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ASSESSMENT OF PERFORMANCE OF COMPLETED DRAINAGE WORKS AGAINST DESIGNED PERFORMANCE FOR TAI HANG TUNG STORAGE SCHEME (THTSS)

FINAL REPORT

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Land Drainage Division
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Hydraulic Analysis and Modelling Work of Tai Hang Tung Storage Scheme and its Associated Drainage System

Final Report

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Executive Summary

The Tai Hang Tung Storage Scheme (THTSS) is an essential component of the West Kowloon Drainage Improvement (Stage 2) Project. The scheme aims to solve the flooding problem in Mongkok. The heart of the flood detention scheme is a 100,000 m^3 underground storage tank beneath the Tai Hang Tung Recreation Ground, a triple side weir system, and transitions to the upstream inlets and downstream channels. During heavy storms, part of the flood flow will spill over the side weirs into the underground storage tank and be temporarily stored; the flow diversion serves to attenuate the flood peaks and prevent downstream flooding. The success of the scheme depends on the proper functioning of the side weir system and the hydraulics at the channel-weir junctions.

The THTSS was commissioned in 2005, and flow monitoring has been conducted during the rainy seasons since 2007. The operation of THTSS has essentially resolved the historic flooding problem; the observed maximum level at Flower Market Street is always below the street level for all storms - thus protecting the downtown Mong Kok area from flooding. Nevertheless, the THTSS performance was put to an extreme test on 7th June 2008. On that day, the Hong Kong Observatory recorded 145.5 mm during 8 to 9 am, which is the highest hourly rainfall on record. The heavy storm led to rapid filling up of the storage tank and minor local street flooding in the vicinity of the pumping station. This storm event suggests the need to analyze the flow data and evaluate the performance of the THTSS system and its associated drainage system using hydraulic models.

A comprehensive review and analysis of the operation of the THTSS has been carried out. One- and two-dimensional models have been developed for the THTSS system including the side weir channels and transitions. The model predictions are validated against detailed laboratory experiments for representative steady flow conditions. Based on in-situ surveys, the as-built design of the THTSS system has been reviewed. An overview and critical review of the post-operation field monitoring program has been carried out. The analysis of the extensive flow monitoring data during 2007-2010 has offered important insights into the fundamental hydraulics of the system during a storm event. The side weir head-discharge relation has been validated against field data. The models have proved extremely useful in the interpretation of the field measurements of the complex turbulent flows - which are inherently noisy, with data gaps, biases and errors induced by instrument failures or sediment deposition.

Both numerical calculations and data show an early spill into the storage tank on June 7, 2008. The flood duration is very different from that of the 50-year design hydrograph, with flood volumes that rapidly fill the storage tank leading to surcharge of the weir channels and local flooding. The rapid rise in flood level in the storage tank and THTSS system are well-predicted; the early spill is related to several discrepancies unaccounted for in the design calculations: differences between actual and design dimensions, unexpected obstructions from utility pipes, blockage of column heads, and effect of sediment. The performance of the THTSS system

depends on the balance of Tai Hang Tung Road and Boundary Street inflows.

Both model calculations and field operation experience show that the early spillage problem can be resolved by raising the weir level to 5.7m PD. From the representative storm events in June 2008 and 24th June 2009, it can be observed that by raising the weir level to 5.7 mPD, weir overflow starts when the upstream inflow (from Tai Hang Tung and Tat Chee Road) is 8.4 m^3/s, as compared to around 7 m^3/s in the original setting (5.5 mPD). The side weir overflow rate has been correspondingly reduced, thus reserving more tank capacity for any subsequent heavier storm. In addition, the calculations show that the decking of Flower Market Street Nullah (in 2010) results in higher side weir overflows and storage tank levels during storms, with slightly reduced level at Flower Market Street.

Based on the review of the flow monitoring data and the hydraulic analysis, the following recommendations are proposed:

1. The use of Sontek Acoustic Doppler Current Profiler (ADCP) has consistently given reliable flow data; ADCP should be adopted for future flow measurement. In view of the problems created by inflow of sediment, consideration should be given to use side-mounted depth and flow sensors in the side weir channels. The depth measurement can also be supplemented by a CCTV in the flow-through side weir channel.
2. In view of the critical importance of the depth measurement in the storage tank, an additional depth sensor inside the storage tank is proposed.
3. The adjustable steel plates at the side weirs should be regularly inspected and any notable gaps appropriately sealed; for optimal operational performance all the weir plates should be properly adjusted to the same level of 5.7 mPD.
4. Currently drainage systems are designed on the basis of storm flows predicted by rainfall-runoff models based on local parameterization. It is recommended that a detailed study be carried out to correlate the predicted inflows from InfoWorks/HydroWorks with field measurements.
5. As a reasonably good understanding of the THTSS hydraulic behavior has been gained, the monitoring program can be gradually reduced in scope to a few essential measurements - an inflow flow sensor at the upstream end and several depth sensors at key locations. Consideration should also be given to develop real time control systems based largely on depth measurements.
6. The decking of the Flower Street Market Nullah gives rise to additional resistance and impairs the THTSS performance. As a compensatory measure, and to ensure the system performs as designed, consideration can be given to the removal of significant cross-utilities in the THTSS system.
7. The THT Recreation Ground can be used to provide emergency flood relief during extreme flood events.