water treatment plant.

During monsoon, there is a provision of transfer of Yamuna water to Bhakhra waters through Sirsa branch of Western Yamuna canal at Indri near Karnal (Report of High Powered Committee, 2010). These linkages illustrate the inter-basin transfers of water. About 40% of drinking water of Delhi is met by the river Yamuna.

Flows in the River

At 75% dependent (assured minimum flows available in 75 percent of the time span under consideration) the notional virgin flows (original flows of the river) in the river upto Okhla is 11.70 billion cubic meter (BCM) and the mean availability is 13.00 BCM, the bulk of which (75.6%) is received as monsoon waters (July-October) and the contribution of snow melting is only about 25-30%. Since there is no upstream storage, only a part of monsoon flows are utilized and the remaining flows are allowed to flow unutilized in the downstream of Okhla. There are heavy inflows during monsoon but the flows are meagre and are mainly contributed by snow melt during monsoon (Report of High Powered Committee, 2010).

Because of higher floods (7 lakh cusecs of water passed over Tajewala weir in 1978; Report of the High Powered Committee, 2010), Haryana, Uttar Pradesh and Delhi planned and constructed extensive drainage and river control works including embankments. The mean availability of water in the river at Tajewala during monsoon (July-October) is 19705 cusecs for distribution among basin States. The discharges higher than 1975 cusecs are received at Tajewala for an average of 28 days during 4 months of monsoon. For half of the monsoon days the availability is perhaps less than mean availability. For non-monsoon season, the mean availability is 2783 cusecs and 4061 cusecs for November-February and March-June, respectively, but the actual availability is much less i.e. about 80% and infact flows at Tajewala touch as low as 1700-1800 cusecs. There are some low height dams and barrages on the river Yamuna and its tributaries in Uttarakhand and Himachal Pradesh and these are run of the river hydroelectric power projects. For the purpose of water storing, the main barrages on the river are: (i) Hathnikund, (ii) Wazirabad, (iii) Yamuna (ITO), and (iv) Okhla (Report of the High Powered Committee, 2010). The above analyses on river flows, barrages, hydraulic structures and flood levels suggest that: (i) Haryana and Uttar Pradesh are the major users of Yamuna river for irrigation purposes where the state of Rajasthan is a marginal user

of Yamuna river, (ii) about 40% of the drinking water of Delhi are met with the river waters, and (iii) 25 to 30% of cumulative annual river flows remains unutilized because of the absence of upstream storages on the river. Renuka dam, Kishan dam and Lakhwar Vyasi dam, may enhance the storage capacity.

The Delhi Development Authority had intended to channelize the river in the city portion (from downstream of Wazirabad to Okhla during MPD 1981-2001) to restrict the flow area in the river and utilize the remaining land for other developmental purposes. The concept of channelization is found not technically feasible, as there are: (i) no flood moderating structures in the upstream and (ii) adverse impacts of higher flow levels in the canalized river section on the entire drainage system. The project is rejected by Flood and Irrigation Department of Delhi, Haryana and Uttar Pradesh. Further, the width of river varies from 1.5 to 2 km only which make it impossible to hold large amounts of discharges during monsoon season.

Quality of Water and Pollution in the River

The Report of the High Powered Committee on Yamuna River Development (2010) also summarizes the status of pollution in different sections of the river. The deterioration of the quality in the river is due to the complete withdrawal of fresh water for irrigation and drinking purposes and cumulative discharges of domestic, industrial and agricultural waste waters into the river, all of which transformed the river into an open sewer in Delhi-Agra stretch. This is adversely impacting riparian ecosystems and endangering public health of inhabitants. The poor sanitation practices especially in unauthorized colonies often lead to epidemic of water bore diseases. The Himalayan stretch of the river (section 1) from the origin to Tajewala (172 km) has good water quality and blocks dry weather flow by Tajewala barrage with the bulk of water is abstracted for irrigation and drinking. In this section, the water is of bathing quality with BOD and DO levels are 1.2 mg/l and 11.7 mg/l, respectively. The Tajewala-Wazirabad stretch of 224 km (upper stream of Wazirabad reservoir) receives (i) only dry weather flow composed of waste water from urban and rural settlements (Yamuna Nagar, Jagadhri, Karnal, Panipat, Sonepat, Saharanpur, Muzaffarnagar etc.) and (ii) the fresh water from Western and Eastern Yamuna canal systems, and these flows are stored

at Wazirabad barrage for meeting the drinking water demand of Delhi Section (Section II). The quality of water in the upstream of Wazirabad is fairly good with average BOD levels in the range of 1.0-2.0 mg/l but with high levels of coliform density and pesticide contaminants. The low BOD levels are due to self purification of water which flows over a distance of 224 km. The Delhi urban stretch of 22 km in the downstream of Wazirabad barrage upto Okhla barrage (Section III) is critically polluted and dry weather flow is almost the treated and untreated sewage from 22 drains and the fresh water flow from upstream or lateral connection and it is perhaps one of the most polluted river stretches in the country with zero DO and over 30 mg/l BOD levels. Apart from domestic sewage of 3452 mld (million litres per day) which includes partly treated sewage and untreated sewage, the river also receives pollution loads (180 mld) from planned and unplanned industries. This pollution load is partly controlled by relocation of industrial suits and setting up of common effluent treatment plants (CETP). The 490 km stretch from downstream of Okhla barrage upto (Section IV) confluence with Chambal is highly polluted and eutrophicated with waste water from urban settlements.

The status of the river was also highlighted by the presentations made by the Applicant (Petitioner), Delhi Jal Board, Central Pollution Control Board and Central Ground Water Board. The Delhi Jal Board also mentioned that 22 km stretch of the river between two barrages receives 80% of total pollution load with BOD more than 40 mg/l and coliform of 24 millions and with no fresh water during dry season; besides sewage, dumping of litter, plastic and solid waste also contributed to the pollution of river.

The Central Pollution Control Board also confirms that water is unfit in this stretch of river for any purpose (Presentation made before the Committee on 17 October 2013). According to Central Pollution Control Board's Report on 'River Yamuna – Waste Water Management Plan in Delhi (2013) the water quality is deteriorated with respect to DO and BOD during 2011/2012 as compared to 2001. The Report gives % flow of sewage from different drains and % BOD (Tones/day) contributed by different drains.

Ground Water Potential

The Central Ground Water Board in its Report on 'Ground Water Potential of the Yamuna Floodplain, NCT Delhi (2013)' states that Yamuna active floodplain aquifer of NCT Delhi occupies 97 sq.km of area and stretches about 35 km along river Yamuna covering 7 districts of Delhi. The 97 sq. km of the active floodplains includes river bed and out of which 16.5 sq. km is under water and the rest 80.5 sq.km has shallow water table. The tube wells dug in the floodplains provides 35 MGD of fresh water from the fresh ground water zone of the aquifers. The thickness of alluvium is 10 to 300 m in the floodplain and depth to bed is 10-150 m below the ground level. Newer alluvium deposits belonging to recent age are extended all along the floodplain area and is composed of clay/silt mixed with tiny mica flakes to medium/coarse sand and gravel and its thickness varies between 45 to 55 m. There are three horizons – the top layer of silt mixed with clay followed by fine to medium grained soils which varies from 4 to 30 m thickness and then followed by sand mixed with gravel which acts as very good aquifer system, particularly in Palla well field area.

The transmissivity of the aquifer system of newer alluvium varies between 730 m^2/day and 2100 m^2/day with hydraulic conductivity ranging between 13 m/day and 20 m/day. The depth to water level in the floodplains varies from 1 to 10 m below ground level (mbgl) both during pre and post monsoon. The ground water flow direction is towards river Yamuna in the upstream of Wazirabad reservoir (north) but in the upstream of Okhla barrage and its downstream (south) the ground water flow is away from the river Yamuna. This is perhaps due to artificial and regulated surface pondage by weir and barrages.

The quality of ground water is fresh in the aquifers to a depth of 30 to 45 m (sometimes upto 65 m in Palla area) with EC, fluoride and nitrates are within the permission levels, but water is saline underlying fresh water and saline/fresh water interface is between 30 to 65 m below ground level. The total fresh ground water in the floodplain area is 615 MCM and the whole floodplain area of NCT Delhi has yield potential of 153 MCM (92 MGD) and the void created due to dewatering of aquifer system will result in 95 MCM of recharging potential. Soni & Diwan Singh (2013) pointed out that the floodplain aquifers have natural storage and recharge even in the absence of sufficient rainfall recharge and hence floodplains are local

source of water for cities located on their banks. They suggested that recharge of floodplain aquifers can be enhanced during monsoon by having running shallow channels form upstream barrage along the elevated embankment and allow the water to drain over the floodplains. Soni et al (2014) highlighted that 50% of the virgin monsoon flow (July-September) is necessary for transport of the river sediment and a similar flow is needed for an adequate recharge of floodplain aquifer along the river. For the lean period (October to June) at least 60% of the virgin flow is necessary to avoid growth of still water algae and to support river biodiversity.

Riverfront Development

There are different proposal developed by different agencies on the riverfront development in the name of Yamuna rejuvenation, many of which are, in fact aimed at development rather than for rejuvenation per se. For example

(i) NCR-Regional Plan 2021,

(ii) Yamuna Action Plan,

(iii) Inland Waterways Authority of India (IWAI),

(iv) NEERI's EMP for rejuvenation of rivers,

(v) DDA's 2004 Master Plan recommendations 1962, 2011 and 2021,

(vi) DDA's Zonal Development Plan's recommendations,

(vii) Yamuna Riverfront Development by Landscape Division of DDA (2010), and

(viii) Report of the High Powered Committee on Yamuna River Development, also dealt with the Yamuna Riverfront Development within the stretch of NCT of Delhi

The MPD (1962-1981) proposed the development of district parks, play grounds and open spaces on the western bank of the river south of Wazirabad barrage. The Master Plan 2001 (1981-2001) mentioned that the river should be made pollution free and large recreational areas should be developed on the bank of the river in a way that the river become an integrated part of the city physically and visually. It also recommended channelization of river, development of riverfront and strict enforcement of the Water Pollution Act. The Master Plan 2021 (2001-2021) talks about the rejuvenation of river Yamuna through a

number of measures including: (i) ensuring adequate flow in the river by upper riparian states, (ii) refurbishment of trunk sewers, (iii) efficient treatment of waste water (iv) sewering of un-sewered areas, (v) recycling of treated effluent and (vi) removal of coliforms. It also mentions that the natural features such as forests, wildlife sanctuary in the bed of river Yamuna and other water bodies should be conserved and kept free from unrestricted and unplanned urban development. The designation and delineation of appropriate land uses and aesthetics of the riverfront should be more fully integrated with the city and made more accessible physically, functionally and visually; water bodies having a minimum size of surface area of 1 ha be preserved and efforts be made at the local level to retain smaller water bodies (Report of High Powered Committee, 2010).

The National Capital Region regional plan 2021 has identified the river zone as a natural conservation zone and recommends that the water bodies should be kept free from any encroachment/development to allow free flow of water. Construction activities for human habitation or any other ancillary purposes are not to be permitted. The activities recommended in the natural conservation zone include agriculture and horticulture, pisiculture, social forestry, plantation including afforestation, regional recreation activities with no construction exceeding 0.5% of the area with the permission of the competent authority (Report of High Powered Committee, 2010).

In spite of these recommendations, the pollution, the encroachment, the dumping of solid waste and draining of wetlands, high siltation of water course have been continuing unabatedly and it may be difficult to identify the presence of river in some segments.

The Prime Minister constituted a High Powered Committee in 2007 on Yamuna rejuvenation and River Development with the following terms:

"(a) Commission studies on different aspects of the development of the river viz. hydrology, ecology, environmental pollution, sustainable use of the river front, to feed into the policy framework.

(b) Develop an operational plan for implementation of the river action programme.

(c) Develop a policy framework and prepare an integrated plan addressing issues of both quantity in terms of flow and quality in the Yamuna river.

(d) Effect inter-sectorial coordination for planning implementation untill such times as a statutory arrangement is in place.

(e) Suggest/list design for a statutory framework.

In order to bring out a comprehensive review of the status and management of river Yamuna in all its dimensions and ramifications, the High Powered Committee appointed a Technical Advisory Group (TAG) in its first meeting on 12 October 2007. The Committee also assigned specific tasks to Central Groundwater Board and National Institute of Hydrology to work out potential for extraction of underground water to supplement the city's needs from the floodplains of riven Yamuna particularly from Wazirabad to Okhla.

The TAG submitted its Report in 2010, which was approved by the High Powered Committee on Yamuna River Development. The Report is a review of different committee's recommendations rather than suggesting strategies for the actual revival of the Yamuna river. It recommended (i) the implementation of upper storage projects, (ii) trapping of groundwater from floodplains, (iii) approved riverfront development as proposed by DDA and (iv) implementation of interceptor sewer system for pollution abatement. The Report also discusses various court orders, decisions taken by different agencies, and Institutional mechanisms and policy options for Yamuna river rejuvenation, development and management.

Inspite of Court Orders and number of Committees and Action Plans for rejuvenation of river, the river in urban stretch 22 km is dead and the floodplains are vanishing. This is evident from the observations made by the Committee during the field visits (Annexures III – X) and geospatial data collected.

FIELD OBSERVATIONS BY THE EXPERT COMMITTEE

The Expert Committee visited the entire river zone (O Zone) of MPD 2021 and the portion belonging to UP from Palla to Jaitpur on both sides western and eastern banks). The observations made by the Expert Committee are given in Annexures 3-9 and also illustrated by site photographs (Figures 1-5). The significant observations are summarized below:

(i) rampant construction of roads and embankments on the active floodplain within the old embankments in many segments of the river leading to massive encroachment;

(ii) construction of houses and or infrastructure development within 300 m from the river channel in some segments;

(iii) construction of bathing ghats on the floodplain and subsequent encroachment around the ghats;

(iv) reclamation of floodplain in the name of developing ghats;

(v) continuous dumping of solid waste into wetlands in some segments;

(vi) reclamation of floodplains for construction of houses in and around religious structures;

(vii) location of cattle farming even on the edges of channels;

(viii) cultivation of vegetables and seasonal crops with high inputs of fertilizers and pesticides;

(ix) construction of roads and other structures under riverfront development scheme of DDA;

(x) development of nurseries and orchards;

(xi) indiscriminate construction of spurs having metaled roads on the top leading to permanent encroachments;

(xii) relocation of dumps from one site to another within the floodplain leading to further encroachment;

(xiii) alteration in the morphology of the river significantly by barrages, bridges/flyovers (with extensive guide bunds), embankments, buildings;

(xiv) continuous discharge of wastewaters and dumping of solid wastes into waters;

(xv) inadequate flushing down of sediments and sludge by the peak floods;

(xvi) constriction of river channel and loss of its natural meandering;

(xvii) reduction in the flood carrying capacity of the river;

(xviii) decline in the groundwater levels in the absence of recharge in the floodplains;

(xix) replacement of the wetland vegetation by exotic water hyacinth and other undesirable species;

(xx) conversion of wetlands and connecting inundation channels into agricultural fields;

(xxi) construction of drains within the active floodplains for carrying sewage from newly developed cities and human settlements outside the embankments;

(xxii) location of ash dykes and creation of Bus depots on the abandoned ash dykes;

(xxiii) small scale plantation of exotics on the floodplain;

(xxiv) establishment of farm houses;

(xxv) sand mining in areas vulnerable to erosion;

(xxvi) discharge of effluents from Power Plants;

(xxvii) unregulated number of bore wells in the upstream;

(xxviii)absence of culverts for the bunds/embankments/road that connect the wetland; and

(xxix) umping of plastics and religious material into the river located outside the embankments

Some of these observations are documented in Figures 1-5 and Annexures 3-9).

Figure 6 illustrates the morphology of river in 1893 with a layer of 'O' zone of 2010 and encroachments in 2012. There is a marked change in the morphology of river in 2010 as compared to that of 1893. For example, in 1893, the river has many channels and vast

floodplains but in 2010 the river has a single channel and the floodplain is greatly reduced. In fact some human settlements in 'O' zone are mapped in the water channel of the river in 1893.

The 'O' zone showing a layer of land use/cover also suggested that the floodplain is drastically reduced and the channel is also sedimented with shoals and islands in the riverbed.

Further developments on the floodplain in the name of river front development and any reduction in the area of the O-Zone will completely destroy the river – especially its water quality and the flood carrying capacity that will in turn threaten the city on both sides.

ISSUES EXAMINED AND OBSERVATIONS

The Committee, while taking into account the ToR of MoEF as directed by the Hon'ble Tribunal and the Tribunal's own directives to the Expert Committee, examined the following major issues for drawing an Action Plan for Restoration and Conservation of Yamuna River:

(i) Whether the river zone, particularly the floodplain is completely free from dumps of garbage and solid waste?

(ii) What is 'O' Zone as defined by MPD 2021? What are its boundaries? How it can be redefined in the light of recent public notification issued by DDA?

(iii) What is Yamuna riverfront development? And how appropriate is the proposed riverfront development scheme by DDA for rejuvenation of the river and its ecological integrity? Is it possible to modify and improve it?

(iv) What is the quality of water in the NCT stretch of the river and how to enhance the quality of water, particularly in 22 km stretch between Wazirabad and Okhla barrage?

(v) How can the river be restored to its natural state and conserved (preserved)?

(vi) Is it possible to manage the NCT portion of the river in isolation from the interstate boundary portion between NCT and UP?

(vii) How the proposed river zone is managed?

(viii) What are the Institutional mechanisms, policy prescription and statutory options are required to conserve the river?

(ix) How the restoration work would be carried and what are the agencies available to undertake the work?

These issues were then clubbed into four major groups which are discussed below.

Dumping of Garbage and Solid Waste and Reclamation of the Floodplains

The Hon'ble Tribunal in its orders of 31 January 2013 and 01 February 2013 in the matter relating to removal of solid waste and debris from the banks of river Yamuna in the on-going

case of Manoj Misra Vs Union of India & Ors (Original Application No. 6 of 2012) constituted a Committee to work out an Action Plan for the removal of solid waste and debris, under the Chairmanship of the Secretary, MoEF, Govt. of India. The Committee did initiate Action Plan for the removal of solid waste and debris, and authorities (DDA, Irrigation and Flood Control Departments of NCT Delhi and UP, Municipal Corporations of Delhi) and DMRC removed substantial amounts of solid waste and debris dumped on the active floodplains.

The river zone between western and eastern embankments/roads in entire stretch of 54 km from Pall to Jaitpur including UP portion was surveyed by the committee during field visits. The detailed observations were given in Annexures (3-9). The significant findings are mentioned below:

(i) At Badarpur Khadar village, reclamation of active floodplains by filling with soil and solid wastes has been widely practiced for expansion of the existing settlement.

(ii) A sewer canal was made with flyash embankments within the active floodplain to discharge sewage from Tronica City and villages around it, and the flyash has been eroded and has been carried into the river.

(iii) Parallel to Sonia Vihar - Badarpur Khadar embankment road, a solid waste dump along the entire stretch was made into a road on the active floodplain and it has been encroached.

(iv) Sand mining in the erosion prone areas of the river has been observed.

(v) Widening of guide bunds and spurs with solid wastes and concretization of the tops of guide bunds and spurs have been widely practised on the eastern bank in the upstream of Wazirabad barrage.

(vi) On the western bank, dumping of solid waste dump has been carried out on the active floodplains along Jagatpur – Palla embankment road.

(vii) Both on the upstream and downstream of Wazirabad reservoir and along both the banks of the river, roads have been constructed to the religious structures and crematoria and illegal settlements using solid waste.

(viii) Cattle farming and cowdung heaps have been found in abundance within the active floodplains all along the stretch, particularly near Jagatpur and Eastern bank near Garhi

Mandu, Usmanpur and Chilla Khadar villages and also all along Pusta Road. Illegal colonies and solid waste dumps have been observed near nurseries located on the active floodplains.

The relocated solid waste dumps along the Pusta Road have been encroached. Active dumping of solid waste and debris have been carried out and filling the wetlands by solid waste dumps and construction of roads across the wetland using solid wastes have been rampant in Garhi Mandu area.

(ix) Active dumping of solid waste and debris have been observed for reclamation of floodplain at Majnu Tilla and the dump almost reached to the water channel.

(x) Concretization of floodplain around Sur Ghat and Qudesia Ghat has been observed.

(xi) At Pantoon bridge and Signature bridge, the floodplain have been filled by solid waste for construction of roads. The DMRC has been dumping solid waste in the active floodplains.

(xii) Near Indraprastha Power Station, the flyash duke has been converted into DTC Bus Depot and active ash dykes have been observed.

(xiii) Make shift temples and ghats have been observed near old railway bridge which generate huge quantities of solid waste and debris, all of which ultimately find its way into the river.

(xiv) Near Millennium Bus Depot, a new road was constructed using solid waste within the floodplain and the Depot itself is located on the flyash dump. In contiguity to it and further southwards (opposite to Sarai Kale Khan Bus Terminal) a massive dump of solid waste is located and the DDA intended to develop a park on it.

(xv) All along the western bank from UP Irrigation and Flood Control Department colony upto Okhla barrage garbage have been dumped into pondage of Okhla barrage; in the upstream of barrage, a road has been constructed using solid waste and dumps of different sizes and shapes of garbage and solid waste have been found in this area.

(xvi) Downstream of Okhla barrage, solid waste dumps and road construction to the religious structures and to DMRC's prefabricated unit and agricultural fields have been widely practised. Infact, construction of houses and massive dumping of solid waste have been undertaken at Jaitpur extension.

(xvii) On the eastern bank in the UP stretch of the river, the entire floodplain has been covered by solid waste dumps, recycling units of solid waste dump and recycled solid

material dumps. The water channel has been completely sedimented due to washing from recycled material dumps and the sediment was red coloured.

In light of the sorry state of affairs in the riverscape, the committee suggests the following measures to prevent the continuing onslaught on the river:

(i) The encroachments, the villages, the cattle farms and nurseries located on the active floodplain i.e. within the embankments should be relocated; (ii) solid waste dumps should be removed; (iii) no sand mining is permitted from erosion prone areas of the river; (iv) roads leading to religious structure should be removed; (v) the solid waste recycling units and dumps of solid waste should be removed from the floodplains; (vi) no widening of spurs and guide bunds and embankment roads should be permitted; and (vii) agriculture should be regulated.

To prevent solid waste dumping, encroachments, construction of roads, ghats, religious structures in the active floodplains of the river and dumping of solid wastes into water across the road, railway and metro bridges and barrages, it is suggested that policing of river is a must. Further, some kind of tree line and a protective structure should be created all along the inner side of embankments/bunds/roads that delimit the river zone.

Delineation of 'O' Zone of MPD 2021

To manage the riparian ecosystems sustainably and to maintain their ecological integrity, it is essential to delineate the present river boundaries, as the boundaries have been continuously changing due to urbanization and change in river morphology due to construction of embankments within the embankments for recovery of land from the river. The boundaries of the river are the embankments / bunds / roads and the portion between the two embankments is the river system / riverscape / riparian system / river zone. These embankments are man-made and new embankments / bunds / roads are being continuously constructed within the old ones as the encroachment / expansion of urbanization has been shifting closer to the river

channel. For example, the river used to flow close to the red fort in the 19th century (1893's), but today the river channel is more than 1 km away from the Red Fort.

What constitutes 'O' zone was defined in MPD 2021.

The NCT of Delhi was divided into 15 zones (divisions) in the Master Plan for Delhi 2021 (MPD 2021). The Zone 'O' covers the river Yamuna/River front. Figure 7 shows the boundaries of Zone 'O' (as on 2010) of NCT Delhi (red line) and UP portion of the river (black). The boundaries are the present embankments/roads/bunds with landuse/land cover area. The river zone which includes Zone 'O' of DDA and UP portion, is delimited as follows:

North: Palla Village

South: Haryana Border - downstream of Jaitpur Village

East: Main road/marginal bund road linking Noida to Wazirabad and from Wazirabad to Badarpur Khadar by Sonia Vihar bund road

West: Ring road from Metcalf house to Okhla; northwards from Metcalf house to Wazirabad and from Wazirabad to Palla village by Palla bund road

Western bank is connected to eastern bank and vice versa by the following road bridges, railroads, metro bridges and flyovers across the river stretch of 28 km of the downstream of Wazirabad barrage upto Jaitpur.

(i) Wazirabad road over the barrage
(ii) Signature bridge
(iii) ISBT bridge
(iv) Shastri Park Metro Bridge
(v) Old Rail road bridge
(vi) Geeta Colony flyover
(vii) Ring Road bypass road
(viii) ITO bridge over the barrage
(ix) Yamuna bank metro bridge
(x) Nizamuddin Rail bridge
(xi) Nizamuddin road (NH 24)

(xii) Barapulla flyover bridge (passing over the floodplain on the right bank)

(xiii) DND flyover

(xiv) Okhla – Noida road over Okhla barrage.

Figure 6 illustrates how the morphology of river has been changed over a time period. In 1893, the river with its vast floodplains having numerous channels was flowing by the side of Red Fort. Infact, some of the today's encroachments were mapped in the main channel of 1893. There is a massive reduction in floodplain width at some stretches, particularly on the western bank. The 'O' zone and its subdivisions are depicted in Figure 9. Figures 10-17 illustrate the topographic features of the riverscape of different subzones of Zone 'O' and UP portion of the river zone. The river zone used in this Report includes not only NCT of Delhi but also UP portion within the embankments/bunds/roads that form the boundary on the west and east. The details of land use /cover in the river zone is given below (Figure 8; Table 2).

Table 2: Area under different land use /cover categories

Land Use	**Area (ha)**
Water bodies	51.286688
Plantation	20.65358
Agriculture	4351.262164
buildings/encroachment	599.146218
Barren Land	319.2872458
Crematorium Graveyards	6.710550076
Cultivation Area	4034.303547
Farm Limit	24.4883632
Forest Area	278.7553007
Garden Parks	210.8338312
Nursery	52.94419042
Open Land	1453.731888
Orchard	15.384075
Permanent Market Area	0.133398435
Plantation Area	13.95039109
Play Ground	19.53834945

Quarries	45.45364547
Reserved Forest	0.00122351
Scrub Area	781.8577521
Sitting Parameter	0.778022937
Stadium	5.786124462
Marshy Swamp	365.037249
Remaining area in UP	1949.538234

It may be noted that the MPD (1962-1982) recommended the development of district parks, play grounds and open spaces on the western bank of the river south of Wazirabad barrage. MPD 1981 – 2001 emphasized that river should be made pollution free and recommended development of large recreational areas on the bank of the river and also channelization of river, riverfront development and strict enforcement of the water pollution. MPD 2001-2021 mentions the rejuvenation of river Yamuna through a number of measures; it also envisages conservation of natural features of the riverbed such as forests, wildlife and waterbodies and free from unrestricted and unplanned urban development. The National Capital Regional Plan 2021 identified the river zone as a natural conservation zone and the waterbodies should be kept free from any encroachment/development.

Nevertheless, most of the plans remain unimplemented and active developments have been continuing to degrade the riparian ecosystems. In 2010, the DDA took a decision to develop Biodiversity Parks (Hindustan Times of 5.5.2010) in the Zone 'O' and this has been subsequently notified as riverfront development scheme.

The proposed land use in Zone 'O' is depicted in the following table --:

Table 3: Proposed Land Use (from MPD 2021)

S. No.	Landuse	Proposed	
		Area (Ha)	% of total area
1.	Residential*	62.21	0.64
2.	Commercial**	39.50	0.41
3.	Industrial*	34.04	0.35

	(Flyash brick plant)		
4.	Recreational (Green)***	2045.00	21.08
5.	Transportation	582.93	6.01
6.	Utilities	172.66	1.78
7.	Government*	1.80	0.02
8.	Public & Semipublic*	181.74	1.87
9.	River & Waterbody****	6591.12	67.84
	Total	**9700.00**	**100.00**

** No additional areas other than existing/earmarked have been proposed under residential, commercial, industrial, government and public and semi-public use zones.*

*** Commercial includes existing IT Park (6.0 Ha), Bottling Plant (28.0 Ha) at Madanpur Khadar, Commercial/Hotel (5.5 Ha) site at CWG Village.*

**** Proposed Recreational uses will be considered as Green Park/herbal park, science park, theme park, etc. will be permitted without any pucca/permanent construction.*

***** The area of 'River & Waterbody' may decrease by 980 Ha (approximately) after the regularization and subsequent change of land use of unauthorized colonies as per Govt. Guidelines/Govt. policy, falling in Zone 'O'.*

The Zone 'O' defined by DDA does not have well-defined boundaries, as the new bunds/embankments/roads have been developed within the old bunds/embankments/roads for human settlements and infrastructure development. Consequently, Zone 'O' is open ended zone with boundaries changing as the encroachments and infrastructural development continue to take place in the ecologically critical functional floodplain ecosystems. These developmental activities in the Zone 'O' led to court cases.

The High Court of Delhi in its order of 29 March 2006 (in the case of WP(C) No. 2112/2002 and WP(C) No. 6891/2004 passed that no construction to take place within 300 meters on either side of Yamuna river except in case of Majnu Ka Tilla and Kalindi bypass where a minimum distance of 120 m from the edge of river Yamuna is permitted (vide order of 11 August 2006 by HC). The HC also constituted Usha Mehra Committee to ensure removal of

all encroachments upto 300 m from both sides of river Yamuna in the first instance, and infact 15,000 Jhuggi Jhopri were removed between 2001 and 2006. **The Court also mentioned in its order the following "No encroachment either in the form of Jhuggi Jhopri clusters or in any other manner by any person or organization shall be permitted. Yamuna was to be redeveloped in such a manner that becomes habitat for trees, forests, and Centre for recreation. We are making it clear that no structure whether it pertains to religious, residential or commercial or any other purpose shall be allowed to exist".**

In 23 August 2007, the then Lt. Governor of Delhi declared that there shall be complete embargo on any new construction other than common wealth games village etc. on the river bed within the floodplains until a detailed hydrological studies and other required studies are carried out. In its meeting 18 June 2008, DDA resolved that the river bed will be retained as a Biodiversity Reserve and no pucca construction should be permitted in this zone.

Inspite of the above court orders and decisions by land owning authorities, the DDA has brought out a public notice on re-delineation and rezoning of the Zone 'O' as a part of review of MPD 2021 as per the provisions of MPD on 28 September 2013 (Annexure 10) to regularize the human settlements (authorized and unauthorized residential areas and villages) by transfer from Zone 'O' to adjoining zones such as D,E,F and P II etc. The areas include Rajghat, IP Power Station, Millennium Bus Depot, Sonia Vihar, Shastri Park, DMRC land, Akshardham temple, CWG, Yamuna Bank DMRC land, Batla House Area, Jaitpur, Meethapur, Okhla, Jagatpur and area under circulation (all of which encompass an area of 3109 ha). It also mentioned that the total area under Zone 'O' was 8534 ha instead of 9700 ha as mentioned in MPD 2021. The difference of 1700 ha is not accountable. Further, there are villages and unauthorized encroachments within the embankment/bunds/roads which are subjected to annual flooding. These include Badarpur Khadar, Garhi Mandu, Usmanpur, Chilla Khadar, and other encroachments. The re-delineated Zone 'O' (river zone will have 4961 ha in place of 8070 ha).

It also redefined the river Yamuna in terms of riverbed, river floodplain and river front (area outside the embankments). The riverfront area is proposed to be used for recreational, tourism oriented infrastructure, transportation facilities, utilities, additional facilities for Samadhi Complex etc.

The Expert Committee is of the view that the river does not recognise the administrative boundaries, and its ecological integrity as well as water quality cannot be ensured by treating the left and right banks of the river separately. It is therefore necessary to consider together the areas of the river and its floodplain lying on the west in the UP territory corresponding with the O-Zone's northern and southern limits. The Committee has named this total area of the river (O-zone of the DDA plus the corresponding areas in UP) as the RIVER ZONE. Our analysis of subzonal maps of Zone 'O' and UP portion of the river yielded the following:

Table 4 gives the area (ha) in each subzone as per DDA and Expert Committee. Table 4 gives the floodplain area in each subzone under west and east banks. The total area of the river zone is 12375.4 ha of which the floodplain is 12366.76 ha (5895.82 ha of west bank and 6470.94 ha of east bank) and the channel is 1411.54 ha.

The flood zone in the 'O' zone is illustrated in Figures 18,19.

Table 4: Area under each subzone of 'O' zone as per DDA, and the Expert Committee

SUB ZONE	Area (ha) (DDA)	Area (ha) (Expert Committee)
UP Border- Wazirabad Barrage	3620.0	2599.6
Wazirabad Barrage- ISBT bridge	1100.0	8102.2
ISBT Bridge- Old Rly Bridge	225.0	1447.3
Old Rly Bridge- I.P. Barrage	800.0	348.3
I.P. Barrage- New Rly Bridge	365.0	1208.9
New Rly Bridge- NH 24 Bridge	390.0	524.1
NH24 Bridge- Okhla Barrage	1300.0	549.8
Okhala Barrage- Haryana Border	1900.0	2903.2
TOTAL	9700.0	12375.4

Table 5: Area under west and east banks of each subzone of 'O' zone including UP portion

SUB ZONE	Floodplain Area (ha) West Bank	Floodplain Area (ha) East Bank
UP Border- Wazirabad Barrage	2557.22	3117.50
Wazirabad Barrage- ISBT bridge	140.78	899.90
ISBT Bridge- Old Rly Bridge	62.74	180.58
Old Rly Bridge- I.P. Barrage	540.58	268.10
I.P. Barrage- New Rly Bridge	103.21	275.70
New Rly Bridge- NH 24 Bridge	80.06	326.46
NH24 Brudge- Okhala Barrage	1027.17	1030.28
Okhala Barrage- Haryana Border	1384.06	372.42
TOTAL	5895.82	6470.94

The total river channel is 1411.54 ha (2010).

Flooding in 'O' Zone

The data on floods in Delhi show that the city has experienced floods at least once every decade since 1947. High floods occurred in 1947, 1956, 1966, 1978, 1988, 1995, 1998, 2010 and 2013 (Figures 18-19). The 1978 flood with water level reaching 207.4 m at old railway bridge had inundated areas as far as Model Town and Mukherjee Nagar. With the top elevation of the embankment on the west side being at about the same level, the high floods with much lower discharge at the Old Railway bridge touch the embankments. Almost entire area of the O-zone gets flooded practically every year with much lower flood levels.

It is important to recall here that following the 1978 flood in Delhi, the Yamuna Standing Committee (YSC) of the Central Water Commission (CWC), in its 37th meeting (May 1979) had decided that " ... *the minimum spacing between future embankments on the banks of the river Yamuna should be* ***5 km*** *and the embankment should be aligned at a minimum distance of at least 600 m from the active river edge at the time of construction of embankments*." The YSC at its meeting on 5 January 2008 decided that a width of 1650 m must be reserved for the river. Unfortunately, this decision has not been followed and today, the maximum distance between the two embankments of the river Yamuna is less than 2 km, and hence the floodwater carrying capacity of the river has been greatly compromised.

Based on the above mentioned observations and taking into account the earlier court order, recommendations made by different Committees and ecological functions of floodplains, the Committee suggests the following:

(i) To maintain the ecological integrity of the riparian ecosystems, the 'O' Zone with 8 subzones as defined by MPD 2021 and UP portion of the river should be declared as riverzone and areas within the identified in each subzone between two existing embankments/bunds/roads should be preserved and conserved and no construction activity of any kind is permitted.

(ii) The areas outside the embankments/bunds/roads should be treated as riverfront as defined by DDA and the human settlements and infrastructure developed (except for millennium Bus Depot, for which the Govt. of NCT of Delhi filed an affidavit in High Court stating that it will be shifted elsewhere) be allowed to remain with stringent regulations on future developmental activities in the area. The river zone may be declared as an ecological sensitive area.

(iii) All villages, encroachments, cattle farming and nurseries located inside the embankments/bunds/roads (active floodplain) should be relocated.

(iv) Agriculture should be regulated.

(v) Waterbodies and their connecting channels should be restored.

(vi) A mosaic of floodplain forests on high elevated areas, on grasslands moderately elevated areas and water bodies with interconnecting channels should be developed.

(vii) A green belt/green way should be developed along the inner embankments/bunds/roads on both sides of the river.

(viii) No new bunds / embankments / roads within the existing boundaries should be allowed.

(ix) Construction of new barrages and bridges should not be encouraged.

(x) A cascade of treatment wetlands should be developed on the western bank and the discharges of 22 drains be diverted into these wetlands before discharging directly into the river.

Riverfront Development Plan of DDA

The second issue that was examined by the Committee is the riverfront development scheme formulated by DDA. The following are the observations and recommendations made by the committee, taking into account the presentations made by DDA the topographic features of the river zone, the re-delineation of the river zone by DDA based on topographic features, the assessments made by different committees constituted on the river front development plan and flood zoning based on the digital model developed using highest flood level in 40 years.

What constitutes riverfront in 'O' Zone was not defined till the public notice issued by DDA on the re-delineation and rezoning of the 'O' zone of MPD 2021 on 23rd September 2013, wherein it was mentioned that riverfront refers to one of the three components of the 'O' zone (river bed, river floodplain and river front) and defined it as the area outside the embankment; it is proposed to use it for recreational, tourism oriented infrastructure, transportation facilities, utilities, additional facilities for Samadhi Complex etc. This is just contrary to the Riverfront Development Plan prepared by DDA and accepted by different Committees with certain limitations.

The River front Development Plan originates from NEERI's proposal on the development of river front area on both sides by channelizing the river. As per the proposed land use in Zone 'O', riverfront does not figure, but 2045 ha was earmarked for recreational (green) and 6591.12 for river and waterbody which makes an area of 8636 ha out of 9700 ha of Zone 'O'. NEERI's Report mentions that "6205 ha for recreational facilities which will include district parks in continuity with vast green spaces, water sports, golf course, tourist cottages, camping sites with public convenience, small shopping plaza, pleasure parks for different age groups, children parks, auditorium, restaurants/café, amusement/antique hall sports Centres, boat club with paddle boats, facilities of swimming with dress changing facilities, gymnastic, skating, rest rooms, etc., parking facilities for different types of vehicles, dispensary, bird sanctuary, race course, science park with reception office, public conveniences, stores, exhibit development, solar energy corner and other service models, amusement park, fun island, children's airport with facilities of helicopter, mini forests, green preservations along bunds, horse riding/training centre and temple complexes, etc.

The proposed riverfront development scheme of DDA includes some of the recreational facilities mentioned in the NEERI's Report (2004). The purpose of channelization is to restrict the flow area in the river and utilize the remaining lands for other developmental

purpose. Such a proposal is technically not feasible because the canalized section can not hold high discharges in the absence of upstream storage facilities (flood moderation structures), and this may threaten the entire city. Further, the higher flow in the canalized section of the river affects the city's drainage system due to back flow. Further, channelization destroys the floodplains and its numerous wetlands, and serious floods (1 in 100 years) may submerge the entire city which may be buried under sediment as it has happened for the township of Srinagar in recent floods. On these grounds the NEERI's proposal has been rejected. Consequently, the river front development plan based on NEERI's Report on channelization cannot be implemented. The reality is that the riverfront development scheme formulated by DDA is entirely based on channelization and river dressing and on the land reclaimed by filling as proposed in the NEERI's Report. Consequently, it cannot be implemented without creation of safe land.

The 2013 low and medium floods, in fact, submerged the floodplains where the river front development scheme is being implemented.

(i) The riverfront development scheme of DDA was formulated using concept widely adopted for the management of Biosphere Reserves where riparian ecosystems form just one component. The zonation like core, buffer and transition zones have altogether different connotation with respect to biosphere reserves and other protected areas such as National Parks and Wildlife Sanctuaries. This concept is just not applicable to riparian ecosystems where the dynamics of riverscape changes, particularly rivers like Yamuna. For example, at one time the river was flowing by the side of Red Fort but today it is about 1 km away from the Red Fort (Figure 6). The meandering of river, sediment load, erosive transportive forces and sedimentation pattern always change in time and space. For example, 1km width of floodplain along 10km stretch of the upstream of Wazirabad barrage was removed by the river in 2013 flood; similarly the meandering has been changed in both upstream and downstream of Wazirabad reservoir. Consequently, the creation of protective and interactive biodiversity zone and public recreation zone with green linkage is unrealistic. For example, the floodplain area where Golden Jubilee Park has been initiated under riverfront development scheme, is close to the meandering river channel and is submerged during annual floods and the elevated fringe portion along the road is also submerged during floods, in the frequency of 1 in 2, 5, or 10 years.

(ii) The scheme did not take into account the present topographical features, contours and flood ways. Therefore, it is schematic and is far from ground reality. For example, the Golden Jubilee Park is in flood way and all the structures developed were submerged and some of which were buried in 2013 floods. The Golden Jubilee Park also reduces the flood recharging area.

(iii) The introductory chapter of the river front development scheme clearly states that commercial area flourishes when it is in balance with recreation or vice-versa snd cites Mayur Vihar DCC (District Centre) and Noida P.B.D. (Public Business District) as examples of successful development along the Yamuna river but both the area are located outside bund road. The riverfront development scheme itself is based on such principles and embodies zonal development plan's recommendations. This is further evident by activities mentioned in the redefined riverfront as per re-delineation of 'O' zone. In fact, all the activities mentioned in redefined riverfront (outside the embankment/bund of 'O' zone) are proposed to be implemented on an active floodplain i.e. inside the bunds / embankments as per the riverfront development scheme.

(iv) it may be noted that many committees including the High Powered Committee on Yamuna Development clearly mentioned the major limitations of the scheme as the areas proposed for development are in the flood way.

The DDA prepared a plan for development in four of the subzones out of 8 subzones as an "Integrated project of Recreational areas along with biodiversity parks". It is noteworthy that the area upstream of Wazirabad is largely rural (except for a few settlements). In subzones other than the four identified by DDA for development between Wazirabad and Okhla, the river flows close to the western embankment leaving only a narrow strip of active floodplain. It is noteworthy that a very large area of the O-zone (about 2700 ha) is already under different kinds of constructions, buildings, samadhis, power houses, settlements etc. besides the guide bunds and other bunds. These are listed in Table 4 based on remote-sensing data.

Table 6: Built-up area in each subzone of 'O' zone

Subzone	**Location**	**Area**	**Side**
I	Badarpur Khadar	8.67	Left (UP)
I	Sonia Vihar	728.41	left
I	Sonia Vihar built	147.92	left
I	Sonia vihar ground	107.25	left
I	Jagatpur to Wazirabad	355.67	right
II	Majnu ka Tila	10.55	right
II	Delhi IT Park	97.36	left
II	South of Sonia Vihar	8.21	left
II	Near Garhi Mandu	5.51	left
III	Budh Vihar & Downstream	10.28	right
III	Opp ISBT	4.27	right
III	Nigambodh Ghat	13.64	right
III	Salimgarh fort	5.59	right
IV	Ghats (Samadhis)	190.58	right
IV	Stadium+Secretariat	49.56	right
V	Indraprastha Power Grid	34.03	right
VI	Millenium Bus Depot	14.88	right
VII	Jamia Nagar	202.95	right
VIII	Madanpur Khadar	208.69	right
VIII	Jaitpur	383.98	right
VIII	Jaitpur Extension	8.13	right
VI	Commonwealth Games Village	107.69	left
V	Yamuna Bank Metro	32.88	left
	TOTAL	2736.7	

The YRFD Plan proposes to alter the topography and contours of the floodplain area within the four subzones of the Zone O on the right (west) side of the river, by raising various structures. According to a CWPRS study in 1987, a reduction in the channel width and construction of guide bunds etc. on the floodplain will increase the hazard of flooding on both sides of the river. During the past 25 years several bridges and flyovers have been constructed and large chunks of land have been brought under permanent construction for various reasons. The river's flood water carrying capacity has been greatly reduced though it has not been estimated by any study. The recent floods in Delhi (2010 and 2013) point to a growing flood hazard even at lower rates of discharge in the river.

The proposals made in the YRFD Plan will not only reduce the flood carrying capacity of the river but also contribute to further degradation of the water quality, besides promoting encroachments within the Zone O.

The YRFD Plan is bound to adversely affect the goods and services of river Yamuna by eliminating and converting the floodplain to other uses. This will particularly affect the water quality, fisheries and groundwater recharge.

In the light of above observations, the Committee recommends the following, along with specific suggestions for each subzone proposed for development by the DDA:

(i) The Riverfront Development Plan as proposed by DDA, an active floodplains of Yamuna, i.e. area between two embankments/bunds/roads is untenable and should be abandoned. Alternatively, the recreational facilities as proposed in the riverfront development may be created outside the embankments where human settlements already exist.

(ii) Floodplain wetlands, water bodies with connected channels and other flood tolerant vegetation should be developed according to the plan for restoration of the river as discussed later. Only regulated organic agriculture may be allowed in certain parts at higher elevation away from the main channel.

Subzone I

The DDA has already developed in the Subzone I, a Biodiversity Park Phase I in 63.6 ha area which is outside the embankment and cutoff from the river. A Phase II of the biodiversity Park in another 121.5 ha area adjacent to it but on the river floodplain (between river channel and the embankment) is under development. The area has no major point source of pollution and the biodiversity Park will include some water bodies and wetlands besides the flood-tolerant vegetation. The Park will not interfere significantly with the flooding of the river upstream of Wazirabad. Hence, we recommend that this development may be continued.

However, in Subzone II, the plan involves construction of several structures, mounds, parking lots, boating facilities and green linkage that is not well defined. Here the channel

flows close to the ghat and the water is highly polluted, shallow and filled with garbage. The area should not be developed as proposed by DDA.

For ***Subzone IV*** (Golden Jubilee Park) two phases are proposed. Some development has already been undertaken. The current programme of development must be stopped forthwith and the area should be restored to the river and its natural floodplain.

In Subzone VII, the proposed plan will degrade the river further, promote flooding. The current programme of development must be stopped forthwith and the area should be restored to the river and its natural floodplain.

In our view, the interests of the river and the city will be best served by abandoning the YRFD Plan, and restoring the remaining floodplain area to bring back it natural functions and biodiversity

RESTORATION OF RIVER YAMUNA AND ITS FLOODPLAIN

The Hon'nle NGT specifically required the Committee to discuss the restoration, preservation and beautification of the river together with its methodology and process to be followed. Therefore the Restoration of river yamuna in the NXT stretch is discussed below in some detail.

Scientific Principles

The Expert Committee has examined the scientific literature on the ecology, conservation and restoration of rivers worldwide in order to reassure its understanding of the scientific principles on which the case of River Yamuna can be taken up for its restoration and conservation. We briefly highlight the salient points of the basic scientific principles which must underlie any conservation and restoration effort for its success.

Rivers and their Floodplains

The ecological integrity of a river depends upon its uninterrupted flow (which maintains the longitudinal connections between upstream and downstream reaches), its seasonally high flows (periodic floodings; which regulate the interactions with floodplains lying laterally to the river channels), and the nature of sediments carried by the river (which influence the vertical connections with the groundwater). The natural functions of a river are governed by the characteristics of its channel, flow regime, water quality, biological diversity, and the riparian and floodplain habitats and their interactions.

Rivers do not flow all the time in channels defined by natural levees (river banks), especially in the lower reaches with low gradient. Seasonally high flows, such as those during the rainy season, exceed the channel capacity and spill over the river banks flooding areas on either side. Frequently very high flows occur at irregular intervals at varying frequency. Internationally, the area lying laterally to the river channels and flooded at least once in 100 years is considered as the floodplain, and the major expanse between the two edges that carries major portion of the 1:100 year flood is known as floodway or river corridor. The naturally formed river banks (levees) and a part of the floodplain immediately adjacent to, and influenced by the river channel, is often distinguished as the riparian zone. Some parts of

the floodplain closer to the river channels experience flooding more frequently during lower magnitude floods of one in 25, 30 or 40 years, than the distant parts.

The floodplains play a critical role in determining the ecological characteristics of a river and provide many ecosystem services. They form a crucial link between the adjacent upland terrestrial habitats and the river. The major and most important functions of floodplains include:

- Moderation of flood peaks through temporary retention of water and spread of water;
- Enhancement of groundwater recharge in larger area and improvement of ground water quality;
- Stabilization of banks by the vegetation and maintaining channel form;
- Maintenance of high biodiversity and high production of natural resources;
- Provision for fresh sediments with high fertility (suitable for high productivity of vegetation for grazing animals or for growing vegetables);
- Filtering sediments, chemicals and nutrients from upslope sources, and thereby improving water quality;
- Maintenance of good stream habitat for fish (and other wildlife also), thereby promoting high fisheries production.

We may quote from: D. Mussared (1997; Living on Floodplains, CRC Freshwater Ecology, Australia) who states:

"Floodplains are as important to rivers as bark is to trees. Most of the processes that drive life in rivers happen around their edges. Just as the sap flows through the outermost ring of a tree, not through its centre, the lifeblood of a river ebbs and flows on its floodplains. The vegetation growing there isn't mere decoration; it is a river's roots and leaves"

In alluvial plains, the rivers usually migrate laterally across the floodway. Periodic flooding causes movement of sediments both downstream and laterally. These two processes continually modify the floodplain. The floodplain provides temporary storage space for

floodwaters and sediments from the watershed. It allows for a *lag period* between the peak runoff caused by, for example, heavy rainfall and flood peak downstream.

Any reduction in the capacity of a river to carry water and/or an increase in the sediment load results in more frequent and severe flooding. Flooding forces the exchange of materials and energy between the river and its floodplain. These exchanges are important for development of fisheries, transport of organic matter, sediments and nutrients between the floodplain and the river. Shallow water bodies and marshes (wetlands) on the floodplain sustain large biodiversity, help recharge groundwater and improve water quality of the river.

In order to protect the rivers for their water quality, biodiversity, and various ecological functions and ecosystem services, it is absolutely necessary that their floodplains are conserved by notifying appropriate zones (based on topography, climate and natural flow regime) with a list of permissible and prohibited activities, and adequate buffers are provided along the active floodplains.

River Restoration: Principles and Approaches

Restoration refers to bringing back an ecosystem to an original or earlier condition in terms of biophysical state and its ecological processes. Restoration of an aquatic ecosystem aims at re-establishing the *"pre-disturbance aquatic functions and related physical, chemical, and biological characteristics. Restoration is ...a holistic process not achieved through the isolated manipulation of individual elements…* (U.S. National Research Council). Restoration therefore requires addressing the root causes of degradation which may have also changed in their nature and magnitude over time. However, the question of what conditions and functions to restore and how far back in time has to be examined with respect to several other factors concerning a specific ecosystem. These include feasibility, potential for sustainability, and social, cultural and economic considerations.

Restoration of a river requires interventions to improve channel morphology (such as depth, bed characteristics and meandering), flow regime, water quality, biological diversity, and the riparian and floodplain habitats in a manner that ensures their interactions. ***Flow regime of a river is the master variable*** that controls all other components and in turn the

river's characteristics. ***Improvement of flow regime and water quality are critical to the restoration of a river*** and necessarily require a catchment wide action. ***Continued discharge of wastewaters without adequate treatment and the absence of adequate flows will negate all efforts to improve the channel, biodiversity and floodplain habitats.*** Wastewater discharges need to be effectively controlled and the treated effluent quality entering the river has to be strictly regulated.

The channel habitat restoration in an alluvial river such as Yamuna requires dredging out of accumulated sediments and sludge, and some re-meandering. The riparian areas need protection against erosion and frequent shifting of the channels. Non-structural approaches such as plantation of appropriate vegetation should be preferred. Riparian / floodplain zones link the stream with its terrestrial catchment, and can modify, incorporate, dilute, or concentrate pollutants before they enter a river. The floodplain habitats with appropriate wetland vegetation help improve the water quality further, and depending upon the extent of floodplain areas and the amount and quality of wastewaters, the river water quality can be restored to a fairly high level. Floodplain restoration involves creation of habitats on low lying land by reconfiguration to promote and enhance interaction between river and adjacent area through hydrological linkages.

Considering the fact that:

- The river channel has silted up in many parts because of the near stagnant conditions and the disposal of solid wastes;
- Most parts of the floodplain have also silted up because of lack of river flows, and large areas have been raised by dumping soil, garbage and solid construction wastes;
- Many water bodies on the floodplain have silted up by excessive growth of weeds such as water hyacinth and by untreated sewage discharge or have been filled up by the farmers for cultivation;
- The floodplain biodiversity has been significantly altered and reduced such that the natural functions of floodplains are lost;
- The groundwater recharge has declined over the years;

We recommend following measure for the restoration and renaturalisation of the present river channel and remaining floodplains for reviving the natural river functions, improving water quality and enhancing groundwater recharge:

1. All waste dumps and solid wastes accumulated on the floodplain must be removed.
2. All encroachments and constructions including bunds, paths, nurseries, houses etc. on the floodplain listed below for each subzone must be removed:
3. Agriculture on the floodplain should be regulated to prohibit use of agrochemicals, and should be restricted to areas beyond 100 m on either side of the river channel.
4. All silted up portions of the river channel should be dredged to remove the organic muck/sludge and the natural levees (river banks) must be protected by appropriate trees/shrubs/grasses which naturally occurred in the area in the past.
5. All water bodies/shallow marshes on the floodplain should be dredged and enlarged so that these can store enough freshwater during the rainy season, help recharge groundwater, and can be used to raise fisheries (or serve as natural breeding/feeding grounds for riverine fishes).
6. The higher elevation areas of the floodplain (approx. 100-150 m belt along the two main embankments) should be developed for treatment wetlands for improving the water quality of the wastewater which will be allowed to pass through them after treatment in the STPs (or *in situ* treatment on storm water drains).
7. Access to the river channel for social/cultural/religious functions should be allowed at pre-identified points in a manner that it avoids construction of pucca paths/roads and lined ghats.
8. Many of the spurs have lost their original purpose because the flow in the river is highly reduced and regulated. Their length can be restricted so as to allow a wider space for the river channel to meander and carry more water.
9. Several wide culverts must be provided in the guide bunds of various road bridges/ flyovers so as to allow free flow of water, connectivity for migration of fauna (such as fish and reptiles) and prevent damage to roads/bunds that may occur during high floods.

SPECIFIC RECOMMENDATIONS FOR SUBZONES

SUBZONE I

The area has no point source of pollution and is ideal for freshwater storage during floods. The area under large farms use groundwater for irrigation and number of wells and ranney wells have been made throughout. Part of the floodplain close to natural levees and part of the river bed on either side of the channel should be desilted for creating water storages. Some proposals have been made in the past to create reservoirs on the river by building barrages or off-the-river. Both are undesirable and require permanent submergence of land. Instead, the creation of relatively shallow (3 m or so) floodplain water bodies will offer more functions for recharge of groundwater and improving downstream flow as well as water quality. During the low water phase the peripheral areas of the water bodies can provide useful plant resources and the water bodies themselves can be used for promoting fisheries (without adding feeds). The loss of agriculture on the floodplain will be more than compensated by fisheries, other resources and the benefits accruing downstream. These areas can also be developed somewhat on the lines of the Biodiversity Park for recreational benefits but without any construction/structures except walking trails or boardwalks.

SUBZONE II

Sur ghat downstream of Wazirabad – It is an artificial pool created for bathing by bringing water through pipes. The pool and adjoining buildings should be dismantled and a proper ghat with steps be provided. The area should be connected with a channel carrying water from Wazirabad barrage/impoundment and properly isolated from the Najafgarh drain.

The Pontoon bridge and the road laid on the floodplain for dry season access should be dismantled, and the entire area should be re-developed as naturalised floodplain. The signature bridge (now under construction) makes it redundant.

There are forest patches of *Prosopis juliflora* along the road that forms the western boundary. This forest patch can be developed into biodiversity parks. On the eastern side, besides Garhi Mandu plantations there are number of water bodies which are silted. The entire floodplain on the eastern bank in this subzone is vulnerable to encroachment and hence a mosaic of

wetlands and floodplain forests should be developed. At some sites reclamation of floodplain by dumping solid waste is being continued.

SUBZONE III

On the western side whatever the floodplain available is occupied by makeshift religious structures and ghats. Night shelters have also been built on the reclaimed floodplains on the eastern bank. Several drains discharge untreated sewage into the river.

On the eastern side, Shastri Park Metro Station and DMRC Depot are located on the active floodplain. There are water bodies, woody vegetation patches, orchards and nurseries. This area can be developed into a mosaic of wetlands, floodplain forests and grasslands.

SUBZONE IV

On the western side the proposed Golden Jubilee Park area and the floodplain around it should be developed into natural floodplain forest and grassland communities without altering the existing topography. There are extensive marshes and water bodies within and outside the roads of Geeta Colony flyover complex, particularly on the backside of Samadhis Complex. These wetlands should be restored and the surrounding elevated areas should be developed in native floodplain vegetation.

DTC bus depot located on the flyash dump should be relocated and the ash dykes should be converted into wetlands after the closure of Power Plant.

On the eastern side there are floodplains which are put to use for seasonal agriculture, orchards and nurseries. Wetlands / waterbodies are also found. Some encroachments do exist in this subzone and these should be relocated. Nurseries should be removed. The wetlands and their inundation channels should be restored. Floodplain forests should be developed in areas where orchards are located.

SUBZONE V

On the western bank, the floodplain is restricted. Except for one green patch where a nursery is located, the floodplain is filled up by the ash generated by abandoned Thermal Power

Plant. The controversial Millennium Bus Depot is located on the flyash dump. A new bund road is created to separate the Bus Depot from the water course of the river. There are some narrow strips of floodplain where nurseries are found. Encroachments also exist within the nurseries. The nurseries and encroachments should be relocated. The Bus Depot should be relocated on the Millennium Park if no land is available, the flyash dump, after bioremediation and proper lining and caping, should be used for the development of Millennium Park.

On the eastern bank, seasonal agricultural fields, orchards and nurseries are common on the floodplains. Waterbodies / wetlands are also found. A mosaic of floodplain forests, grasslands, wetlands with wetland corridors and greenways should be developed. Native biotic communities should be used in the restoration of the area. Some encroachments are also found and these have to be relocated.

SUBZONE VI

On the west, there are floodplains but much of it is filled up and a part of it has already developed into woodlands. A portion of the filled up floodplain is encroached. The encroachment should be removed. A biodiversity park should be developed on the remaining filled up area.

On the eastern bank a bund was carved out for building Common Wealth Games village and Akshardham temple. Akshardham elevated metro station is also located. There are orchards, nurseries and agricultural fields besides waterbodies. The nurseries should be relocated. Native biotic communities should be established. The wetlands and their inundation channels should be dredged and restored.

SUBZONE VII

Upstream of DND flyover

On the western side, there are some constructions which should be removed. A network of wetlands with their corridors should be developed into treatment wetlands from NH24 to DND flyover and the outfall from Barapulla drain should be allowed to pass through these wetlands before allowing it into the river. There are agricultural fields and compensatory

afforestation plots and also patches of *Eucalyptus* plantations. Greenways should be developed on the spurs and guide bunds that intersect the wetlands.

On the eastern bank, agricultural fields, cattle farms, nurseries and orchards are located. There are also wetlands and some drains discharge their contents into the wetlands. The cattle farms and nurseries should be removed. The wetlands and their corridors should be dredged and should be developed into treatment wetlands.

Between downstream of DND flyover and upstream of Okhla barrage

There are encroachments, solid waste dumps and roads on the floodplains of western bank. Untreated sewage is discharged into the wetlands. There are islands in the pondage area. There are 3 or more channels of the river and some of which are connected to wetlands and marshes. The network of wetlands on the western side should be developed into treatment wetlands after dredging. The pondage area of the barrage should also be dredged. The wetlands and marshes and the channels have to be dredged. After dredging, a mosaic of floodplain forests, grasslands and catchment and treatment wetlands with green linkages and greenways should be integrated with Okhla Bird Sanctuary and should be designated as Biodiversity Park.

SUBZONE VIII

The encroachments, the solid waste dumps and spurs and roads constructed on the floodplains of western bank should be removed. Jaitpur extension should be relocated. The *Prosopis juliflora* patches found in UP portion and DDA area should be replaced by Biodiversity Park with native communities.

On the eastern side, the solid waste dumps, the solid waste recycling units, recycled solid waste material dumps should be removed. The entire 8 km stretch of UP should be developed into Biodiversity Park and is integrated with Okhla Bird Sanctuary. Farm houses should also be removed.

The settlement in Jaitpur extension on the left side of the embankment / road from Okhla barrage to Jaitpur must be removed / relocated elsewhere and the entire floodplain up to the river channel must be restored. Agriculture should be regulated to remain seasonal and without use of any agrochemicals.

INSTITUTIONAL MECHANISMS AND STATUTORY OPTIONS

The Report of the High Powered Committee on Yamuna River Development (2010) has reviewed the different authorities, the committees and the court orders passed with respect to rejuvenation of the river Yamuna in the stretch of NCT of Delhi. Some of the important existing authorities and committees constituted for the management of the river Yamuna are described below.

Although water is a state subject as per the Constitution (entry 18 of the 3rd Schedule of the Constitution, waters of interstate rivers (like Yamuna river) are regulated by Entry 56 of the 3rd Schedule). The Article 262 (1) states that: 'Parliament may by law provide for the adjudication of any dispute or complaint with respect to the use, distribution or control of the waters of, or in any interstate river or river valley' and Article 262 (2) provides that: 'Notwithstanding anything in this constitution, Parliament may by law provide that neither the Supreme Court nor any other court shall exercise jurisdiction in respect of any such dispute or complaint as is referred to in above clause'. In light of the Article 262 (1) and (2), Parliament enacted Interstate water Dispute Act 1956 and any water dispute in sharing of water etc. has to be dealt with under this Act.

'Ministry of Water Resources, Government of India is the nodal agency for the development, conservation and management of water as a national resource and provides technical guidance/ assistance to the States on irrigation, multipurpose hydro-projects, ground water, exploration, command area development, drainage, flood control and water logging etc.

In any interstate river the dominant issues are sharing of water, construction of storage projects, flood control and environment. With respect to Yamuna, the existing institutional mechanisms are as follows':

Sharing of water

This is a critical issue for the rejuvenation of Yamuna. There was a MoU signed by the Chief Ministers of 5 basin States (Haryana, Uttar Pradesh, Himachal Pradesh, Rajasthan and Delhi)

and the Union Minister of Water Resources on 12May 1994 for sharing surface water and this MoU assessed and distributed water available up to Okhla. For implementation of the MoU and regulate the available flows, the MoU also created Upper Yamuna River Board (UYRB) which has also brought into existence under the Chairmanship of the Member of Planning Commission (Water, Planning and Projects). To supervise the working of UYRB and ensure the implementation of 1994 MoU, an Upper Yamuna River Committee (UYRC) consisting of Chief Ministers of the basin States with Union Minister/ Minister of State of Water Resources as the Chairman, was constituted.

In spite of these committees the three upper storage projects are not yet implemented because of refusal of Rajasthan for Lakhwar Vyast Project although UYRC constituted a Steering Committee on 12 April 2006 to address the issue.

Flood Control

As a rule flood control works in a State is the State's responsibility but for an interstate river, like Yamuna river the construction of flood control works on the Yamuna is regulated by a Yamuna Standing Committee of the Central Water Commission which is headed by Member (River Management) of the Central Water Commission with Chief Engineers of concerned basin States as members. The committee formulated guidelines for the construction of flood control works and also to address the issues among the basin States relating to flood control works.

Environmental Issues

The Pollution Control Boards of each States are concerned with the quality of water in their respective reaches. The Central Pollution Control Board is entrusted to address the issue of pollution of one basin State flowing into another basin State. The National River Conservation Directorate (NRCD) of the MoEF monitors the conservation of the river system and constituted a High Powered Committee to decide the requirement of minimum flow in the river in 1997. The committee headed by the Member, Planning Commission as the Chairman with Chief Secretaries of basin States as members, took a decision that 10 cumecs be released into river as minimum and the share of each basin State to the minimum flow was also worked out.

The different agencies within the Delhi and their functions and responsibilities with respect to Delhi stretch of the river is given in the table.

Table 7: Functions and Responsibilities of different agencies in Delhi

SN	Name of Agency	Functions	Nature of Responsibility
1.	Delhi Development Authority	Determining Land use	Planning
		Enforcing Land use	Monitoring/Prevention/Regulatory
2.	Delhi Pollution Control Committee/Central Pollution Control Board	Testing and monitoring water quality	Regulatory
		Securing Water Quality	Regulatory
3.	Irrigation and Flood Control	Flood Control works	Project specific planning and execution
4.	Industries Department	Management of industrial effluents	Planning and execution of projects (CETP)
			Sealing of polluting industries
			Relocation of non-conforming industries
5.	Delhi Jal Board	Management of Domestic Waste	Planning, execution, and monitoring projects (STP, Interceptor sewers)
		Use of raw water	Planning, and execution of projects (WTP)
6.	Local Bodies (MCD/NDMC)	Management of storm water drains	Planning, execution and maintenance
			Prevention of deposit of solid wastes into the drains and even river; prevention of encroachments and developments.

In spite of all these agencies, committees and authorities, the river is dead in the urban stretch of 22 km between Wazirabad and Okhla barrages.

The High Powered Committee constituted by the Prime Minister (2010) suggested the following after taking into account the status of the river:

(a) "The inter-agency coordination between various public stakeholders (planners, developers, regulators, service providers) in the Delhi stretch needs to be substantially improved at all levels".

(b) "An apex body to achieve integration and coordination between the planning, execution, funding and regulation of steps intended to improve river water quality and developments along its banks appears to be an immediate necessity".

(c) The Report also suggests the following Statutory Options to rejuvenate and manage the river Yamuna.

Option I

The Central Government may constitute the Yamuna River Board under River Boards Act, 1956 to regulate the water distribution among States and GNCTD may constitute the Yamuna River Basin (Development & Regulation) Authority by legislation which will not include power to make Master Plan and land use and it will require consent of President of India.

Option II

The Yamuna River Basin (Development & Management) Authority may be constituted for development of the river basin and preparation of Master Plans and zonal plans and for regulation of the land use and other activities in the basin area by the Parliament of India.

Option III

The National Yamuna River Basin (Development & Management) Authority may be constituted by the Central Government under section 3 of the Environmental Protection Act for regulation of minimum water flow, Master Plan and land use, and the State Authority may be constituted by the Government o Delhi for development work as per Master Plan of National Authority. The powers of Central Pollution Control relating to water pollution may be delegated to the river Yamuna Basin Authority to which, the powers of Central Government under section 5 of the EPA for issuing directions for controlling pollution may also be delegated.

The Central Government may enact legislation for creating a two-tier mechanism for effectively dealing with inter-State river development and regulation for minimum ecological flow of water. The Report also suggested National level Authority be created for overseeing development, rejuvenation and management of the river Yamuna.

To sum up, the Report of High Powered Committee on Yamuna River Development constituted by the Prime Minister did not spell out any action plans for rejuvenation of the river but simply summarized the status on (i) upstream storages; (ii) share of waters among basin States and the minimum flows into the river; (iii) pollution abatement activities by DJB; (iv) riverfront scheme of DDA. It recommended the followings projects: (i) construction of upstream storages (Himachal Pradesh and Uttaranchal); (ii) interceptor sewer projects (DJB); (iii) expansion of existing STP capacity of sewerage network (DJB); (iv) Yamuna riverfront development (DDA) with certain stipulations; (v) development, management and utilization of ground water from the floodplains (DJB) and (vi) public awareness (GNCTD, MCD).

In light of the observations made on the status of the river, and evaluation of proposed Institutional mechanisms and Statutory Options proposed by the High Powered Committee on Yamuna River Development, the committee suggest the following Institutional Mechanisms and Statutory Options for implementations of the recommendations made in this Report.

(i) An apex Authority should be assigned the responsibility of integration and coordination among multiple agencies involving the rejuvenation of river should be created. This authority will include the heads of DDA, CPCB, DJB, MCDs, DPCC, CWC, and Scientists / Technologists.

It is suggested that the High Powered Committee for Yamuna River Development chaired by the Lt. Governor, Delhi (constituted by the Govt. of India in August, 2007), be expanded to include the Chief Secretary, U.P as well as five expert members in the fields of River Science and Engineering and its mandate may also include integrated management and coordination among various planning, execution, funding and regulatory agencies of the two states to be involved in the restoration and management of the river in the Delhi stretch. The HPC should

also closely liaise with the NGRBA for better integration of their activities, since Yamuna is a sub-basin of the Ganga Basin.

Additional Recommendations

1. Successful restoration of the river for its ecological functions and their future sustainability will depend heavily on the provision for Environmental Flows through the entire 52 km stretch. Despite an earlier Supreme Court direction for providing 10 cumecs of freshwater flow downstream of Wazirabad, the desired flow has not yet been made available. The Committee recommends that the Environmental Flows requirements, particularly for the lean season, may be re-assessed for the entire 52-km stretch and the required flows be ensured at the earliest.

2. To secure the ecological integrity of the river, to prevent encroachment and dumping of solid wastes and to prevent unauthorized constructions, and unregulated cultivation, river policing by a dedicated unit should be enforced by the respective states.

3. For promoting: (a) public awareness on the conservation of river Yamuna, (b) participation of the society in the restoration of the river and (c) long-term studies and monitoring on the riparian ecosystems and their management, the Committee suggests the establishment of an autonomous Society / Trust like Delhi Biodiversity Foundation.

WATER QUALITY AND WASTEWATER IN RIVER YAMUNA

The Expert Committee examined also the issues related to the Supreme Court case, in the matter of WP(C) No. 725/1994 and 'And Quite Flows the Maily Yamuna' as required in the ToR by the Ministry of Environment and Forests. The case relates to the issue of environmental pollution of the river and lack of flow. The Expert Committee Considers this as a highly relevant and connected issue because the restoration of the river cannot be contemplated without ensuring that all sewage, wastewater and storm water enter the river after treatment to the prescribed standards and the water quality in the river is significantly improved by other supporting actions including the provision of environmental flows in the entire stretch.

The Expert Committee made the following observations, after taking into account the recommendations by different committees, presentations made by DJB, Central Water Commission and Irrigation and Flood Control Department of NCT of Delhi and UP.

(i) The river Yamuna is one of the most polluted rivers in India and pollution is mostly contributed by domestic sewage (untreated/partially treated), industrial effluents and agricultural practices. Mostly the towns and cities located along the river Yamuna contributes to maximum pollution lead. In fact the Delhi-Agra stretch of the river is the most polluted segment and is an open sewer in some stretches within NCT of Delhi and UP; the river bed cannot be distinguished from surrounding agricultural fields and is totally dried with no water during dry season. In Delhi, the urban stretch of 22 km between Wazirabad and Okhla barrages is a threat to public health and the aquatic ecosystems are extinct; it is this stretch that contributes 70% of the pollution load in Yamuna (more than 40 mg/l BOD, 24 millions of coliform and absence of DO). About 22 sewers, each having several sub-sewers empty their contents (a total of 3452 MLD) into the river and this accounts 80% of the pollution load, six of these drains (Najafgarh, Shahdara, Savita Vihar, Maharani Bagh, Barapulla and Sen Nurseries Home drains) contribute 90% of the flow and 80% of BOD levels. The total waste water generated is about 3800 MLD, but the treatment capacity is only 2460 MLD and the capacity for carrying waste water to STPs is only 1556 MLD. Besides domestic sewage, industrial effluents (180 MLD) form planned and unplanned industrial areas also contribute

to the pollution load of the river. The solid waste is also dumped into water. For example, the following Table gives the extent of solid waste dumped into the river.

Table 8: Solid waste dumped over 1 month (September 2009) from one of the 9 bridges (Source: Agrawal & Krause, 2013)

Items	**Number of Sacks**	**Amount**
Polybag	22	180 kg
Paper	18	220 kg
Cloth	7	80 kg
Glass	1	30 kg
Paintings	5	300 pieces
Idols	10	250 pieces
Earthen pots	Pieces	5 kg
Organic waste	50	1000 kg

Besides solid waste dumping, agricultural residues, fertilizers and pesticides form agriculture and wading cattle farming are also contributed to the pollution. Clothes washing, cattle --- and bathing and open defecation by large population residing in river catchment also contributes to rive pollution.

(ii) The status of the water quality in the downstream of Wazirabad barrage is as follows:

(a) no lean season flow in the downstream of Wazirabad barrage, (b) 22 major drains discharge their collective load in Yamuna river, (c) BOD levels are over 50 mg/l, (d) presence of unacceptable levels of coliform density, nitrates and phosphates, (e) absence of DO, and (f) presence of molecules originating from pharmaceutical and related industries.

The Delhi Jal Board and the Central Pollution Control Board appraised the status of pollution in the river Yamuna and the mitigative measures followed to reduce the pollution load to a level that allow the functioning of aquatic ecosystem. The Report of the High Powered Committee on Yamuna River Development also reviewed the extent of pollution of the river and the efforts made to clean the river. The significant observations made are summarized below:

(iii) Inspite of the constitution of a number of Committees, court orders passed and Action Plans prepared and implemented, no improvement in the quality of water and poor flows in the urban stretch was observed. These aspects have been excellently summarized by Manoj Misra (2013). The Report of High Powered Committee (2010) summarised the actions plans proposed and implemented for addressing the issues of minimum ecological flows and pollution abatement in the riven Yamuna.

(a) The basic requirement is the environmental (ecological) flow of fresh water in the downstream of Wazirabad reservoir during lean period. Since there was no release of Delhi's share of water from Hathnikund for drinking purpose in spite of agreements (MoU) among river basin States, the SC passed an order on 09 February 1996 - "*We order and direct that Delhi shall continue to get as much water for domestic use from Haryana through river Yamuna which can be consumed and filled in the two water reservoirs and treatment plants at Wazirabad and Hyderpur-----." "----we, therefore, close the proceedings by requiring Haryana to make available the aforesaid quantity of water to Delhi throughout the year. Let it be made clear that any violation of this direction would be viewed seriously and the guilty persons would be dealt with appropriately. This order of ours would bind, not only the parties to this proceedings but also the upper Yamuna River Board*." The MoU was signed among basin States of U.P., Haryana, Rajasthan, Himachal Pradesh and NCT of Delhi for sharing of surface flow of Yamuna waters in May 1994 for total allocation of 0.724 BCH (0.58 in July-October, 0.068 in November-February and 0.076 in March-June). The MoU also stressed the need for upper storage. An upper Yamuna River Board was constituted for monitoring and regulate the available flows so that the basin states get their allocated share. This Board is under the control of upper Yamuna River Committee.

A MoU was also signed by basin States except for Rajasthan for the construction of upper storage facilities - (i) Renuka dam across the river Giri in Himachal Pradesh, (ii) Kishau dam across Tons river in Uttarakhand and Lakhwar Vyasi across Yamuna in Uttarakhand. Because of the refusal of Rajasthan to sign the above MoU, these storage facilities did not come up.

(b) In response to I.A. writ petition No. 537 of 1992 filed by Commander S.D. Sinha & others vs Union of India & others, in the matter of release of minimum flow into river Yamuna by upper riparian states, the SC ordered that the High Powered Committee constituted by the River Conservation Directorate (NRCD) of the Ministry of Environment & Forests should

determine the minimum flow in river Yamuna and also to determine the respective shares of the riparian states for release of further fresh water in river Yamuna so as to maintain the minimum flow. Accordingly, the High Powered Committee met on 25 May 1999, wherein it was agreed by the basin states to release their share of minimum flow (10 cusec) into the river Yamuna downstream of Wazirabad. NRCD is the nodal agency to advice and monitor the release of minimum flow in the rivers and release of the same by concerned states/agencies.

Inspite of the above orders by SC and signing of MoU by basin States, there is no flow in the downstream of Wazirabad during lean season

(c) The SC also passed an order on 4 August 2004 in the matter of 'And Quite Flows the Maily Yamuna' in the case of CWP No. 725/1994, for setting up a High Powered Committee, to suggest an action plan for river Yamuna, under the Secretary, Ministry of Water Resources, Government of India. The Committee made recommendations and these were incorporated in MPD 2021. Some of the recommendations included in MPD 2021 are:

(i) minimum flow in river Yamuna to be ensured by upper riparian States, (ii) Refurbishment of trunk sewerage system, (iii) rehabilitation of major trunk sewers which are dilapidated, (iv) untreated sewage that enters into Najafgarh and Shahdara drains should be treated before releasing into major drains by laying internal sewerage system or installation of decentralized treatment plants, (v) laying of sewer lines in the unsewered areas of Delhi, (vi) treatment of industrial effluent through common effluent treatment plants, (vii) utilization of treated waste water, (viii) removal of coliform at STP, and (ix) environmental studies of the existing major drains should be conducted before their covering.

The SC also took note of the Report published by the Government of NCT of Delhi on the interceptor sewer concept as a solution to clean Yamuna, and constituted an Expert Committee to examine the feasibility of implementing the interceptor sewer system; the Committee recommended for its implementation. Presently the Delhi Jal Board has been implementing the interceptor sewer system.

(d) The MoEF has also taken action to clean the river by initiating Yamuna Action Plan I (YAP) with the special assistance from Japan Bank for international Corporation (JBIC). In these programmes the emphasis was the construction of drain interceptors, diversion of sewer lines, sewage pumping stations and sewage treatments among Delhi, Haryana and UP, with

NRCD is the executing agency. In Yamuna Action Plan II was also implemented to have a visible and tangible impact on the immediate improvement of water quality, formulation of Master Plan for sewerage in Delhi and project preparation for YAP III. The NCT of Delhi also undertook some projects on the abatement of pollution in the river Yamuna through installation of CETPs.

The impacts of these projects undertaken so far are minimal on the quality of water in the river Yamuna.

(e) The Parliamentary Standing Committee (219th Report of 13 December 2010) writes "The Committee notes that the actions have been initiated to augment the lean season flow in the river Yamuna and is of the view that such actions would not have much impact unless and until it is pursued in a time bound manner. The Committee opinions that the Ministry should fix time frame for carrying out the measures recommended by the High Powered Committee for Yamuna river development and would like to see better implementation and --------".

The High Powered Committee (2010) simply reviewed the status of different schemes proposed but suggested some institutional mechanisms for implementation of the recommendation made by different Authorities and Court orders.

(f) On the on-going case relating to 'Maily Yamuna' the SC also appointed a committee, under the Chairmanship of the Secretary, Ministry of Environment & Forests (MoEF), Government of India, to look into 'Maily Yamuna' matter. The committee appointed a technical subgroup with Member Secretary of CPCB as the convener. The subgroup requested the IIT Roorkee and IIT Delhi to provide solutions to clean the water of Yamuna in the downstream stretch of Wazirabad reservoir up to Okhla. A proposal has already been submitted to CPCB by both the IITs for feasibility studies.

Based on the above analyses, the following are suggestions of the Committee:

(i) Enhanced flows of fresh water into NCT of Delhi stretch of the river Yamuna must be ensured to sustain the ecological functions of riparian ecosystem downstream of Wazirabad.

(ii) Preparation of a complete Sewerage Master Plan 2031 for both sewered and unsewered areas

(iii) Rehabilitation of sewerage infrastructure

(iv) Augmentation of the capacity of STPs

(v) Efficient and effective technologies that reduce BOD levels to less 5 mg/l in treated water and reduction in coliform density

(vi) Apart from engineering and technological solutions to clean the river, the Expert Committee recommends the following:

(a) construction of cascade of wetlands on the elevated portions along the western bank from downstream of Wazirabad barrage to Okhla barrage and pass the entire sewage, from all the major drains after treatment in STPs, through the cascade of treatment wetlands before discharging into river;

(b) construction of wetlands along smaller drains before discharging their content into major drains;

(c) introduction of bioremediation techniques for reducing coliform density and organic load;

(d) development of greenways along the drains, which will (i) prevents the discharge of organic matter into the river and improve water quality and its ecology, (ii) prevent erosion and degradation of soil on the banks of the drains, (iii) form a habitat for biodiversity, and (iv) provide clean water to the communities for recreational purposes.

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FIGURES