7 Summary and Conclusions

Ambient flow conditions in both the physical model and the prototype had significant variations at a large range of frequencies including the frequency at which the tow effects occur. A fast Fourier transform filtered information above 0.02 Hz.

Prototype return velocity and drawdown compared to physical model return velocity and drawdown in the Kampsville site showed that the Froude model with geometric scaling of vessel size resulted in model values greater than the prototype. The physical model draft had to be reduced from purely geometric scaling for agreement between model and prototype. The physical model also generated a wave and flow at the bow greater than the prototype data. This bow effect was likely related to the rapid acceleration that must be used in the physical model because of the limited flume length.

Variability of return velocity was evaluated using nine identical experiments in the physical model. The standard deviation of the maximum return velocity was 12 percent of the maximum return velocity.

Rake angle experiments determined the effect on return velocity and drawdown. It appears from Figures 34-38 that values for drawdown and return current are consistently higher for 0.16 rad (90 deg) than 0.05 rad (26 deg). Further conclusions will await additional experiments on the Clark's Ferry physical model.

Experiments were conducted using a stationary boat in a flow moving at the speed of the vessel, which changed a dynamic event to a steady one making measurements much easier. However, the rough water surface present when simulating high vessel speeds makes this form of experimenting questionable.

The vertical profile of return velocity change was investigated to determine how to interpret and compare return velocities taken at different distances from the bottom. During passage of a tow, the flow depth can be separated into a lower zone in which boundary layer growth can inhibit maximum return velocity and an upper zone in which the return velocity is nearly uniform. The lower zone is generally confined to the lower 0.5 m of the depth.

Experiments were conducted to determine the influence of upbound versus downbound tows relative to variable magnitudes of ambient currents. For low ambient currents, influences were negligible. Further conclusions regarding this issue will await additional data from the Clark's Ferry model.

A normalized return velocity time-history was developed for future use in analytical models that require the time-history of vessel changes. The magnitude of return velocity was normalized by the maximum return velocity, and time was normalized by the time required for the barges to pass a given point.

A numerical simulation using the HIVEL-2D model assessed the flume length adequacy as well as comparing return velocity and drawdown from the prototype, the physical model, and the numerical model. Numerical simulations of the physical model flume and of a much longer reach with the same cross section (over the entire length) as the experiment section showed that the 61-m-long experiment section in the physical model resulted in return velocity and drawdown equal to long river reaches. The return velocity magnitude in the numerical model and the prototype *William C. Norman* were compared. The maximum return velocity from the numerical model was 9 percent greater than the prototype based on the average of results at five velocity meters.

A large body of far field physical forces data in the form of return velocity and drawdown form were developed in this study. These data are available for future development of analytical models and for numerical model verification.