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Tracy Experimental Laboratory Facilty Investigations:

Leaky-Louver Development Preliminary Results

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by

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Tracy Experimental Laboratory Facility Investigations: Leaky-Louver Development Preliminary Results

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Executive Summary

- Louver-line orientation influenced louver-line velocity distributions. For all angles tested, velocities (sweeping and normal components) increased from upstream to downstream along the louvers. However, the 15° louver skewed velocity distributions the most and the 45° orientation the least. As expected, this effect diminishes with increased louver spacing since a larger louver spacing represents a smaller flow resistance.
- Louver spacing also influenced louver-line velocity distributions. Smaller louver slat spacing produced greater non-uniformity due to increased resistance to flow.
- Analyses of 35 fish release/recover experiments conducted at 15°, 30°, and 45° straight-line louver arrays (side bypass) with 2-, 4-, and 6-inch slat spacings suggest larger fish may be more effectively separated from smaller fish with the 30°, 2-inch configuration. However, further verification of these findings is needed.

Objective
To determine the leaky-louver configuration (louver angle, spacing, and orientation) that best separates large and small fish (i.e., diverts fish >6 in and passes smaller fish).

Introduction
Reclamation is actively investigating ways to improve operations and salvage efficiency at the existing facility (TFCF) and to assist with the design of the new experimental facility (TFTF). One element under development is a leaky louver to separate large and small fish (i.e., divert larger fish to one holding system while passing smaller fish to a second holding system). Predation is known to occur at the current facility and separation and removal of larger predatory fish is desirable.

Test Facility Description
The Tracy Experimental Laboratory Facility in Denver was constructed in 1998 to evaluate louver-bypass characteristics in an attempt to improve screen efficiency at the TFCF and to assist with design of the new TFTF. The laboratory model is a full-width, ½-depth representation of the secondary louver channel at the TFCF. The physical dimensions are 10-ft wide, 80-ft long, and 4-ft deep. The maximum discharge capacity is 40 ft^3/s with average channel velocities ≤ 2.5 ft/s. A single louver line was modified (and guide vanes

removed) to test the leaky-louver concept. To date, we've tested 15°, 30°, and 45° louver arrays with 2-, 4-, and 6-inch slat spacings. Louver slats were oriented perpendicular to the flow.

Methods

Hydraulic

Velocity was measured in the approach channel and along the louver array. Approach channel velocities were measured at three cross sections upstream of the louvers and included three profiles taken at 0.25, 0.5, and 0.75 ft depths. The louver-line velocities were measured at 9 stations along the louvers about 4 in upstream of the louver at 0.25, 0.5, and 0.75 ft depths (Figure 1). Velocities were read with a 3-Dimensional Acoustic Doppler Velocimeter (ADV). Table 1 provides the louver configurations and hydraulic characteristics for the initial series of tests.

The model was operated to achieve average channel velocities ranging from 2.0-2.5 ft/s by adjusting the flow depth. The target flow depth was 2.0 ft. The target bypass velocity ratio of 1.2 was achieved by adjusting the bypass discharge to obtain the desired bypass entrance velocity.

Biologic

All leaky-louver experiments were conducted in the dark with fish that had been acclimated to flume water for at least 24 hours. A minimum of 3 releases were conducted for each louver configuration (specifically, 15° 2-inch, 15° 4-inch, 15° 6-inch, 30° 2-inch, 30° 4-inch, 30° 6-inch, 45° 2-inch, 45° 4-inch, 45° 6-inch). A mixture of large and small fish were included in each release. A large fish efficiency (#large fish in holding tank/(#large fish in holding tank + #large fish in sieve net))and small fish efficiency (#small fish sieve net/(#small fish holding tank + #small fish sieve net)) were calculated. Fish that remained in the channel were excluded from these efficiency calculations. Underwater strobe lights were used to help move the fish through the channel. The effectiveness of these lights will be addressed in a separate document.

Results and Discussion

Hydraulic

The primary indicators for louver hydraulic performance were approach channel velocity and louver-line velocity distributions. Approach channel velocity profiles were not influenced by louver-line orientation, however, louver-line velocity distributions were. Furthermore, louver spacing influenced louver-line velocity distributions.

Figures 2-7 represent the louver-line velocity distributions for each louver spacing and correspond to the three louver-line orientations tested. The louver-line velocity distributions are plotted from upstream to downstream. The three readings at each station are shown (i.e., locations 1-3 represent velocities at 0.25, 0.5, and 0.75 ft depths at the first or upstream most measurement station along the louvers). Velocity distributions were similar for each louver orientation. In each case, both sweeping and normal component velocities increased from upstream to downstream along the louvers which shows the non-uniformity in velocity distributions along angled louvers of this type.

The orientation of the louver structure tends to push more flow toward the bypass and produce higher velocities and consequently greater head loss near the bypass entrance. However, the magnitude of this increase is reduced with increased louver spacings. This results from increased louver hydraulic efficiency (or decreased overall headloss) with increasing louver spacing when guide vanes are not used. Guide vanes are currently used at the TFCF to improve uniformity of the louver velocity distribution.

Figures 5-7 show the data for each louver orientation at the three louver spacings. There was a significant change in louver velocity distribution with changes in louver-line orientation. The 15° orientation skewed velocity distributions the most and the 45° orientation the least. As expected, this effect diminishes with increased louver spacing since a larger louver spacing represents a smaller flow resistance. Smaller approach angles skewed velocity distributions along the louver array.

Biologic

A total of 35 fish release experiments were conducted in February and March, 2000. In general, the leaky louver design was moderately successful for fish > 6 inches and very successful for smaller fish (Tables 2 and 3). The 4- and 6-inch spacing designs allowed almost twice as many large striped bass to pass through the louvers compared to the 2-inch design and thus were determined to be too "leaky". Therefore, we recommend the 2-inch spacing.

There was no statistical difference among the 15°, 30°, and 45° 2-inch screen tests (ANOVA, P=0.4459). However, the 15° screen was rejected from further study because of logistic problems associated with an automated rake cleaner system. The 45° screen was also rejected because of the reduced sweeping velocity component as compared to the 30° screen. Consequently, we recommend the 30°, 2-in louver array as most favorable, but emphasize that further verification of these findings is needed.

The next series of leaky-louver tests will focus on evaluating a mechanical crowder, then a combination of the crowder with the strobe lights (the strobe lights will be tested under field conditions in the next 3 months). Following this, we will continue to evaluate various leaky-louver configurations including variable slat spacing and orientation, alternating areas with and without guide vanes, curved and straight-line louver configurations, and center and side bypasses.

Table 1. Summary of hydraulic characteristics for the louver configurations tested February-March, 2000.

Louver angle	Slat spacing (in)	Q_{ch} (ft^3/s)	D_{ch} (ft)	V_{ch}* (ft/s)	Q_{bypass} (ft^3/s)	D_{bypass} (ft)	V_{bypass} (ft/s)	Bypass ratio	V_{ch}** (ft/s)
15°	2.00	36.30	2.07	2.00	2.60	1.94	2.68	1.34	2.05
	4.00	36.20	1.96	2.11	2.60	1.93	2.69	1.28	2.05
	6.00	35.90	1.86	2.21	2.50	1.80	2.78	1.26	2.30
30°	2.00	36.30	2.12	1.96	2.60	2.06	2.52	1.29	1.98
	4.00	36.37	1.87	2.22	2.57	1.83	2.81	1.26	2.30
	6.00	36.42	1.70	2.45	2.45	1.63	3.01	1.23	2.48
45°	2.00	36.41	2.29	1.82	2.70	2.30	3.10	1.15	1.84
	4.00	36.40	1.85	2.25	2.5	1.82	2.28	1.01	2.27
	6.00	36.43	1.78	2.34	2.47	1.73	2.14	0.92	2.42

* -Average channel velocities computed using measured discharge and flow depth.
**-Average channel velocities computed using channel velocity measurements.

Table 2. Summary of fish release recapture experiments for fish <6-inch (150 mm) total length.

Louver angle	Slat spacing (in)	Number of experiments	Rainbow trout % passing through louvers (range)	Striped bass % passing through louvers (range)	Splittail % passing through louvers (range)
15°	2.00	3	78.3 (75-80)	75.6 (66.6-88.8)	83.8 (80-85.7)
	4.00	4	82.2 (77.7-85.7)	87.9 (75-100)	87.4 (77.7-100)
	6.00	4	77.5 (50-100)	--	91.3 (87.5-100)
30°	2.00	7	85.4 (66.6-100)	84.5 (66.6-100)	85.6 (62.5-100)
	4.00	3	93.3 (80-100)	77.7 (66.6-100)	89.2 (77.7-100)
	6.00	3	73.8 (50-100)	83.3 (50-100)	90.9 (80-100)
45°	2.00	5	91.6 (66.6-100)	73 (40-100)	89 (80-100)
	4.00	3	72.2 (50-100)	68.3 (25-100)	96.6 (90-100)
	6.00	3	58.3 (0-100)	87.7 (80-100)	81.2 (63.6-100)

Table 3. Summary of fish release recapture experiments for fish >6-inch (150 mm) total length.

Louver angle	Slat spacing (in)	Number of experiments	Rainbow trout % louvered into holding tanks (range)	Striped bass % louvered into holding tanks (range)
15°	2.00	3	60.9 (40-66.6)	32.5 (25-40)
	4.00	4	43.6 (14.3-66.0)	13.9 (0-25)
	6.00	4	26.3 (11.1-42.8)	31.7 (30-33.3)
30°	2.00	7	24.4 (0-40)	53.2 (14.3-75)
	4.00	3	22.2 (0-66.6)	37.9 (25-55.5)
	6.00	3	5.5 (0-16.6)	30 (12.5-40)
45°	2.00	5	41.6 (33.3-50)	49.6 (33.3-83.3)
	4.00	3	37.5 (0-75)	23.7 (10-50)
	6.00	3	100 (100)	11.8 (0-30)

Flume length - 80 ft
Flume width - 10 ft
Flume depth - 4 ft
Bypass width - 0.5 ft
Max discharge - 40 ft^3/s
Channel velocities - 0-2.5 ft/s

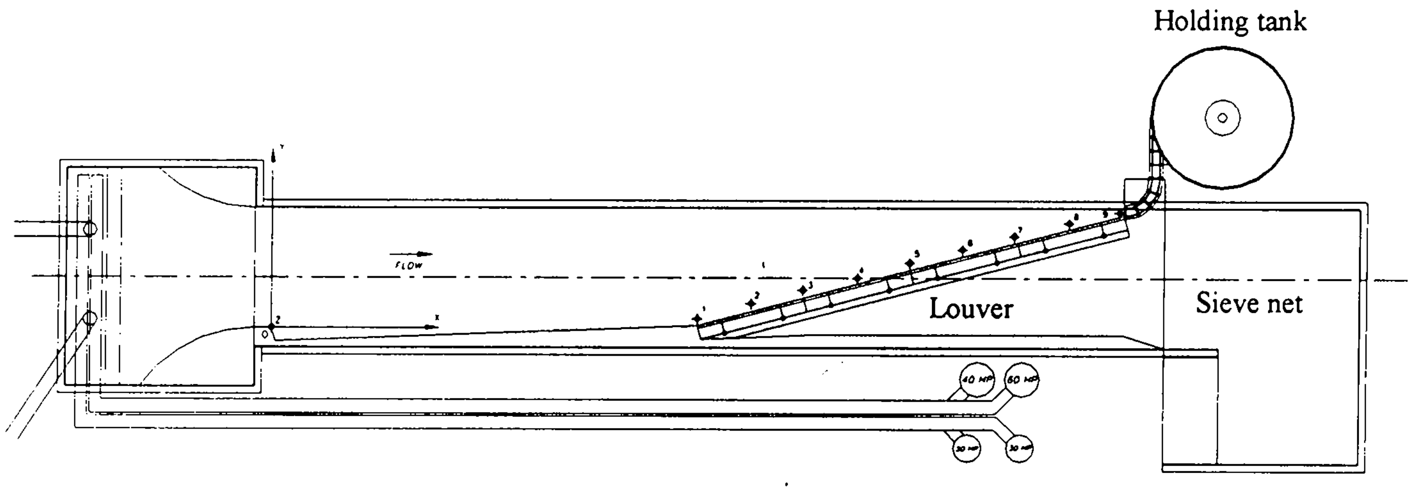

Figure 1. Schematic of the Tracy Experimental Laboratory Flume.

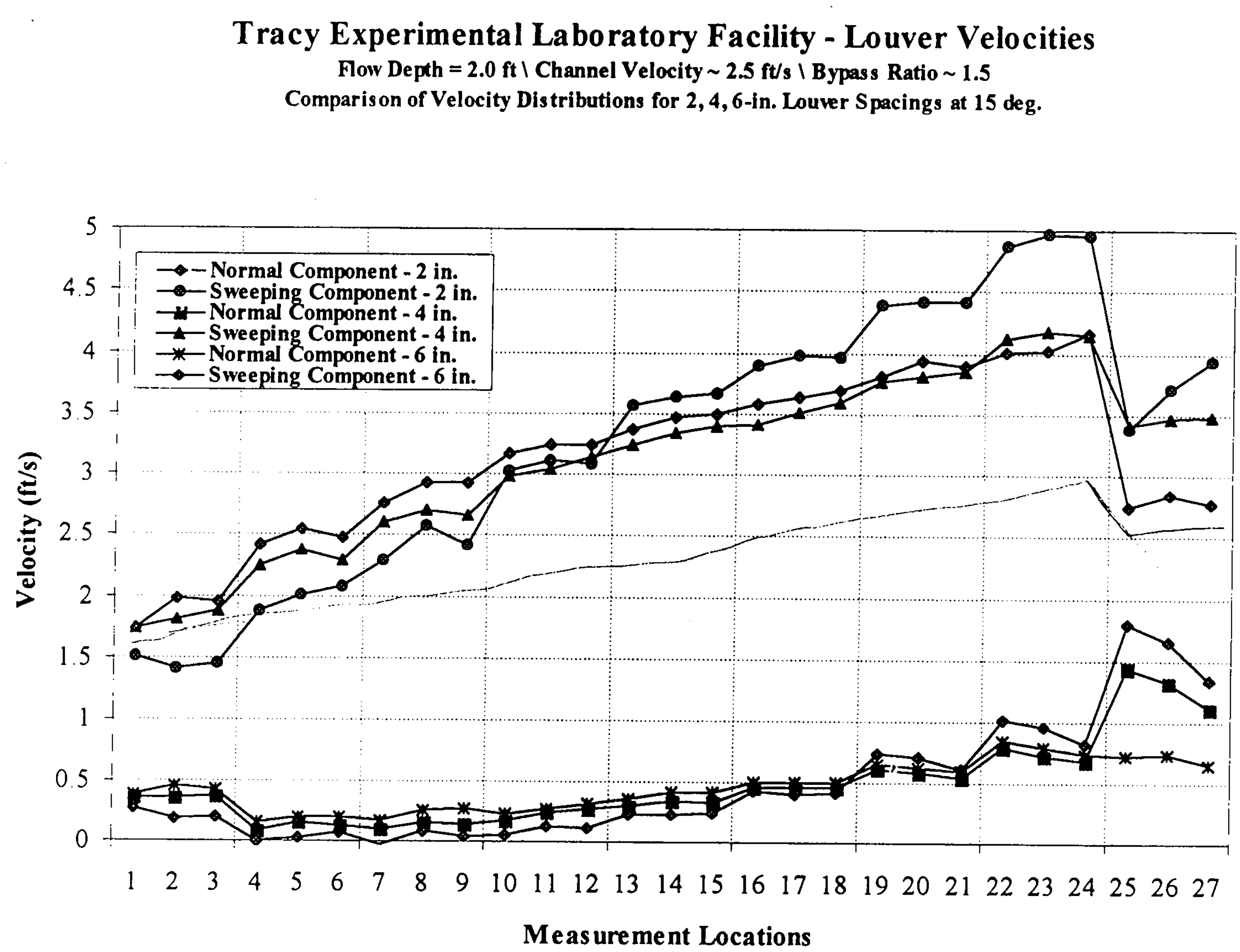

Figure 2. - Comparison of louver velocity distributions for louver spacings of 2, 4, and 6-in. at a louver angle of 15 degrees.

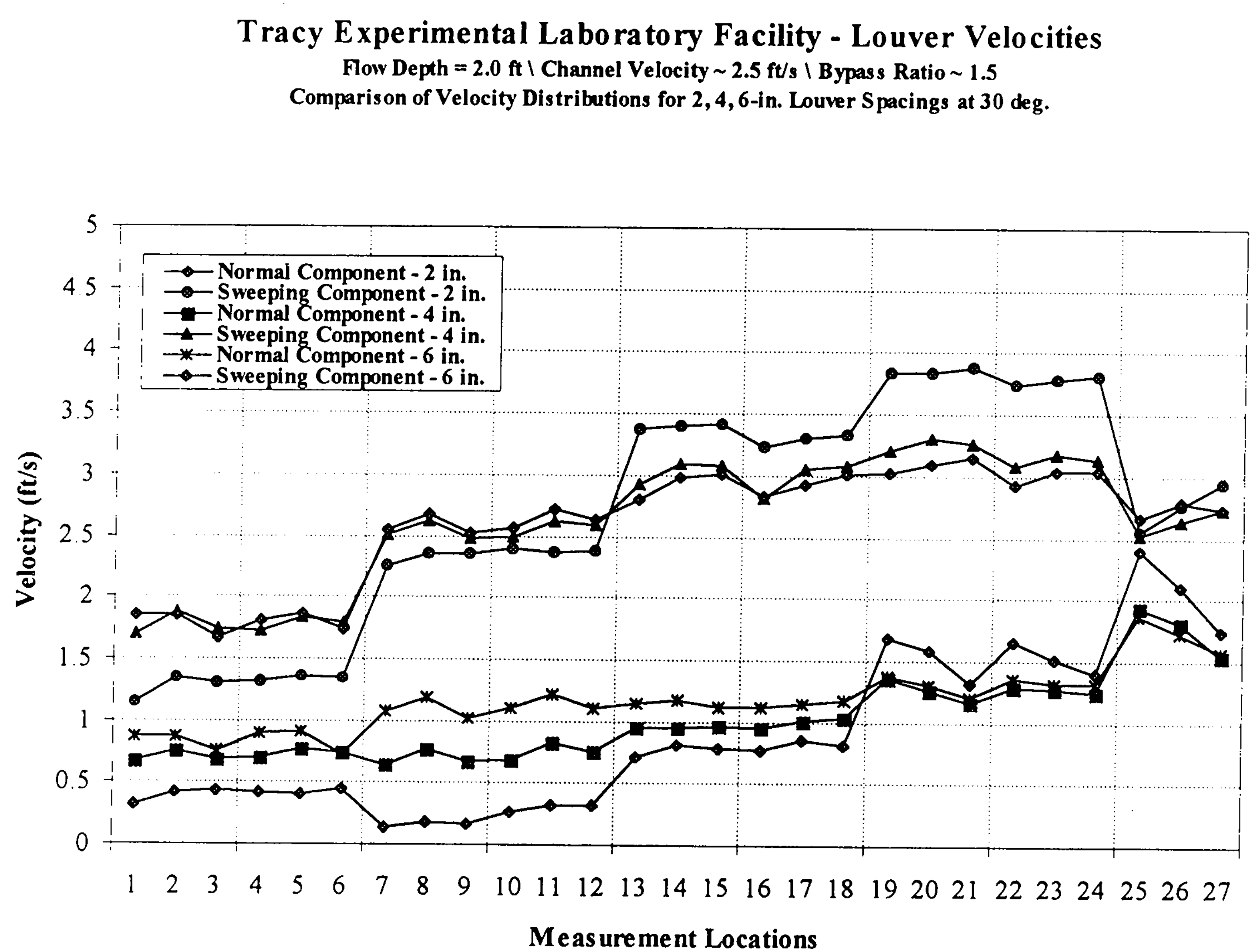

Figure 3. - Comparison of louver velocity distributions for louver spacings of 2, 4, and 6-in. at a louver angle of 30 degrees.

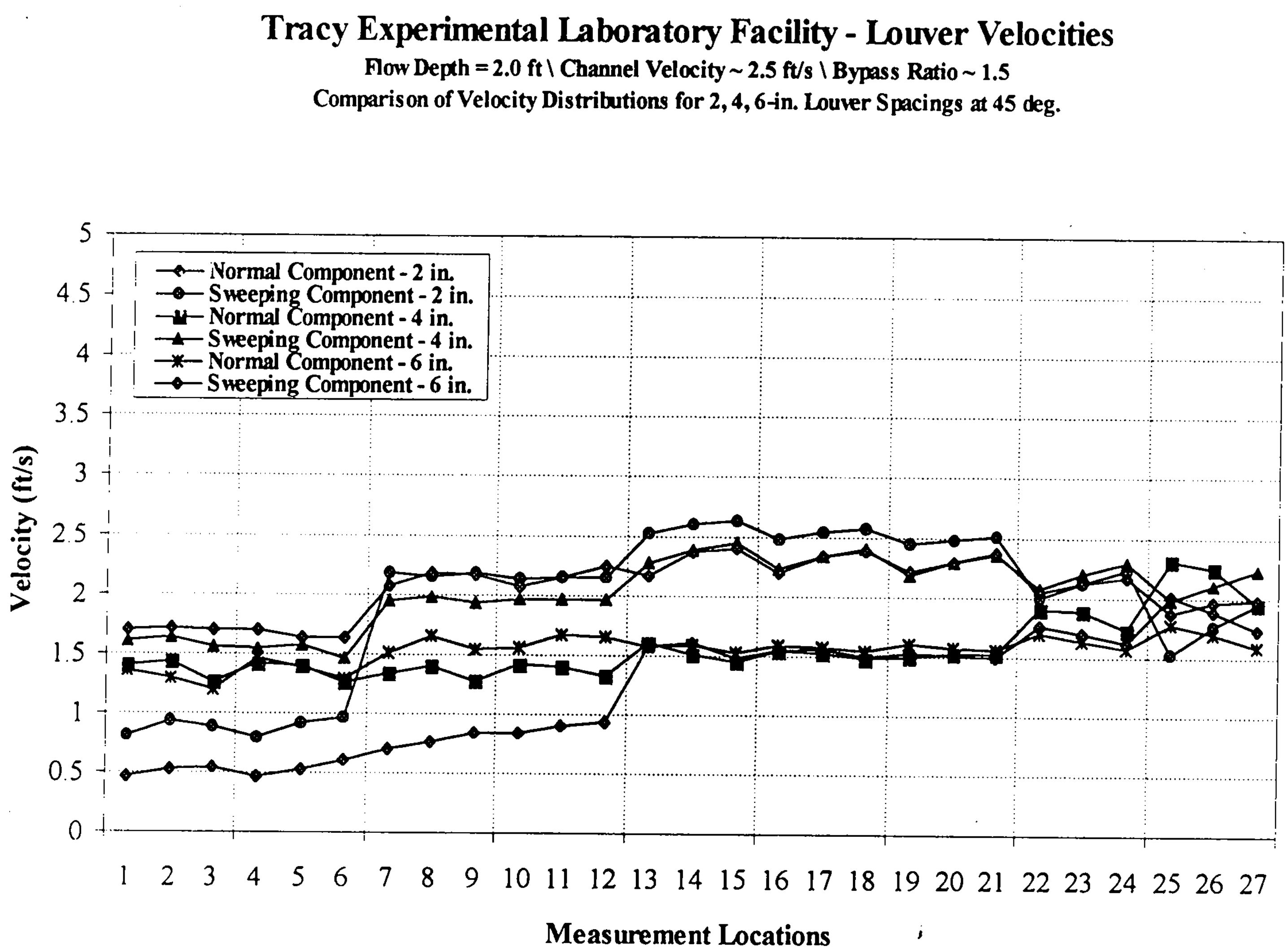

Figure 4. - Comparison of louver velocity distributions for louver spacings of 2, 4, and 6-in. at a louver angle of 45 degrees to approach channel.

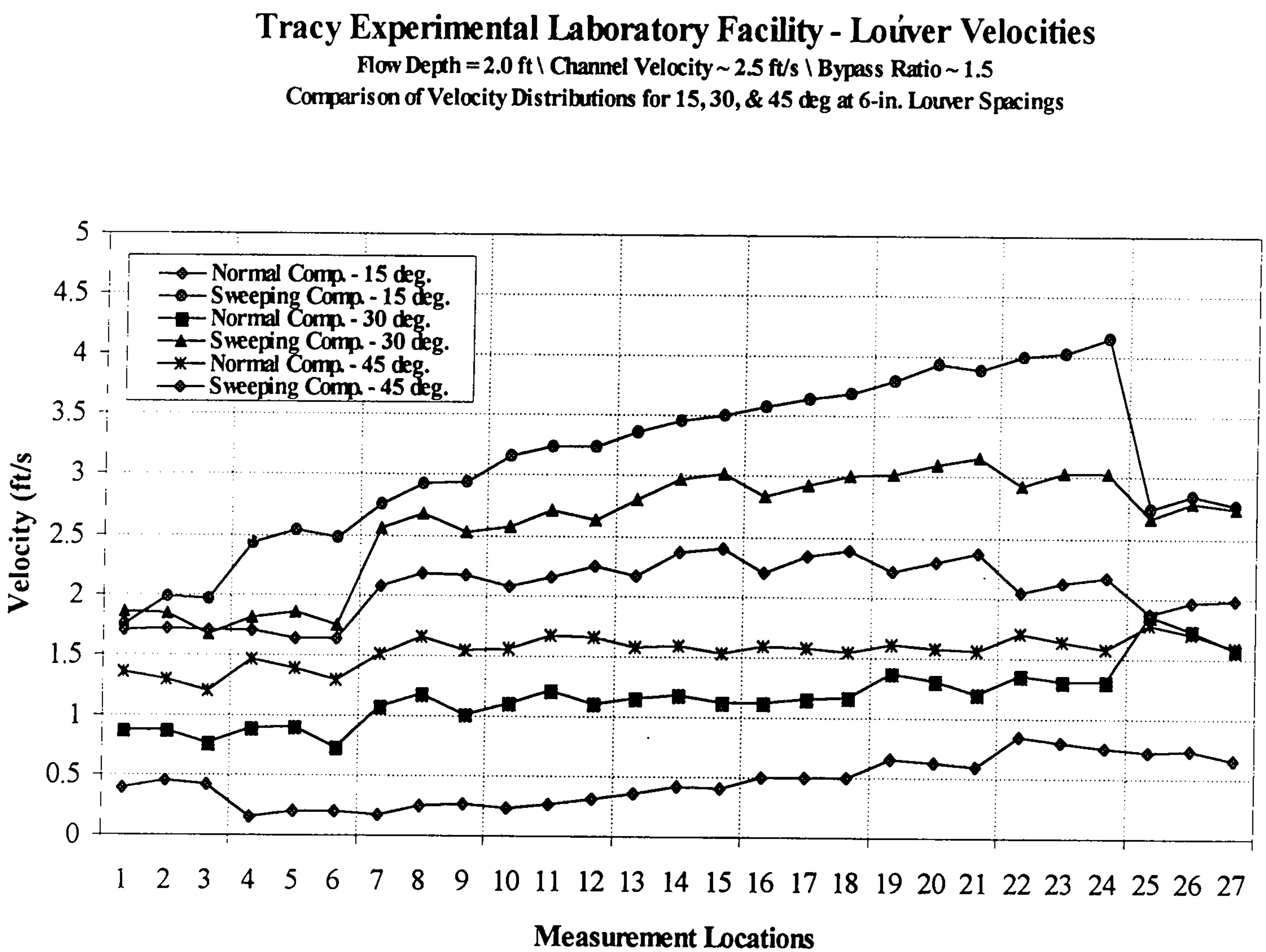

Figure 5. - Comparison of louver velocity distributions for louver angles of 15, 30, and 45 degrees at a louver spacing of 6 in.

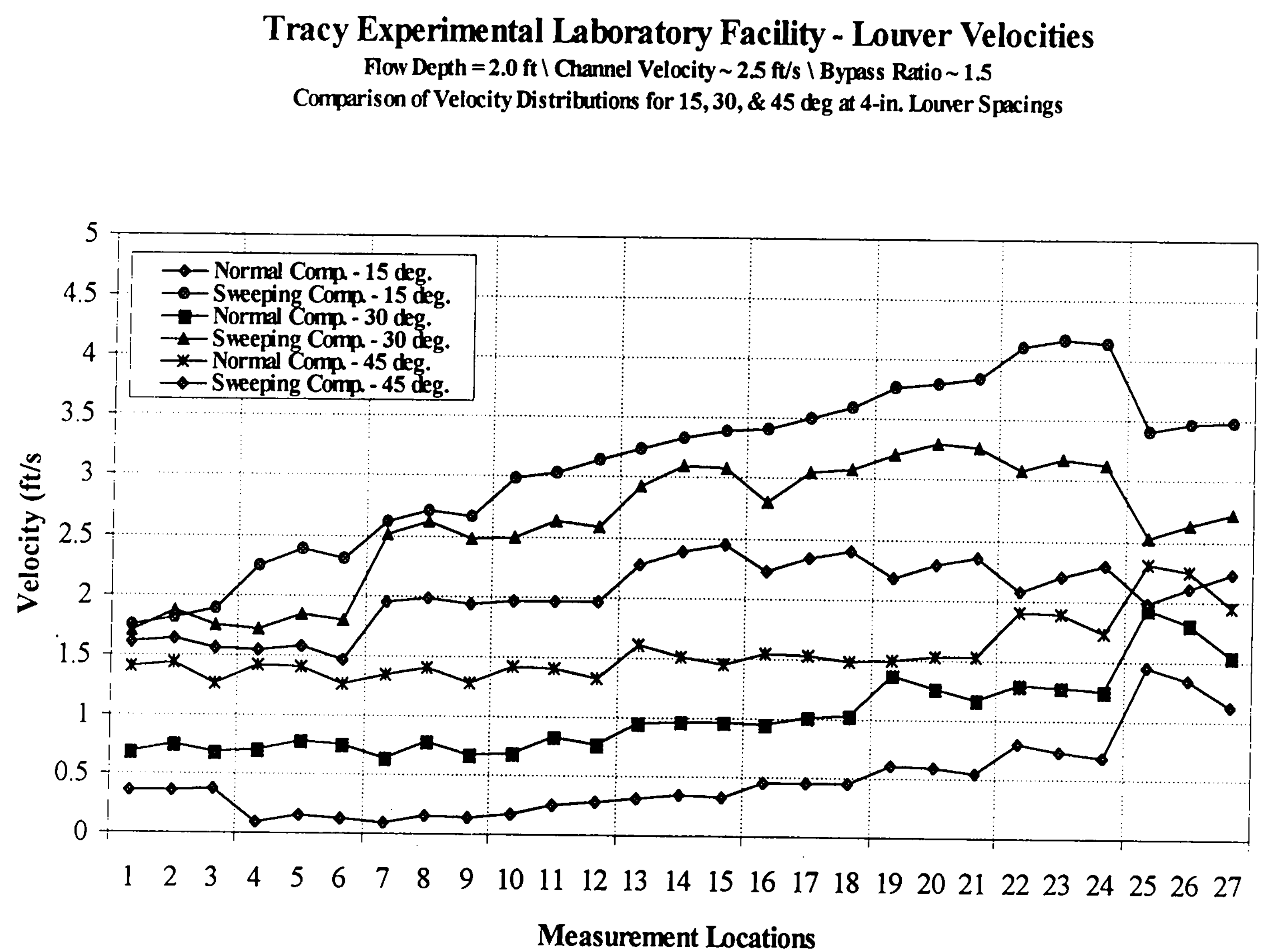

Figure 6. - Comparison of louver velocity distributions for louver angles of 15, 30, and 45 degrees at a louver spacing of 4 in.

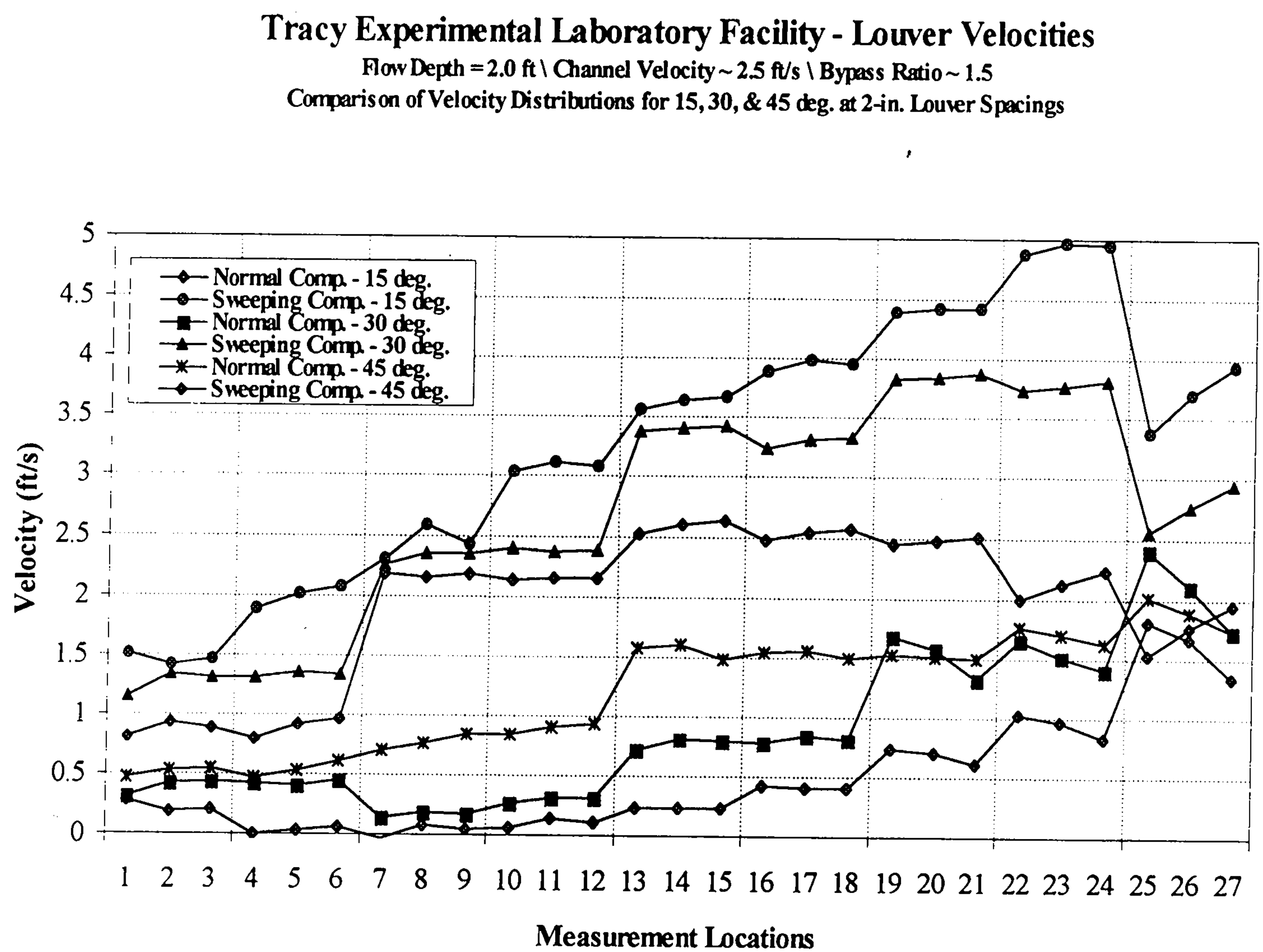

Figure 7. - Comparison of louver velocity distributions for louver angles of 15, 30, and 45 degrees at a louver spacing of 2 in.

PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

Project Name Tracy Experimental Laboratory Facility Investigations: Leaky-Louver Development Preliminary Results WOID TRFHV

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REVIEW CERTIFICATION

Peer Reviewer - I have reviewed the assigned Items/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: Diana Weigmann, Group Manager (D-8290)

Review Date: 04/13/00 Signature: Diana Weigmann

Preparer - I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Members: ______________________ Date: __________
Signature

______________________ Date: __________
Signature