Acoustic Doppler Current Profiler (ADCP) Measurements of Velocity Fields on Upper Klamath Lake Approaching the A-Canal Intake

by Tony Wahl and Tracy Vermeyen (D-8560)

BACKGROUND

A-Canal withdraws water from Upper Klamath Lake just upstream from the Link River Dam to serve the Klamath Project in south-central Oregon and northern California. The canal entrains juvenile and adult fish of two endangered species of lake suckers—the Lost River sucker and the shortnose sucker. A Biological Opinion originally issued in 1992 by the U. S. Fish & Wildlife Service identified Reasonable and Prudent Alternatives (RPA) requiring Reclamation to reduce entrainment of individuals of both species.

One alternative for reducing sucker entrainment into A-Canal is the construction of a positive barrier fish screen facility at the headworks of A-Canal. To support engineering evaluation of this alternative, staff from the Water Resources Research Laboratory (WRRL) headquartered in Denver collected velocity data on Upper Klamath Lake in the vicinity of the headworks using an ADCP on three dates during 1998. These data will provide designers with information about velocity fields approaching the headworks under a variety of operating conditions, which will be useful for identifying potential locations and layouts for a screen structure. The data will also be used by the WRRL for calibration and operation of a physical hydraulic model of the proposed screen structure in the laboratory in Denver. This model study will be carried out as part of the design process.

DATA COLLECTION

Data were collected using an RD Instruments broadband ADCP, operated from a moving boat. The ADCP uses the Doppler shift principle to measure velocities along four acoustic beams projected downward below the moving boat. The instrument sends out a precise acoustic signal and then listens for backscattered acoustic signals reflected off of acoustic scatterers in the water column (e.g., suspended sediment). The Doppler shift of the backscattered signal is proportional the velocity of the scattering particle. The beams diverge both longitudinally and laterally as shown in figure 1, so that the velocity reported by the instrument is the average of measurements made along each of four different acoustic beams, rather than a measurement at a single point beneath the instrument. Individual velocity measurements are made within discrete vertical depth cells, or bins, with a height of 25 centimeters each, yielding a velocity profile from near the surface to near the bed. Velocities cannot be measured very near the surface because the transducer must be submerged and because there is some time delay between the send and receive modes of operation for the instrument. Velocities also cannot be measured very near the bed (approximately the last 10 percent of the depth) due to a phenomenon called side-lobe interference. Three orthogonal components of velocity are measured, and internal compass and tilt sensors allow the velocities to be referenced to the Earth coordinate system (east/north/up). In addition to the velocity data, the ADCP records the bathymetry along the transect. One ping in each measurement ensemble is used to track the motion of the ADCP relative to the channel bottom using the same Doppler shift technique used to measure velocity. This measurement allows the water velocity measurements to be corrected for the relative boat motion, and permits tracking of the position of the instrument during the transect. A laptop computer was used to configure the ADCP and collect the data. A portable global positioning system (GPS) was also connected to the laptop computer so that continuous GPS data were recorded simultaneously with the velocity data. The GPS was also used to record waypoints at the beginning and end of each transect. Total time required to record about 15 to 20 transects was typically 2 to 4 hours. We did not make any attempt to use the same transect lines on the three different dates, but rather just tried to cover the area of interest in approximately the same level of detail each time.

The ADCP used for this work was a 1200 kHz system loaned to us by the USGS-Biological Resources Division in Ft. Collins, Colorado. We used the power supply and mechanical mounting equipment for the WRRL's ADCP, which has 300 kHz and 600 kHz transducer heads. The USGS's 1200 kHz unit has improved depth resolution for shallow-water applications.

Velocity data were collected on three dates, under three different operating conditions, as summarized in table 1. In addition to differences in lake level and A-Canal flowrate, the flow through the spillways, outlets, and power penstocks at Link River Dam is significant because it must pass by the A-Canal headworks, thus influencing the velocity field in the vicinity of the intake.

Table 1. — Hydraulic conditions during ADCP data collection efforts.

Date	Upper Klamath Lake Elevation, ft	A-Canal Diversion Flow, ft^3/s	Flow Past Link River Dam, ft^3/s	Number of Transects
May 12, 1998	4143.08	355	4020	16
July 14, 1998	4142.66	1005	1460	22
Sept. 16, 1998	4140.20	1000	1373	14

The first two data collection efforts coincided with near-maximum reservoir water levels and relatively low and high ratios of withdrawal to bypass flow, respectively. In September the reservoir was drawn down and diversions into A-Canal were near the maximum values typically experienced during the late summer and early fall months. This was a very wet year in the Klamath Falls area, and the lake level stayed much higher than normal until late in the summer. The flow conditions on September 16 were set specifically for our data collection, with the A-Canal headworks being opened about 30 minutes prior to the beginning of data collection. Details of each data collection effort are contained in WRRL Travel Reports, TR-98-11, TR-98-16, and TR-98-21.

Figure 2 shows a general plan view of the area in which measurements were made. Features to note include the reef channel at the entrance of the Link River arm of the lake, the orientation of the A-Canal intake channel and headworks (labeled U.S.R.S. Canal in the figure), and the location of Link River Dam. Figure 3 shows the bathymetry of the lake in the vicinity of the A-

Canal headworks. The most notable feature is the relatively shallow area immediately downstream from the east abutment of the Lakeshore Drive bridge.

Figures 4, 5, and 6 show the ADCP transects along which data were collected on each of the three dates, with a dot indicating the starting point of each transect. Figure 4 also indicates the location of Link River Dam and the main body of Upper Klamath Lake relative to the area of interest. The transect locations were computed using the starting GPS waypoint for each transect and the subsequent relative movement computed by the bottom-tracking feature of the ADCP. The area covered by the transects was 8+ acres. The approximate channel boundaries and the location of the A-Canal headworks and the Lakeshore Drive bridge are shown on the figures. A few transects appear to extend beyond the channel boundaries or cross under the bridge, when in fact we did not cross under the bridge on any transect. These anomalies are likely due to errors in the GPS data for the transect starting points, or imprecision in the approximate channel boundaries shown on the figures. Tables A1, A2, and A3 summarize the GPS waypoints. The column for estimated horizontal error shows that most waypoints had an estimated error of a few meters, but a few have estimated errors on the order of tens or even hundreds of meters. This is probably the result of momentary loss of satellite coverage for the GPS unit. Three of the starting waypoints were adjusted (see notes to tables A1-A3) prior to creating figures 4, 5, and 6, in order to produce a better fit with the waypoint recorded at the end of the transect, or to produce a more realistic fit of the transect with the channel boundaries and location of the bridge and headworks structures. These adjustments were made with reference to notes and sketches of transect locations made as data were being collected. Large estimated horizontal errors do not always indicate an inaccurate waypoint reading; some of the transects with the largest estimated errors in the starting waypoint required no adjustment.

In addition to the raw velocity data, the ADCP computes the discharge across each transect line. This can be used as an indicator of data quality. Table 2 summarizes the discharges measured by the ADCP and compares them with the flows reported by the project for each day. The ADCP-measured flows are well within the expected accuracy range of the instrument.

VELOCITY DATA ANALYSIS

Figures 7, 8, and 9 show the horizontal velocity fields approaching the A-Canal headworks for the May, July, and September datasets. These figures were constructed using the depth-averaged velocities at each point on each transect; each vector is the average of the east and north velocities measured throughout the depth of the water column.

Each of the figures shows flow entering the A-Canal intake channel primarily from the south and southwest. The flow vectors point almost straight north along the east bank of the Link River arm of the lake, just south of the A-Canal intake. This effect is most pronounced in the September 16 data, when the canal withdrawal was near maximum and the lake level was 4140.20 ft.

Table 2. — Comparison of ADCP Measurements of Discharge

Date	Transect Description	Average ADCP Discharge (ft^3/s) and Number of Transects	Discharge Reported by Project, ft^3/s	Percent Difference
May 12	Across Link River Arm, Upstream from Headworks	4603 (9 transects)	4375	+5.2
	Across A-Canal Headworks	408 (2 transects)	355	+14.9
	Across Link River Dam, Downstream from Headworks	4257 (5 transects)	4020	+5.9
July 14	Across Link River Arm, Upstream from Headworks	2575 (12 transects)	2465	+4.4
	Across A-Canal Headworks	995 (3 transects)	1005	-1.1
	Across Link River Dam, Downstream from Headworks	1350 (7 transects)	1460	-7.5
Sept. 16	Across Link River Arm, Upstream from Headworks	2388 (6 transects)	2373	+0.6
	Across A-Canal Headworks	997 (4 transects)	1000	-0.3
	Across Link River Dam, Downstream from Headworks	1368 (4 transects)	1373	-0.4

Beginning at the upstream end of the reach in which measurements were made, in the May and July data (figs. 7 and 8) the location of the cutout channel through the reef at the entrance to the Link River arm is evident by the high velocities in portions of transect 15 (May) and transect 21 (July); data were not collected in this area during September. This acceleration of flow through the reef channel and the general right hand bend as the flow enters the Link River arm of the lake produces a flow concentration along the left bank (looking downstream) as the flow approaches the Lakeshore Drive bridge. As the flow passes through the bridge section, it continues in a southeasterly direction, rather than turning directly east to enter the A-Canal intake. This is caused by the momentum the flow has attained in passing through the bridge section, and the relatively shallow depths on the east side of the channel downstream from the bridge, which restrict the flow through this area. The effect is that the flow goes past the A-Canal intake, and finally turns back to the north and proceeds up the east side of the channel into the A-Canal intake. This has been described in the past by those familiar with the site as a large eddy causing flow to enter the A-Canal intake from what many describe as the downstream direction. The relative influence of momentum and channel bathymetry that produce this effect probably vary with different operating conditions. When flows past Link River Dam are high (e.g., May), momentum has a greater influence. When the lake level is reduced (e.g., September), the influence of bathymetry is increased.

The eddy line is quite apparent in figure 7 (May 12 data) by following transect 10 (see fig. 4 for transect numbers). This transect nearly follows the eddy line, as shown by near zero velocities along most of the transect. All three datasets show a region of poorly organized flow along a line beginning just south of the east abutment of the Lakeshore Drive bridge, and extending to the southeast.

These flow patterns have implications for a fish screen design at this site. For a fixed-plate screen to take advantage of sweeping flows toward Link River Dam, the screen would have to be located well out into the body of the Link River arm of the lake, beyond the eddy line apparent in figures 7-9. This would produce a very large and expensive structure. If a fixed-plate screen were located closer to the headworks, inside of the eddy line, then approach flows would actually be generally northward, flowing away from Link River Dam. It may be difficult in this case to meet sweeping velocity criteria. A V-oriented screen installed farther downstream in the throat of the intake channel might overcome this problem, but would require a more elaborate bypass system to return fish to the lake.

Plots of data from individual transects have been included as figures 10-15. Each of these figures shows the vertical variation of the east or north velocity component as a function of distance along the transect line. The figures are all constructed so that the zero of the horizontal axis is the beginning of the transect and the viewer is looking toward the A-Canal intake (refer to figs. 4-6 for further orientation). These figures illustrate the relatively shallow flow depth in the region south of the east bridge abutment, and the dramatic variation in flow direction and magnitude along the course of some of the transects. For example, figure 15 (transect number 16, collected September 16, 1998) shows that flow is northward toward A-Canal in a narrow region along the east bank, and southward toward Link River Dam on the west side of the channel. All of the figures show that there is little vertical variation in the velocity profiles, so the depth-averaging technique used to construct the vector plots (figs. 4-6) is appropriate.

CONCLUSIONS

The data collected between May and September 1998 do an excellent job of illustrating the flow conditions prevalent in the vicinity of the A-Canal intake. In general, flow approached the intake channel from the south, along the east bank Link River arm of Upper Klamath Lake. This effect was observed under all operating conditions studied in 1998. This observation has implications for the design of a fish screen structure at this site. The data presented here should be useful in the development of conceptual designs, and will also be used to establish appropriate boundary conditions in a future physical hydraulic model of the proposed fish screen structure.

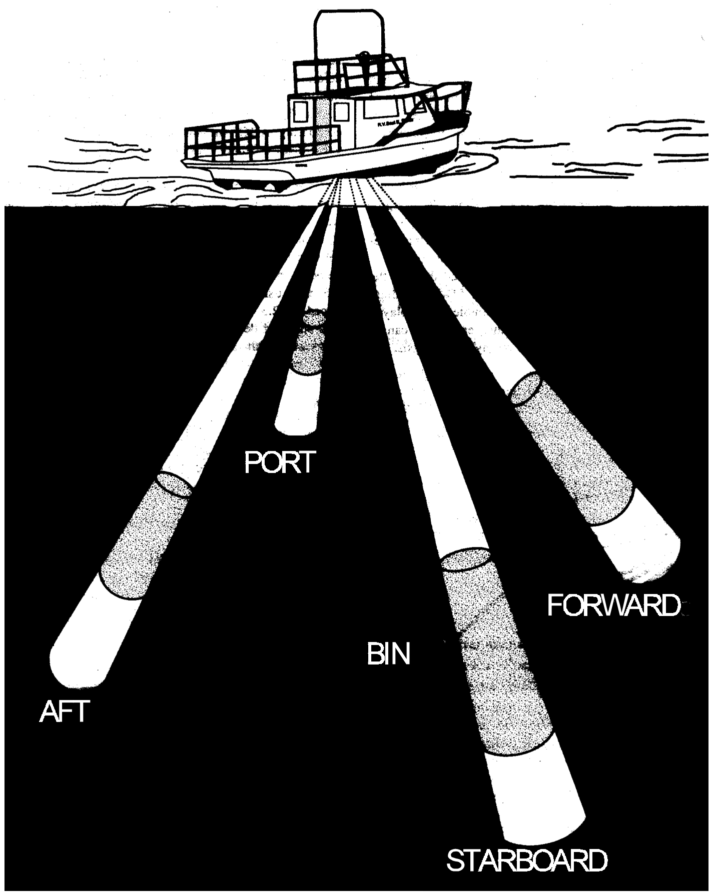

Figure 1. — Typical acoustic beam configuration for a boat-mounted ADCP.

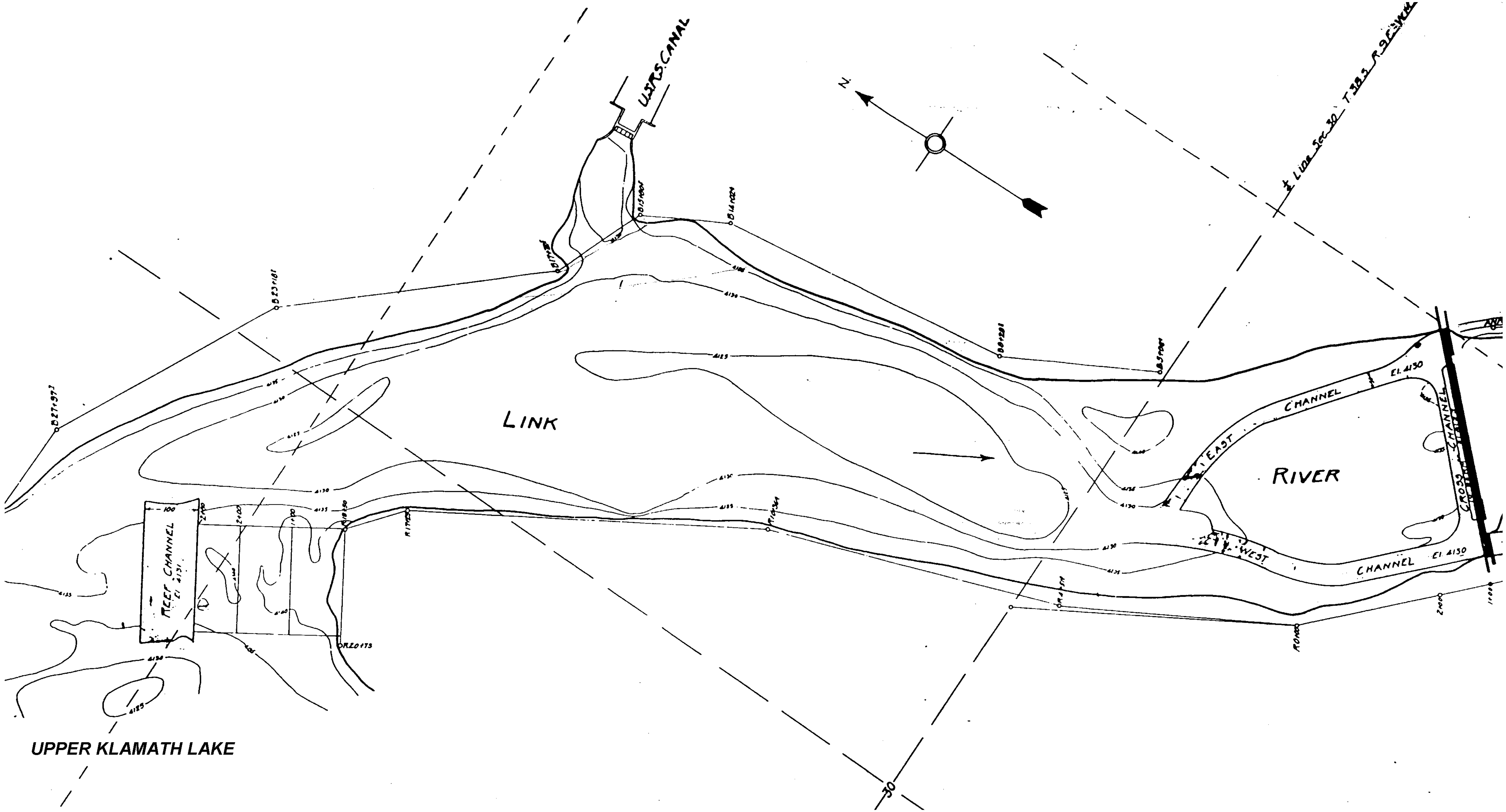

Figure 2. — Plan view of the Link River arm of Upper Klamath Lake showing the A-Canal headworks (at top, labeled U.S.R.S. Canal), Link River Dam, and the excavated reef channel.

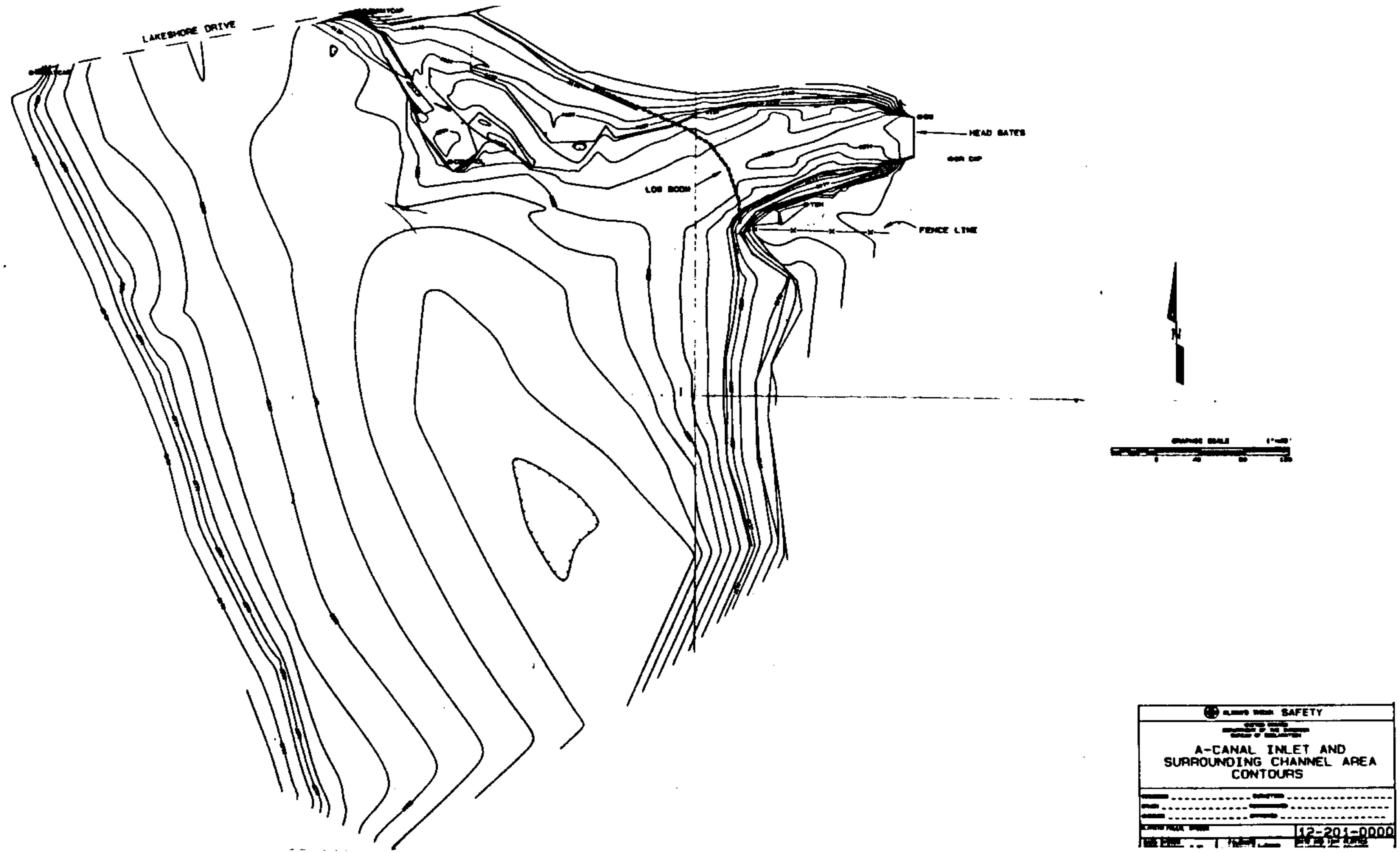

Figure 3. — Bathymetry of Upper Klamath Lake south of the Lakeshore Drive bridge, in the vicinity of the A-Canal headworks (upper right). Note the region of shallow depth immediately south of the east bridge abutment. Figure 2 shows this to be outside of the channel boundaries; it is in fact submerged at high lake levels, but there is little depth of flow.

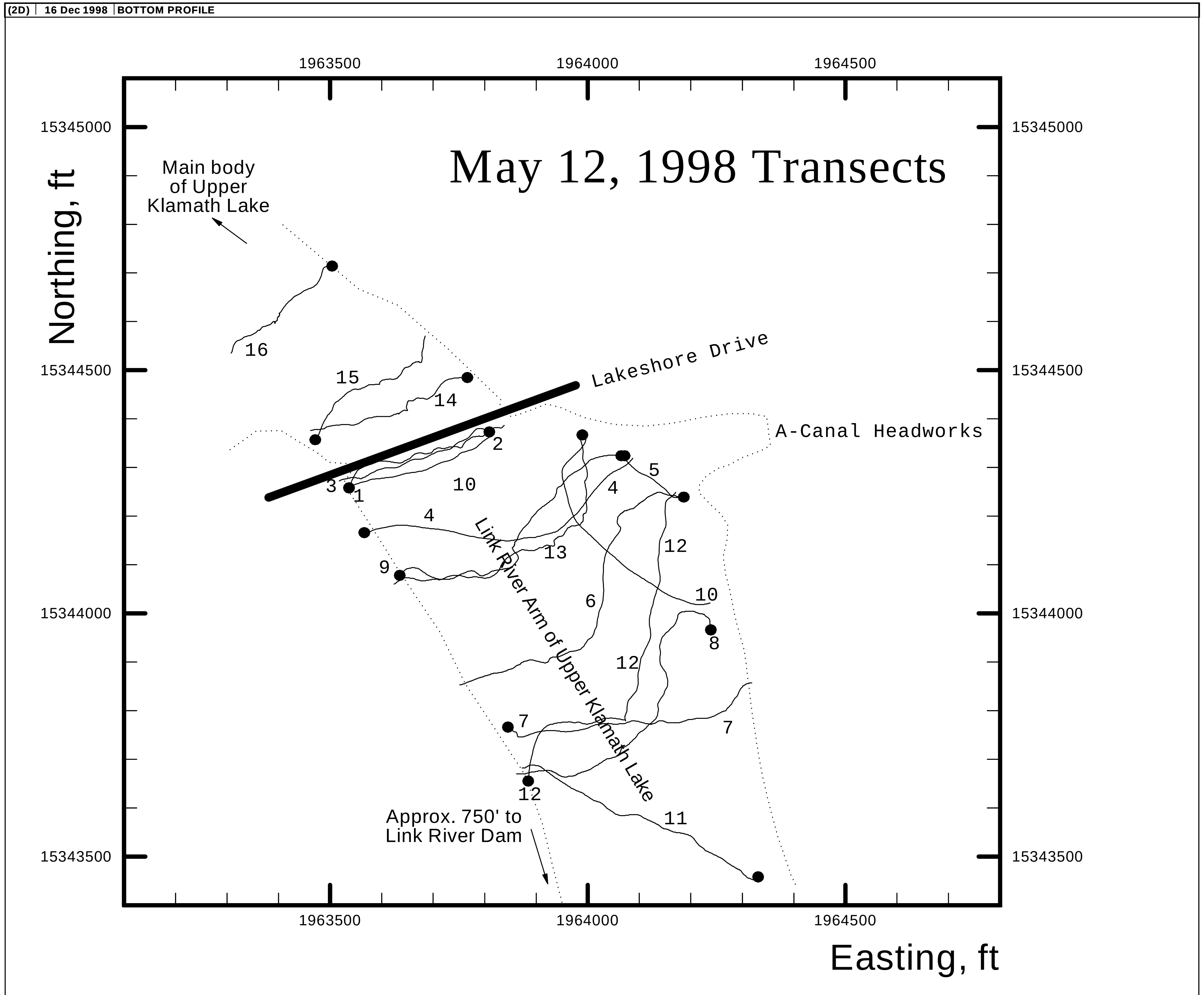

Figure 4. — ADCP transects collected May 12, 1998. Flow into A-Canal was 355 ft^3/s, and flow toward Link River Dam was 4020 ft^3/s. Upper Klamath Lake elevation was 4143.08.

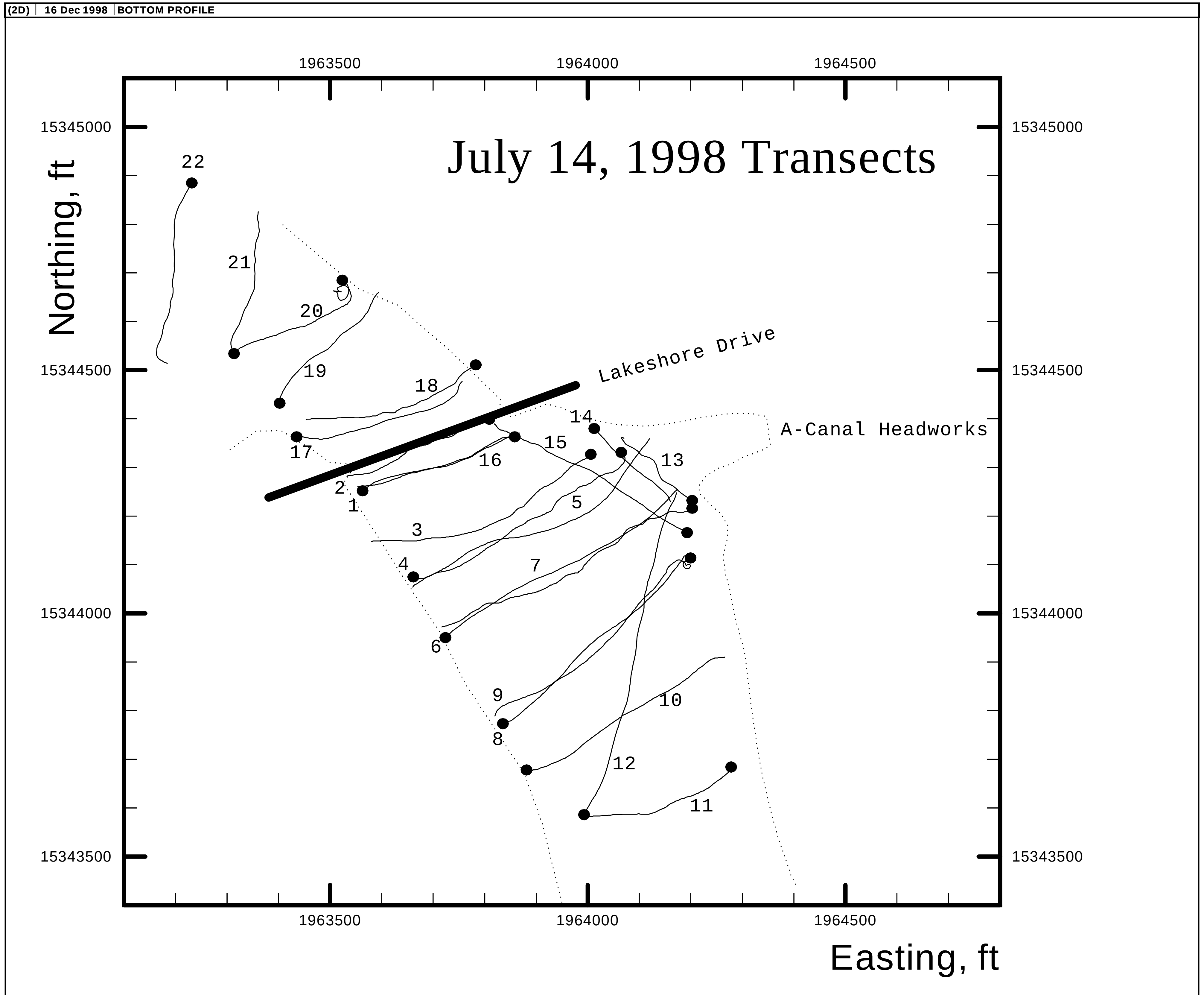

Figure 5. — ADCP transects collected July 14, 1998. Flow into A-Canal was1005 ft^3/s, and flow toward Link River Dam was1460 ft^3/s. Upper Klamath Lake elevation was 4142.66.

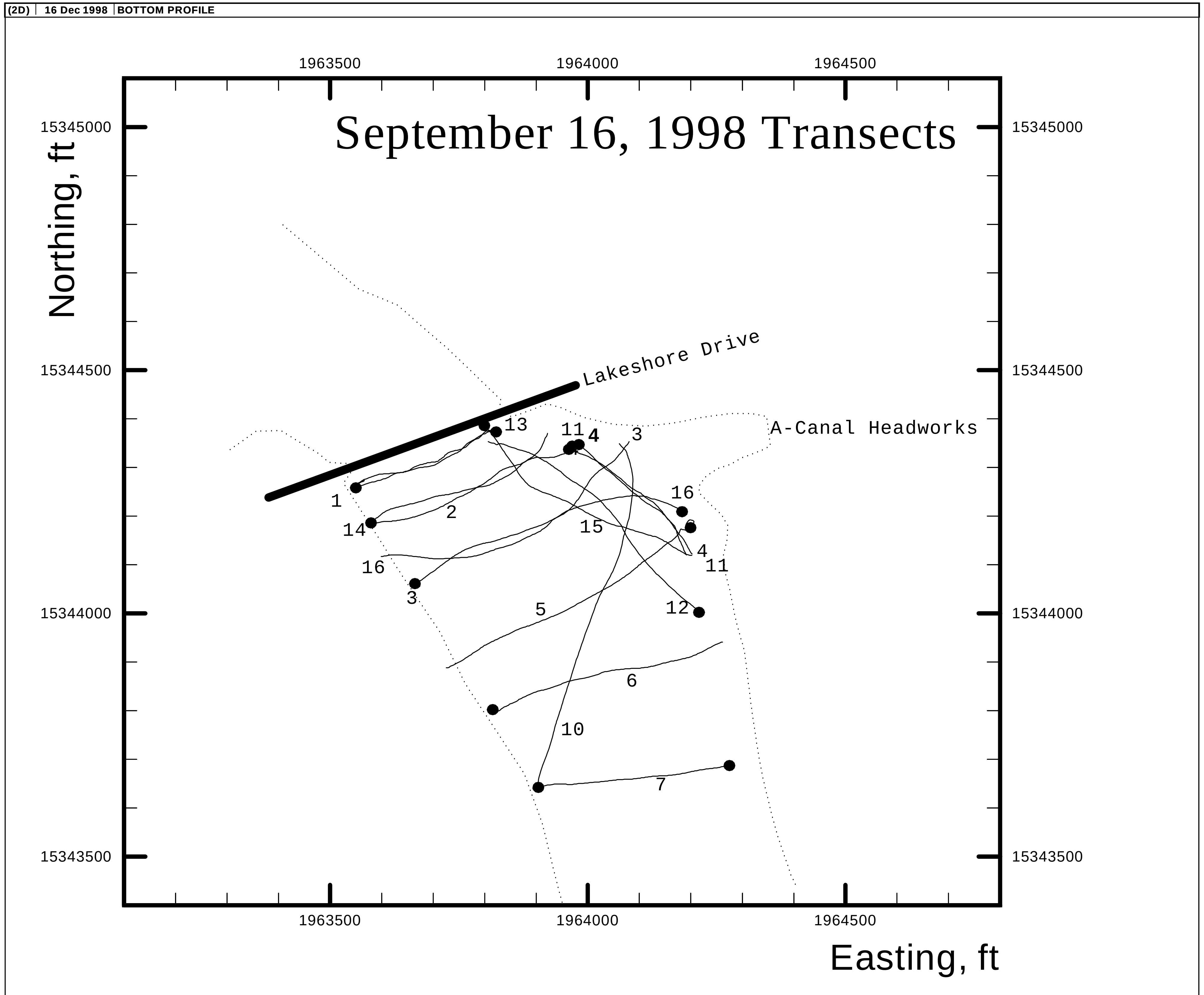

Figure 6. — ADCP transects collected September 16, 1998. Flow into A-Canal was 1000 ft^3/s, and flow toward Link River Dam was 1373 ft^3/s. Upper Klamath Lake elevation was 4140.20.

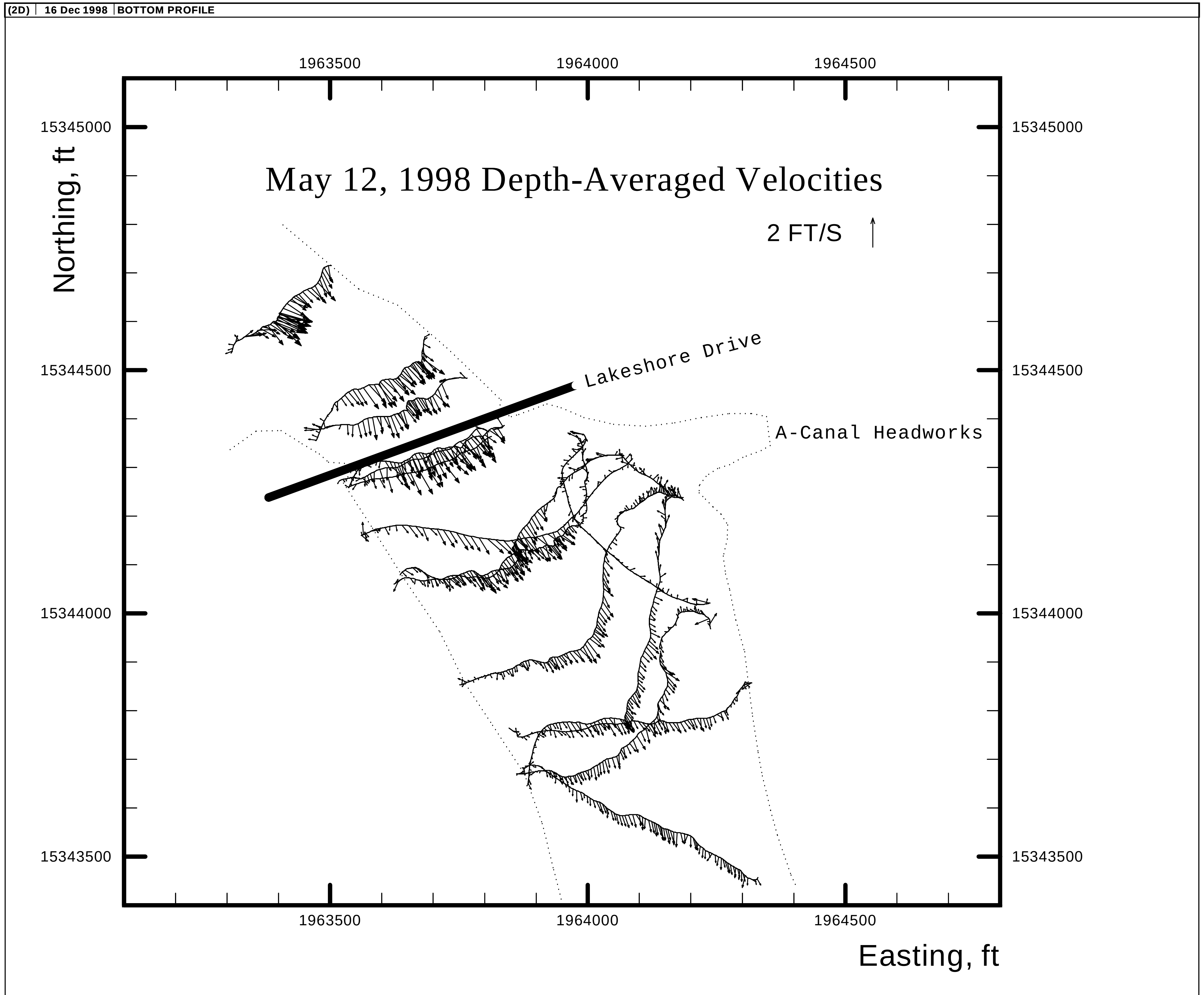

Figure 7. — Depth-averaged velocity vectors for ADCP transects collected May 12, 1998. Flow into A-Canal was 355 ft^3/s, and flow toward Link River Dam was 4020 ft^3/s. Upper Klamath Lake elevation was 4143.08. For clarity, vectors are shown for only each fourth data point along each transect.

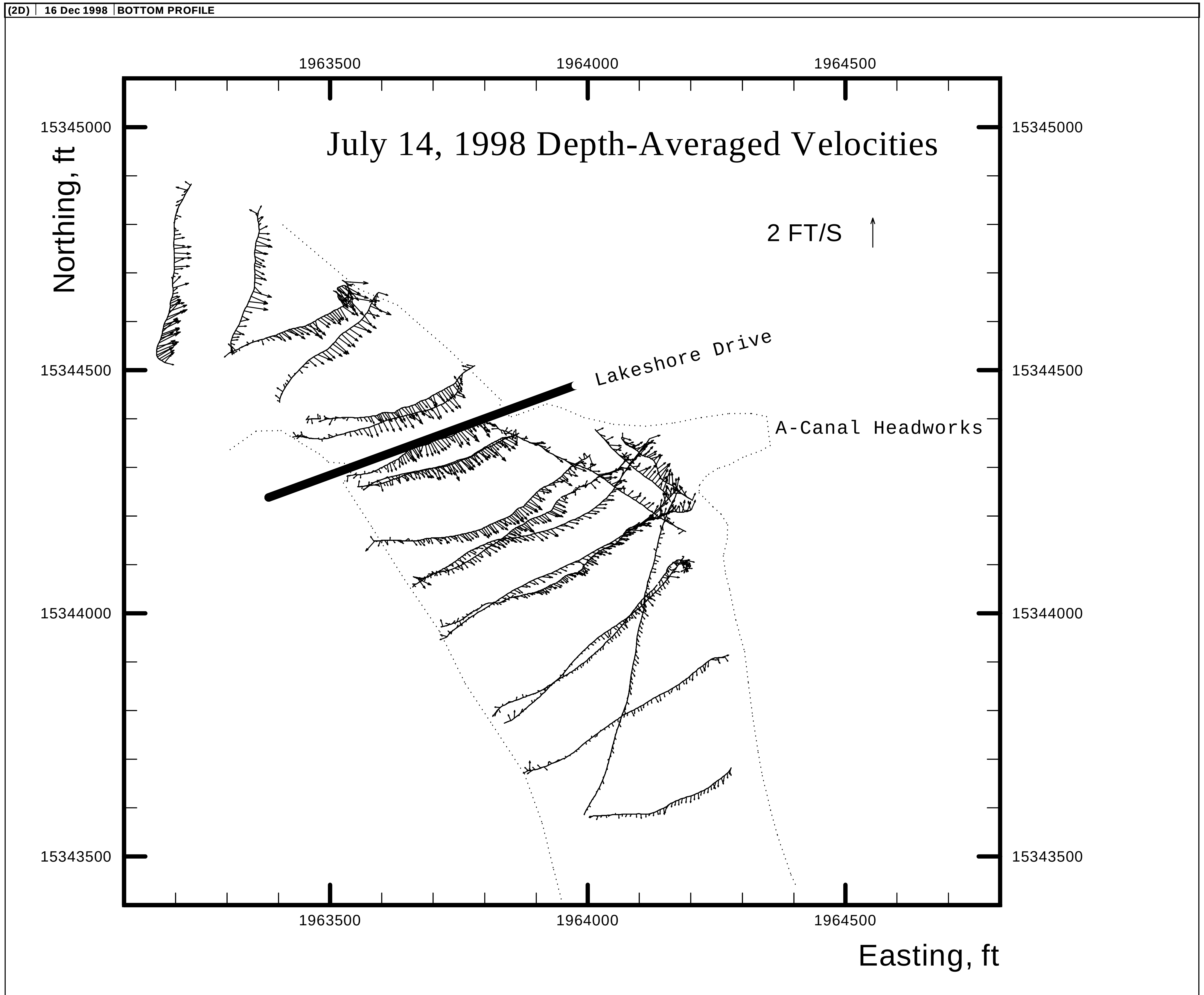

Figure 8. — Depth-averaged velocity vectors for ADCP transects collected July 14, 1998. Flow into A-Canal was1005 ft^3/s, and flow toward Link River Dam was1460 ft^3/s. Upper Klamath Lake elevation was 4142.66. For clarity, vectors are shown for only every other data point along each transect.

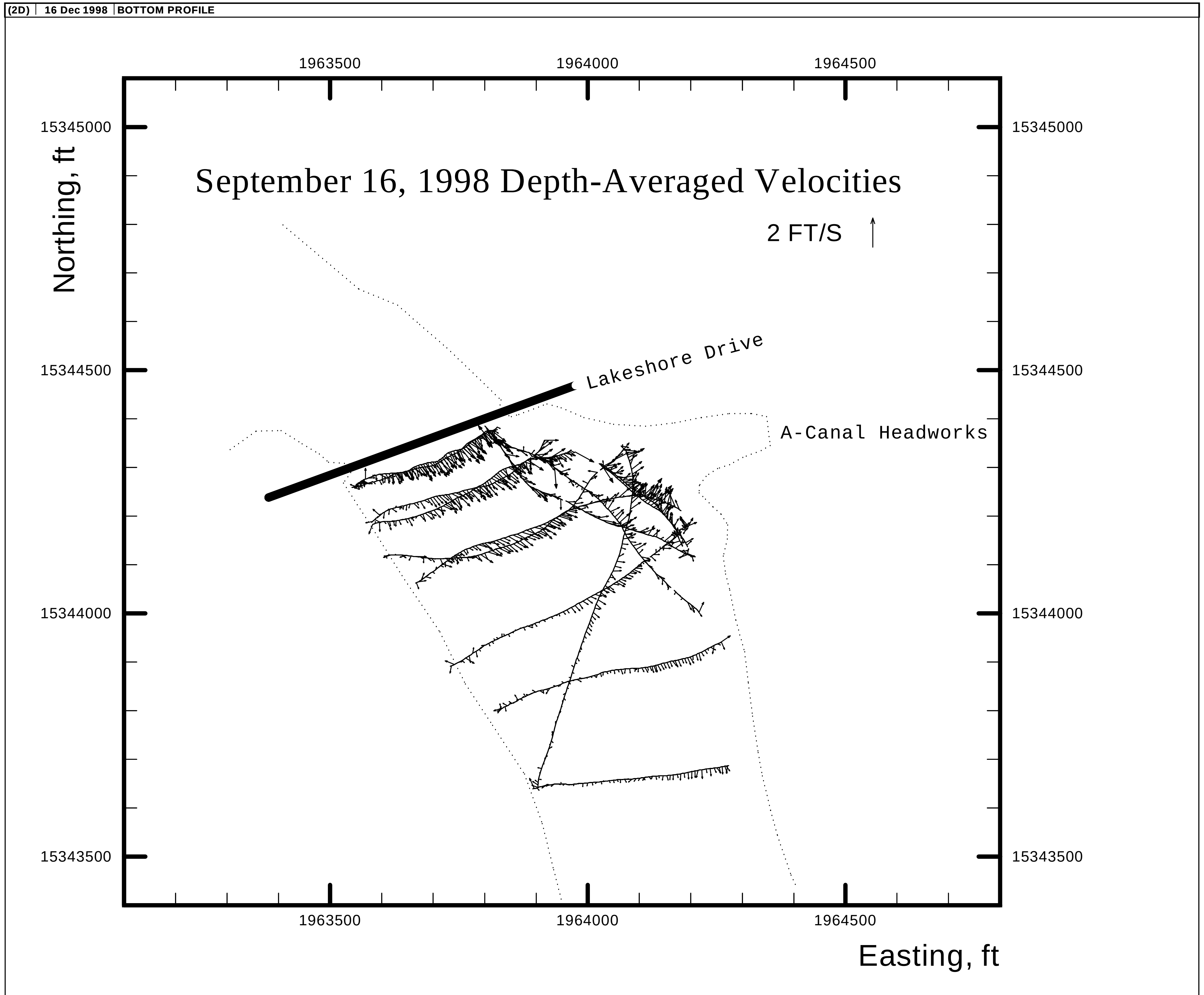

Figure 9. — Depth-averaged velocity vectors for ADCP transects collected September 16, 1998. Flow into A-Canal was 1000 ft^3/s, and flow toward Link River Dam was 1373 ft^3/s. Upper Klamath Lake elevation was 4140.20. For clarity, vectors are shown for only every other data point along each transect.

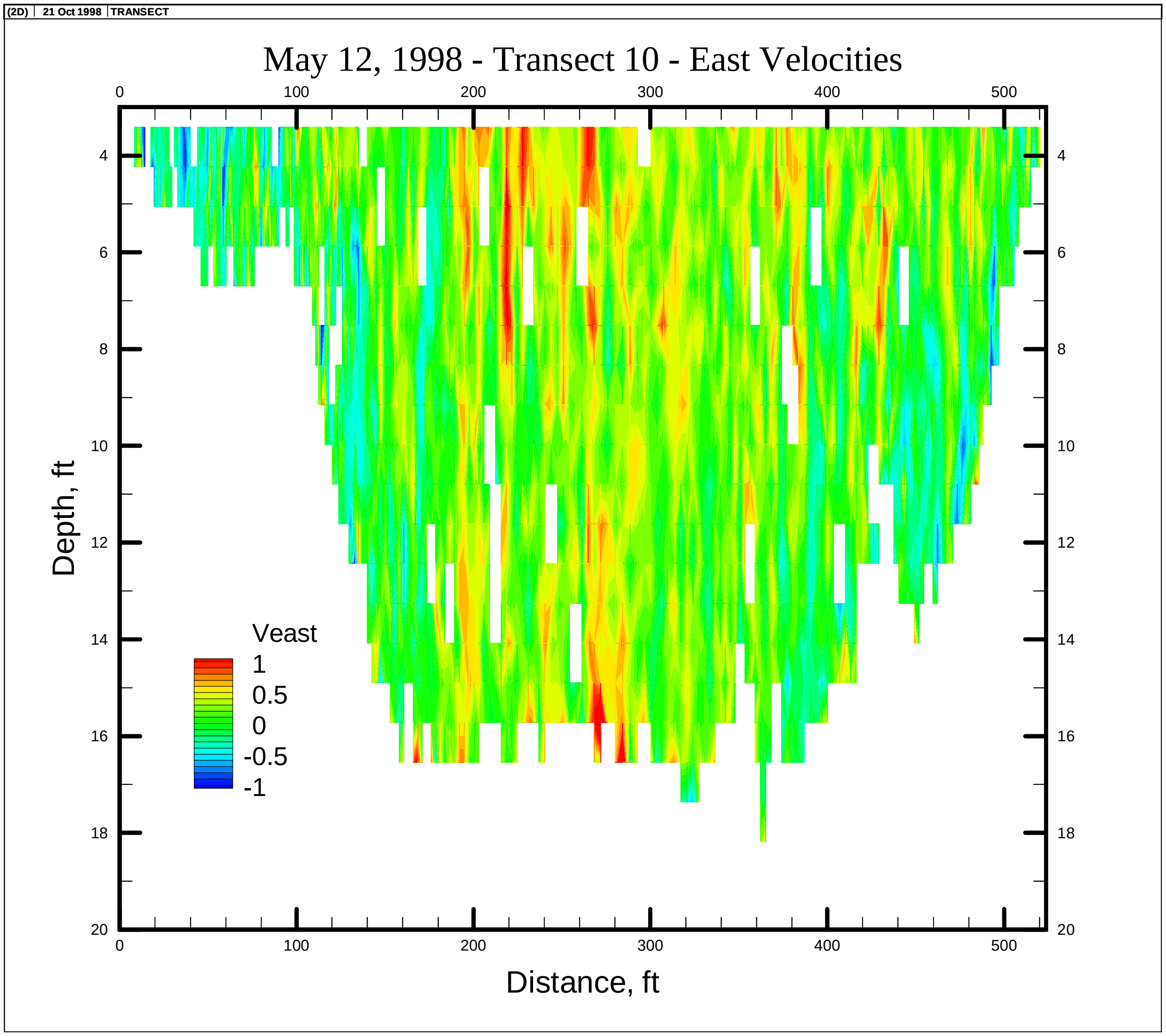

Figure 10. — ADCP velocity data collected on transect 10 across the mouth of the A-Canal intake channel, May 12, 1998. Colors indicate the magnitude of the east velocity vector. View is toward the A-Canal headworks, with the left edge of the plot near the east abutment of the Lakeshore Drive bridge, and the right edge on the east bank of the Link River arm of the lake, just south of the A-Canal intake channel.

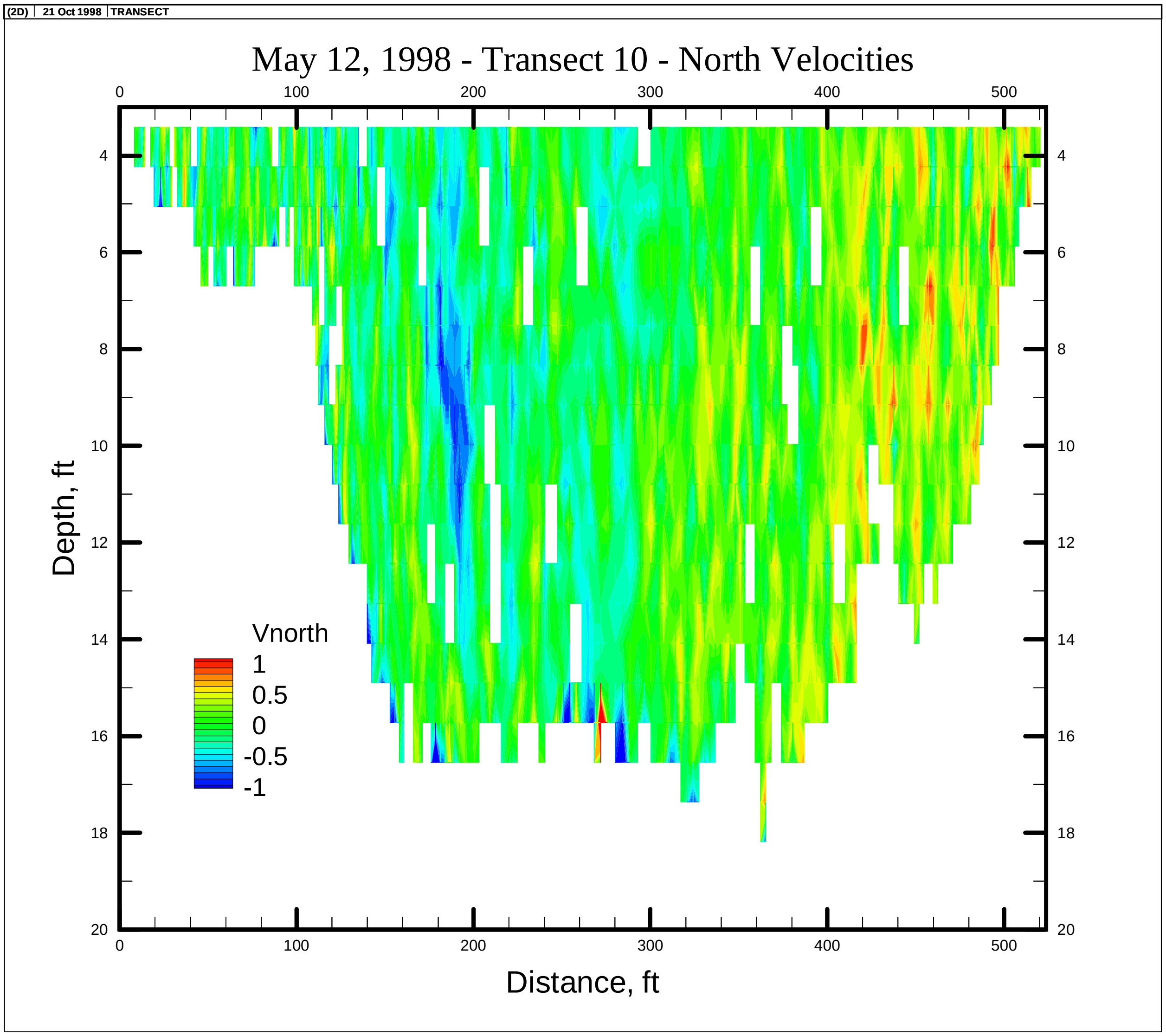

Figure 11. — ADCP velocity data collected on transect 10 across the mouth of the A-Canal intake channel, May 12, 1998. Colors indicate the magnitude of the north velocity vector. View is toward the A-Canal headworks, with the left edge of the plot near the east abutment of the Lakeshore Drive bridge, and the right edge on the east bank of the Link River arm of the lake, just south of the A-Canal intake channel.

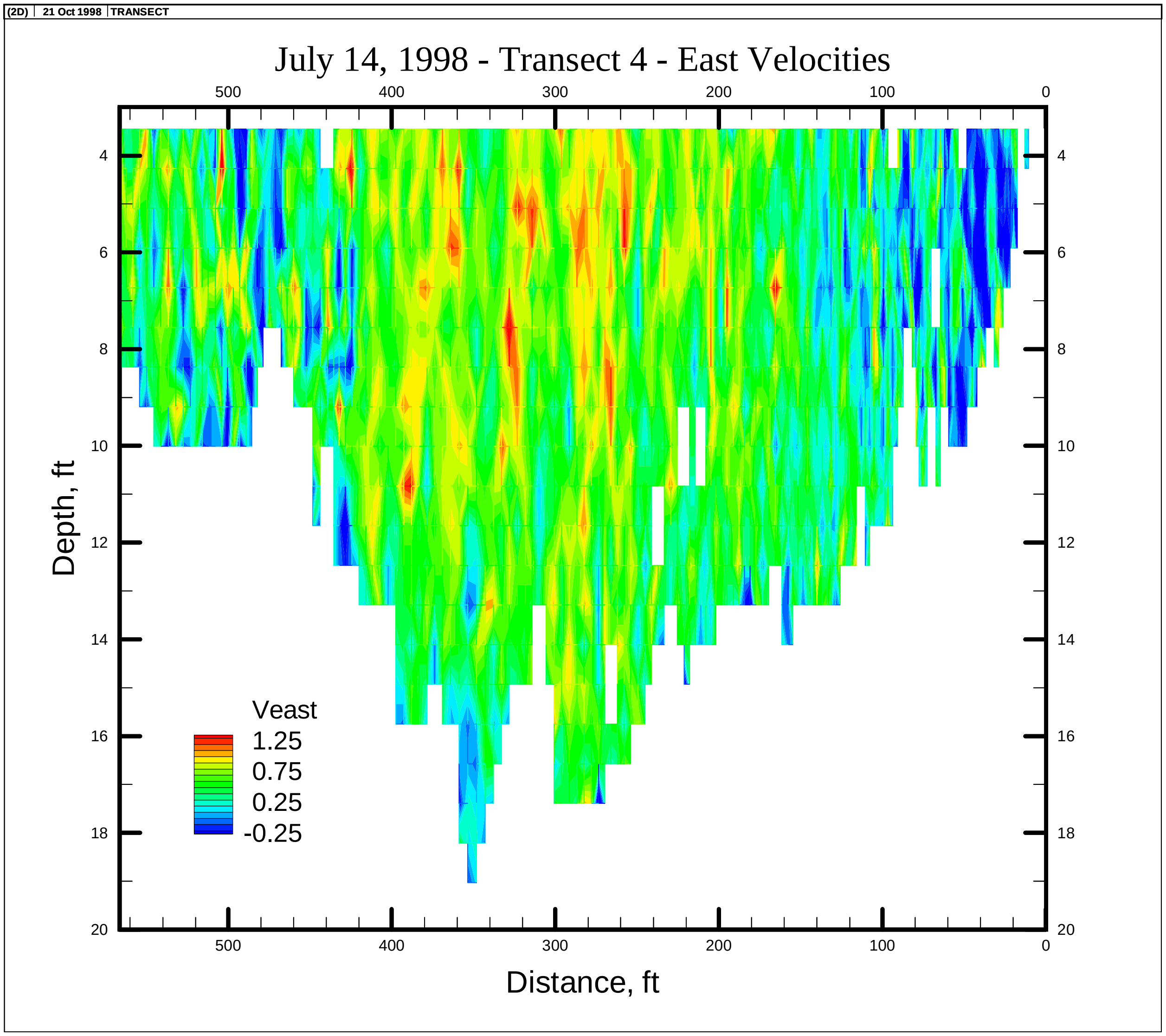

Figure 12. — ADCP velocity data collected on transect 4, July 14, 1998. Colors indicate the magnitude of the east velocity vector. View is toward the A-Canal headworks from the Lakeshore Drive bridge. The left edge of the plot is near the east abutment of the bridge, and the right edge is on the west bank of the Link River arm of the lake. The negative east velocities at the left edge of the plot indicate flow away from the A-Canal intake. Also note the relatively shallow depth at the left edge of the plot.

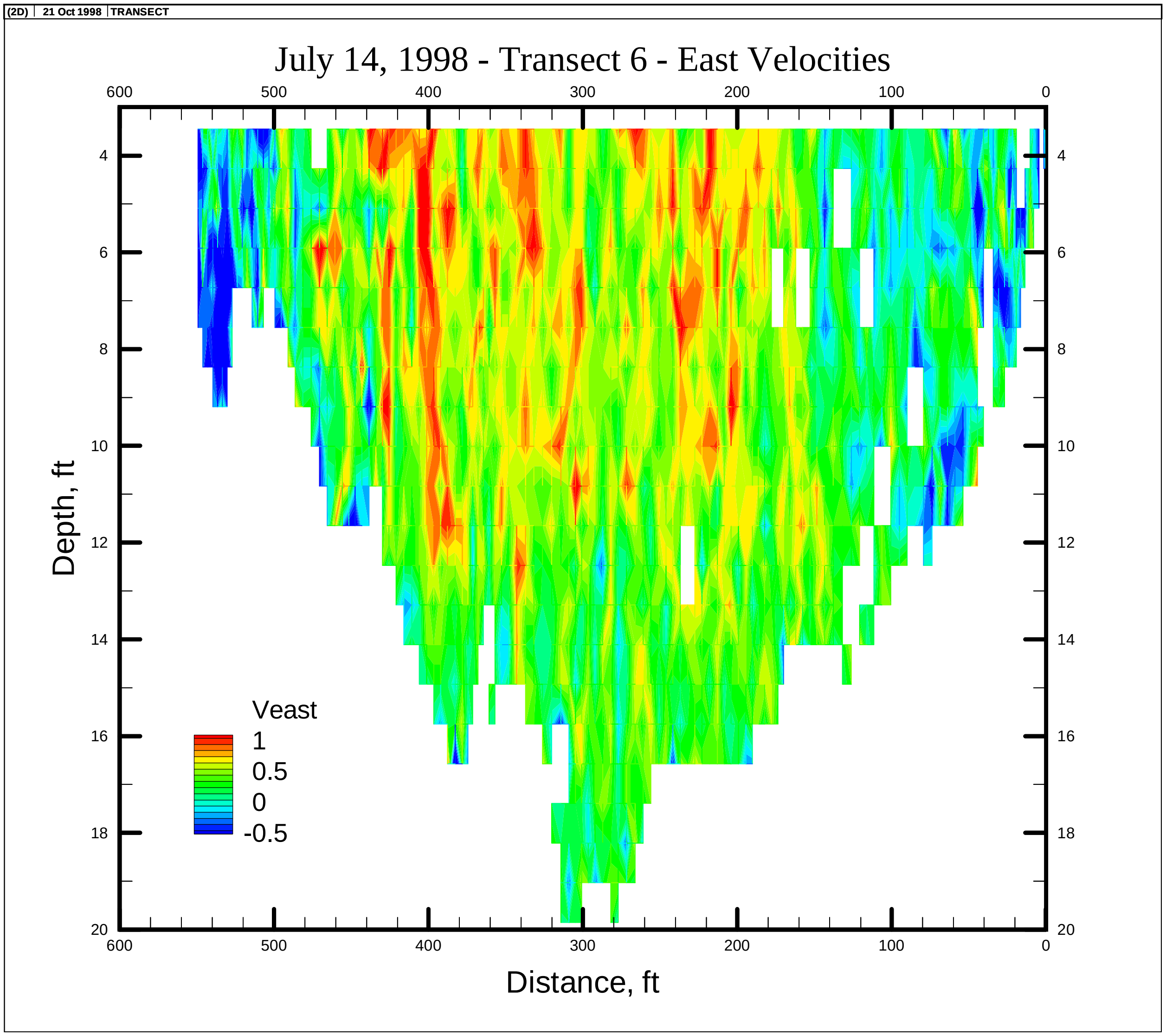

Figure 13. — ADCP velocity data collected on transect 6, July 14, 1998. Colors indicate the magnitude of the east velocity vector. View is toward the A-Canal headworks from the Lakeshore Drive bridge. The left edge of the plot is near the east abutment of the bridge, and the right edge is on the west bank of the Link River arm of the lake. The negative east velocities at the left edge of the plot indicate flow away from the A-Canal intake.

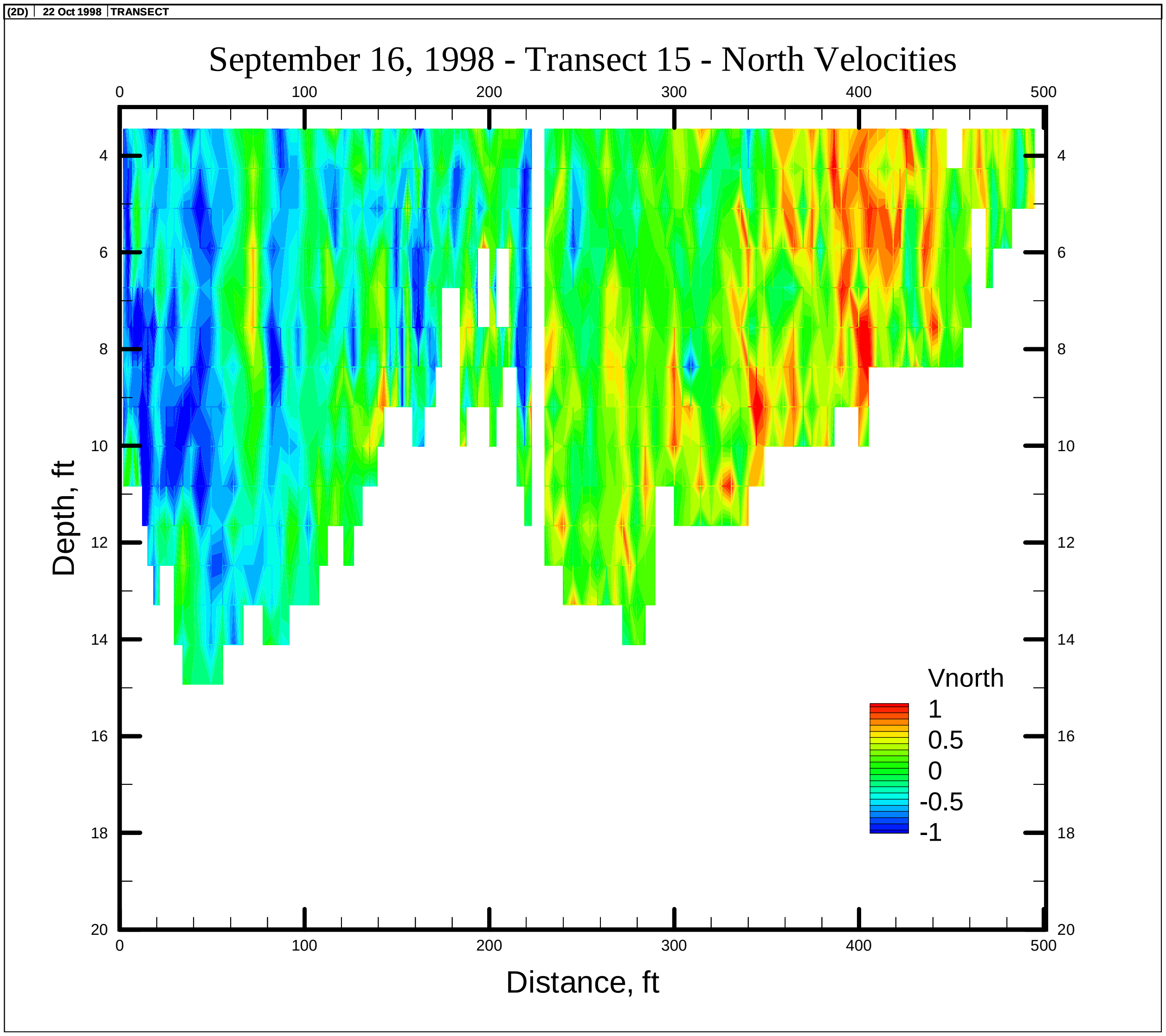

Figure 14. — ADCP velocity data collected on transect 15 across the mouth of the A-Canal intake, September 16, 1998. Colors indicate the magnitude of the north velocity vector. View is toward the A-Canal headworks from the west bank of the Link River arm of Upper Klamath Lake. The left edge of the plot is near the east abutment of the Lakeshore Drive bridge, and the right edge is at the east bank of the Link River arm of the lake. The negative north velocities at the left edge of the plot indicate flow toward Link River Dam, and the positive velocities on the right side of the plot are northward into the A-Canal intake.

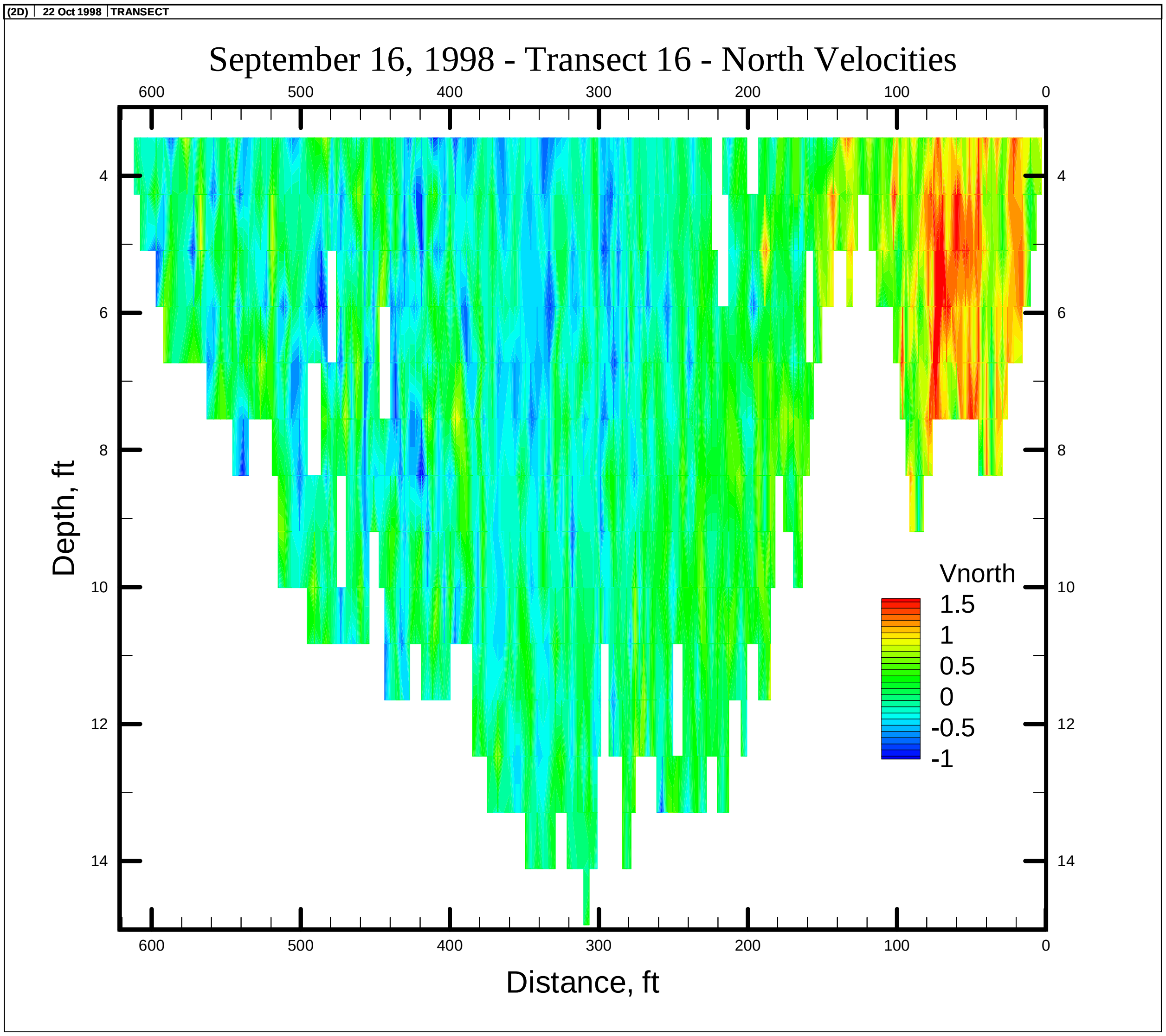

Figure 15. — ADCP velocity data collected on transect 16 across the Link River arm of Upper Klamath Lake, September 16, 1998. Colors indicate the magnitude of the north velocity vector. View is toward the A-Canal headworks from Link River Dam. The left edge of the plot is on the west bank of the Link River arm of the lake, while the right edge of the plot is at the east bank, just south of the A-Canal intake channel. The negative north velocities at the left edge of the plot indicate flow toward Link River Dam, while the positive velocities on the right side of the plot are northward into the A-Canal intake.

Table A1. — GPS data for May 12, 1998.

Transect	WayPt #	Name	CoordSys	Zone	Easting (m)	Northing (m)	HorizDatum	Estimated Horizontal Error
Start 1 & 3	WP275	MARK275	UTM/UPS	10T	598486	4676930	WGD	8
Start 2	WP276	MARK276	UTM/UPS	10T	598569	4676965	WGD	8
Start 4	WP277	MARK277	UTM/UPS	10T	598495	4676902	WGD	7
End 4	WP278	MARK278	UTM/UPS	10T	598648	4676951	WGD	7
Start 5	WP279	MARK279	UTM/UPS	10T	598649	4676950	WGD	8
End 5	WP280	MARK280	UTM/UPS	10T	598685	4676931	WGD	14
Start 6	WP281	MARK281	UTM/UPS	10T	598684	4676924	WGD	4
End 6	WP282	MARK282	UTM/UPS	10T	598548	4676795	WGD	21
Start 7	WP283	MARK283	UTM/UPS	10T	598580	4676780	WGD	17
End 7	WP284	MARK284	UTM/UPS	10T	598712	4676808	WGD	4
Start 8	WP285	MARK285	UTM/UPS	10T	598700	4676841	WGD	4
End 8	WP286	MARK286	UTM/UPS	10T	598590	4676751	WGD	4
Start 9	WP287	MARK287	UTM/UPS	10T	598516	4676875	WGD	4
End 9	WP288	MARK288	UTM/UPS	10T	598611	4676966	WGD	4
Start 10	WP289	MARK289	UTM/UPS	10T	598624 *	4676963 *	WGD	19
End 10	WP290	MARK290	UTM/UPS	10T	598698	4676863	WGD	4
Start 11	WP291	MARK291	UTM/UPS	10T	598728 *	4676686 *	WGD	44
End 11	WP292	MARK292	UTM/UPS	10T	598592	4676748	WGD	6
Start 12	WP293	MARK293	UTM/UPS	10T	598592	4676746	WGD	6
End 12	WP294	MARK294	UTM/UPS	10T	598679	4676922	WGD	4
Start 13	WP295	MARK295	UTM/UPS	10T	598647	4676950	WGD	4
End 13	WP296	MARK296	UTM/UPS	10T	598517	4676865	WGD	144
Start 14	WP297	MARK297	UTM/UPS	10T	598556	4676999	WGD	5
End 14	WP298	MARK298	UTM/UPS	10T	598472	4676966	WGD	4
Start 15	WP299	MARK299	UTM/UPS	10T	598466	4676960	WGD	4
End 15	WP300	MARK300	UTM/UPS	10T	598530	4677025	WGD	4
Start 16	WP301	MARK301	UTM/UPS	10T	598476	4677069	WGD	4
End 16	WP302	MARK302	UTM/UPS	10T	598417	4677018	WGD	6

* WP289 adjusted to (598595 East, 4676976 North) to improve fit with end waypoint and surrounding structures and channel boundaries

* WP291 adjusted to (598746 East, 4676723 North) to improve fit with end waypoint and surrounding structures and channel boundaries

Table A2. — GPS data for July 14, 1998.

Transect	WayPt #	Name	CoordSys	Zone	Easting (m)	Northing (m)	HorizDatum	Estimated Horizontal Error
Start 1	WP303	MARK303	UTM/UPS	10T	598584	4676962	WGD	5
End 1	WP304	MARK304	UTM/UPS	10T	598492	4676930	WGD	5
Start 2	WP305	MARK305	UTM/UPS	10T	598494	4676928	WGD	5
End 2	WP306	MARK306	UTM/UPS	10T	598581	4676964	WGD	5
Start 3	WP307	MARK307	UTM/UPS	10T	598629	4676951	WGD	5
End 3	WP308	MARK308	UTM/UPS	10T	598502	4676901	WGD	5
Start 4	WP309	MARK309	UTM/UPS	10T	598524	4676874	WGD	17
End 4	WP310	MARK310	UTM/UPS	10T	598664	4676948	WGD	5
Start 5	WP311	MARK311	UTM/UPS	10T	598647	4676952	WGD	5
End 5	WP312	MARK312	UTM/UPS	10T	598531	4676867	WGD	4
Start 6	WP313	MARK313	UTM/UPS	10T	598543	4676836	WGD	5
End 6	WP314	MARK314	UTM/UPS	10T	598685	4676923	WGD	11
Start 7	WP315	MARK315	UTM/UPS	10T	598689	4676917	WGD	4
End 7	WP316	MARK316	UTM/UPS	10T	598544	4676842	WGD	5
Start 8	WP317	MARK317	UTM/UPS	10T	598577	4676782	WGD	12
End 8	WP318	MARK318	UTM/UPS	10T	598688	4676886	WGD	28
Start 9	WP319	MARK319	UTM/UPS	10T	598688	4676886	WGD	4
End 9	WP320	MARK320	UTM/UPS	10T	598577	4676792	WGD	4
Start 10	WP321	MARK321	UTM/UPS	10T	598591	4676753	WGD	4
End 10	WP322	MARK322	UTM/UPS	10T	598712	4676817	WGD	4
Start 11	WP323	MARK323	UTM/UPS	10T	598712	4676755	WGD	4
End 11	WP324	MARK324	UTM/UPS	10T	598628	4676725	WGD	4
Start 12	WP325	MARK325	UTM/UPS	10T	598625	4676725	WGD	4
End 12	WP326	MARK326	UTM/UPS	10T	598690	4676920	WGD	5
Start 13	WP327	MARK327	UTM/UPS	10T	598689	4676922	WGD	5
End 13	WP328	MARK328	UTM/UPS	10T	598647	4676964	WGD	8
Start 14	WP329	MARK329	UTM/UPS	10T	598631	4676967	WGD	9
End 14	WP330	MARK330	UTM/UPS	10T	598679	4676916	WGD	9
Start 15	WP331	MARK331	UTM/UPS	10T	598686	4676902	WGD	4
End 15	WP332	MARK332	UTM/UPS	10T	598571	4676970	WGD	9
Start 16	WP333	MARK333	UTM/UPS	10T	598569	4676973	WGD	4
End 16	WP334	MARK334	UTM/UPS	10T	598489	4676936	WGD	9
Start 17	WP335	MARK335	UTM/UPS	10T	598455	4676962	WGD	11
End 17	WP336	MARK336	UTM/UPS	10T	598558	4676997	WGD	4
Start 18	WP337	MARK337	UTM/UPS	10T	598561	4677007	WGD	8
End 18	WP338	MARK338	UTM/UPS	10T	598462	4676967	WGD	3
Start 19	WP339	MARK339	UTM/UPS	10T	598445	4676983	WGD	9
End 19	WP340	MARK340	UTM/UPS	10T	598506	4677052	WGD	9
Start 20	WP341	MARK341	UTM/UPS	10T	598482	4677060	WGD	13
End 20	WP342	MARK342	UTM/UPS	10T	598416	4677018	WGD	9
Start 21	WP343	MARK343	UTM/UPS	10T	598418	4677014	WGD	4
End 21	WP344	MARK344	UTM/UPS	10T	598431	4677102	WGD	4
Start 22	WP345	MARK345	UTM/UPS	10T	598393	4677121	WGD	4
End 22	WP346	MARK346	UTM/UPS	10T	598380	4677017	WGD	4

Table A3. — GPS data for September 16, 1998.

Transect	WayPt #	Name	CoordSys	Zone	Easting (m)	Northing (m)	HorizDatum	Estimated Horizontal Error
Start 1	WP363	MARK363	UTM/UPS	10T	598490	4676930	WGD	
End 1	WP364	MARK364	UTM/UPS	10T	598572	4676969	WGD	5
Start 2	WP365	MARK365	UTM/UPS	10T	598618	4676956	WGD	5
End 2	WP366	MARK366	UTM/UPS	10T	598496	4676906	WGD	5
Start 3	WP367	MARK367	UTM/UPS	10T	598525	4676870	WGD	5
End 3	WP368	MARK368	UTM/UPS	10T	598650	4676952	WGD	10
Start 4	WP369	MARK369	UTM/UPS	10T	598622	4676957	WGD	10
End 4	WP370	MARK370	UTM/UPS	10T	598692	4676892	WGD	5
Start 5	WP371	MARK371	UTM/UPS	10T	598688	4676905	WGD	5
End 5	WP372	MARK372	UTM/UPS	10T	598551	4676815	WGD	4
Start 6	WP373	MARK373	UTM/UPS	10T	598571	4676791	WGD	
End 6	WP374	MARK374	UTM/UPS	10T	598702	4676824	WGD	4
Start 7	WP375	MARK375	UTM/UPS	10T	598711	4676756	WGD	4
End 7	WP376	MARK376	UTM/UPS	10T	598598	4676744	WGD	4
Start 10	WP377	MARK377	UTM/UPS	10T	598598	4676742	WGD	4
End 10	WP378	MARK378	UTM/UPS	10T	598651	4676949	WGD	5
Start 11	WP379	MARK379	UTM/UPS	10T	598616	4676954	WGD	5
End 11	WP380	MARK380	UTM/UPS	10T	598688	4676892	WGD	4
Start 12	WP381	MARK381	UTM/UPS	10T	598693 *	4676852 *	WGD	236
End 12	WP382	MARK382	UTM/UPS	10T	598573	4676964	WGD	5
Start 13	WP383	MARK383	UTM/UPS	10T	598573	4676965	WGD	135
End 13	WP384	MARK384	UTM/UPS	10T	598489	4676932	WGD	5
Start 14	WP385	MARK385	UTM/UPS	10T	598499	4676908	WGD	5
End 14	WP386	MARK386	UTM/UPS	10T	598604	4676965	WGD	5
Start 15	WP387	MARK387	UTM/UPS	10T	598566	4676969	WGD	5
End 15	WP388	MARK388	UTM/UPS	10T	598688	4676889	WGD	5
Start 16	WP389	MARK389	UTM/UPS	10T	598683	4676915	WGD	5
End 16	WP390	MARK390	UTM/UPS	10T	598506	4676889	WGD	5

* WP381 adjusted to (598723 East, 4676898 North) to improve fit with end waypoint and surrounding structures and channel boundaries