Takeaway points from MRC Secretariat's view on the 3rd Technical Symposium on Environmental Protection in the Lancang-Mekong River Basin, Nanjing, China

The Mekong River Commission (MRC) and Ecosystem Study Commission for International River of its Dialogue Partner China jointly organized the 3rd Technical Symposium on 'Capacity Building and Experience Sharing on Sediment Control and Management for River Dams' on 16-17 October, in Nanjing, China. The two-day symposium hosted more than 40 participants comprising government officers from Mekong River Commission (MRC) Member Countries and its Line Agencies, experts and private sectors from China including Ecosystem Study Commission for International Rivers (ESCIR), the Institute of Water Resources and Hydropower Research of the Ministry of Water Resources of China, China Renewable Energy Engineering Institute, Hohai University, Nanjing University of Information Science and Technology – College of Hydrology and Meteorology, China Institute of Water Resources and Hydropower Research, Tsinghua, the Asian International Rivers Centre of Yunnan University, HydroChina Kunming Engineering Corporation and HydroLancang.

Experts shared experience, knowledge, and studies on sediment control and management of river dams that could contribute to new guidelines and tools useful for effective planning and development in the Lancang-Mekong River Basin — to maximize regional benefit and minimize transboundary impacts. This paper highlights takeaway points from the MRC Secretariat's (MRCS) views as follows:

The MRCS was impressed by works on **Sediment Control and Flushing Measures in the Yellow River**, presented by our colleagues during the 3rd Joint Technical Symposium. Annual sediment load (1.6 billion tons) and sediment concentration (30 kg/m^3) for 1919-1959 were the highest rank in the world. Starting from the 1970s, forty years of applying integrated approach of sediment management including water soil conservation (retaining/trapping), sediment deposition, sediment flow guiding, regulation and channel training, warping and dredging, significantly decreased the annual sediment load from 1.1 billion tons (1960s-1990s) to 0.25 billion tons (2000s-2010s) – a reduction more than 70% of the annual sediment load. The presenter also informed the symposium about efforts with soil conservation in upper parts of the Yellow river that led to reduction of sediment loads in the Yellow river.

Additionally, a Chinese participant presented **a Basin-wide Integrated Monitoring Information System** that corporates modern information system, Internet of Things (IOT), cloud technology to establish a professional and dynamic monitoring system for hydropower operation management of 300 GW for the whole China. The system collects real-time information of hydro-meteorological data, environmental protection, power utilization, and infrastructure safety. The system facilitates data collection from sites, data processing, storage, visualization and application for entire project life cycle from construction phase to operation phase. The system helps enhance optimized operation and management of hydropower, improve water

resources utilization, promote sustainable hydropower development and coordinated development of economy, society and environment in the basin.

A presentation on Ecological Restoration of Lancang River Hydropower Development delivered by HydroLancang revealed a plan of 23 hydropower cascade on the Lancang River in China. While other hydropower is under studies and designs, six hydropower (Gongguoqiao, Xiaowan, Manwan, Dachaoshan, Nuozhadu and Jinghong) are currently in full operation. It also introduced restoration of aquatic ecology and terrestrial ecology during the construction and operation of the hydropower cascade – fish migration measures, fish breeding and releasing, fish habitat protection, slope protection with vegetation and rehabilitation. It finally claimed that HydroLancang has exploited hydropower resources of Lancang River by maximized overall comprehensive benefits of the River and its strengths in the construction and operation management of the cascade and actively carried out scientific researches, design and construction of aquatic and terrestrial ecological restoration as well as the coordinated development of hydropower and eco-environmental protection. HydroLancang also mentioned that ecological restoration together with forestation and vegetation in upper part of the Lancang Basin might reduce the annual sediment load by more than 50%.

The Environmental Management Division of the MRCS presented Potential impacts of hydropower on fisheries in the Lower Mekong Basin and informed the symposium that the Mekong River Basin is recognized as one of the richest areas of biodiversity in the world since it is home of more than 1,000 fish species in the basin claimed by many researchers. However, the MRCS dataset only recorded 470 species including 4 critical endangered species, 9 endangered species, 14 vulnerable species and 44 endemic species. Hydropower development would threaten fish resources by a loss of 550,000-880,000 tons if all eleven mainstream dams were in place.

The Technical Support Division of the MRCS delivered two specific presentations on (1) MRC Discharge and Sediment Monitoring Project (DSMP) and (2) Application of the DSMP monitoring results and future challenges. The following summarises the findings from these two activities.

MRC Discharge and Sediment Monitoring Project (DSMP): The project was initiated in 2009 to improve the understanding of sediment transport and sediment characteristics in the Lower Mekong Basin. The DSMP includes the collection of discharge and suspended samples at 15 sites on the mainstream Mekong/Bassac Rivers, 1 site on the Tonle Sap River, and 1 site in the lower 3S River. Samples are collected more frequently during the wet season when most sediment is transported through the catchment. Sediment grain-size analysis and bed load monitoring is included at a sub-set of the sites. The results from 2009-2013 have been compiled and analysed.

Suspended sediment concentrations tend to be highest during the onset of the wet season, and decrease over time. Concentrations are generally in the range of 200 to 400 mg/L during the wet season, however at sites in the central catchment concentrations in excess of 1,000 mg/L have been recorded, although there is some question about the sampling methodology used at these sites.

In 2009-2013, annual suspended sediment loads in the LMB ranged from an average of 10.8 million ton at Chiang Sean, to 76.8 million ton at Stung Treng. Results from the 3S River system suggest the catchment is contributing about 8.5 million ton of the annual suspended sediment

to the mainstream, or a little over 10% of the total load. The suspended load of the Mekong mainstream is predominantly composed of medium to fine sand in the upper catchment, grading to fine sand and silt in the lower river, and clays in the Delta.

Bedload measurements are limited to three locations (Chiang Saen, Nong Khai and Kratie) and annual bedload transport rates from all sites ranged from 1.3 to 4.1 million ton, based on a variety of methods. These ranges represent 3% to 15% of the annual suspended sediment load at the respective sites. The bedload was dominated by gravel, pebbles and coarse sand at Chiang Saen, fine and medium sand at Nong Khai, and coarse to fine sand at Kratie.

Compared to historic suspended sediment concentrations and loads, the DSMP results show a substantial decrease in sediment transport. The annual sediment load entering the LMB from China has decreased from an average of 84.7 million tons (1960-2002) to 10.8 million tons at Chiang Saen. The annual sediment load at downstream channel at Pakse has decreased from an average of 147 million tons to about 66 million tons.

The observed magnitude of the reduction in sediment transport is consistent with predicted reductions associated with the trapping of sediments in the impoundments of the Yunnan Cascade hydropower projects in China. Sediment loads from the 3S Rivers are also consistent with predicted reductions following hydropower development in the sub-catchment. At present, only about 16% of the sediment load is entering from China, and about 13% from the 3S, with the largest sediment contribution to the mainstream now derived from other tributaries in the LMB. These values do not reflect the sediment reductions associated with hydropower commissioned in tributaries since 2013, including Nam Ou, which is a major tributary with respect to flow and sediment.

Moreover, the MRC has used the DSMP sediment monitoring results in the following projects. The MRC ISH (Initiative for Sustainable Hydropower) Project, Guidelines for Hydropower Environmental Impact Mitigation and Risk Management in the Lower Mekong Mainstream and Tributaries has used the measured sediment loads and grain-size distributions in an internationally recognised 3-dimensional model (Delft-3D) to predict the sediment trapping associated with the implementation of the Northern Laos Cascade (Pak Beng, Luang Prabang, Xayaburi, Pak Lay and Sanakham) about 150 km from Vientiane. The results show that annual sediment loads downstream of the cascade will reduce from 20 million tons to about 6 million tons. Mitigation measures could only increase this volume by up to 1 million until larger volumes of sediment became available for transport.

The MRC Council Study – Study on Sustainable Management and Development of the Mekong River has used the sediment monitoring results to develop and calibrate a sediment transport model for the LMB, including the Tonle Sap Lake and the Delta. The results of this model show trapping of 97% of the sediment load at the head of the delta if all planned mainstream dams are implemented. Mitigation measures that included a re-design of the Sambor dam could increase this value to 10%.

The sediment starvation will make direct geomorphic impacts on the river system. 'Erosional wave' will progress downstream of dam sites – deepening and widening channel, increasing river bank instability and changing tributary confluences. Additionally, there is a potential erosion and instability, and reduction in sediment and nutrient delivery to the Tonle Sap Lake, Delta and Coastal area.

Furthermore, the results from the above monitoring and studies have highlighted the following challenges and recommendations.

Different modelling projects have arrived at different conclusions with respect to sediment trapping in the Northern Laos Cascade. All models *'agree'* that sand will be effectively trapped in the impoundments, but silt and clay will be largely transported through. However, the assumptions about the grain-size distribution of the sediment load entering the impoundments have varied widely, and account for the differences in model results. Additional grain-size monitoring is warranted, and uniform definitions for size fractions for clay/silt/sand should be agreed to within the Mekong and Lancang.

The ISH and MRC Council Study modelling efforts have clearly shown that although mitigation measures on mainstream dams can increase the transport of sediment through impoundments, the volume of increase is small due to the lack of sediment entering from tributaries or the Lancang River. Sediment mitigation needs to be considered in all areas of the catchment. A whole-of-catchment approach is required to identify potential sediment pathways and focus mitigation investment in these areas to increase the flux of sediment into the mainstream Mekong.

The large volume of sediment that is stored in the Mekong River channel provides a *'buffer'* for the river system. As it erodes and is removed, the impacts from sediment trapping will accelerate. Including geomorphic monitoring of river channels to document the rate at which sand is being eroded from the channel is required to better understand the time-frame for changes in the river.

Sand and gravel mining in the Mekong River removes large quantities of material on an annual basis and has the potential to accelerate and exacerbate the impacts from hydropower. Deriving accurate sediment budgets that include the volumes of materials extracted from the river as well as trapped in hydropower is necessary to understand and manage the relative impacts of these activities. Identifying alternative sources of material for construction and land filling would decrease pressure on the river system.