COMMONWEALTH OF VIRGINIA

MARINE RESOURCES
ADVISORY SERIES

VIRGINIA INSTITUTE OF MARINE SCIENCE
GLOUCESTER POINT, VIRGINIA 23062

NO. 2
JANUARY, 1969

JAMES RIVER HYDRAULIC MODEL

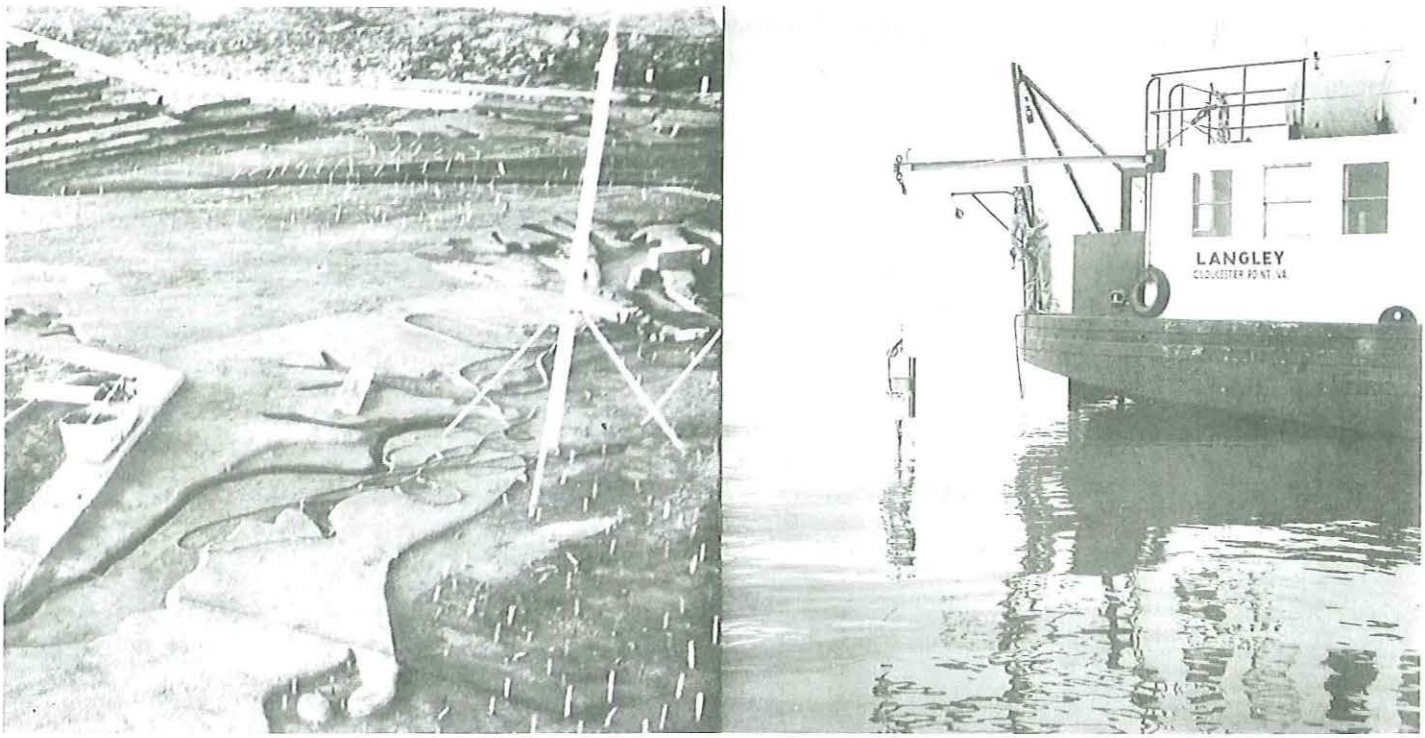
MULTI–PURPOSE MARINE RESEARCH TOOL

FOR SCIENCE, GOVERNMENT AND INDUSTRY

Inside a hangar-like shed down at Vicksburg, Mississippi is a unique research tool valuable to science, government, and industry. This is the James River Hydraulic Model–a miniature version of Virginia's most important tidal river system. The model was built by Virginia in cooperation with the Norfolk District Engineers' Office and the Waterways Experiment Station of the U.S. Army Corps of Engineers. It is operated jointly by the Virginia Institute of Marine Science at Gloucester Point and the Corps.

Investigators use the model to study the river's "natural" processes under controlled conditions. Tides, currents, freshwater flow, saltwater intrusion, and sediment deposition as they occur in the tidal James are duplicated in it. They also run tests to determine how these processes will be affected by river and harbor projects before expensive man-made changes actually occur. Thus, scientists learn more about the physical workings of the lower James Estuary. Working with engineers they examine construction and sewage discharge proposals for their possible effects on valuable natural resources. Industrialists with shoreline factories that use water for transportation, waste-removal, cooling and other manufacturing processes examine present river-oriented operations or future developments and determine how these change or are changed by existing river conditions.

The James River Model can be an invaluable aid to Virginia in planning an orderly development of resource potentials throughout the entire tidal basin from Richmond to Hampton Roads–planning which calls for tailoring river and harbor projects so that desirable economic and social advantages may be realized.



Various stages of model construction: templates were lowered into ground and concrete molded over them. Hydraulic resistance strips protrude from model bed (upper left). VIMS scientists conducted field studies of the James River to gather hydrographic information needed for model construction and verification (upper right). View inside shed where model is housed: salinity withdrawal apparatus appears in left background, tide gauge in middle background, and tide control mechanism (clocklike) in right background.

A MODEL IS BORN

Nearly fifteen years ago municipal and industrial interests that used the James River urged deepening the 25-foot channel from Hampton Roads to Richmond to 35 feet so larger vessels could navigate upstream. The economics of inland shipping would thus be improved because deepdraft ships could dock at Richmond and Hopewell. Others felt that a deeper channel through the upper tidal James would open new avenues for industrial development in that area.

Few objections were voiced at first. But as time passed, fear arose that this navigation project might have serious effects on the multi-million dollar oyster industry. Oystermen protested that valuable seed oyster beds near the James River Bridge might be seriously damaged or even destroyed. Scientists predicted that physical changes in the estuarine portion of the river would surely result. The Virginia General Assembly delayed approval of the project until a scientific study could determine the various physical and biological effects that would result from channel modification.

As part of this study, scientists from VIMS recommended building a physical scale model of the tidal James to test the proposed change under conditions resembling those in nature. The model would enable them to accurately pinpoint natural conditions before and after deepening.

Funds became available for research on the problem in 1964 when the General Assembly appropriated $300,000 to the Commission of Fisheries (now the Virginia Marine Resources Commission) in Newport News. This included construction of a suitable hydraulic model.

THE MODEL MAKERS

The U.S. Army Corps of Engineers was selected to build and operate the James River Model. It possessed the necessary skill and facilities; furthermore, the Corps contributed about $100,000 toward building costs. The model was built at the Waterways Experiment Station (WES) in Vicksburg, where a dozen other hydraulic models are also housed. (WES is the principal research and engineering study facility of the Corps). VIMS provided bathymetric information (bottom contours), and the necessary oceangraphic data (salinity distribution, current speed and direction, etc.) for model construction and verification.

VIMS PROVIDES DATA

The Commission selected VIMS to conduct the necessary research for determining the effect of channel deepening on oyster production in James River. VIMS then initiated a multi-disciplinary research project (labeled Operation James River) that provided information concerning the physical and chemical processes in the James and the effects of these phenomena on the biological activities occurring in the estuarine portion of the River.

In 1967 reports were submitted to the Governor and General Assembly of Virginia stating that tests in the model had revealed channel modification would not seriously affect the oyster industry. The navigation project was approved.

RETAINED BY VIRGINIA

After the Corps of Engineers fulfilled its contract with Virginia for the Channel Study and completed certain studies of its own, the model could have been dismantled. Regulations governing WES allow it to destroy models when there is no longer any need for them. Virginia, however, acted quickly and requested that the model be kept in operating condition for future uses. The Commonwealth had invested over $400,000 in this experimental facility and VIMS scientists urged officials to retain it for continued use by the State in developing the important James River Basin and by the communities and industries located along the river.

The model was saved. The Corps agreed to a program of joint financing and use by both the Commonwealth and the Federal Government. The model is kept on standby status and VIMS pays monthly rental of $300 to cover costs of maintaining it when not in use. As it has worked out, the model has been in almost continuous operation since the Channel Study was completed in late fall of 1966.

REPRODUCES NATURE IN MINIATURE

The James River Hydraulic Model is an experimental device used by scientists and engineers to duplicate nature in miniature. One horizontal foot in the model equals 1,000 feet in the river; one vertical foot represents 100 feet. Four days in nature are scaled down to one hour on the model; a normal 12 ½ hour tidal cycle is condensed to only 7 ½ minutes.

A protective shelter houses the model to avoid local wind effects, dilution from rain, and to allow uninterrupted operation in winter. The model is 550 feet long and 130 feet across at its widest point. The bed is molded of concrete and covers some 25,000 square feet.

The entire James River Tidal Tributary from its fall line at Richmond through Hampton Roads into the Cheseapeake Bay and including 200 square miles of Atlantic Ocean is formed in the model. Tidal portions of all major tributary streams are included: the Elizabeth, Nansemond, Pagan, Warwick, Chickahominy, and Appomatox Rivers.

Man-made obstructions that interrupt the river's flow are also built to scale in the model. Replicas of existing piers, bridges, tunnels, and the U.S. Navy's James River Reserve Fleet have been added to duplicate the physical effects of these structures.

MODEL SCALES

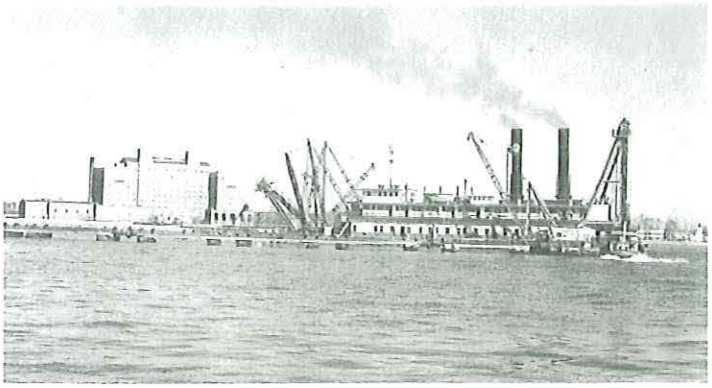
Scale	Ratio Model: Prototype
Horizontal Distance	1:1000
Vertical Distance	1:100
Water Velocity	1:10
Discharge Rate	1:1,000,000
Volume	1:100,000,000
Salinity	1:1
Time	1:100

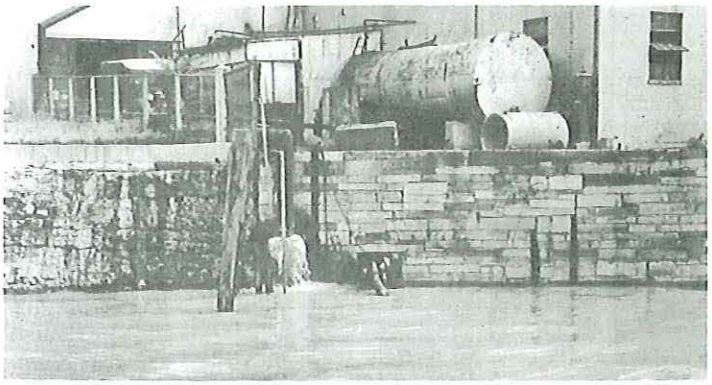
Tides, currents, freshwater flow, saltwater intrusion, and sediment deposition are simulated with known accuracy. An automatic tide control mechanism regulates rise and fall of the water level by alternately filling and draining water in the system. Variable copper "hydraulic resistance" strips duplicate bottom roughness, and they can be adjusted to make currents behave as they do in the river.

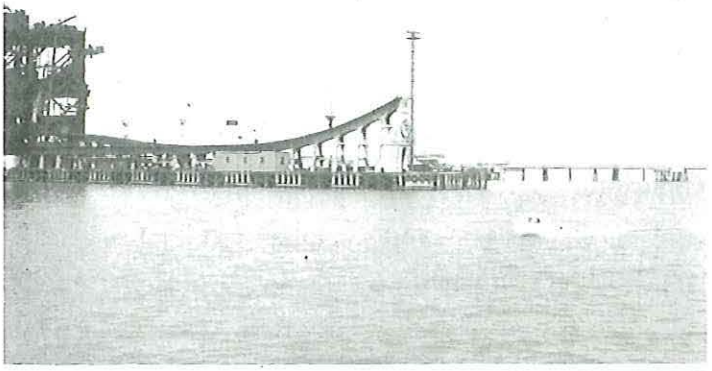
Stategically located inflow devices regulate the amount of fresh water introduced. Artificial sea water from a large supply tank is pumped upstream by the simulated tidal action to imitate saltwater intrusion. Gilsonite may be introduced at different points along the model bed to simulate sedimentation and scouring. Dyes may be used to study circulation and simulate introduced chemicals, suspended particles and even, to a degree, planktonic organisms.

Measurements in the model are taken with various instruments. Tidal heights are obtained with stationary point gauges. Current velocities are measured with miniature Price rotating cup meters. Salinity samples are drawn by vacuum into vials through small intakes set in the model at various depths. Sediment grids indicate where silt may be deposited. Time-lapse photography and florescence detectors are used in dye diffusion and disperal studies and in sedimentation and circulation studies.

Because the model reproduces, records, and measures physical factors with known accuracy and precision, scientists and engineers can demonstrate existing conditions of the river or any new condition induced by either man or nature.







The model is a useful tool for studying effects of various river and harbor projects on natural river processes and for determining how these projects will be affected by the river. Channel dredging, waste outfall, terminal, shell planting (from top to bottom).

SERVES MANY PURPOSES

The James River model is useful to private and public groups on local, state, and national levels. Some recent studies and proposed ones are as follows:

- Virginia Electric and Power Company used the model to test the environmental effects of heated effluent from a proposed nuclear power plant to be located at Hog Point in Surry County.
- The City of Newport News used the model to help choose one of three possible plans for a proposed fill project at Newport News Point.
- The Hampton Roads Sanitation District Commission used the model to help select the best site for a sewage treatment plant outfall.
- The Navy used the model to aid in solving navigation channel and berthing area sedimentation problems.
- VIMS scientists are using the hydraulic model to test the accuracy and precision of such devices and as an experimental "flume" to develop mathematical models of estuarine circulation.
- The Federal Water Pollution Control Administration, VIMS, and the State Water Control Board of Virginia are using the model to study the dispersal and diffusion of pollutants.
- VIMS projects a series of tests to study distribution of simulated plankton in the estuarine portion of the James.
- The Corps of Engineers plans to use the model to conduct tests relating to spoil disposal and other projects.

The Virginia Institute of Marine Science is the state's official research, service, and education center in marine science and engineering. Main facilities are at Gloucester Point on the York River across from Yorktown.

USE COORDINATED BY VIMS AND CORPS

The operational responsibility for the Commonwealth's interests in the James River Hydraulic Model was assigned to VIMS by the General Assembly with the concurrence of the Virginia Marine Resources Commission. The model is now a facility of the Institute, and its use is coordinated by formal agreement between VIMS and the Corps of Engineers.

To get full benefit from the model, VIMS and WES have made its uses available to qualified private industries, political subdivisions, state and federal agencies, and scientific institutions. Since a heavy demand is expected, certain conditions have been imposed to maintain an orderly and productive operation–as follows:

1) All use–state, city or county, public or private–must be cleared through VIMS.

2) Schedules will be established by VIMS through consultation with the prospective users and the Corps.

3) Copies of all data resulting from use of the model will be forwarded to VIMS as it is generated. This includes raw data, sem-digested data, and reports of results.

4) All costs of modification, special verification, use, and reporting of model work will be borne by the user. The Commonwealth assumes no responsibility or liability for results.

5) Public users, especially federal and state agencies, will have priority over private users.

6) Studies that will help solve problems of interest to Virginia will also be given assigned preference where possible.

CHECK LIST OF ACTUAL OR POTENTIAL MODEL USES

[ ] Verifying field studies of the physical processes of the tidal James River

[ ] Improving capability of hydraulic models.

[ ] Developing suitable mathematical models of estuarine and fresh water portions of tidal tributaries.

[ ] Serving as an educational tool for training future estuarine and marine scientists and engineers.

[ ] Determining physical and, indirectly, biological influence of the various tidal tributaries such as Nansemond, Elizabeth, Pagan, Warwick, and Chickahominy Rivers.

[ ] Obtaining "before and after" views of the effects of navigation projects on the physical structure and function of the lower estuary.

[ ] Experimenting with alternate navigation routes and various channel depths–for example, the old channel at Burwells Bay

[ ] Determining effects of upstream changes of river flow – for example, by dam or reservoir construction and operation.

[ ] Determining effects of other engineering projects on the river.

[ ] Determining release dates for impounded waters to maintain river flow and protect marine life from adverse salinity conditions.

[ ] Determining capacity of the estuary for receiving industrial and domestic wastes.

[ ] Determining paths of radioactive or other contaminants if introduced into the estuary.

[ ] Assisting in determination of effects of sewage outfall locations on seafood production and recreational uses on the river–for example, Warwick River Outfall.

[ ] Conducting water outfall and intake studies to prevent recirculation of wastes in plant processing systems.

[ ] Determining ability of the estuary to provide cooling water for industry without serious ecological effects.

[ ] Selecting proper sites for nuclear power plants to reduce environmental hazards.

[ ] Selecting best location and design of terminals, piers, and seawalls.

[ ] Conducting "before and after" studies of siltation resulting from activities along the river.

[ ] Selecting proper sites and times to carry out spoil disposal operations.

[ ] Choosing best places to plant shells for oyster repletion programs.

[ ] Planning for suitable future uses of the tidal James.

[ ] Others