Sedimentation Study of Peligre Reservoir, Haiti

Study Summary

Prepared for:

Banco Interamericano de Desarrollo

División de Energía, Departamento Sectorial de Infraestructura y Medio Ambiente (INE/ENE)
Stop W-0504
1300 New York Avenue, N.W.
Washington, D.C., 20577 - USA

Prepared by::

GM MORRIS ENGINEERING

250 Tanca St.
P.O. Box. 9024157 Old San Juan
Tel. (787) 723-8005 Fax. (787) 721-3196
www.gmaeng.com

Sedimentation Study of Peligre Reservoir, Haiti

This Engineering study was undertaken to document Peligre Reservoir current volume and sedimentation rate, to determine the feasibility of continuing hydropower generation for the next 20 years, and to identify remedial measures which may sustain long-term operations of this facility for multiple uses.

This work has been performed by Gregory L. Morris Engineering under contract with the Inter-American Development Bank (IADB) under Contract PDP-8-049-00.

Project Description and Scope

Peligre dam and reservoir regulates approximately 6,480 km^2 of the Artibonite River watershed. The project was constructed during 1953-56 to supply irrigation water and control flooding in the Artibonite Valley, an agricultural area extending from the coast upstream for a distance of approximately 50 km. In 1971 the dam was modified to include hydropower generation, supplying the city of Port au Prince. The dam and power station are shown in **Figure 1**.

Figure 1: Peligre Dam Downstrem Face

Reservoir Storage Loss

To determine the current volume of Peligre Reservoir a bathymetric survey was conducted during the months of April and May, 2008. Twenty five cross sections were measured across the main water body, with the reservoir pool level fluctuating between 151.9m and 154.3 m during this period. Cross-section locations are shown in **Figure 2**. Both bathymetric and land survey techniques were used, to measure the flooded and non-flooded areas of the partially full reservoir.

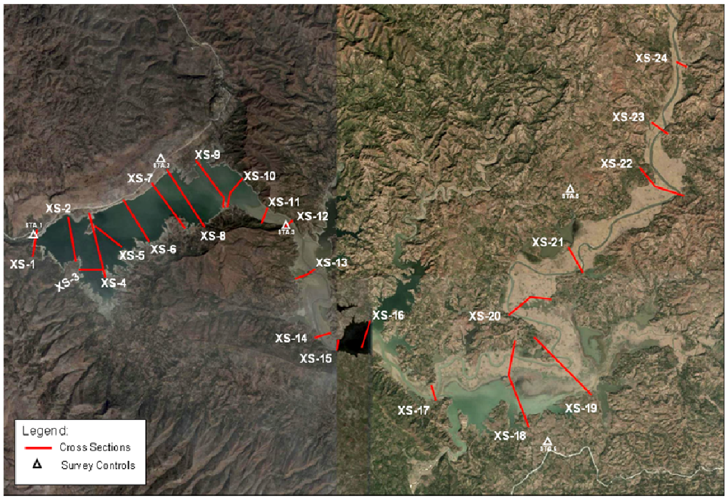

Figure 2: Location of Survey Cross-Sections

The reservoir has now lost 50% of its initial volume. The current total volume is 297 Mm3, of which 249 Mm3 represents active storage above the minimum generating water level of 153 m. The decline in reservoir volume over time and 20-year projected volume are presented in **Figure 3.**

The long-term rate of storage loss due to sedimentation is 6 Mm3/year, equivalent to an annual loss of 1% of initial volume. This translates into a reservoir half-life (50% sedimented) of only 50 years and is considered a high rate of sedimentation.

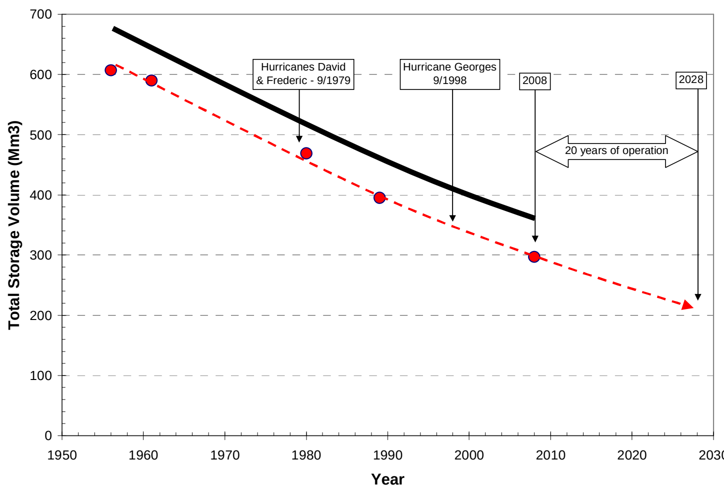

Figure 3: Historical Decrease in Total Storage Volume in Peligre Reservoir.

Continuation of the historical sedimentation pattern indicates that an additional 90 to 100 Mm^3 of capacity will be lost during the next 20 years, leaving about 200 Mm^3 of total capacity by year 2028 as shown in **Figure 3**. Sedimentation during the next 20 years is not anticipated to reach the power intake at the dam and adversely affect hydropower production.

Reservoir Operation

Several different energy generation scenarios were simulated in a hydrologic water balance model. The scenarios evaluated consisted of applying fixed operating rules in which the rate of hydropower generation is controlled by the reservoir level. This analysis indicates that it will be possible to maintain current levels of hydropower generation, even with substantial additional sedimentation. However, as the reservoir live storage volume is decreases due to sedimentation, the need to adhere to standardized operating rules becomes more important, particularly from the standpoint of guaranteeing downstream irrigation deliveries.

The simulations performed indicate that loss of storage volume due to sedimentation during the next 50 years to 100 years, resulting in a live pool of between 50 and 100 Mm3, will not have a significant impact on total power generation potential, as long as the sediment is excluded from the power intakes. Raising the dam will be beneficial, but is not necessary to sustain existing levels of power production during the next several decades.

Projection of Future Sedimentation

Sediments are depositing in Peligre reservoir in the shape of an advancing delta, and river flows during drawdown's has scoured a river channel across these sediment beds, as shown in the air photo of sediment deposits during reservoir drawdown (**Figure 4**). Sediment beds are used for agriculture during drawdown. The delta deposits are advancing toward the dam, and the top of the delta is currently located near kilometer 6 upstream

Figure 4: Sediment Deposits 22 km Above Dam

dam face (see **Figure**). In the upper portion of the reservoir the top of the delta has reached a

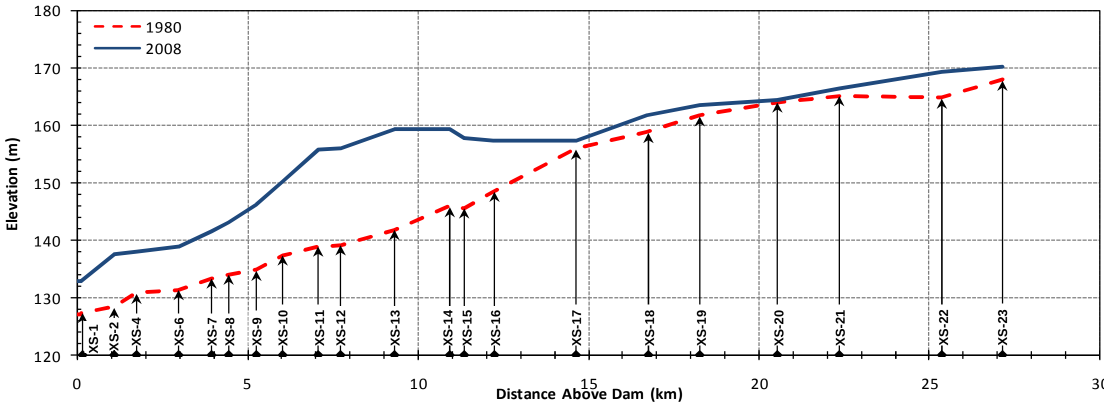

Figure 5: Longitudinal Profile Along Peligre Reservoir for 1980 and 2008.

relatively stable elevation. At present, storage volume is being lost primarily by advancement of the delta in the downstream direction, as evidenced by the data in **Figure** which compares 1980 and 2008 profiles.

Sediment transport modeling was undertaken to better understand the rate and pattern of sediment deposition along the reach of the Artibonite River impounded by Peligre dam over the next 100 years using the Bureau of Reclamation sediment transport model SRH-1D. **Table 1** and **Figure** shows the storage volume variation over time for the simulated scenarios.

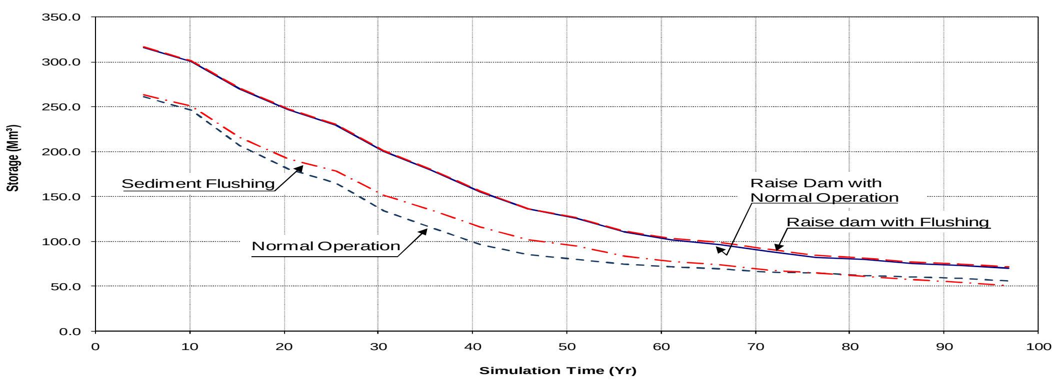

Figure 6: Change in Volume Over Time for Peligre Reservoir.

Table 1: Total Reservoir Volume by Sediment Transport Simulation Scenario.

Simulation Period (years)	Reservoir Storage Volume (Mm3) a/			
	Normal Opn.	Flushing	Raise Dam w/Normal Opn.	Raise Dam w/ Flushing
10	284	289	550	551
20	210	223	355	357
30	159	177	275	276
60	81	88	135	138
100	61	55	86	91

a/ Volume determined using the average-end-area method.

Figure 7 shows the pattern of sediment accumulation for various scenarios. These simulations indicate that most sedimentation will occur in the downstream portion of the reservoir, but

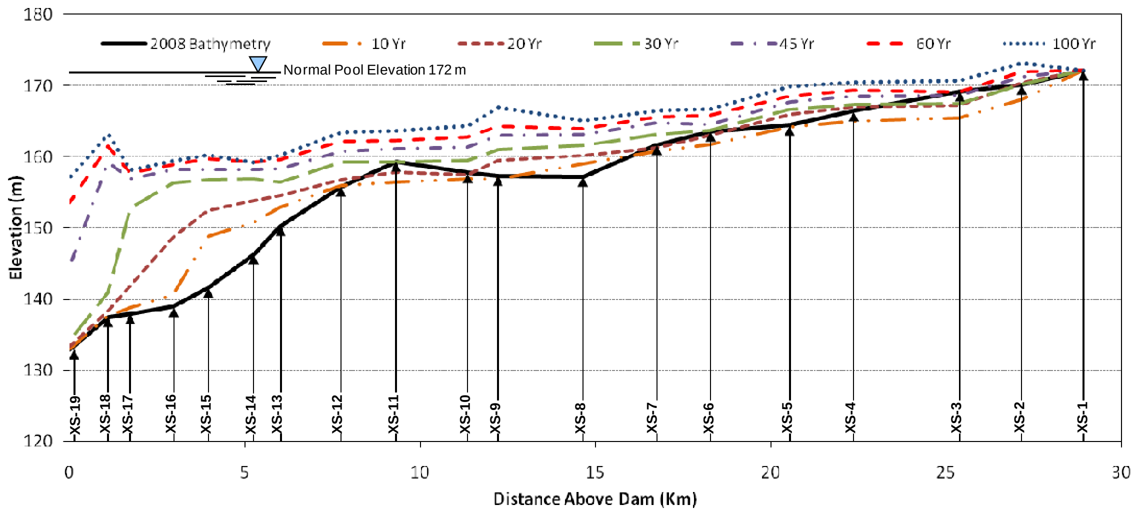

Figure 5: Simulated Sediment Accumulation Over Time fo Peligre Reservoir.

sediment is not anticipated to approach the area of the existing intakes during the next 20 years. Simulation results also indicate that the reservoir trap efficiency and the rate of storage loss will decline over time, and reservoir capacity will tend start to stabilize in the vicinity of 50 Mm3 some 80 to 100 years in the future.

Strategies to Achieve Sustainable Reservoir Operation

A combination of techniques can be employed to achieve the long-term sustainable operation of Peligre reservoir. Hydrologic simulations indicate that a relatively small storage volume can maintain energy production at current levels, and also sustain irrigation deliveries about 90% of the time. The rate of storage loss can be minimized, and the sustainable storage volume maximized, by a combination of techniques.

- Hydrologic data. All of the analysis performed in this study depends on the hydrologic dataset provided by EDH. A key to optimizing the reservoir to sustain its long-term operation will be accurate hydrologic records, and especially information on large sediment-producing events. We recommend that procedures for the acquisition and storage of hydrologic data be improved.

- Flushing. Reservoir emptying and flushing, as currently practiced, should be continued. In addition to allowing maintenance of the intake facilities, this practice provides only modest benefits in terms of preservation of storage capacity, but will maintain the bottom outlets free of the accumulation of sediment and debris, and will also enable the advance of sediment into the reservoir to be visually monitored.

- Increase Minimum Operational Level. By increasing the minimum operational level, coarse sediment will tend to be deposited further upstream and more distant from the dam. We recommend that the minimum operational level be increased to 160 m.

- Modify hydropower intake. Twenty or more years from now the hydropower intake should be modified to withdraw water from a higher level in the reservoir. **Figure 8** presents conceptual intake modifications to exclude sediments from the turbines when the delta face reaches the dam.

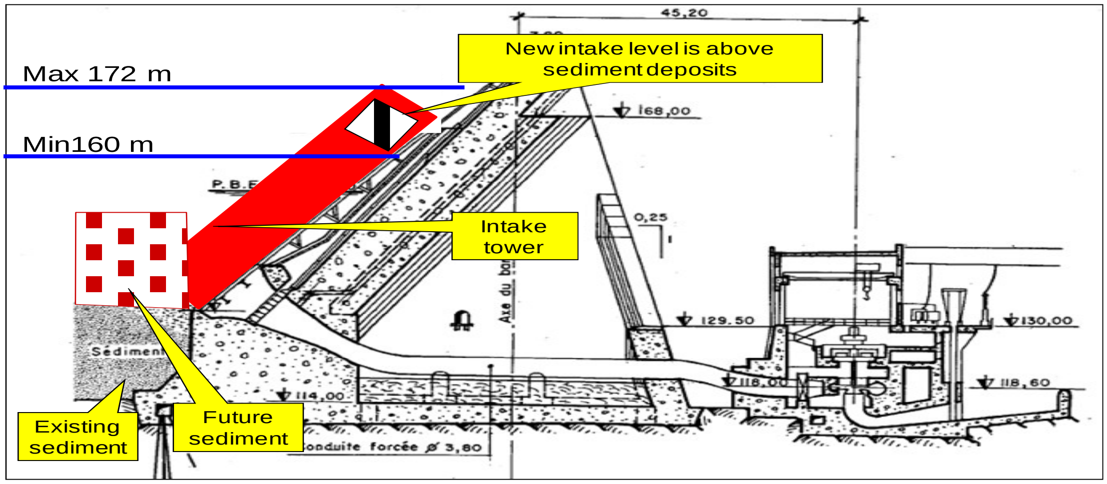

Figure 6: Conceptual Intake Modification.

- Raise the dam. It is not necessary to raise the dam in the foreseeable future for the purpose of maintaining hydropower generation. However, rising of the dam and increasing the depth of the existing crest gates may be necessary as a dam safety measure to preventing overtopping if it becomes infeasible to operate the bottom outlets.

- Sediment pass-through. Sediment pass-through may be implemented as sediment deposits approach the dam, and should definitely be used to pass large sediment-producing events through the reservoir as sedimentation becomes advanced approximately 40+ years in the future. It will be an important procedure for minimizing deposition during large storm events that deliver large sediment volume into the reservoir. It may be necessary to modify the crest gates, and to also raise the dam, to maximize the long-term effectiveness of sediment pass-through.

All of the techniques presented above are considered technically, institutionally, and economically feasible. They are techniques which can be implemented by EDH at their own facilities, and which can result in the long-term sustained operation of the reservoir.

The following two techniques are not foreseen as reliable or feasible methods to achieve the sustainable operation of Peligre dam.

- Dredging. We do not foresee the need for either localized or large scale dredging. Rather, the intake modifications should be made so that the intake structures can be maintained free of sediment during sediment flushing or pass-through events, thereby eliminating the need for localized dredging. Large scale dredging is considered infeasible due to high cost and limited disposal options.

Summary, Conclusions and Recommendations

Hydraulic simulations indicate that for the condition that will prevail over the next 20 years, hydropower production can be maintained at current levels while providing a reliable supply of water for downstream irrigation without modifying the dam.

It will be possible to sustain the operation of Peligre reservoir indefinitely, relying on a combination of sediment management techniques including reconfiguration of the hydropower intake, sediment flushing, sediment pass-through, possibly raising the dam. We do not anticipate the need or desirability of reservoir dredging. EDH should improve its hydrologic and operational data collection and management procedures.