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DISCUSSION REPORT
FOR
HYDROGRAPHIC AND CURRENT SURVEY

S.A. Kirchhefer

Unpublished Manuscript

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Hydraulics Division

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PREFACE

This report was undertaken by Dr. Kirchhefer at my request to initiate discussion as to the most efficient deployment of men and equipment for the field studies in the Detroit - St.Clair Rivers.

T. M. DICK

March 1974

SUMMARY

This report investigates the geometry, hydraulics and operational needs with respect to containing oil spills in the Detroit and St. Clair Rivers. The studies indicate that only a few locations may be suitable to trap oil. Consequently, hydrographic and current surveys may only be required at certain locations.

RÉSUMÉ

Ce rapport examine la nécessité, aux plans géométrique, hydraulique et opérationnel, de contenir les nappes d'huile dans les rivières Detroit et Sainte-Claire, D'après les études effectuées sur cette question, on ne peut contenir ces nappes qu'à quelques endroits. Par conséquent, les études hydrographiques et de courant ne seront nécessaires que dans certaines zones.

DISCUSSION REPORT

FOR

HYDROGRAPHIC AND CURRENT SURVEY

OBJECTIVE

This paper outlines briefly, for discussion and planning purposes, a proposed strategy for the Hydrographic and current survey and other units involved in implementing the means to combat an oil spill on the St. Clair and Detroit Rivers.

1. Problem

1.1 Time Lapse

Any contingency plan requires time to react and to mobilize man and materials. The time elapsing will obviously vary with the situation. Factors are: the time of day when the spill occurs, the time taken for the information to reach persons able to initiate action and, the time to deploy the boom.

During this time, the spill will be moving downstream with the strong current. It is evident, therefore, that major oil trapping stations should not be located too far upstream.

1.2 Hydraulic

Flow velocities in the rivers are generally high, making deployment of oil booms and capture of oil slicks difficult; the forces on the booms are very great and, in addition, pose problems for work boats. Available information on currents and study of charts permits the tentative selection of a few possible sites where success is more likely attainable.

1.3 Shore Access and Storage

Because of the strong current, rapid deployment of oil spill control material is essential. Consequently, equipment and material must be stored at accessible sites on the shore and, moreover, these locations must be close to those locations suitable for hydraulic reasons.

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2. Parameters Affecting the Location of Booms

2.1 Average Travel Speed

The average slick travel speed is defined as the velocity at which spilled oil drifts downstream and is assumed to be equal to the surface current.

The calculations of average flow velocities in the river are based on data given by the Laboratory Technical Report by N.L. Crookshank and the U.S. Army Corps of Engineers.

In the St. Clair River, the average velocities vary from 0.6 to 0.75 m/sec. for a minimum discharge of 2,800 m^3/sec. and increase up to 2.0 m/sec. for a discharge of 8,500 m^3/sec. The difference of daily water surface elevation was recorded to be 0.9 to 1.40 m.

Similar flow conditions are encountered in the Detroit River where the velocities are slightly lower, ranging from 0.5 to 1.50 m/sec.

(a) Transverse Velocity Variation

Due to variations in depth across the bed, lower velocities are found near the banks and maximum velocities in deeper parts of the river. In the present case, the cross-sections of the rivers are sensibly prismatic and the average velocity in the main channel is assumed to be 10% higher than the average velocity in the rivers.

(b) Vertical Velocity Variation

The surface velocity is usually 10% to 20% higher than the average flow velocity. In the present case (average depth of the river = 10.0 m., roughness ≃ 0.2 cm.), an increase of 10% is estimated according to the theory by Rouse*.

Consequently, the travel speed of spilled oil in the main channel, owing to river speeds, ranges over the values in Table 1.

ST. CLAIR RIVER		DETROIT RIVER	
Discharge		Discharge	
Minimum	Maximum	Minimum	Maximum
0.90 m/sec.	2.40 m/sec.	0.60 m/sec.	1.80 m/sec.

Table 1. Range in Surface Velocities

* Hunter Rouse, Engineering Hydraulics, Proceedings of the Fourth Hydraulics Conference, Iowa Institute of Hydraulic Research, June 12 - 15, 1949.

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2.2 Reaction Time

The reaction time is defined as the time elapsed between the cause of the oil spill (tanker collision, valve failure) and the complete installation of the oil trapping device and may be approximated as follows:

			Minimum Time
(a)	Observation (at day time)	:	20 min.
(b)	Information to man in charge	:	10 min.
(c)	Contacting men and driving to the site of installation	:	30 min.
(d)	Installation and alignment of barrier, skimmer, etc.	:	60 min.
	Total	:	120 min. = 2 hours

Assuming that trained men and necessary equipment (boat, etc.) are available at any time, and that the weather conditions are favourable, a minimum reaction time of two hours is estimated.

2.3 Forces Acting on Booms

The magnitude of forces acting on a boom is governed by the flow conditions and the projected area of the submerged part of the structure. Considering the change of momentum of the flow yields:

$$F = C_D \sigma A U^2$$

where,
- F = force [N]
- σ = mass of water per cubic metre [kg/m^3]
- A = projected area (length x depth) [m^2]
- U = flow velocity [m/sec.]
- C_D = drag coefficient

For the St. Clair and Detroit Rivers, the minimum projected length of a barrier is about 400 m. Assuming further a submerged depth of 0.60 m and a maximum velocity of 1.0 m/sec. (maximum for hydraulic reasons) yields a force acting on the downstream direction of the structure of about 25 tons. The actual stress in the anchor chain depends, of course, on the design of the mooring system (number of chains, angle between chain and flow direction) but it is evident that substantial anchors will be required.

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3. Possible Areas for Boom Installation

3.1 St. Clair River

Shipping accidents causing major oil spills could take place anywhere in the river or adjacent lakes. The scene of accident and the derived parameters, such as reaction time and average travel speed, determine the suitable site for boom installation.

(a) Oil Spill in Lake Huron

Containment of oil spills in the lake by means of installed barriers is ineffective because the flow velocity piling up the oil at the barrier is approximately zero. However, spills occurring in the lake near the course of the river could be treated further downstream. Employing the figures for reaction time and average travel speed, the distance for the first structure is calculated:

REACTION TIME	Average Travel Speed		Distance	
	Minimum	Maximum	Minimum	Maximum
= 2 Hours	0.90m/sec.	2.40 m/sec.	6,500 m	17,300 m

In practice, this means that there is little point in installing a barrier upstream of Stag Island (see Figure 1).

(b) Oil Spill in the St. Clair River

For the section of the river downstream from Stag Island to cross-section 22-11, a suitable location for an oil trap depends very much on the prevailing flow velocity. Considering that boom devices at the present standard are effective only to a maximum velocity of 0.6 to 0.9 m/sec., there is no guarantee for successful boom operation in the deep water section of the river.

Another solution is the installation of oil booms in areas near the banks. Those areas may have lower flow velocities and are indicated in Figure 1 at points "A", "B", "C". Floating barriers, for example, could be used to guide drifting oil in the strong current towards those relatively calm locations.

In the delta region (from cross-section 22-11 to Lake St. Clair) where the river divides into several channels, lower flow velocities and mooring forces are suspected. Possible areas for boom installation are marked in Figure 1 at points "D", "E", "F".

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3.2 Detroit River

A similar situation as described above is encountered in the Detroit River. For the region between Lake St. Clair and cross-section 8-23 in Figure 2, the estimated reaction time and travel speed permit the following calculations of the travel distance:

REACTION TIME	Average Travel Speed		Travel Distance	
	Minimum	Maximum	Minimum	Maximum
= 2 Hours	0.60 m/sec.	1.80 m/sec.	4,300 m	13,000 m

Except for minimum discharges, the flow velocity also exceeds the maximum velocity, allowing satisfactory boom operation.

In the case of an oil spill in Lake St. Clair, near the river course, the first reasonable location for a barrier is downstream of Bell Island (see Figure 2, point "G").

Further downstream, cross-section 8-23 to Lake Erie, the river branches into several channels which probably reduces the flow velocity and, consequently, the mooring forces. Possible stations are at points "H", "I", "J".

3.3 Near Bank Collection Booms

The flow velocity near the bank is less than in the shipping channel and may allow effective use of oil barriers. Preferable locations are close to the potential source of spills since the oil tends to spread due to surface tension. A permanent installation of barrier, skimmer, etc., would be advisable.

4. Boom Operation in the Presence of Ice Floes

Typical ice booms are not able to withstand ice forces. If ice is running in the river, the forces will be too high unless the booms are made very heavy. Therefore, in the presence of ice floes, collection and control of oil spills should take place in Lake St. Clair or Lake Erie by means of floating barriers.

5. Recommendations

Possible locations for trapping oil, which were chosen under consideration of suitable river geometry and lower flow velocities, are shown in Figure 1

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at points A, B, C, D, E, F and in Figure 2 at points G, H, I, J. The development of an oil spill control scheme, however, necessitates additional information.

(a) Detailed hydrographic and current survey should be concentrated at the sites suggested, based on confirmation that shore access is likely for deployment of structures and oil removal equipment.

(b) Hydraulic studies should look into permanent deployment of structures directing surface currents away from banks. Forcing major oil spills to stay off shore could minimize the cost for bank clean-up.

(c) Hydrographic and current survey strategy ought to be discussed at a one-day workshop organized by coordinators at an early date.

(d) Survey of shore access to be undertaken immediately.

S. KIRCHHEFER

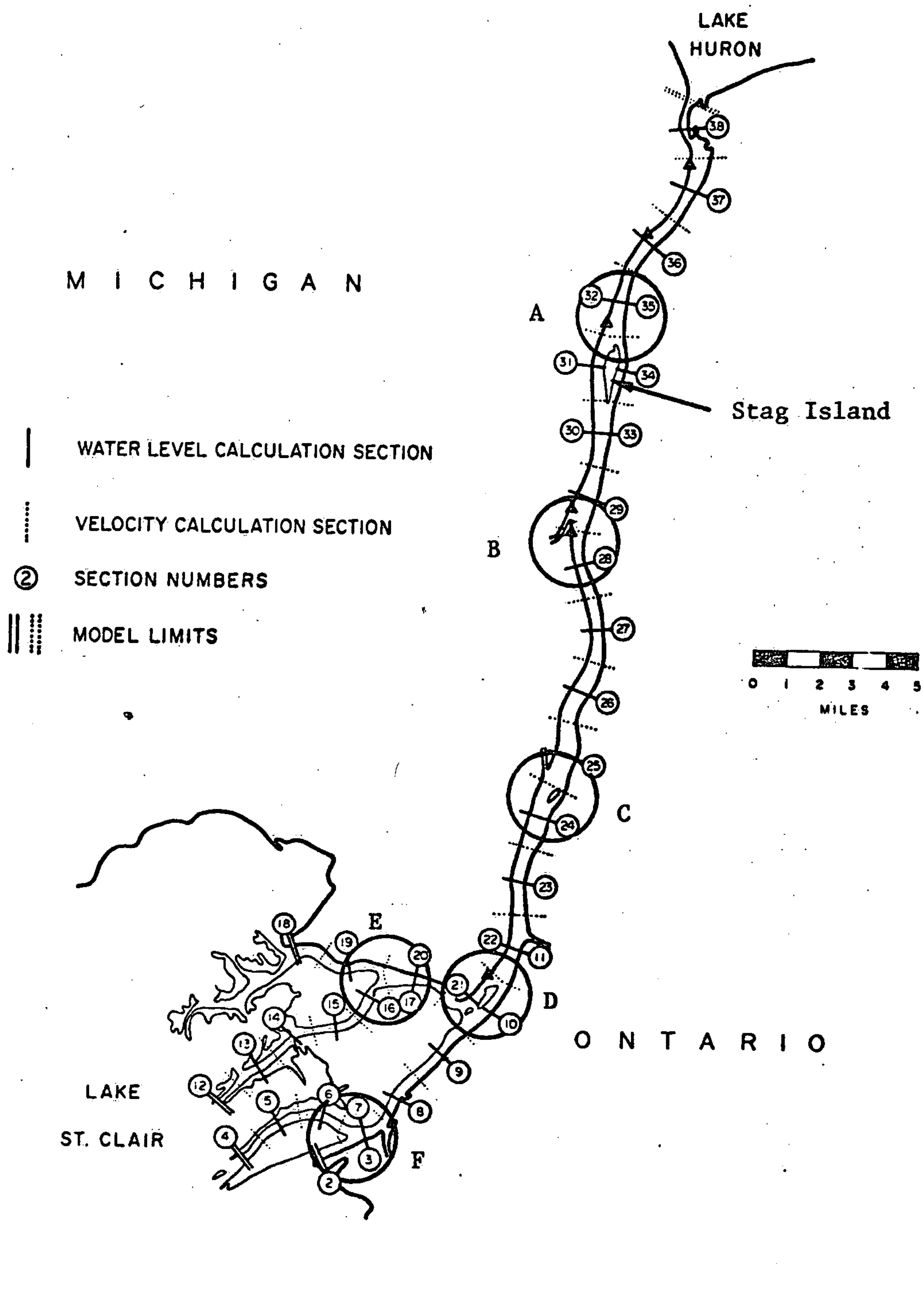

FIG.1 ST. CLAIR RIVER SECTION LOCATIONS
(from: "Containment of Oil Slicks on the St. Clair and Detroit Rivers, by N.L. Crookshank)

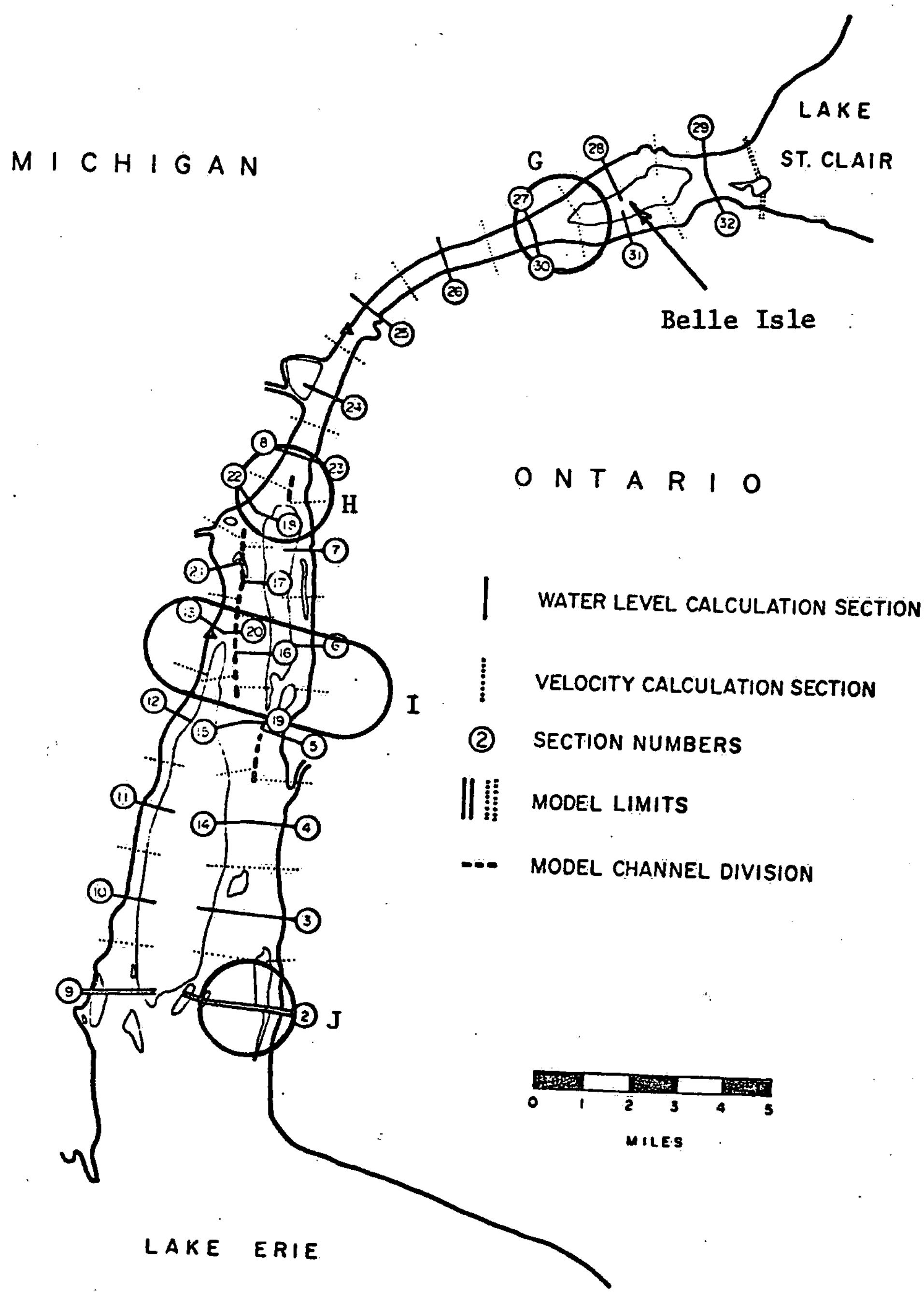

FIG. 2 DETROIT RIVER SECTION LOCATIONS

(from: "Containment of Oil Slicks on the St. Clair and Detroit Rivers" by N.L. Crookshank.)