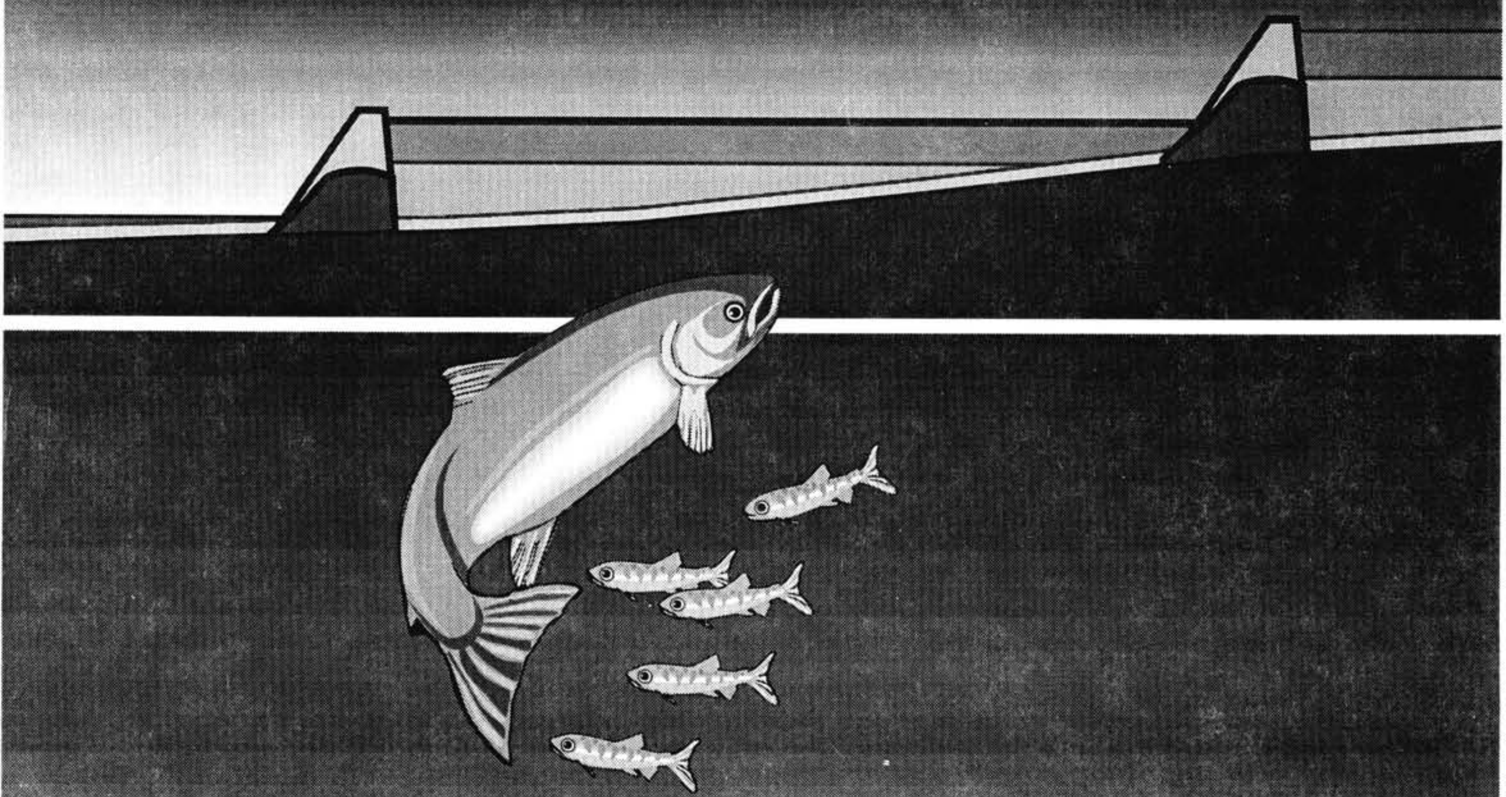
US Army Corps
of Engineers
Walla Walla District

1992 Reservoir Drawdown Test

Lower Granite and Little Goose Dams

Appendix M

Results of Hydrology Studies



December 1993

APPENDIX M

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APPENDIX M

LOWER GRANITE AND LITTLE GOOSE PROJECTS

RESULTS OF HYDROLOGY STUDIES DURING THE 1992 DRAWDOWN TEST

1. **Introduction.**

Prior the spring of 1992 questions regarding the effect of a reservoir drawdown on turbidity, sediment transport, and flow velocities were generally handled by providing estimates based on mathematical models and comparisons with similar situations in other rivers. The recent drawdown of Lower Granite and Little Goose Pools provided a unique opportunity to collect a wide variety of hydraulic and sediment transport data under conditions that had not existed since completion of these projects. Of particular interest were factors which could have an impact on fish migration.

When comparing fish movement with the water velocity distribution in a river system, in addition to river hydraulic parameters, one must consider the relative movement of each fish as it actively swims or seeks a favorable position in the water column in response to various stimuli such as stage of development, water temperature, water velocity, availability of food, etc. For instance, an object near the shoreline would typically experience a much lower stream velocity than one in the center. A passive object floating near the surface may be caught by the secondary surface-current and swept out to the center of the channel where the downstream velocity is the fastest. At other locations in the river an object may be caught a current that is moving in a circle or even upstream. If fish do not remain randomly distributed within the channel cross section, then the vertical and horizontal velocity distribution will have a bearing on the average travel time. Velocity also varies with the longitudinal position in the reservoir. Velocities at the upstream end of the reservoir may be 20 times as much as the velocity in the forebay area. While a drawdown will extend the high velocity reach farther downstream, velocities at the dam are only marginally changed.

During the planning stages for the drawdown test it was anticipated that the drawdown would increase velocities, increase the turbidity, pick up bed material at the upstream end of the reservoir and transport it farther into the pool. Major changes in lateral flow patterns were also expected as the upper portion of each pool reverted to riverine conditions. The current would erode recent sediment deposits, and the river would settle down into the pre-pool channel thalweg. The lower two-thirds of Lower Granite Pool was expected to remain as a pool with erosional and velocity impacts diminishing in a downstream direction.

A variety of tests were scheduled in order to collect as much data as possible relating to the above hydraulic parameters, and changes in these parameters resulting from the drawdown. Investigations performed under the direction of the Hydrology Branch were as follows:

a. Water turbidity based on light transmissivity.
b. Sediment transport.
c. Gross changes in the channel bed geometry.
d. Changes in the horizontal and vertical velocity distribution at selected river transect locations.
e. Maximum and average travel times based on dye detection or tracing tests.

The United States Geological Survey (USGS) performed all of the data collection work, with the exception of channel cross section and profile surveys. In order to keep the data together in one area, the entire preliminary USGS report has been included in Appendix M3. This report covers temperature, turbidity, sediment transport, and dye test data, but does not include the Acoustic Doppler Profiler velocity measurements. These data were not available in readable form at the time the report was assembled. The material in Appendix M3 should be regarded as provisional until the USGS has had the opportunity to review the data and present it in a formal publication later this year.

2. **Discharge and pool levels during the drawdown.**

Inflows to Lower Granite Project during the drawdown were unusually low. In fact, the average flow for the month of march has been lower on only 3 of the previous 17 years of the project life. The 1975-1992 average inflow to Lower Granite Pool for the month of March is 56,000 cfs. During the drawdown the inflow only averaged 30,100 cfs which was less than 6,000 cfs above the minimum recorded average for this period. Discharges for the Clearwater River at Spaulding and the Snake River at Anatone are indicated on Plates 1 and 2 in Appendix M2-1.

In order to provide representative flow conditions for nitrogen-supersaturation tests during the drawdown it was necessary to periodically create high flows by releasing water over the dam spillways. Two spill tests occurred just prior the drawdown and addition tests occurred on all but two of the 14 days of maximum drawdown. During a spill test the flow would typically change from 0 to as high as 100,000 cfs in a few minutes, remain high for two or three hours, and then drop down to 10,000 cfs and remain at this level until the pool refilled. Discharges for Lower Granite and Little Goose Dams are indicated on Plates 3 and 4. Pool levels on Lower Granite reflected not only the general drawdown pattern but also the effects of the rapid changes in discharge resulting from spill tests. Plate 5 indicates the water surface elevations for three locations within the Lower Granite Pool. The spill tests can be seen as sharp dips in the forebay curve. Note the these dips are apparent in the confluence curve as well, indicating that backwater effects from the pool extended (to a reduced degree) up to the confluence gage at RM

139.5. Water surface elevations at both ends of the Little Goose Pool are indicated on Plates 6 and 7.

Due to the low river flows and anticipated fish migration in April, only about two weeks of full drawdown were available. In order to take advantage of this very short window numerous tests were planned to be in progress at the same time. It was virtually impossible to avoid some conflict. The discharge fluctuations resulting from spill tests at Lower Granite Dam and power peaking at Hells Canyon Dam created unsteady flow conditions which interfered with sediment transport and velocity measurements in the reservoir. With spill tests occurring nearly every day, it was virtually impossible to collect a complete set of data over the entire reservoir at a single flow rate. At nearly every measuring location in the lower half of the reservoir the data contained either a very high or very low discharge at one of the pool levels. Lack of steady flow conditions primarily complicated attempts to compare velocity and travel-time calculations with field data. However, the flow variation allowed hydraulic data to be collected at a much wider range of flows than would have naturally occurred during this time.

3. **The dye tracing test**

The dye tracing (or dye detection) test attracted considerable public interest during the drawdown. The purpose of this was to provide a direct measurement of water travel time. It was hoped that data collected as the dye cloud moved down the river would provide a better understanding of the motion of the medium in which fish are swimming as they migrate through the pool. This data could then be compared, both with mathematical models of the river, and with statistical data on fish movement during downstream migration.

During the planning process it was decided to perform dye tests only during maximum drawdown. Sufficient manpower was not available to man the detection equipment for the length of time required for the dye to move through the reservoir during full pool conditions. It is also likely that the dye would have dispersed to such an extent that the results would have been of little value.

In order to conserve dye and time, the length of the reservoir was divided up into two reaches which allowed the dye- tracing test to be performed concurrently in separate locations. The first test was started at noon on the 17th of March just below the Clearwater River confluence at RM 138.34. At 7:30 on the 19th of March, while the first dye test was still in progress, a second dye test was started at RM 148.09. The first test covered the slow-moving portion of the Lower Granite Pool; while the second test was conducted in a reach which was converted to a free-flowing condition by the drawdown.

a. **The test downstream of the Clearwater Confluence.**

Three motor boats assembled along a line at River Mile 138.34 for the beginning of the first dye test. At exactly 1200 hrs the boats began to release 275 lb of Rhodamine WT dye. The dye was released uniformly across the cross section in 15 to 30 seconds. Figure 1 shows the boats releasing the dye. The dye cloud could be visually followed from the vantage point of Red Wolf Bridge. The boils and swirls resulting from large scale turbulence in the flow were very apparent. As the dye cloud moved downstream the dye in the center of the channel moved faster than that near the shorelines leaving a sharp interface between the dye and the clear river water along the sides of the channel. A leading tongue of dye, carried swiftly by the current in the center of the channel, passed under the bridge first; then the fluorescent, orange-red cloud slowly spread laterally toward the shore. Fifty-five minutes after the dye was released an airplane, taking aerial photos of the river, recorded part of the test on film. The dye was still clearly visible, with the leading edge at RM 135.7.

As the dye moved down the river, boats, stationed at six- mile intervals, measured the concentration of the dye as it passed. Dye samples were collected at several uniformly spaced points across the width of the river in a single pass. Sampling passes were performed at timed intervals. As the samples were collected, a test tube was filled with liquid from the sample and placed in the fluorometer. Inside the fluorometer the test tube was exposed to a beam of ultraviolet light and the intensity of the resulting fluorescence was displayed. Since the intensity of fluorescence is proportional to the concentration of dye, this test provided a means of determining the dye concentration of each sample. Figure 3 shows a technician collecting a sample of river water. The fluorometer can be seen in Figure 4. The dye cloud was monitored for a total of 78 hours. The results were presented as plots of dye concentration vs. time. See dye concentration graphs at the end of Appendix M3. It will be noted that the dye concentration decreased and the dye cloud tended to spread out as it moved down the river. After 24 hours of measuring low concentrations of dye at RM 108.31 the effort was terminated.

As previously mentioned in this report, very large fluctuations in discharge were occurring at Lower Granite dam while the dye was moving through the lower reservoir. As indicated on plate 3, spill tests at Lower Granite Dam resulted in mean hourly discharges that varied from 110,000 down to 10,000 cfs on the 17th and again on the 19th of March. Inflow at the upper end of the reservoir was more uniform, but still varied from 30,000 to 41,000 cfs during the dye test. These discharge fluctuations created an unsteady flow situation in the reservoir. The discharge (and pool elevation) varied rapidly both with time and location throughout the length of the reservoir. An unsteady flow model would be required to accurately model water-particle travel time under these conditions.

Figure 1. Releasing Dye at River-Mile 138.34.

Figure 2. Dye cloud moving downstream as viewed from Red Wolf Bridge.

Figure 3. Collecting samples for dye concentration test.

Figure 4. Fluorometer instrument used to measure dye fluorescence.

Table 1 lists the travel times for the dye test. The "leading edge" represents the downstream limit of the dye cloud as it moves down the river, and consists of material which has followed the highest velocity portions of the current. The leading edge indicates the fastest possible transit time for a passive object at the existing pool level and discharge. The centroid of the dye concentration curve represents the best estimate of average water-particle travel time. While the approximate trailing edge was included to give the reader an idea of the amount that the dye cloud spread as it moved downstream. It should be noted that the leading edge traveled about 25 to 30% faster than the centroid. The dye cloud spread longitudinally as it moved down-river, reaching a length of about 10 miles in the vicinity of Lower Granite Dam. The spread of the dye cloud was caused by several factors including the difference is velocity across the cross-section, turbulence, and Brownian motion of the dye molecules. Table 2 compares the average water-particle travel times as measured by the dye test and as calculated with a mathematical model of the river. The comparison is surprisingly close despite the unsteady flow conditions during the dye test. See Plate 8 in Appendix M1. It should be noted that the flat, truncated shape of the concentration curve leaves the location of the peak, centroid and trailing edge somewhat uncertain at RM 108.31.

TABLE 1

DYE-TRACING TEST UPSTREAM OF CLEARWATER CONFLUENCE

TRAVEL TIME IN HOURS OF POINTS ON CONCENTRATION CURVE

RIVER MILE	LEADING EDGE	PEAK	CENTROID	TRAILING EDGE
138.34	0.0	0.0	0.0	0.0
135.7	0.9			
132.05	2.5	3	3.8	7
126.07	8.6	12	12	17
120.46	19.6	23	25	31
113.90	36	43	48	70
108.31	54	78*	78*	108*

* Rough approximations (See explanation in text)

TABLE 2

TRAVEL TIMES FOR DYE-TRACING TEST COMPARED WITH MATH MODEL

RIVER-MILE	DYE-TEST CONCENTRATION CURVE CENTROID	MATH MODEL AVE. TRAVEL TIME
138.34	0.0	0.0
132.05	3.8	4.4
126.07	12	12
120.46	25	25
113.90	48	43
108.31	78*	71

* Rough approximation.

b. **The test upstream of the Clearwater River confluence.**

The dye tracing test upstream of the Clearwater River was performed near maximum drawdown in a reach of the river that was almost entirely unaffected by Lower Granite Pool. Although Hellsgate Dam was power-peaking, the flow variation was very small (about 1000 cfs) during the 5 hours required for the dye to transverse the 8.66-mile test reach. The steady flow conditions during this test provided an opportunity to make a direct comparison with water travel times calculated with a steady-state mathematical model.

The test was started at 0730 hrs on 19 March 1992 when 15 lb of dye was released at RM 148.09. Boats were stationed a RM 145.15, 142.0, and 139.43 to monitor the dye concentration as it moved downstream. Plots of the measured concentrations at each measuring site are shown at the end of the USGS report on the dye tracing test. See Appendix M3.

The time when the leading edge of the dye cloud passed, the time of maximum concentration, the centroid, and the approximate trailing edge were estimated from the concentration plots. These values are presented graphically on Plate 9.

The average water-particle travel time was also calculated with program HEC2, a standard-step computer backwater model developed by the U.S. Army Hydrologic Engineering Center. This model has been used to calculate average velocities, travel times, and other hydraulic parameters in previous studies. Taking into consideration the lag time from the USGS gage at Anatone, the average estimated discharge during the test was 25,000 cfs. Using this discharge, the velocity calculated by the mathematical model was compared with the field data from the dye tracing test. The results are listed on Tables 3 and 4 and are presented graphically on Plate 9.

TABLE 3

DYE-TRACING TEST UPSTREAM OF CLEARWATER CONFLUENCE

	TRAVEL TIME IN HOURS OF POINTS ON CONCENTRATION CURVE			
RIVER MILE	LEADING EDGE	PEAK	CENTROID	TRAILING EDGE
148.09	0.00	0.00	0.00	0.00*
145.15	0.75	1.08	1.38	2.88*
145.15	1.25	1.50	1.93	3.75*
139.43	2.25*	2.58	3.06	4.75*

* Approximate values

TABLE 4

TRAVEL TIMES FOR DYE-TRACING TEST COMPARED WITH MATH MODEL

RIVER-MILE	DYE-TEST CONCENTRATION CURVE CENTROID	MATH MODEL AVE. TRAVEL TIME
148.09	0.00	0.00
145.15	1.39	0.96
142.00	1.93	1.93
139.43	3.06	3.01

A relatively-large discrepancy at the RM 145.15 monitoring point has not been completely explained. A relatively-smaller discrepancy was noted at the first monitoring point (RM 132.05) in the first dye test. Non-uniform dye distribution or hydraulic anomalies at the monitoring site may be a partial explanation. It was noted that apparently-high concentrations of dye, arriving late at the fifth data collection point near the left shore, accounted for most of the 24-minute discrepancy. With the exception of the 24-minute deviation at RM 145.15, the water-particle travel times measured by the dye test and calculated by the model were almost identical. The average water-particle velocity was 4.2 fps and the difference in total travel times, as estimated by the two methods, was less than 3 minutes. The agreement of the last two points is better than would be expected considering the sampling interval (5 minutes) and the possible error in locating the concentration centroid. These results provide additional assurance that the mathematical model has provided accurate estimates of the average water-particle travel time both in the reservoir and in free-flowing reaches of the river. A comparison of the field data with an unsteady flow model is planned for the future.

4. **Sediment transport.**

The effects of sediment transport and erosion within the system were evident from the results of several measurements: 1) Water turbidity before and during the drawdown, 2) Suspended and bedload transport, and 3) By mathematically calculating volume changes in the channel bed based on cross sections surveyed before and after the drawdown.

Sediment transport was measured at four points on the Snake River and at two points on the Clearwater. See Sediment Site Locations map on Plate 10. The complete data is listed in Appendix M3, Tables 8 and 9. Sediment entering the reservoir was measured at the USGS gage near Anatone on the Snake River and the USGS gage at Spaulding on the Clearwater River. Both of these gages are far enough upstream to be unaffected by changes in the reservoir levels. Changes in sediment transport resulting from channel bed erosion or deposition could be detected by four additional temporary gaging sites located downstream. Temporary sites were located just upstream of the confluence at RM 139.94 on the Snake River and 0.41 on the Clearwater. Two additional sites were located at RM 137.17 and 132.05 on the Snake River to monitor sediment activity and map the extent of downstream sediment movement.

Tables 8 and 9 in Appendix M3 indicate that there was less than 1100 tons/day of sediment entering the reservoir at any time during the drawdown test. Before the start of the drawdown test monitoring sites downstream to Silcott Island also registered low transport rates, with the single exception of a measurement made at Red Wolf Bridge. This high sediment discharge coincided with a sudden drop in the reservoir water surface accompanied by a sudden, 200% increase in discharge resulting from spillway testing at Lower Granite Dam.

Sediment discharge was again measured 5 to 6 days into the drawdown test. At this point in the drawdown only moderate increases in sediment transport were measured downstream of the gage sites, but the pattern indicated that erosion was in progress upstream of the confluence on both the Snake and Clearwater Rivers. See the bar charts for the Snake and Clearwater Rivers on Plate 10. At maximum drawdown sediment transport on the Snake River increased to nearly 39,000 tons/day on the 17th of March with 18,000 tons/day coming from the reach above the confluence. The Snake River transport probably increased to at least 68,000 tons/day below the confluence on the 18th since the Clearwater River was discharging 50,000 tons/day. These figures suggests that over 1 million tons of sediment could have been in transit during the 15 days of maximum drawdown. Although sediment transport rates in the confluence region ranged up to around 50- to 70,000 tons/day, sediment transport at Silcott Island never exceeded 5000 tons/day. This dramatic reduction in sediment transport indicates that nearly all of the sediment that was activated during the drawdown test, was picked up in the upper part of the pool and then redeposited before reaching Silcott Island.

5. Erosion and deposition of sediment

Calculations of the volume change in channel bed geometry between surveyed channel cross sections provided a second method for evaluating sediment transport. Surveys at selected cross sections were made before and after the drawdown. The location of these surveys is shown on Plates 11 through 15. Comparative cross section over-plots are found on Plates 17 through 31. The surveys clearly indicate that massive erosion occurred in the lower Clearwater turning basin area and in the confluence area of the Snake River. The material was only carried a short distance and then redeposited. The areas of erosion and deposition are indicated on a plan view of the confluence area, Plate 16. About 390,000 cy of material was eroded immediately downstream of the Blue Bridge (RM 141.21) and then redeposited within the next mile downstream. About 700,000 cy of material was eroded between RM 139.64 and 138.34. An additional 346,000 cy of material was eroded from the Clearwater River between the CPRR Bridge and Memorial Bridge. In many areas erosion below the water surface profile at maximum drawdown extended down to the pre-reservoir channel bed. Some redeposition occurred on the north side of the Clearwater River where the channel widens at the Confluence. Heavy deposition amounting to at least 600,000 cy occurred downstream of the Port of Clarkston with measurable deposition extending down as far as RM 135 at the downstream end of the Port of Wilma.

Only minimal erosion, generally amounting to less than two feet was indicated by surveys at the Deep-Water Disposal Site at RM 119. See Plates 23 through 25. Apparent deep erosion indicated at one location on Range 16.00 was likely due to a minor horizontal miss-alignment of the surveying boat as it traversed along a steep cliff line.

Only minor erosion occurred at Schultz Bar during the short drawdown of Little Goose Pool. Surveys taken before and after the drawdown are shown on Plates 26 through 29. Lateral movement of material toward the south shore is apparent between RM 100.96 and 101.07, and at 101.42. Erosion depths 3 to 5 feet can be seen at ranges 101.07 through 101.19. Minor erosion of the dune surface and redeposition along the south side of the dune was apparent during a visual inspection of the area. A large part of the dune was exposed during the drawdown with the low flow channel generally following the navigation line. A longer period of drawdown would likely result in much greater erosion and the development of a well-defined channel through Schultz Bar.

The drawdown apparently had little or no effect on the channel in the Almota area, even though sediment depths of several feet have been measured on the south side of the channel. See plots of Ranges 103.57 through 104.45.

Erosion of delta regions at the mouth of tributary streams was evident throughout the length of Lower Granite Reservoir. Typically the tributary stream would begin to erode a channel through the upper part of the delta as the pool level dropped. See Figures 5 and 6. Much of the eroded material would often be redeposited in a fan shaped deposit farther down on the delta. As the pool continued to drop the channel would extend downstream through these new deposits as well as the underlying delta. These channels continued to widen and gradually increase in depth throughout the drawdown test. Rough calculations indicated that 10% or more of the delta material may have eroded during the drawdown tests. Since the erosion consisted of channel entrenchment the % loss in the delta areas depended on the width of the delta compared with the width of the eroded channels. During the drawdown one channel through the Alpowa Creek delta eroded to a depth of 12 ft and a width of more than 40 ft. See Plates 30 and 31.

6. **Velocity mapping.**

The USGS, under contract with the Corps of Engineers, measured the cross sectional velocities at full pool, partial drawdown (mid-pool), and at the lowest pool levels. An Acoustic Doppler Current Profiler (ADP), supplied by RD Instruments was used to map the cross sectional velocities at selected sediment- range locations. This instrument provided detailed information on the direction and magnitude of flow at numerous points in the plane of the selected cross section. The ADP sends out acoustic signals through four transducers mounted on the end of a cylindrical instrument package. The magnitude and direction of the water velocity vector is determined by measuring the Doppler shift of the returning signal which is reflected off of small particles of moss, debris, or sediment carried by the water. Each transponder provides a component of velocity in the direction of the transponder signal. The Doppler shift of reflected signals from the bottom of the channel indicates the movement of the boat relative to the bottom. An onboard computer stores the data and resolves the velocity components into a single velocity vector with a magnitude and direction at each measured point. It also keeps track of the movement of the boat in relation to the bottom, and calculates the discharge across the section. Tables listing the magnitude and direction of the array of velocity vectors measured at each section are being prepared for publication by the USGS. Figures 7 and 8 show the profiler crew in action.

This method had some limitations:

1. Velocities cannot be measured very near or above the transducer, and they are not likely to be accurate near the channel bottom. This limits the accuracy of data in shallow water.

Figure 5. Erosion of mud flats at Steptoe Canyon.

Figure 6. Delta erosion at mouth of Alpowa Creek.

Figure 7. USGS boat recording water velocities as it moves across the river along a sediment range line.

Figure 8. Close-up of USGS crew operating a computer which records transmissions from the Acoustic Doppler Profiler (red cylinder mounted on side of boat).

2. The instrument had a depth limit less than the maximum depth of the pool, and was unable to reach the bottom at several sections near the dam at full pool. Missing data was filled in by Price-Meter velocity readings. See large shaded blocks in the plots for RM 108.31.

3. Some data were missing in areas near the shore which were inaccessible to the boat. The total discharge listed on the velocity maps was generally based the measured portion of the section and did not include flow passing through the unmeasured areas along the shoreline. In most cases the missing data represented a very small percentage of the total flow.

4. When sediment transport was very high and the bottom was eroding, the instrument at times confused bed-load movement along the bottom with movement of the boat. This resulted in distance errors and distortion of the surveyed section. Possible examples of this problem are seen in velocity maps for Ranges 0.41 and 138.34.

In most cases data were collected at existing sediment range locations in order to take advantage of historical geometric data. An attempt was made to collect a complete set of data including velocities at full pool (elev. 733-738), mid-pool or partial drawdown (around elevation 720), low pool (elevation 705), and "low-low" pool when the pool was lowered to a minimum of 697. Due to frequent spill tests it was not possible to obtain a complete set of velocity transects at a single, steady flow rate. Nearly all of the monitoring sites in the lower half of the reservoir contain at least one measurement which was taken during an either very high or very low discharge. For example: An apparently negative (upstream) discharge of 1000 cfs was measured on the 27th of February at 1120 hrs at RM 120.46. (See the velocity profiles and velocity map in appendix M2) Apparently, the transient wave from a brief, total closure of Lower Granite Dam arrived just as the velocity-transect measurement was in progress. Partial or complete sets of velocity data were collected at the following river-mile locations:

TABLE 5

Snake River		Clearwater River
141.21	130.66	2.34
139.43	120.46	1.26
138.34	119.00	0.41
137.17	108.31	
132.05		

Additional data were collected at full pool on Little Goose Pool and at low pool in Lower Granite Pool during the dye tracer test. A map showing the locations of all measurement sites on Lower Granite Pool is found on Figure 1, Appendix M3. The range locations are shown in greater detail in Appendix M1, Plates 11 and 12.

The velocity data are presented in graphical form in Appendix M2. Note that the graphs are arranged in sets with the first graph showing average velocity profiles, followed by surface velocities, and then individual shaded plots indicating the vertical as well as horizontal variation of velocity across the section. In all of the plots an attempt is made to maintain a relationship with the physical geometry of the section. In the line plots the reader should view the graph as if he was looking down at the river with the flow moving from the bottom to the top of the page. Positive velocity is shown by positive values in the downstream direction, while negative values are shown in the upstream direction from the zero line. The location of the measurement along the cross section is indicated by the distance on the abscissa. These distances correspond to distances on the velocity maps that immediately follow.

In order to simplify the graphical presentation, measured velocity vectors were resolved to a single component in the calculated direction of the prevailing flow. The average azimuth of the measured velocity vectors appeared to provide the best estimate of the prevailing flow direction. Numerous, relatively-large variations in the prevailing azimuth both with respect to previous measurements at the same location and with respect to the expected direction of flow (based on the geometry of the channel) were noted. These variations have not been completely explained to date. It is thought that magnetic interference either from ferrous objects in the boat or in the surrounding land may be a consideration. Some interference was noted when a steel mount was initially used for the sonar transponder. The calculated prevailing (ADP Azimuth) provided results which were consistent and agreed with hydraulic theory. For this reason the calculated prevailing azimuth was used instead of a flow azimuth based on the channel geometry. A comparison of the two azimuths is contained in the first table in Appendix M2.

The first graph in each set in Appendix M2 indicates velocities averaged vertically at selected points along the channel width. The resulting values were generally smoothed by calculating running averages across the section. In the second plot only the velocity measured in the surface layer were shown. The surface layer varied from 0.5 to 2 meters in depth, depending on the total depth of the water. Maximum velocities generally occurred in this layer.

Following the line-graphs in each set are several graphs which show the channel in cross-section. Velocities were represented as shaded rectangles with darker shades representing higher velocity ranges, and outlined rectangles representing negative (upstream) velocities. The reader should carefully study the Legend on each graph which indicates the velocity range covered by each shade. The velocity range for a given sediment-range location was kept the same for all plots at a single monitoring location in order to provide a visual sense of the change in velocity resulting from changes in the discharge or pool levels. A disadvantage of this procedure is that the graph in each set which depicts the lowest average velocity condition looses detail, since the full range of velocity may be fall within only two or three shade ranges. This might give the false impression that there is little variation in velocity across the section at lower flows.

In order to provide additional information and greater detail the shade ranges in Appendix M2 were changed for each sediment-range location. In deeper parts of the pool the entire range from white to solid black might cover only 0 to 1.0 fps while at the upper end of the pool this same range of shades might represent a spread of velocities from 0 to 7 fps. Theoretically, under steady flow conditions, the velocities should be lowest at full pool, a little higher at mid-pool, and highest at low pool. Due to unsteady flow conditions resulting from power peaking and spillway tests, only a few complete sets of data were collected under relatively steady-state conditions.

Inflow to Lower Granite pool generally averaged between 25,000 and 35,000 during the drawdown. It was pointed out earlier in this report that spill tests created large variations in flow during the drawdown. This situation is reflected in several of the velocity graphs. At range 138.34 a flow of 15,700 was measured. At range 132.05 one set of data shows a flow of 58,300 cfs. At Range 120.46 the full pool velocity was measured 80 minutes after discharge at Lower Granite dam was reduced to zero. The local flow, perhaps due to hydraulic transients, was only 1000 cfs - and the discharge appears to be upstream! Flows as high as 90,000 cfs were mapped at the ranges nearest to the dam.

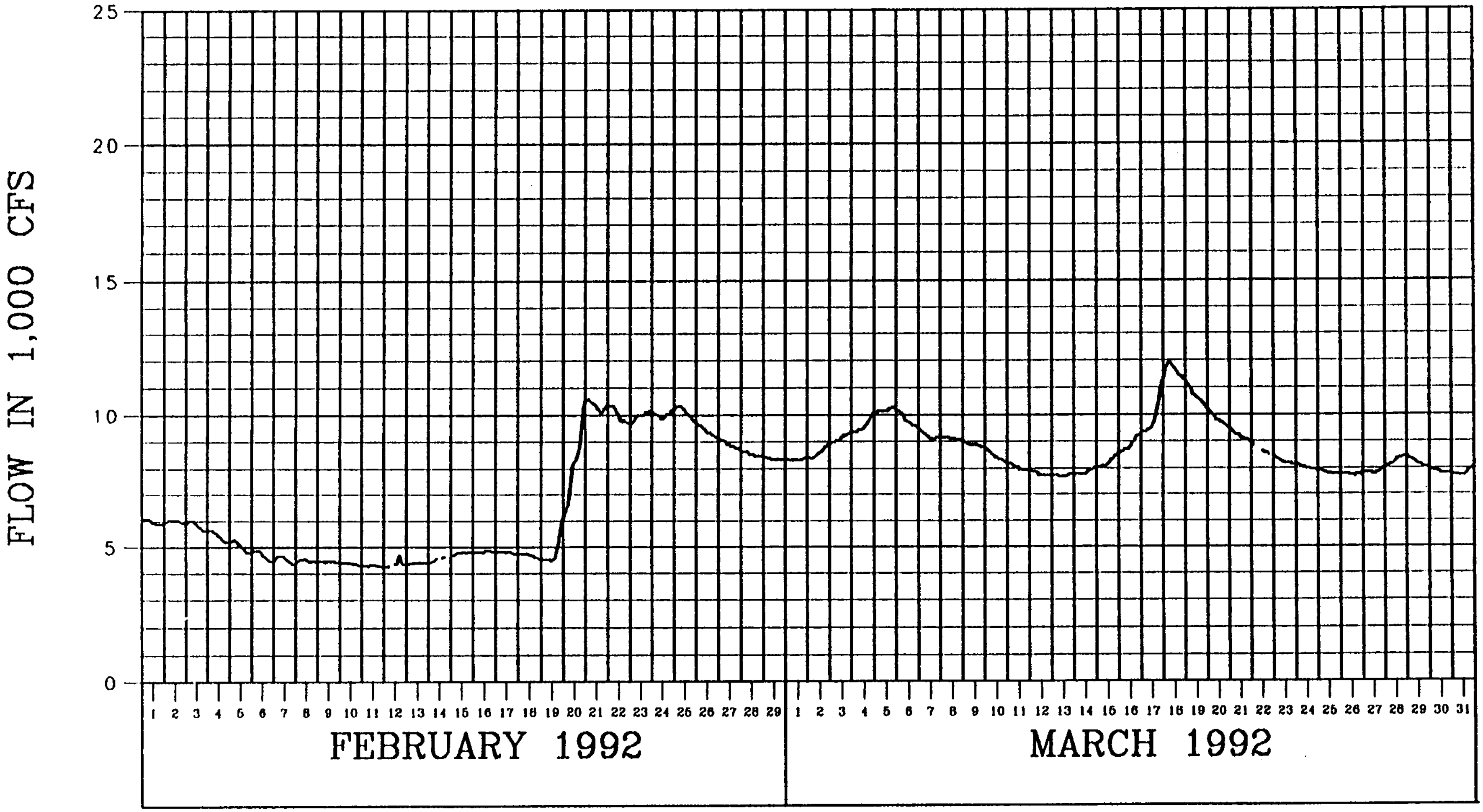
The set of velocity graphs for sediment range 139.43 indicate a typical sequence for conditions in the upstream end of the pool where the drawdown drastically reduced the area available for flow. At this location the drawdown reduced the flow area to about 20% of its full pool level and increased the cross- sectional average velocity by a factor of 5. Maximum velocities near the center of the channel were increased a similar amount (from 0.9 fps to 4.7 fps). At RM 119, a 28 ft drawdown increased the velocity by a factor of 1.9. At the downstream end of the pool the large discharge variations between separate profiling efforts, as well as changes in the dam operation from generator to spillway discharge, tended to mask the effects of the drawdown. At the normal flow of 25,000 cfs velocities were very low (0.3 fps or less) even at maximum drawdown. At Range 107.73 at near maximum drawdown (elev. 699.3) and a spill of 90,000 cfs, the maximum velocities were still less than 1.0 fps. Changes in the average cross section velocity in the pool are inversely proportional to the change in cross sectional area. Theoretically a 35 ft drawdown near the dam should reduce the cross-sectional area by 37% and increase velocities by a factor of about 1.6.

In summary, it should be noted that velocities were much higher, even at full pool, at the upstream end of the reservoir than in the vicinity of Lower Granite Dam. The drawdown also produced a much greater change in velocity at the upstream end of the reservoir compared with changes at the downstream end. Velocities were low to start with near the dam and remained low even during maximum drawdown.

Note: Appendix M4 is a follow-up study completed in May 1993.

APPENDIX M1: GRAPHS AND MAPS

Contents



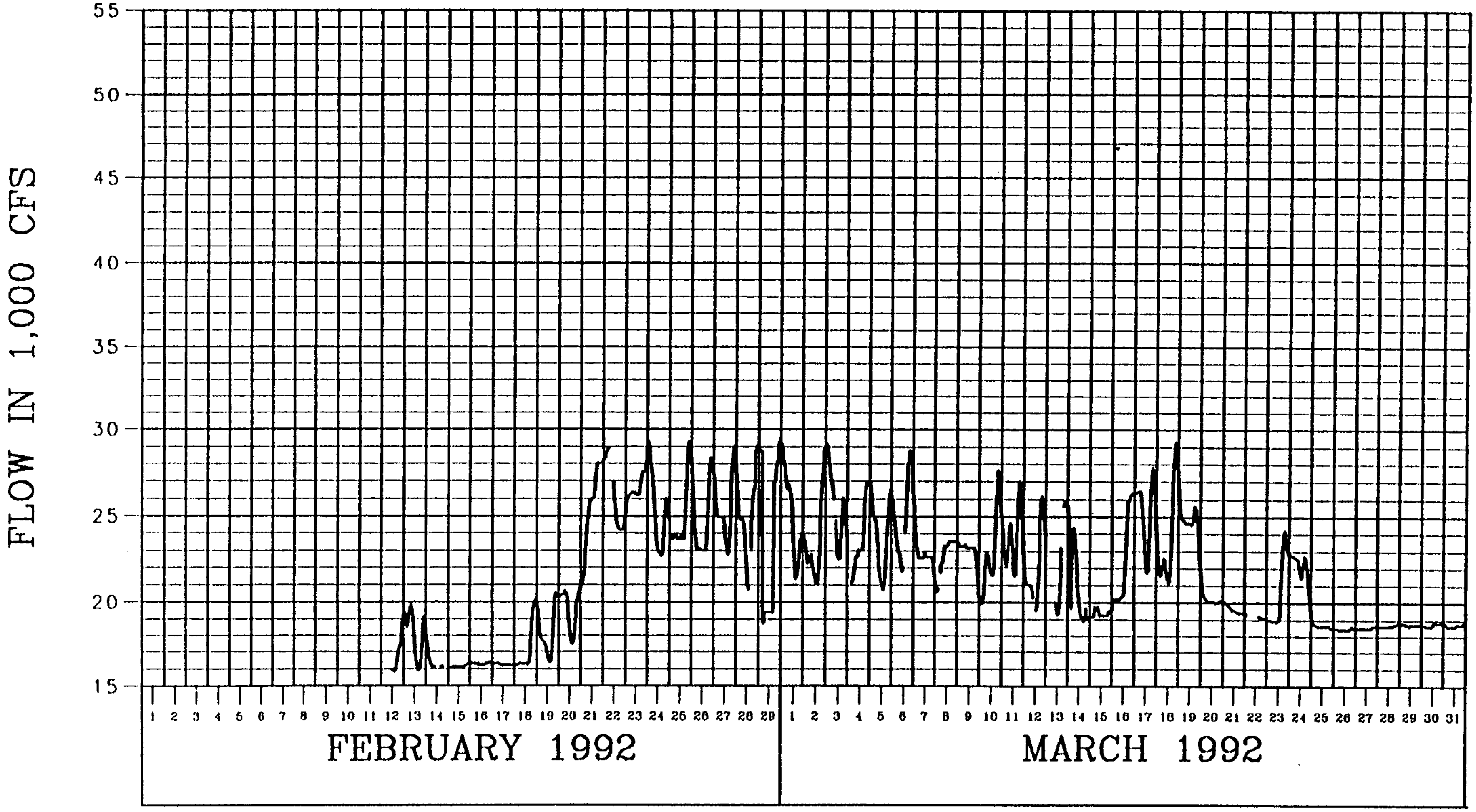
CLEARWATER RIVER AT SPALDING

NOTES:
1. USGS gage #13342500; CLEARWATER RIVER AT SPALDING, IDAHO
2. River Mile: 11.6; Elevation: 770.5 feet (NGVO);
3. Drainage Area: Approx. 9,570 square miles
4. Period of record: Aug 1910–Oct 1913, Oct 1924–Jan 1925, Apr 1925 to cur. yr.

SNAKE RIVER BASIN

MARCH 1992 RESERVOIR DRAWDOWN TEST

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA – HYDROLOGY BRANCH



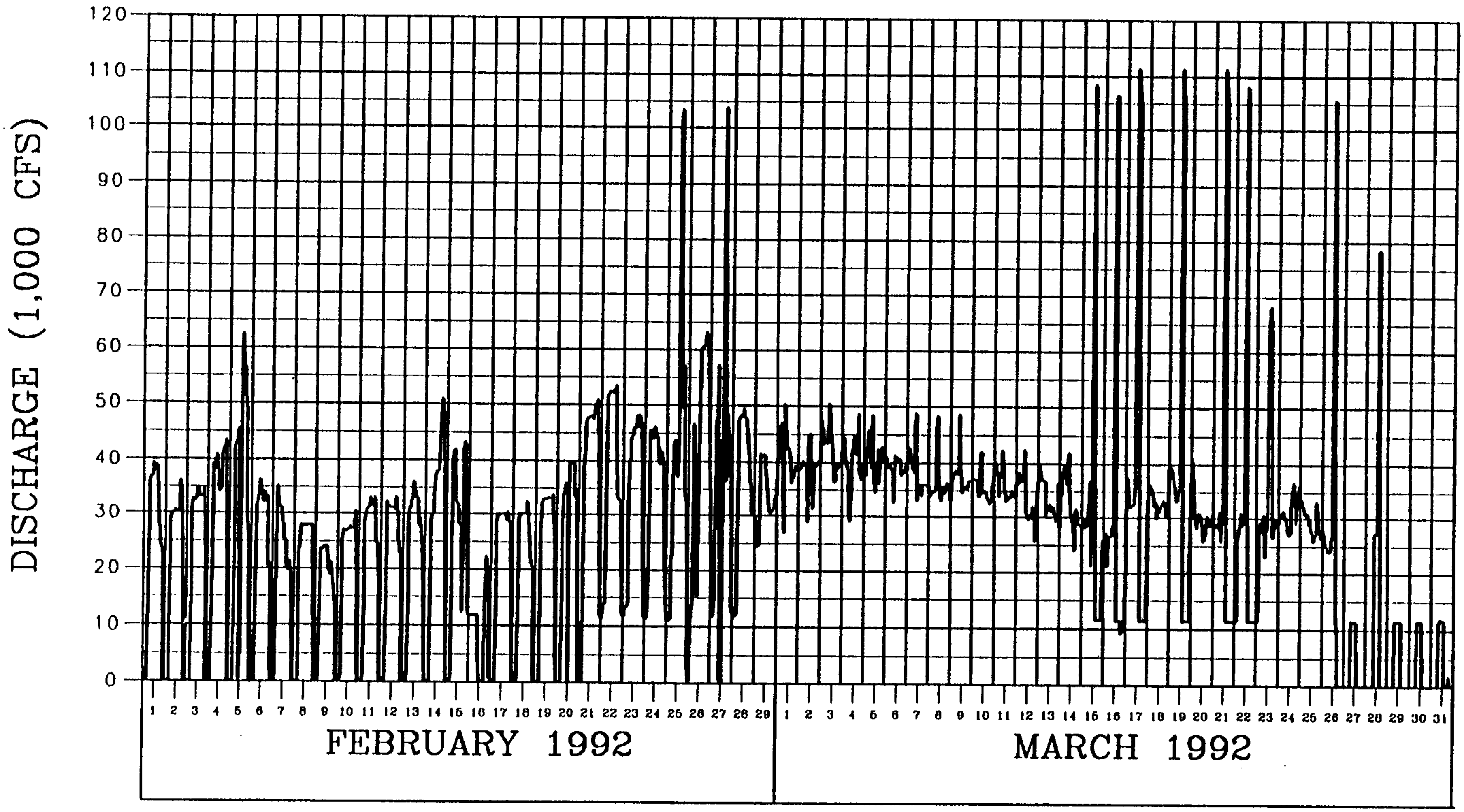
SNAKE RIVER NEAR ANATONE

NOTES:
1. USGS gage #13334300; SNAKE RIVER NEAR ANATONE, WASHINGTON
2. River Mile: 167.2; Elevation: 806.78 feet (NGVD);
3. Drainage Area: Approx. 92,960 square miles
4. Period of record: July 1958 to current year

SNAKE RIVER BASIN

MARCH 1992
RESERVOIR
DRAWDOWN TEST

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA – HYDROLOGY BRANCH

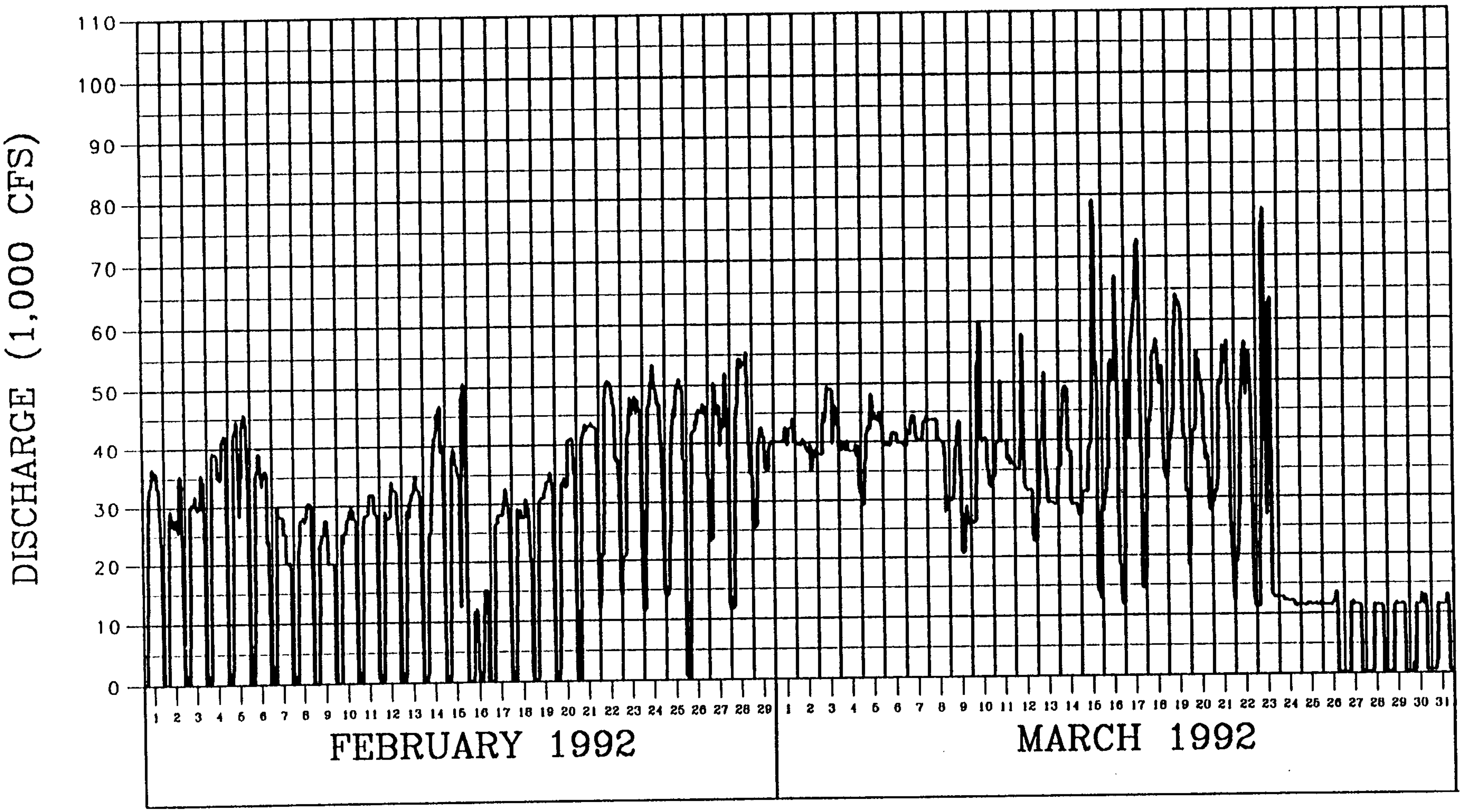


LOWER GRANITE DAM RELEASE

SNAKE RIVER BASIN

MARCH 1992 RESERVOIR DRAWDOWN TEST

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA – HYDROLOGY BRANCH



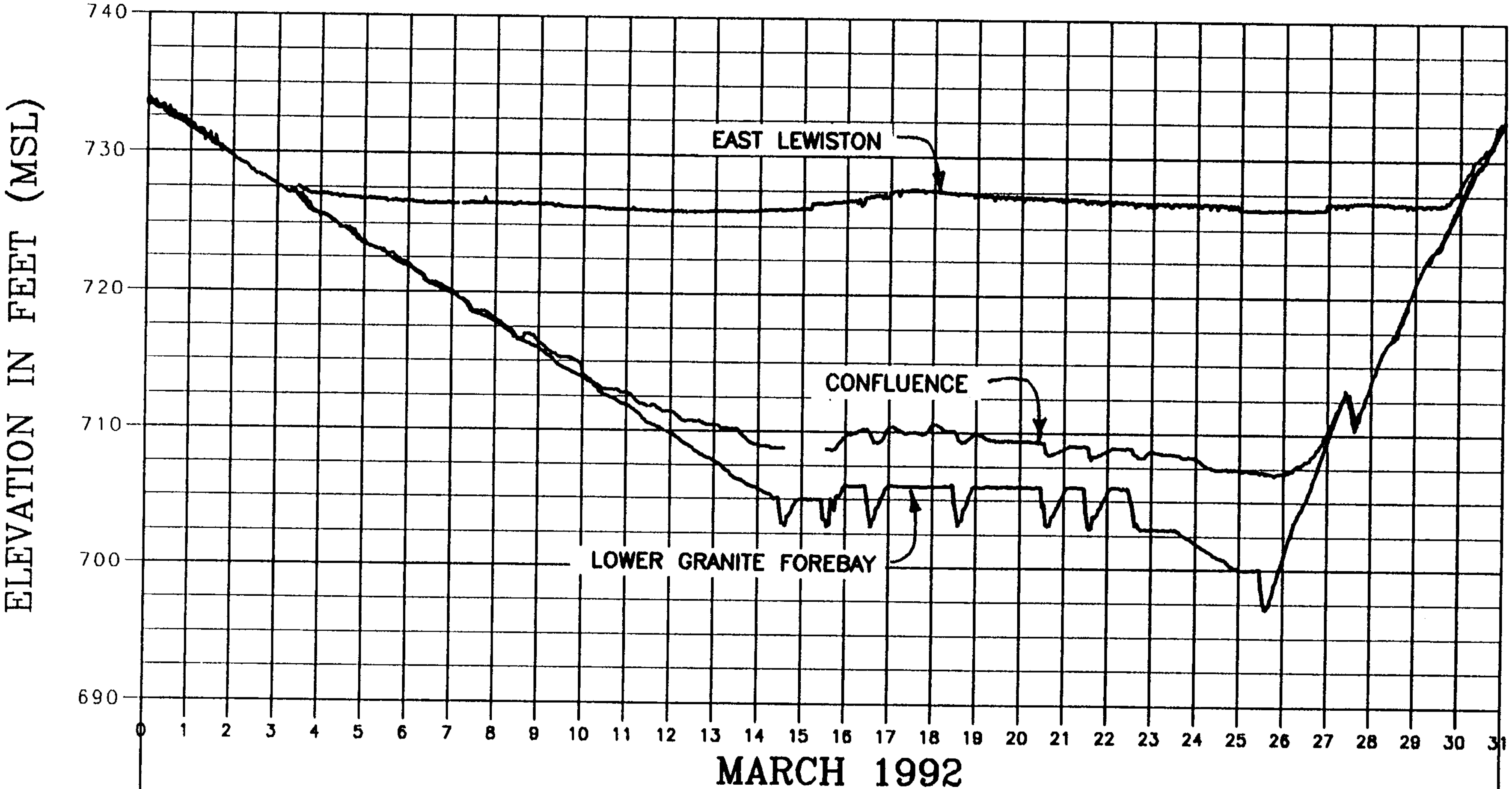
LITTLE GOOSE DAM RELEASE

SNAKE RIVER BASIN

MARCH 1992 RESERVOIR DRAWDOWN TEST

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

PLATE 4

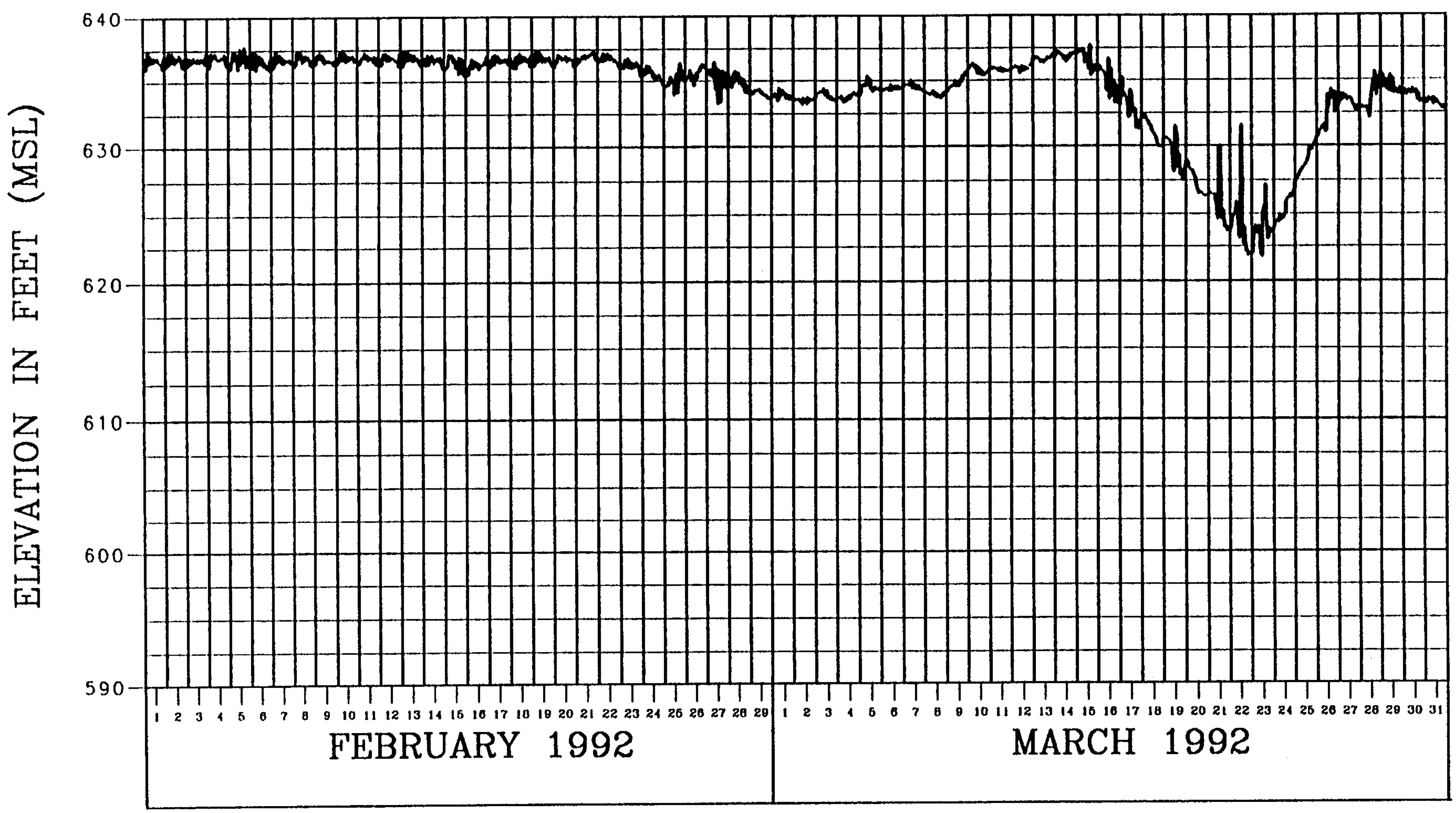


LOWER GRANITE POOL
WATER SURFACE ELEVATIONS

SNAKE RIVER BASIN

MARCH 1992
RESERVOIR
DRAWDOWN TEST

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH



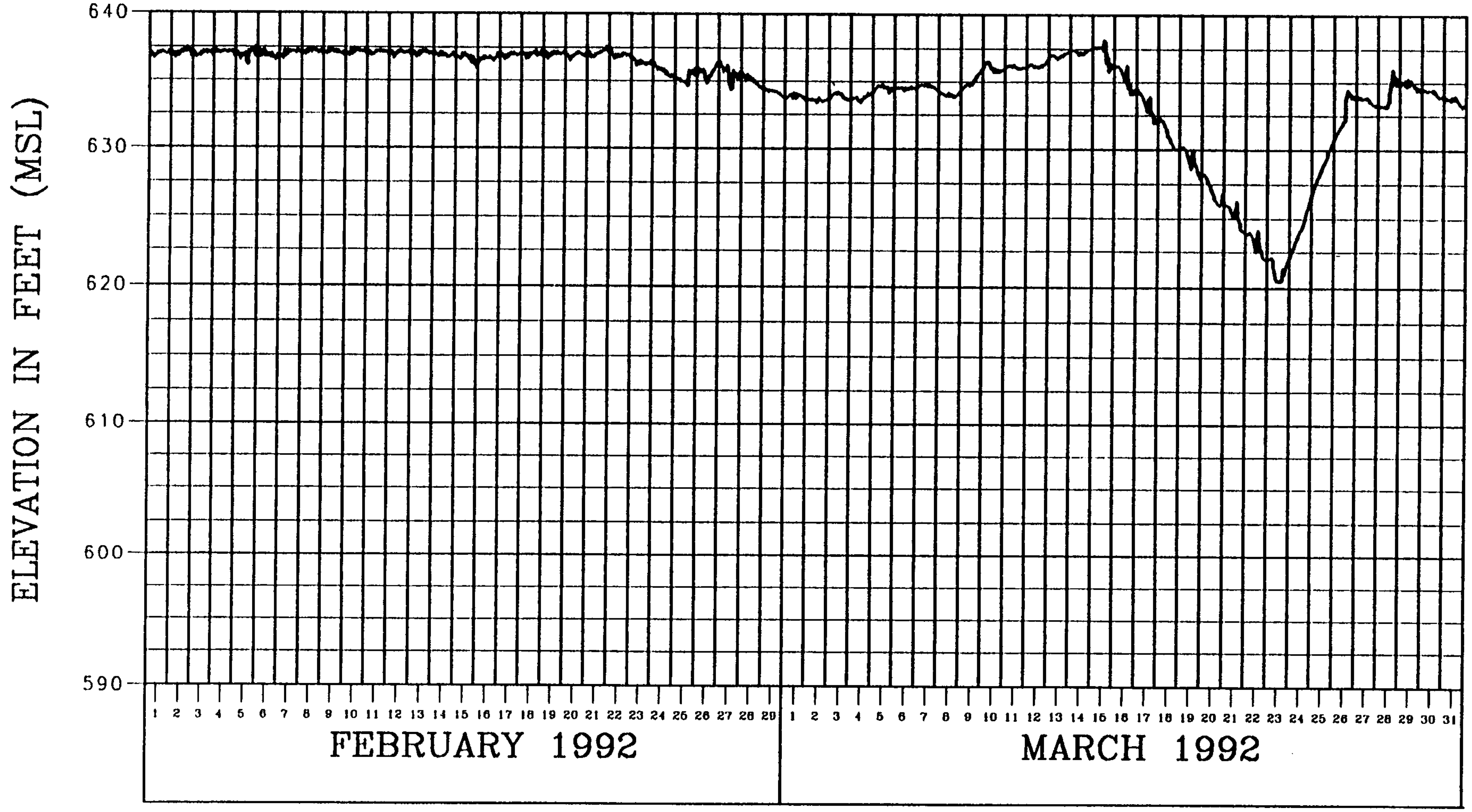
LOWER GRANITE DAM TAILWATER

SNAKE RIVER BASIN

MARCH 1992 RESERVOIR DRAWDOWN TEST

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA – HYDROLOGY BRANCH

PLATE 6



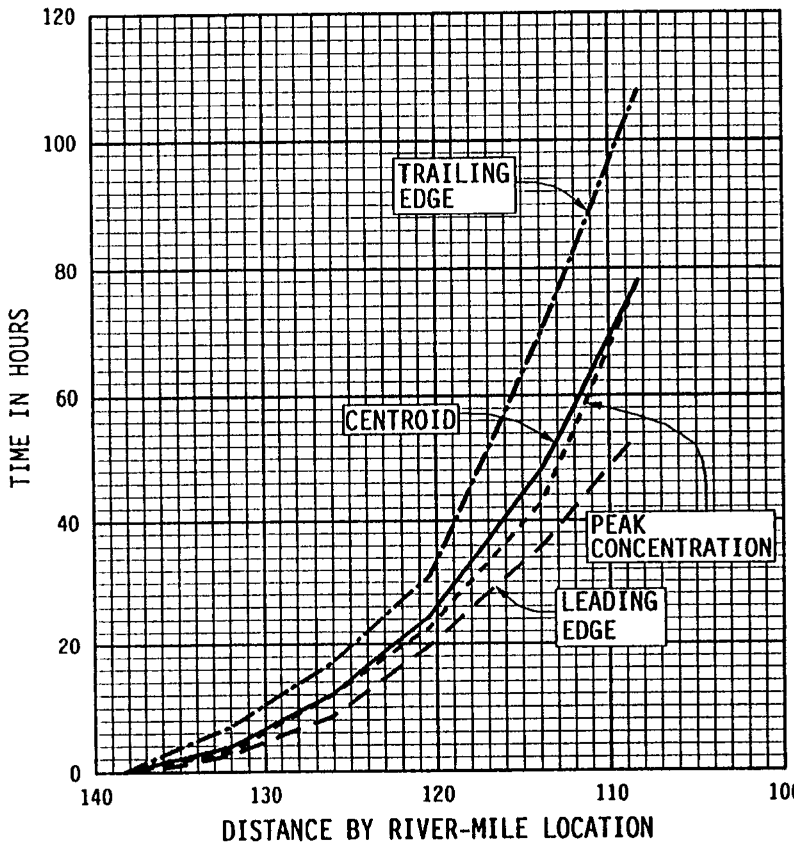
LITTLE GOOSE DAM FOREBAY

SNAKE RIVER BASIN

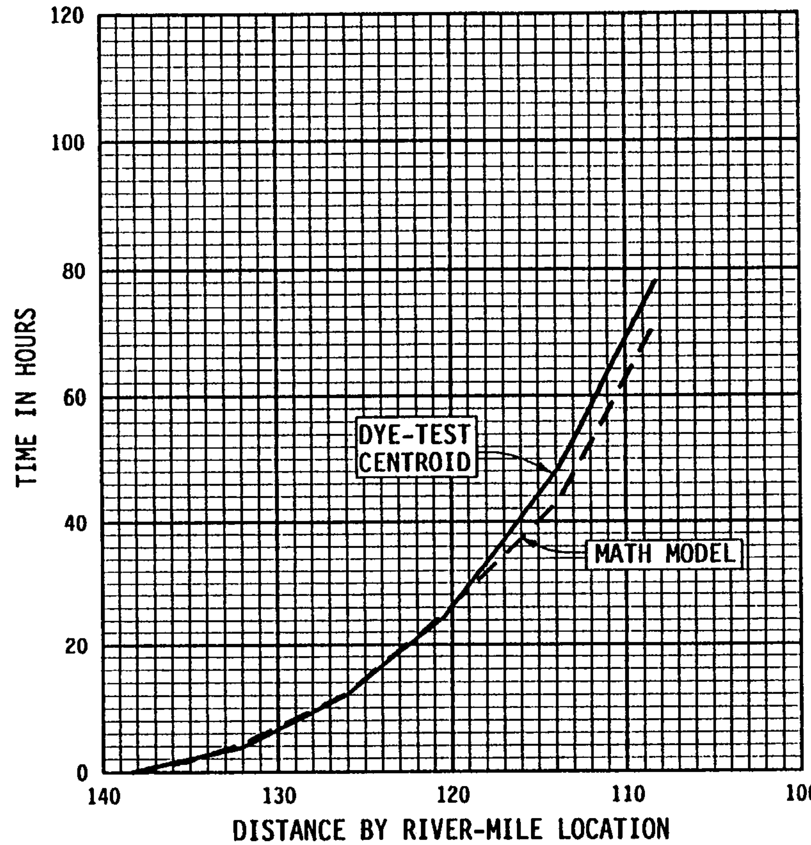
MARCH 1992
RESERVOIR
DRAWDOWN TEST

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA – HYDROLOGY BRANCH

PLATE 7



DYE TEST DOWNSTREAM OF CLEARWATER CONFLUENCE



DYE DETECTION TEST COMPARED TO COMPUTER MODEL

NOTE:

1. THE CENTROID (OR CENTER OF MASS) OF THE DYE CONCENTRATION CURVE WAS SELECTED AS THE BEST ESTIMATE OF THE AVERAGE WATER-PARTICLE TIME. THE AVERAGE TRAVEL TIME WAS MATHEMATICALLY MODELED USING THE HYDROLOGIC ENGINEERING CENTER'S COMPUTER BACKWATER MODEL (HEC-2).
2. FLOW VARIATIONS OF UP TO 100,000 CFS OCCURRED DURING THIS TEST RESULTING IN UNSTEADY FLOW CONDITIONS. THE MATH MODEL PROVIDES ONLY A ROUGH COMPARISON SINCE IT IS A STEADY-STATE MODEL. FLOWS FOR THE MODEL WERE ESTIMATED BY SUMMING TWO STREAM GAGES (U.S. GEOLOGICAL SURVEY GAGES, "SNAKE RIVER NEAR ANATONE, WA. AND CLEARWATER RIVER AT SPAULDING, ID.). THE AVERAGE DISCHARGE (34,150 CFS) AND FOREBAY ELEVATION (705.58) WERE DETERMINED BY AVERAGING HOURLY VALUES BETWEEN 1200 HRS. 17 MARCH AND 1800 HRS. 20 MARCH 1992.
3. THE PEAK CONCENTRATION, CENTROID, AND TRAILING EDGE ARE ONLY ROUGHLY APPROXIMATED AT R.M. 108.31 SINCE THE DYE TEST WAS TERMINATED BEFORE THE SHAPE OF THE CONCENTRATION CURVE WAS WAS WELL DEFINED
4. THE "TRAILING EDGE" IS ONLY AN APPROXIMATE VALUE INDICATING THE APPROXIMATE TIME WHEN THE DYE CONCENTRATION APPROACHED THE BACKGROUND LEVEL.

PRELIMINARY

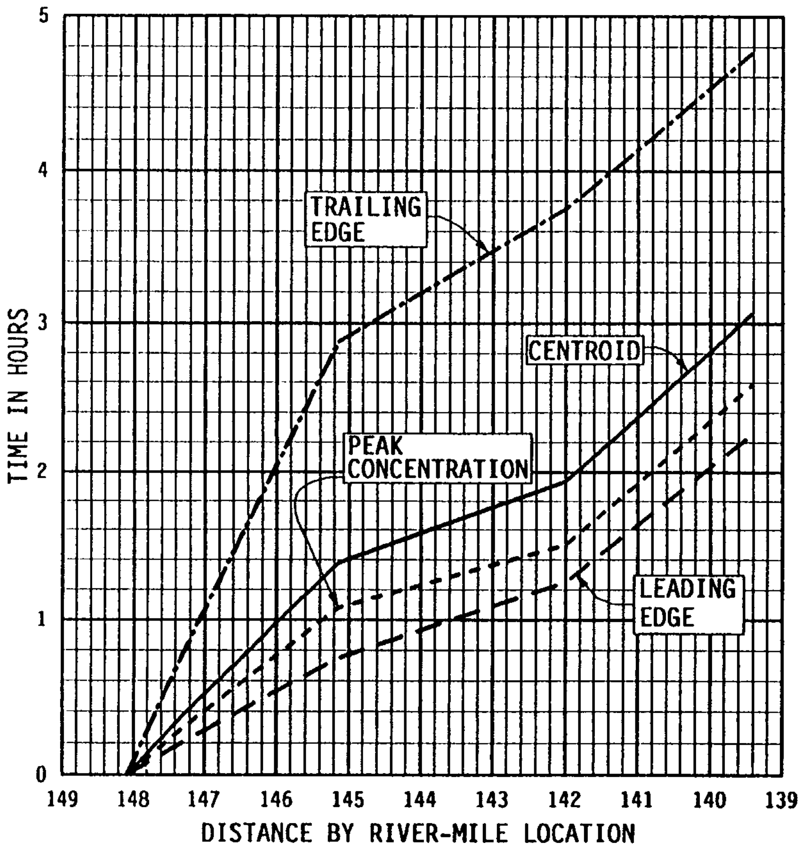
SNAKE RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

DYE DETECTION TEST
DOWNSTREAM OF CLEARWATER CONFLUENCE

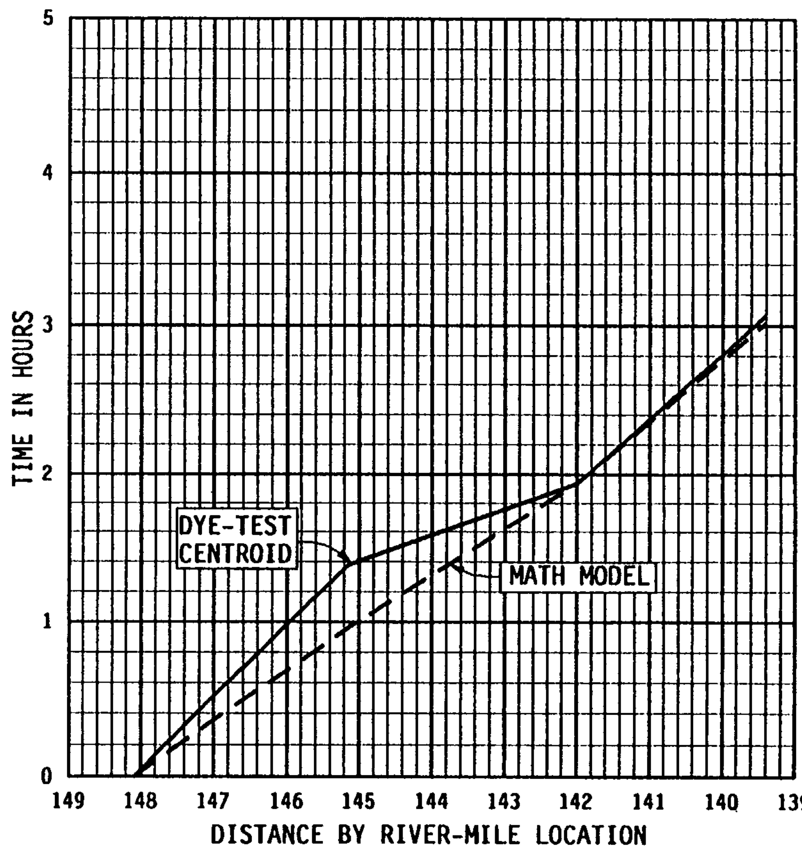
1200 HRS. 17 MARCH & 1800 HRS. 20 MARCH

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	18 SEPT. 1992



DYE-TEST UPSTREAM OF CLEARWATER CONFLUENCE



DYE DETECTION TEST COMPARED TO COMPUTER MODEL

NOTE:

1. THE CENTROID (OR CENTER OF MASS) OF THE DYE CONCENTRATION CURVE WAS SELECTED AS THE BEST ESTIMATE OF THE AVERAGE WATER-PARTICLE TRAVEL TIME. THE AVERAGE TRAVEL TIME WAS MATHEMATICALLY MODELED USING THE HYDROLOGIC ENGINEERING CENTER'S COMPUTER BACKWATER MODEL (HEC-2).
2. FLOW VARIED BY ABOUT 1,000 CFS DURING THE TEST. THE AVERAGE DISCHARGE (BASED ON THE U.S. GEOLOGICAL SURVEY GAGE "SNAKE RIVER NEAR ANATONE, WA.") WAS APPROXIMATELY 25,000 CFS.
3. THE "TRAILING EDGE" IS ONLY AN APPROXIMATE VALUE INDICATING THE APPROXIMATE TIME WHEN THE DYE CONCENTRATION APPROACHED THE BACKGROUND LEVEL.

PRELIMINARY

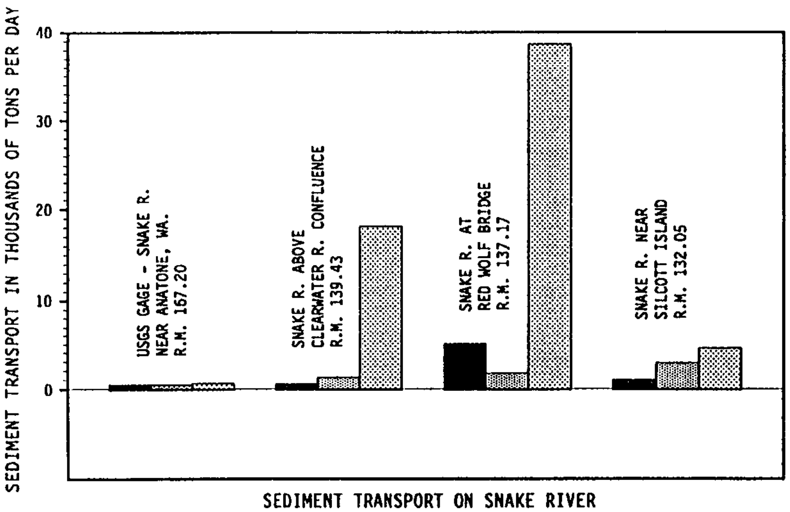
SNAKE RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

DYE DETECTION TEST
UPSTREAM OF
CLEARWATER CONFLUENCE
19 MARCH 0730 - 1200 HRS.

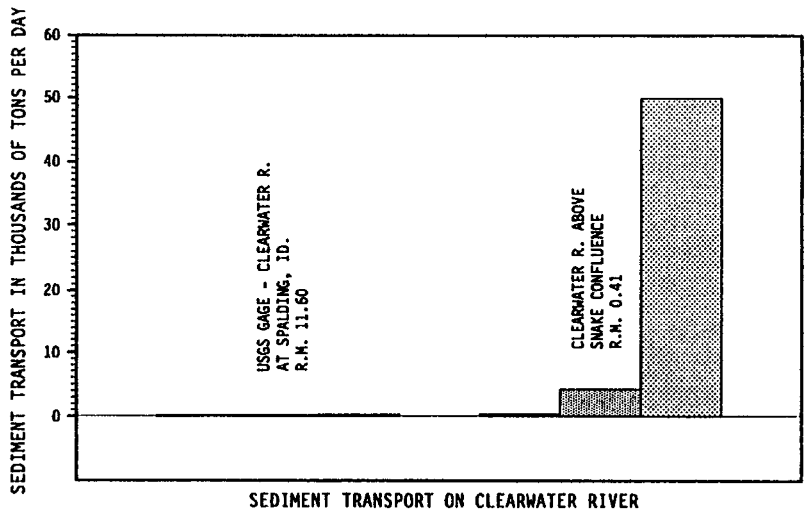
U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	8 SEPT. 1992

PLATE 9



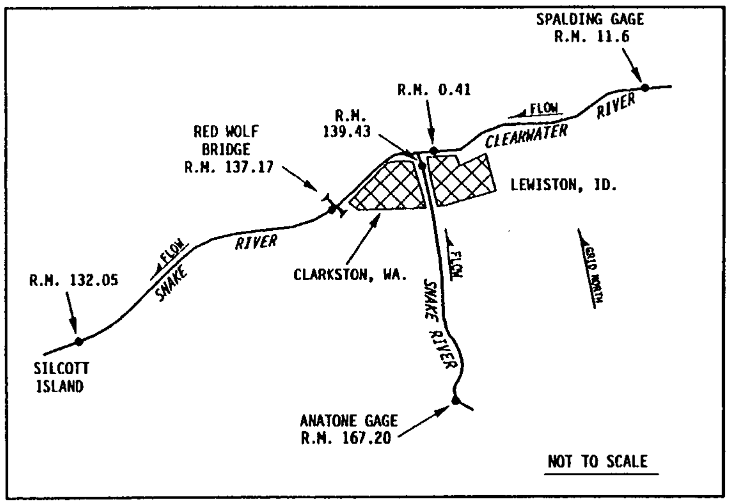
SEDIMENT TRANSPORT ON SNAKE RIVER
BEFORE AND DURING DRAWDOWN TEST



SEDIMENT TRANSPORT ON CLEARWATER RIVER
BEFORE AND DURING DRAWDOWN TEST

LEGEND

- BEFORE DRAWDOWN (FULL POOL) AVERAGE POOL ELEVATION - 737.00
- PARTIAL POOL AVERAGE POOL ELEVATION - 723.50
- MAXIMUM DRAWDOWN (LOW POOL) RANGED FROM 704.00 - 710.00



SEDIMENT SITE LOCATIONS

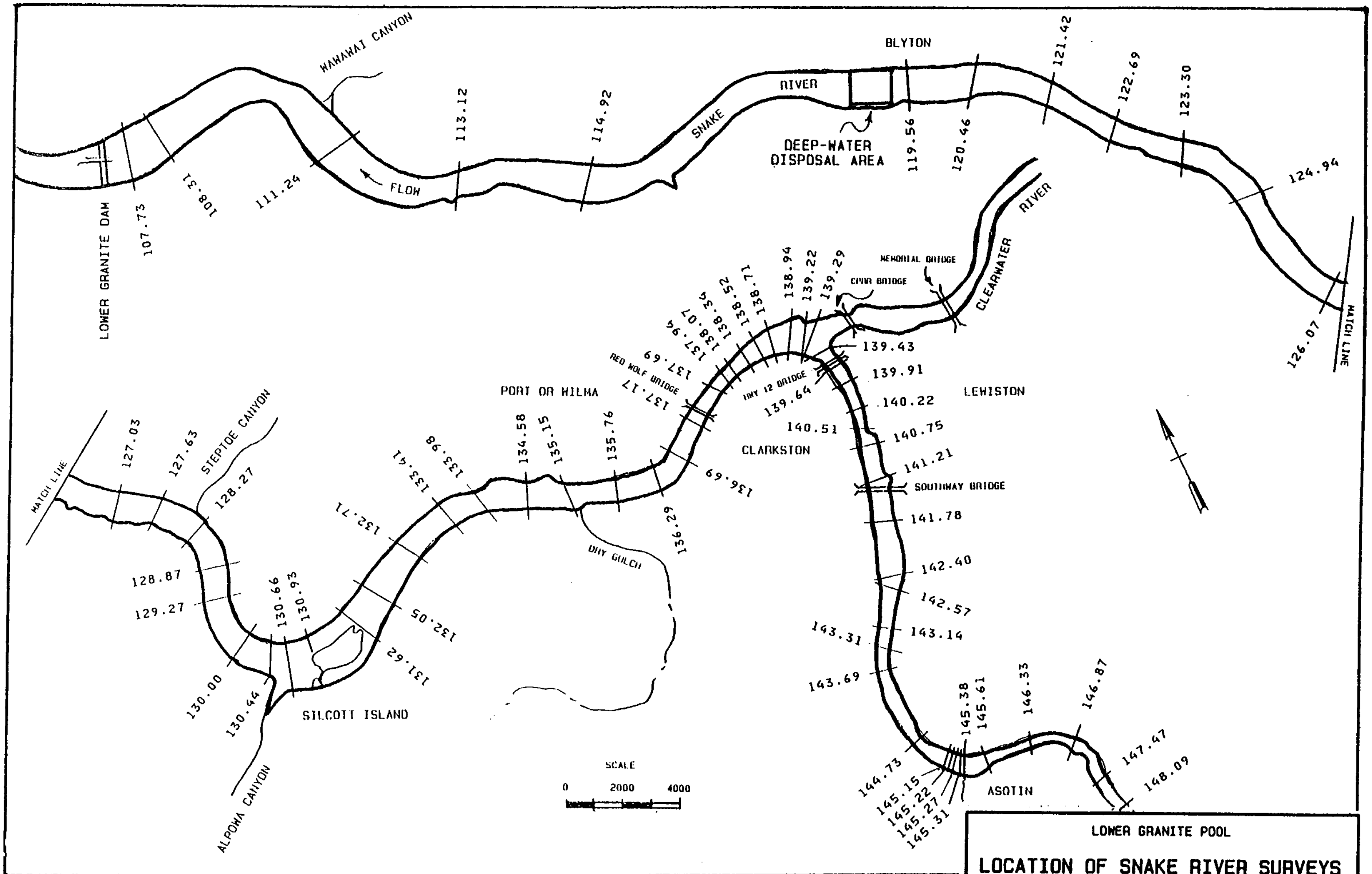
NOTE: HIGH SEDIMENT TRANSPORT BEFORE DRAWDOWN AT R.M. 137.17 MAY HAVE BEEN CAUSED BY SPILLWAY TESTING. SEE DISCUSSION IN REPORT.

SNAKE & CLEARWATER RIVER BASINS
LOWER GRANITE POOL DRAWDOWN TEST

SEDIMENT TRANSPORT DURING DRAWDOWN TEST

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	6 AUGUST 1992

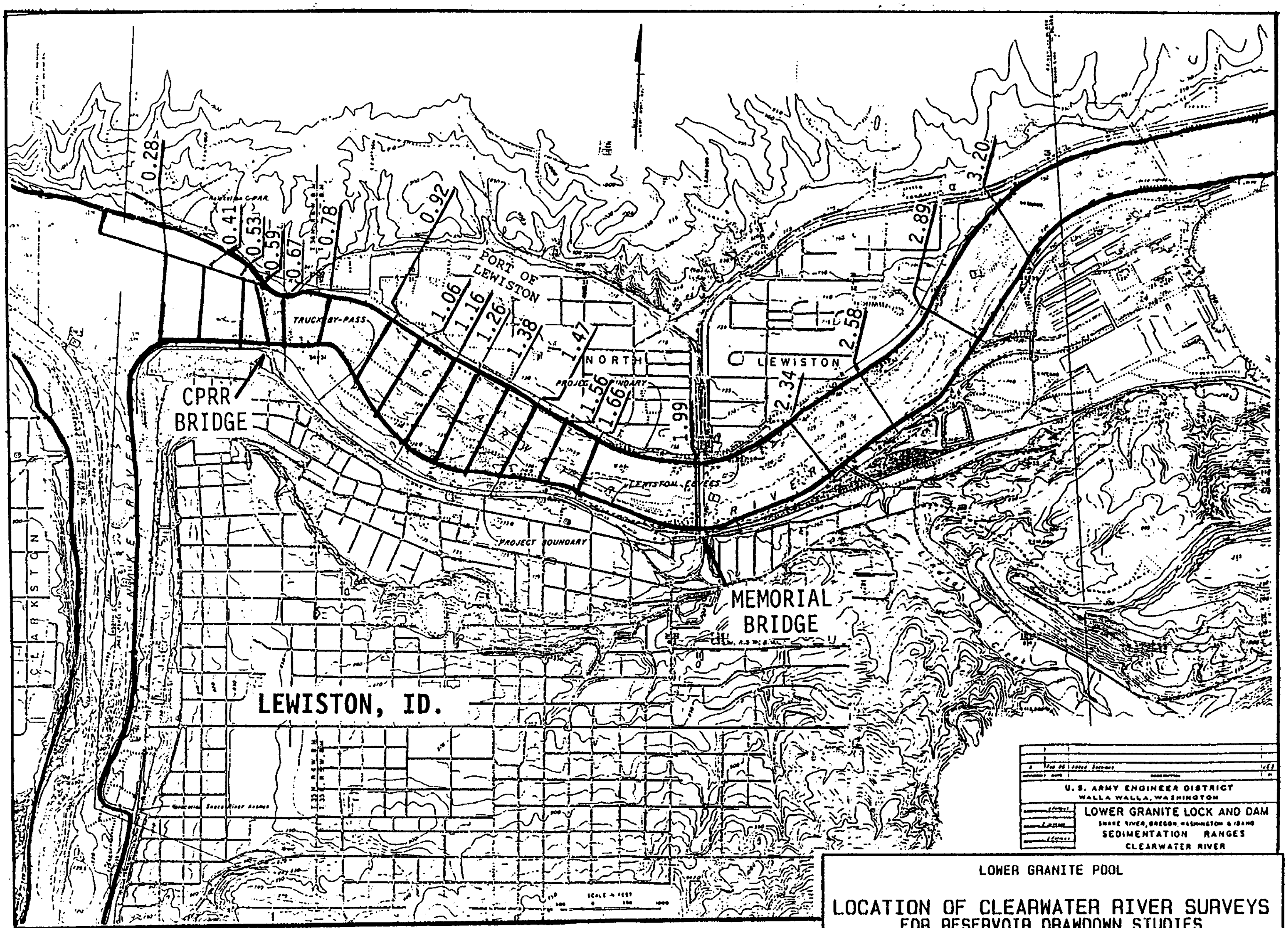


LOWER GRANITE POOL

LOCATION OF SNAKE RIVER SURVEYS
RESERVOIR DRAWDOWN STUDIES

Department of the Army
Walla Walla District
Hydrology Branch

PLATE 11

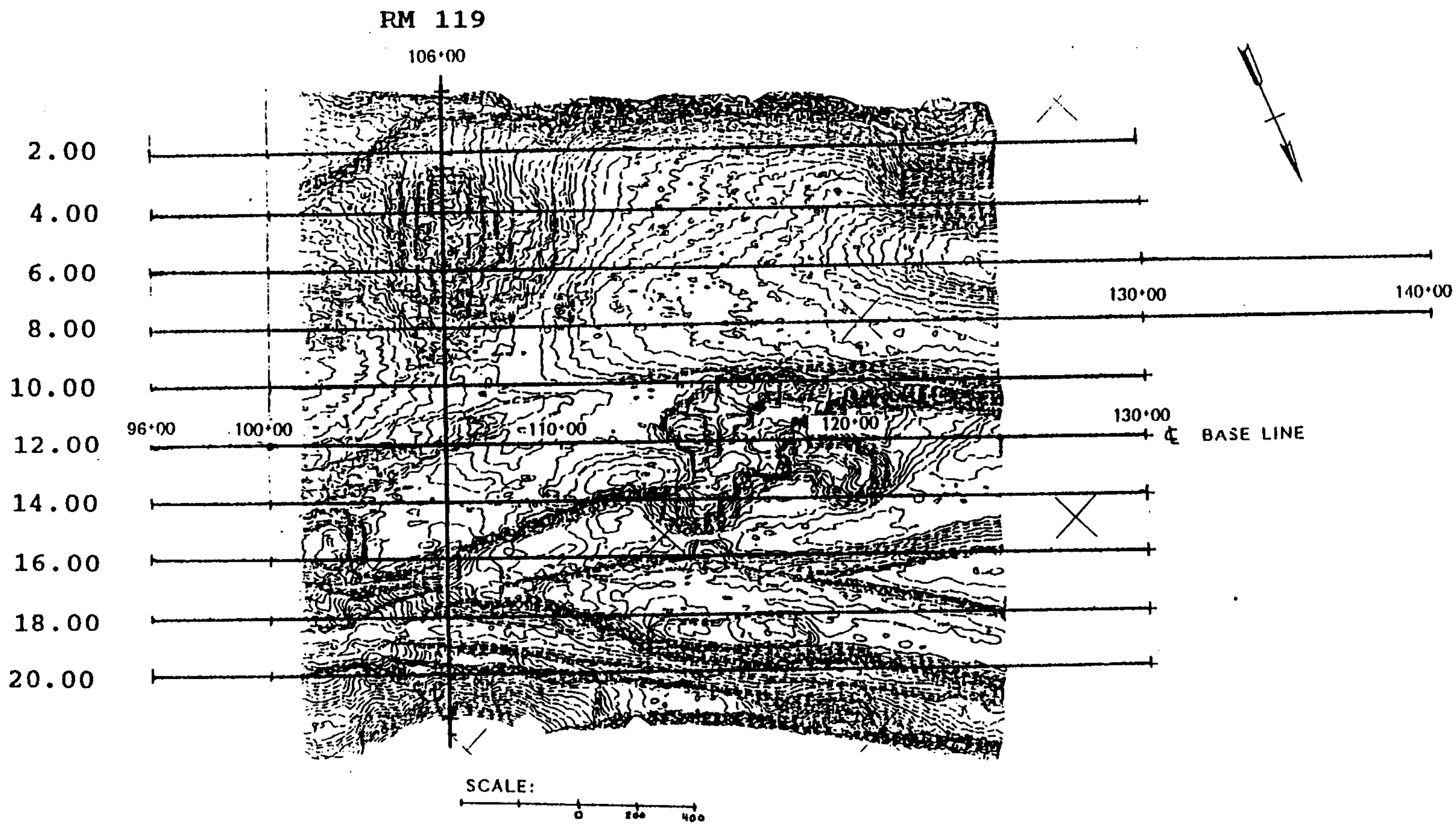


LOWER GRANITE POOL

LOCATION OF CLEARWATER RIVER SURVEYS FOR RESERVOIR DRAWDOWN STUDIES

Department of the Army
Walla Walla District
Hydrology Branch

PLATE 12



REQUIRED SURVEYS

1. Survey a complete river cross section at Base Line Station 106+00.

2. Survey ten profile lines spaced 200 ft apart parallel to the Disposal Base Line. The profiles should start at STA 96+00 and end at STA 130+00 except two lines which extend to STA 140+00.

DEEP-WATER DISPOSAL SITE SURVEYS
FOR RESERVOIR DRAWDOWN TEST

LOWER GRANITE POOL

DEEP-WATER DISPOSAL SITE SURVEYS
FOR RESERVOIR DRAWDOWN STUDIES

Department of the Army
Walla Walla District
Hydrology Branch

PLATE 13

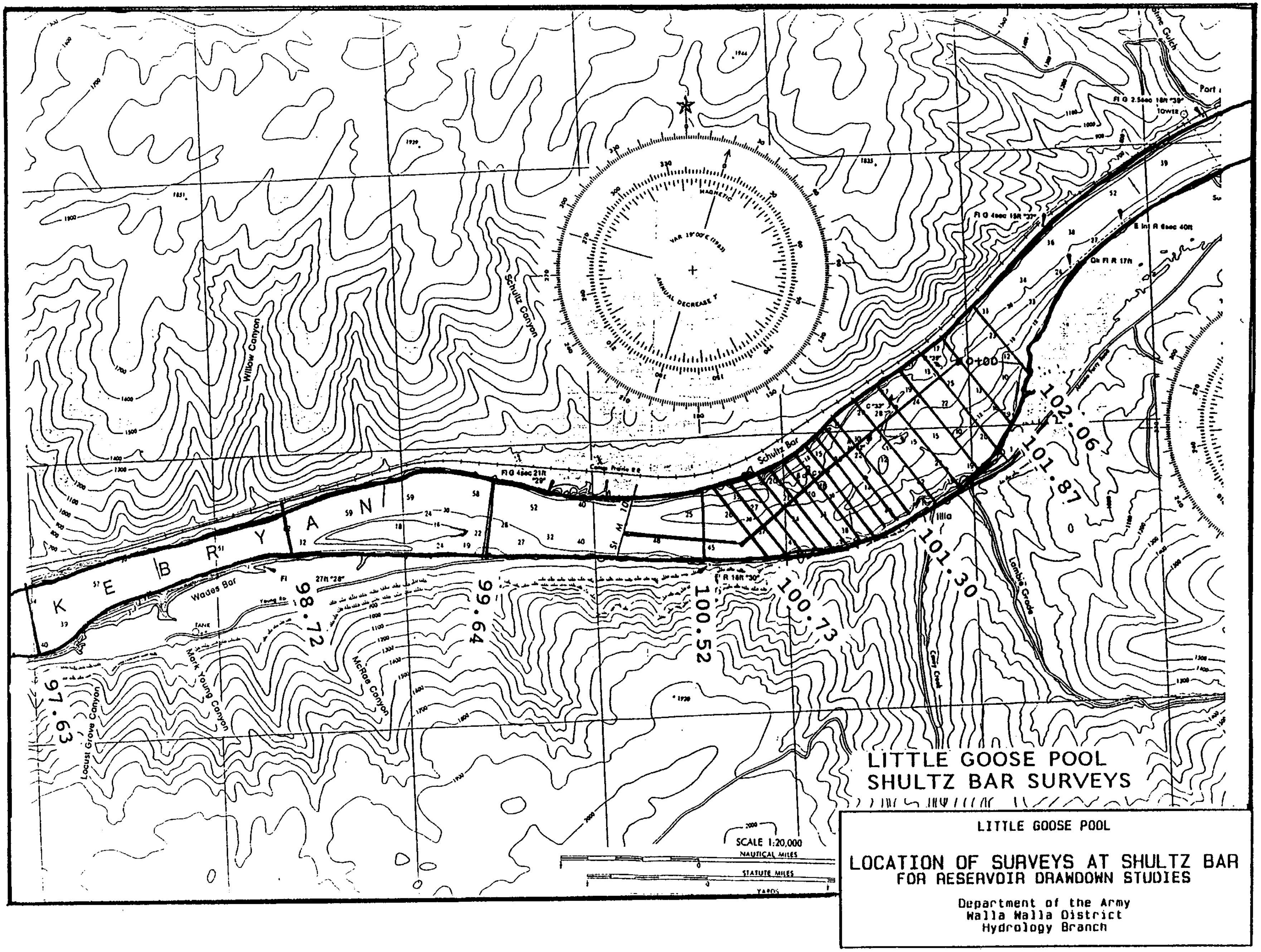
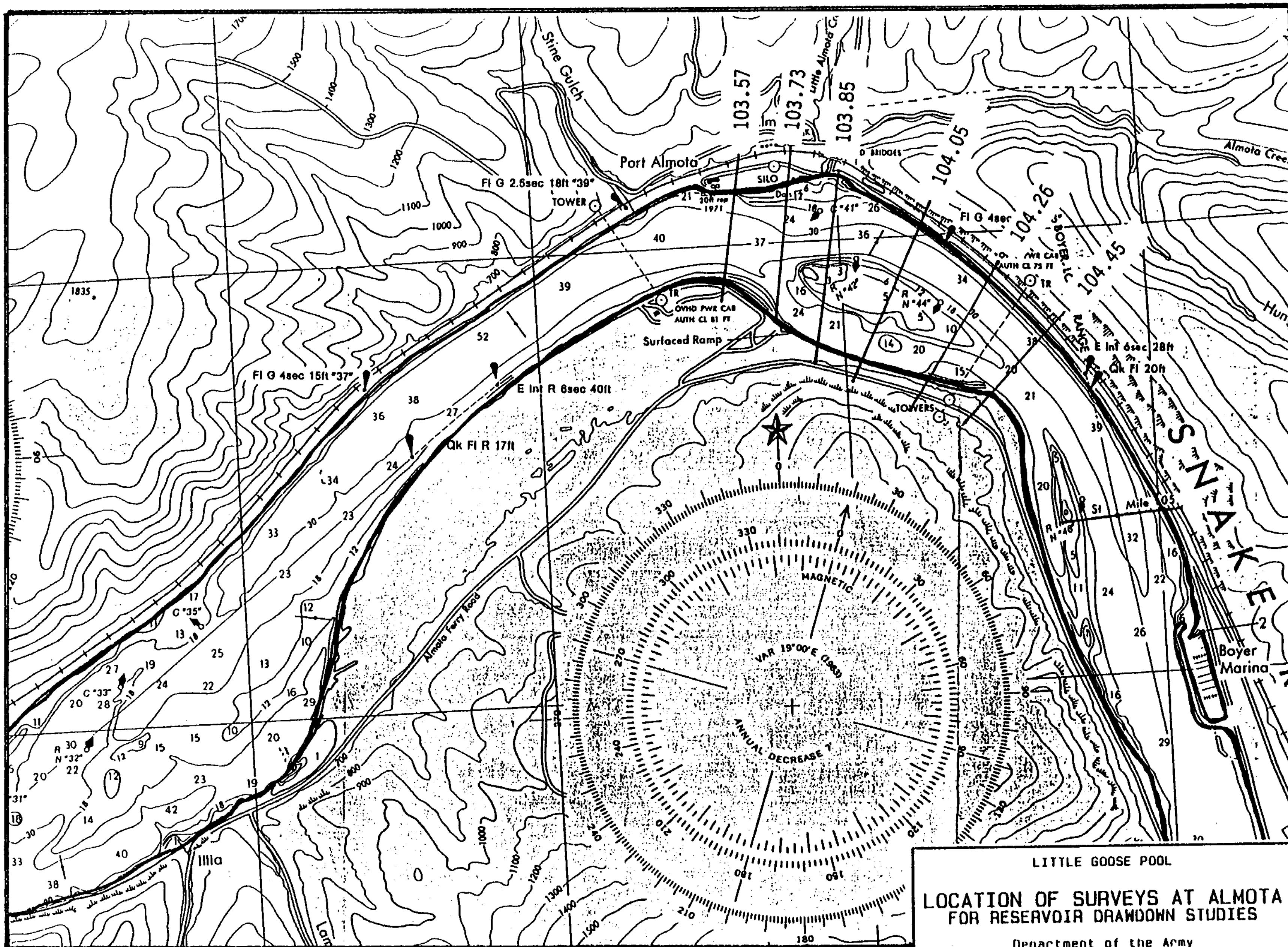

LITTLE GOOSE POOL
SHULTZ BAR SURVEYS
LITTLE GOOSE POOL
LOCATION OF SURVEYS AT SHULTZ BAR
FOR RESERVOIR DRAWDOWN STUDIES
Department of the Army
Walla Walla District
Hydrology Branch
SCALE 1:20,000
NAUTICAL MILES
STATUTE MILES
YARDS
97.63
98.72
99.64
100.52
100.73
101.30
101.87
102.06
0+00
K E B R Y A N
Schultz Canyon
Willow Canyon
Schultz Bar
Wades Bar
Locust Grove Canyon
Mark Young Canyon
McRae Canyon
Lambie Grade
MAGNETIC
VAR 19°00'E (1983)
ANNUAL DECREASE 7'

PLATE 14

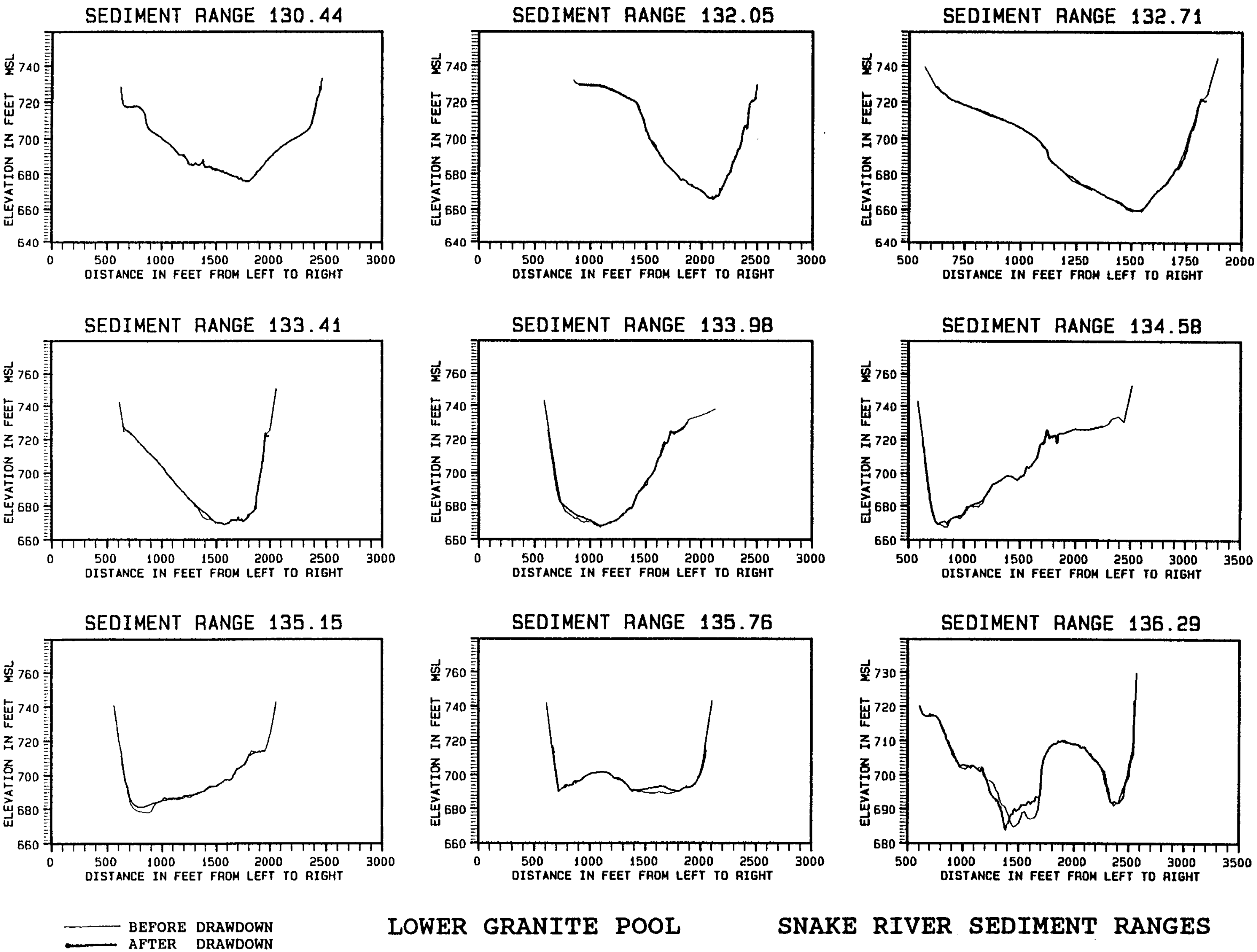


LITTLE GOOSE POOL

LOCATION OF SURVEYS AT ALMOTA
FOR RESERVOIR DRAWDOWN STUDIES

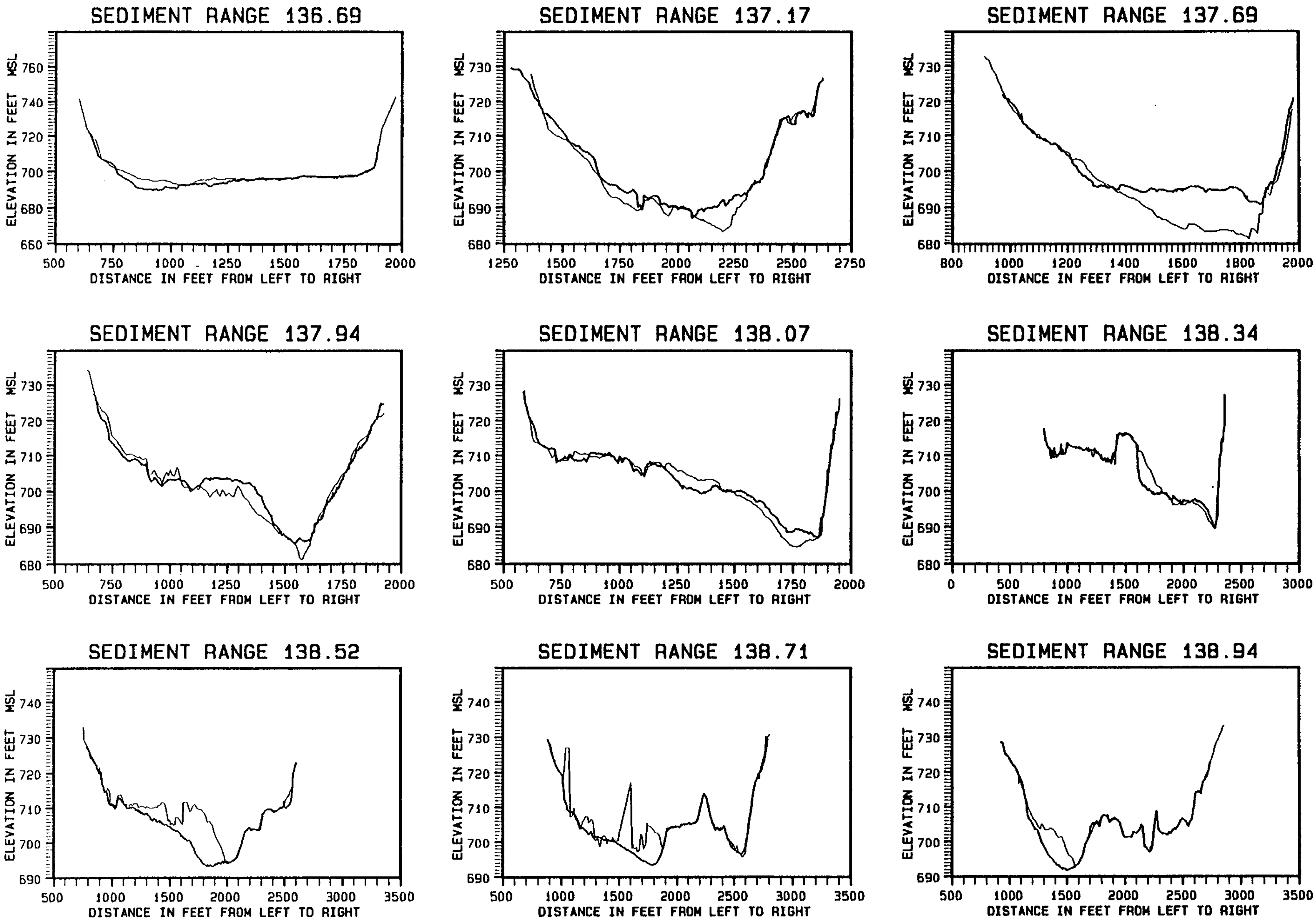
Department of the Army
Walla Walla District
Hydrology Branch

PLATE 15



LOWER GRANITE POOL SNAKE RIVER SEDIMENT RANGES

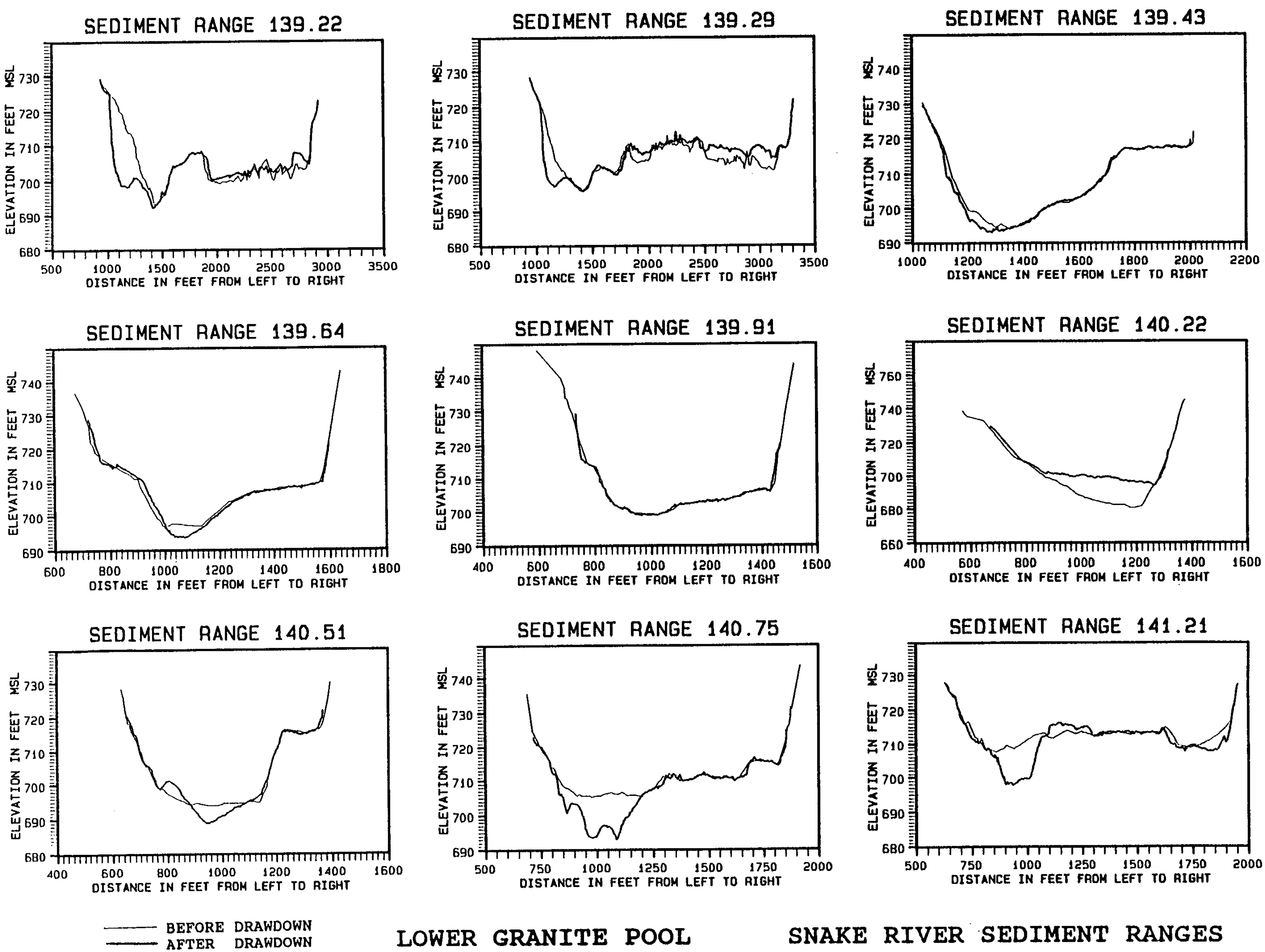
PLATE 17



BEFORE DRAWDOWN
AFTER DRAWDOWN

LOWER GRANITE POOL SNAKE RIVER SEDIMENT RANGES

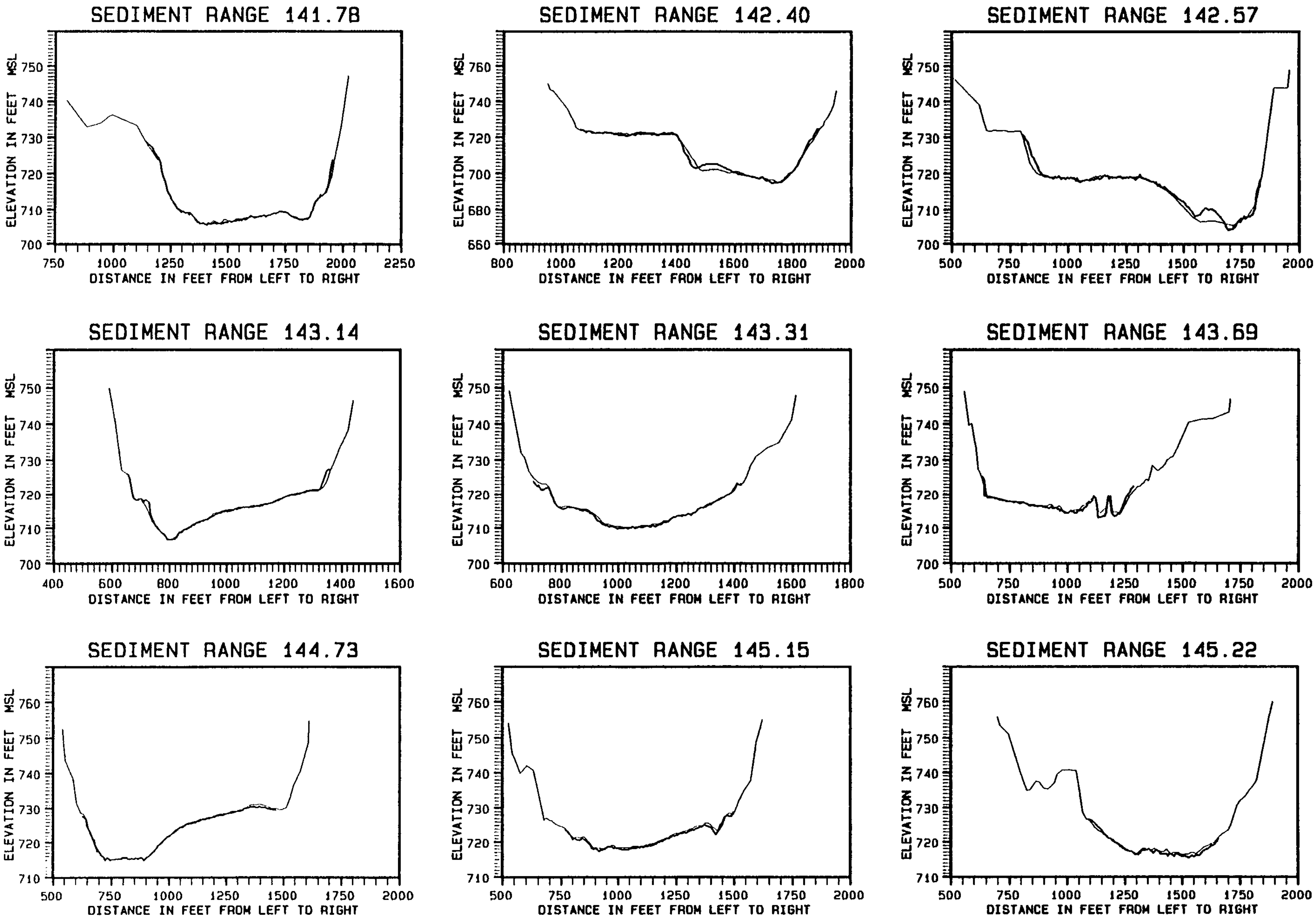
PLATE 18



LOWER GRANITE POOL

SNAKE RIVER SEDIMENT RANGES

PLATE 19

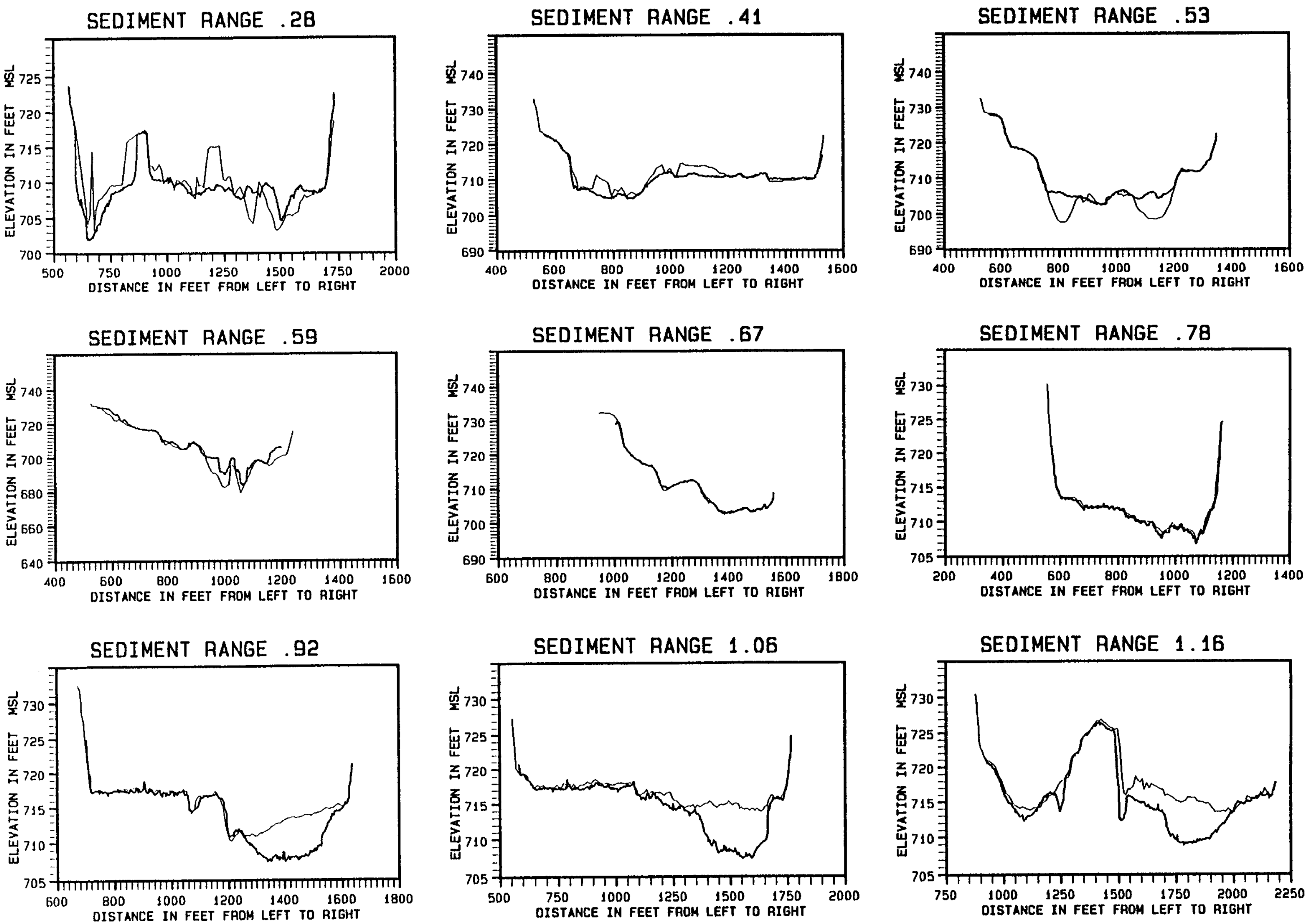


BEFORE DRAWDOWN
AFTER DRAWDOWN

LOWER GRANITE POOL

SNAKE RIVER SEDIMENT RANGES

PLATE 20

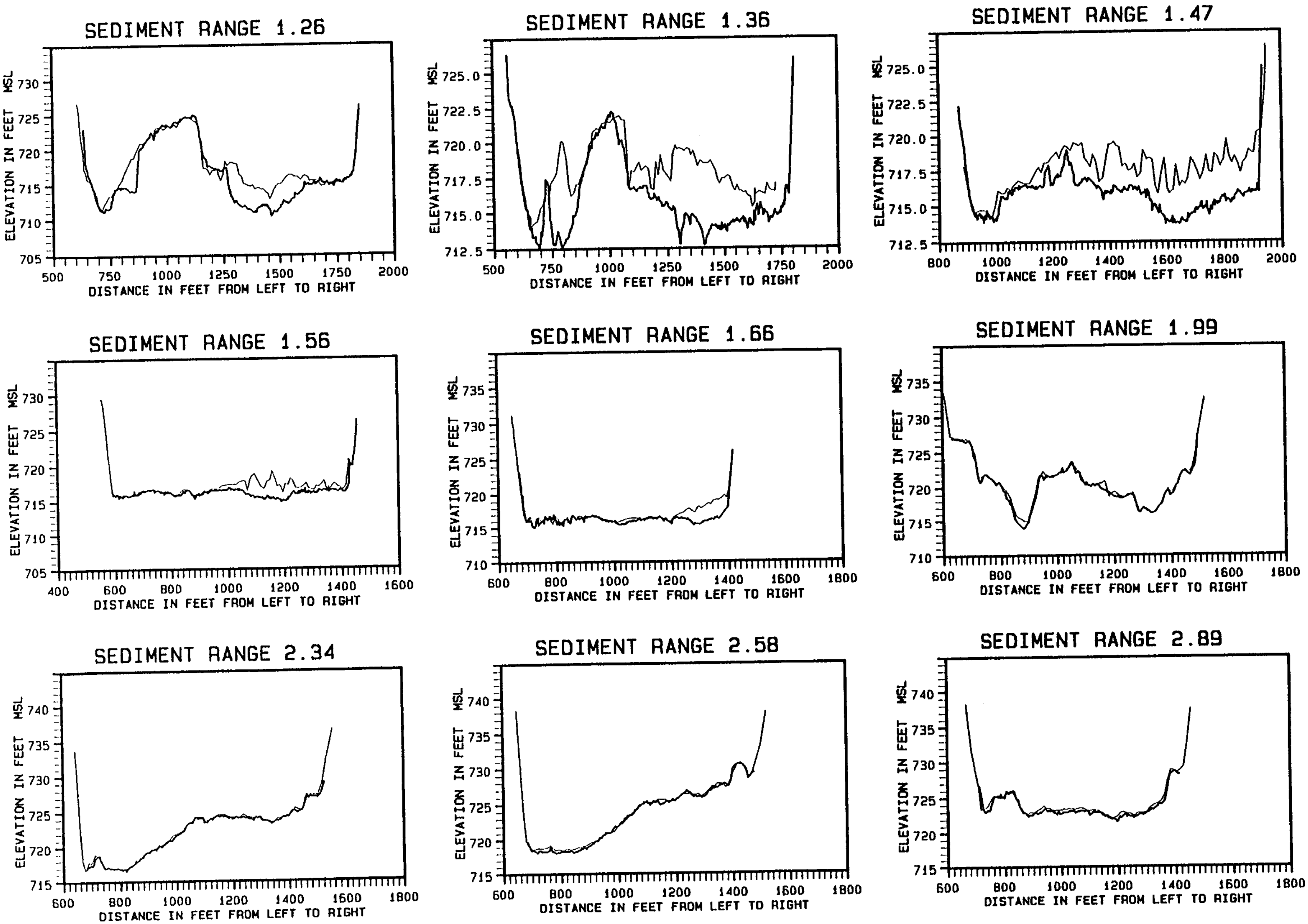


BEFORE DRAWDOWN
AFTER DRAWDOWN

LOWER GRANITE POOL

CLEARWATER RIVER SEDIMENT RANGES

PLATE 21

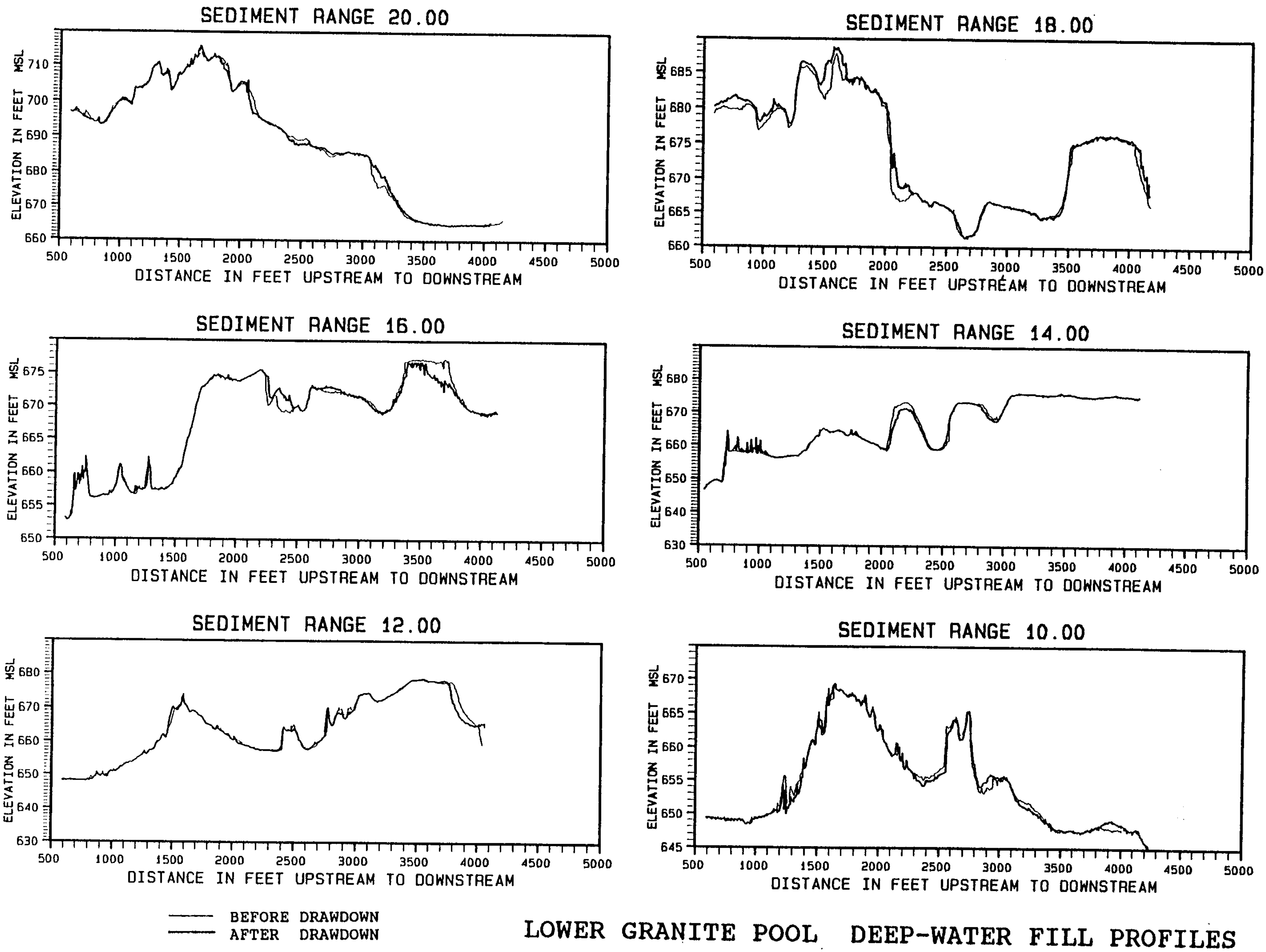


BEFORE DRAWDOWN
AFTER DRAWDOWN

LOWER GRANITE POOL

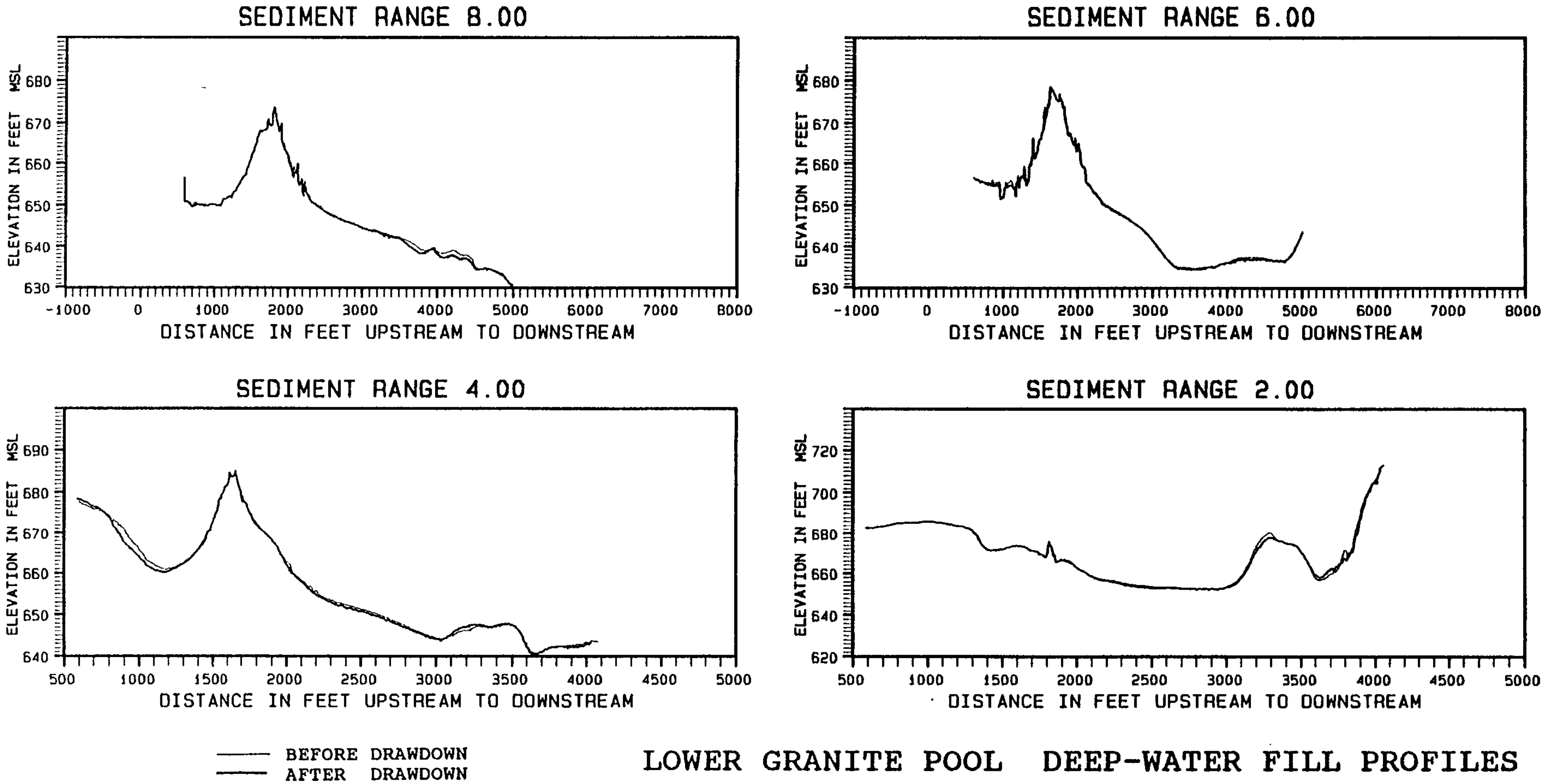
CLEARWATER RIVER SEDIMENT RANGES

PLATE 22



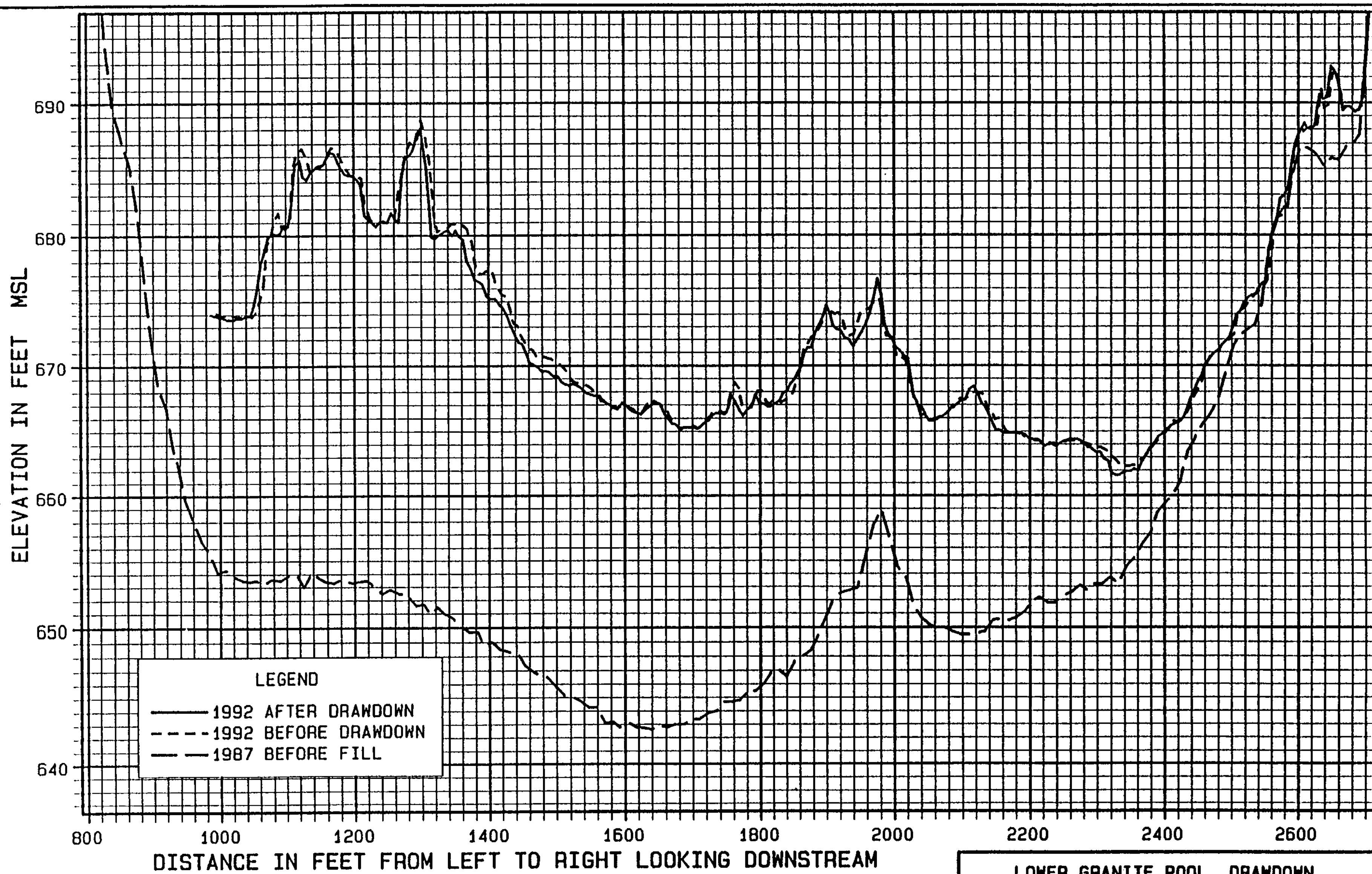
LOWER GRANITE POOL DEEP-WATER FILL PROFILES

PLATE 23



LOWER GRANITE POOL DEEP-WATER FILL PROFILES

Note: Profiles were surveyed parallel to the dredge base line and plotted at 200 ft intervals starting near the south shore and progressing toward the north shore. The dredge base line location corresponds to the location of Sediment Range 12.00 in this series of plots.



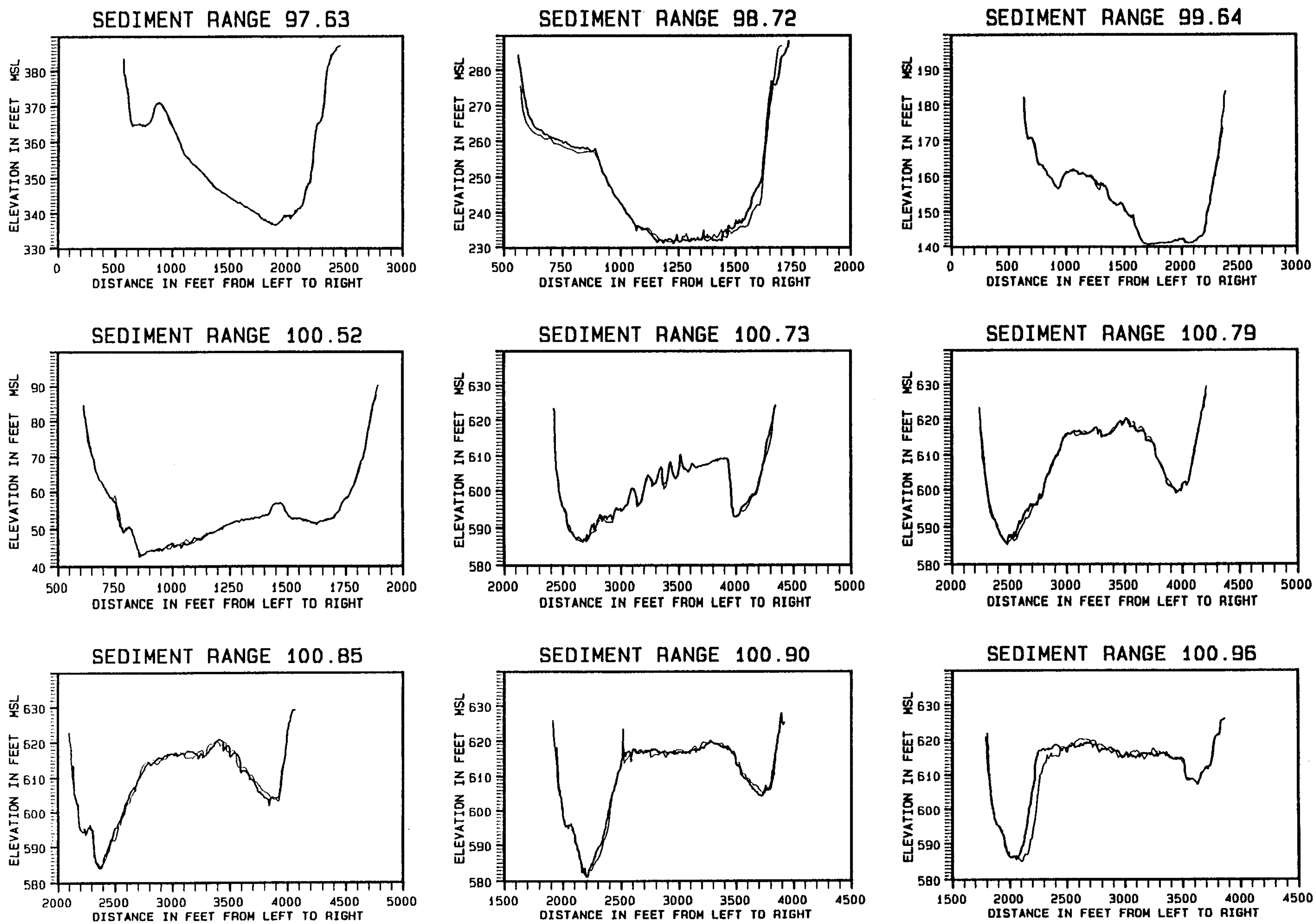
Note: This channel cross section was surveyed at River-Mile 119 on the Snake River.

LOWER GRANITE POOL. DRAWDOWN

DEEP-WATER DISPOSAL SITE

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

7 MAY 1992

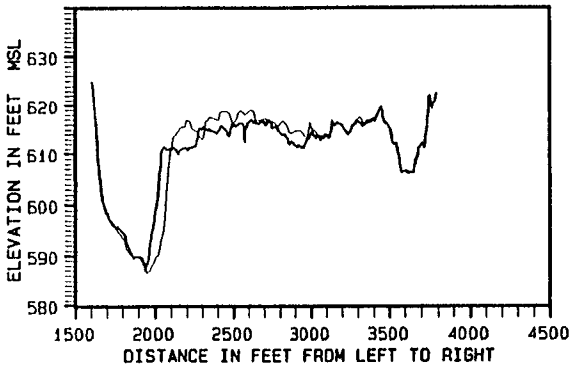


BEFORE DRAWDOWN
AFTER DRAWDOWN

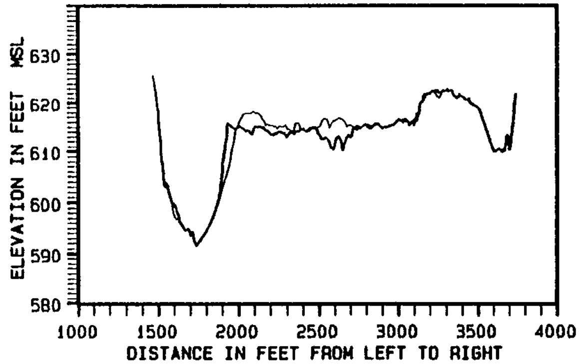
LITTLE GOOSE POOL SNAKE RIVER

PLATE 26

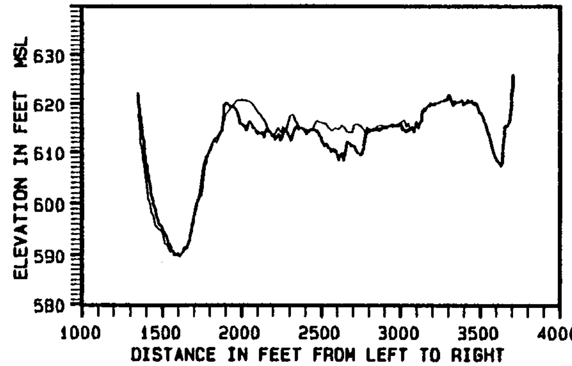
SEDIMENT RANGE 101.02



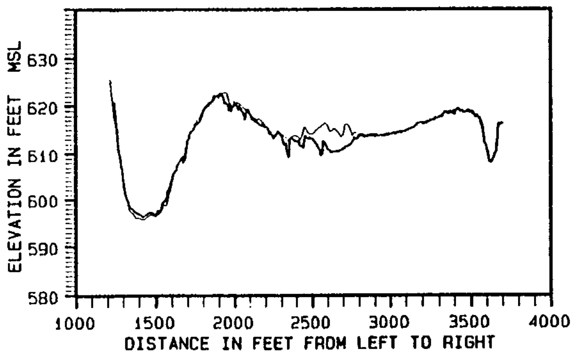
SEDIMENT RANGE 101.07



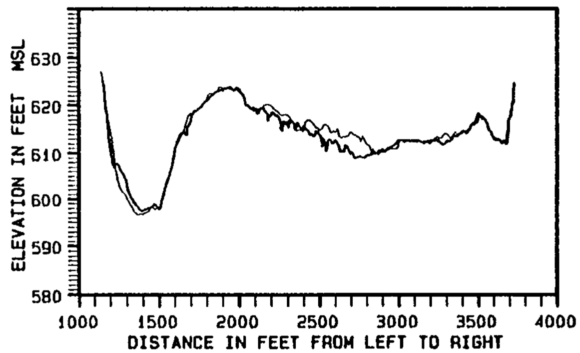
SEDIMENT RANGE 101.13



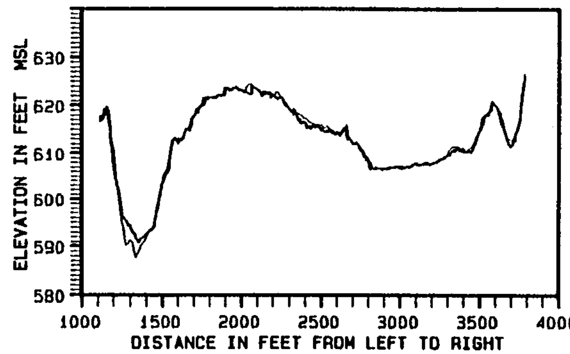
SEDIMENT RANGE 101.19



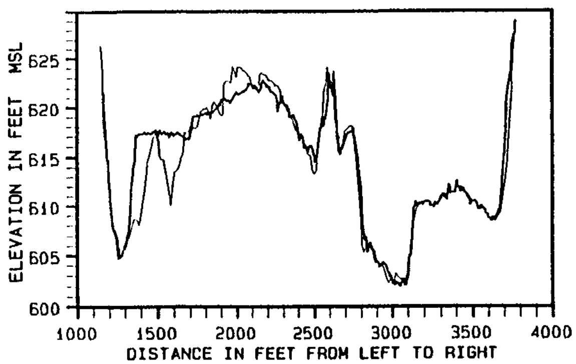
SEDIMENT RANGE 101.25



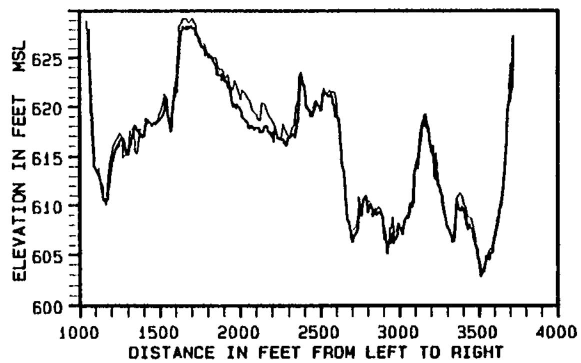
SEDIMENT RANGE 101.30



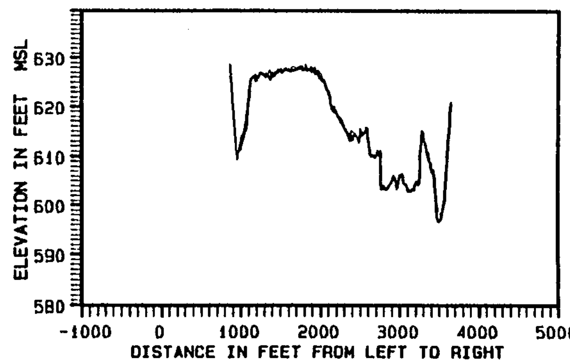
SEDIMENT RANGE 101.42



SEDIMENT RANGE 101.53



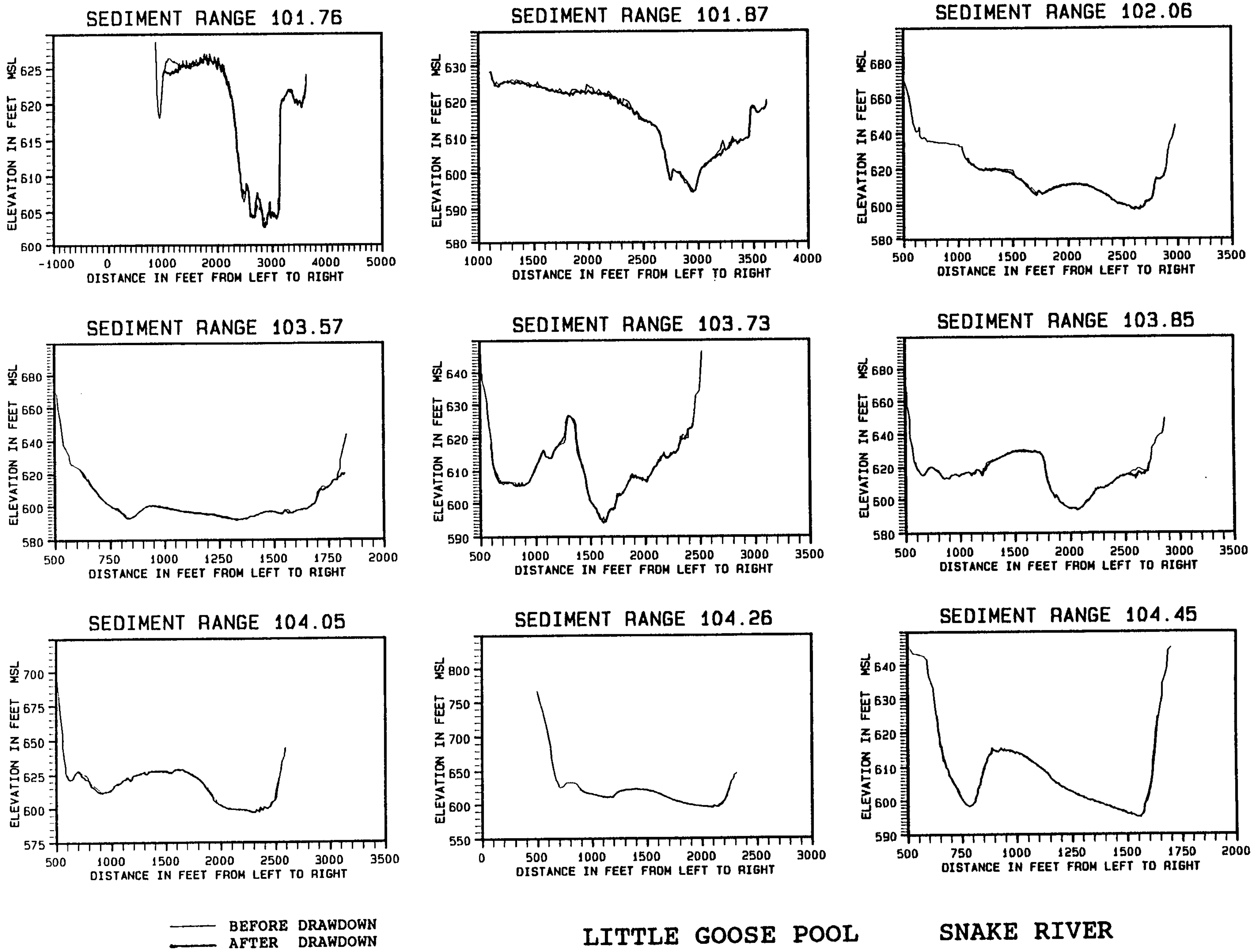
SEDIMENT RANGE 101.64



BEFORE DRAWDOWN
AFTER DRAWDOWN

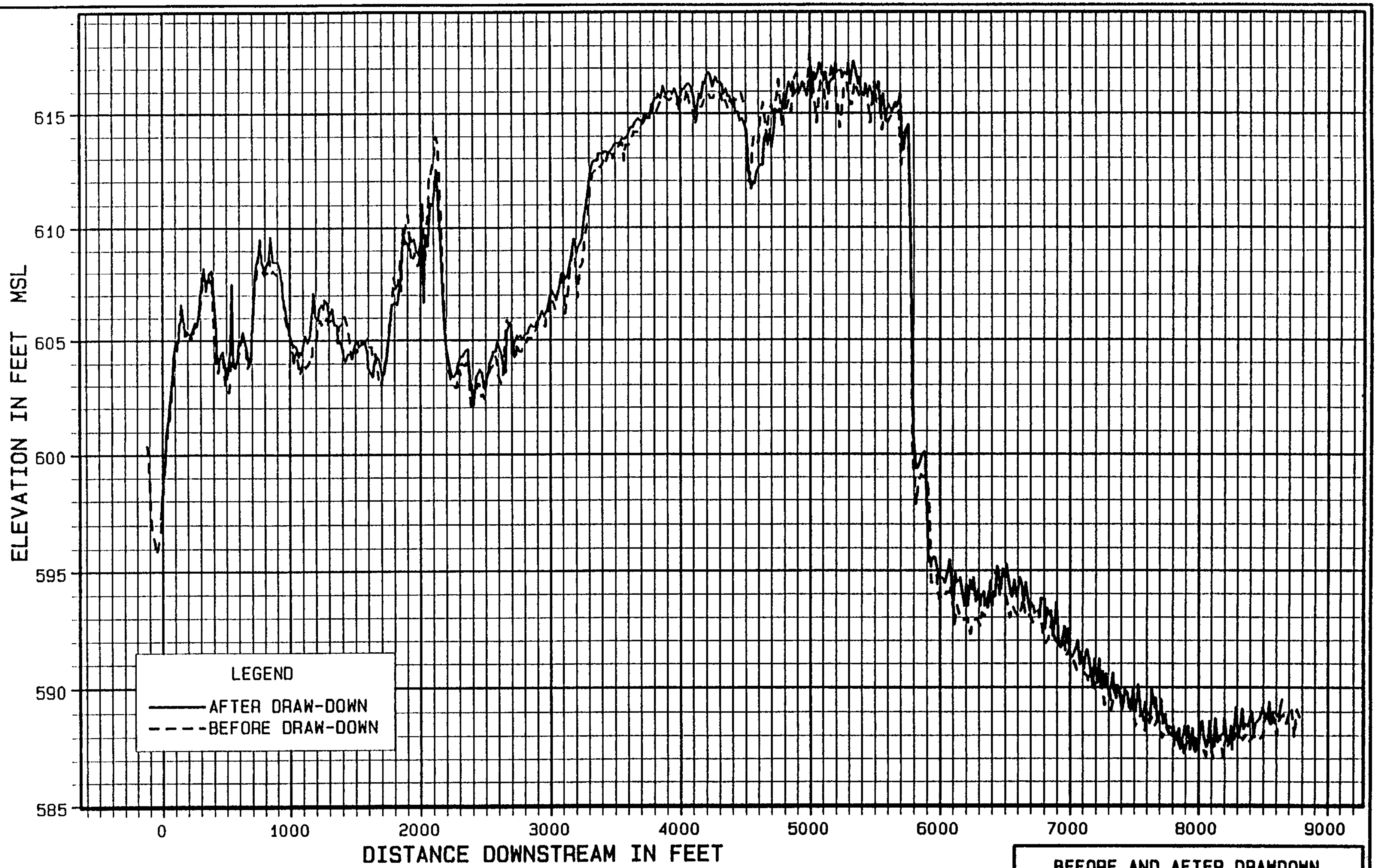
LITTLE GOOSE POOL SNAKE RIVER

PLATE 27



LITTLE GOOSE POOL SNAKE RIVER

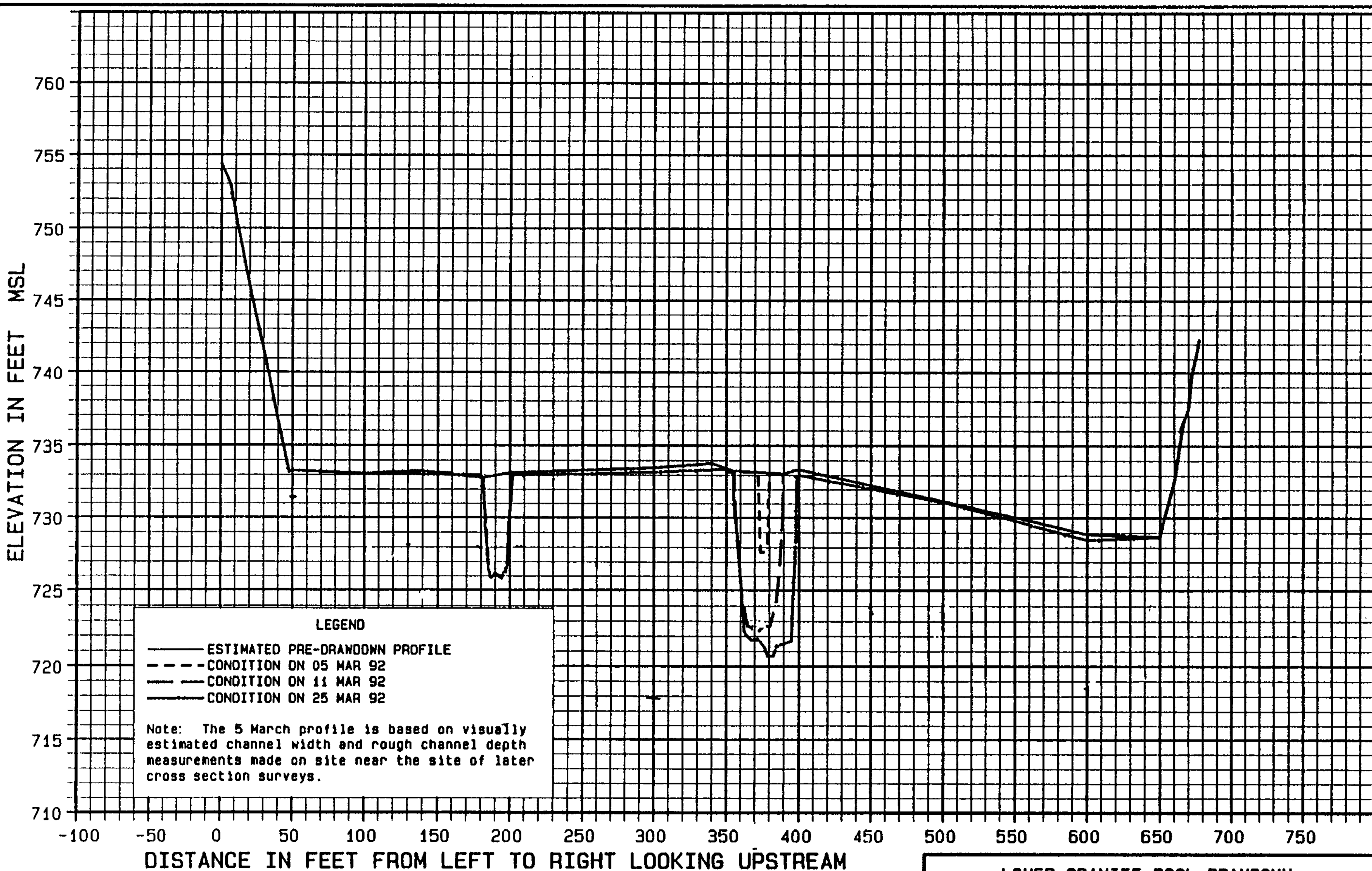
PLATE 28



BEFORE AND AFTER DRAWDOWN
SCHULTZ BAR PROFILE

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

11 JUN 1992



LOWER GRANITE POOL DRAWDOWN

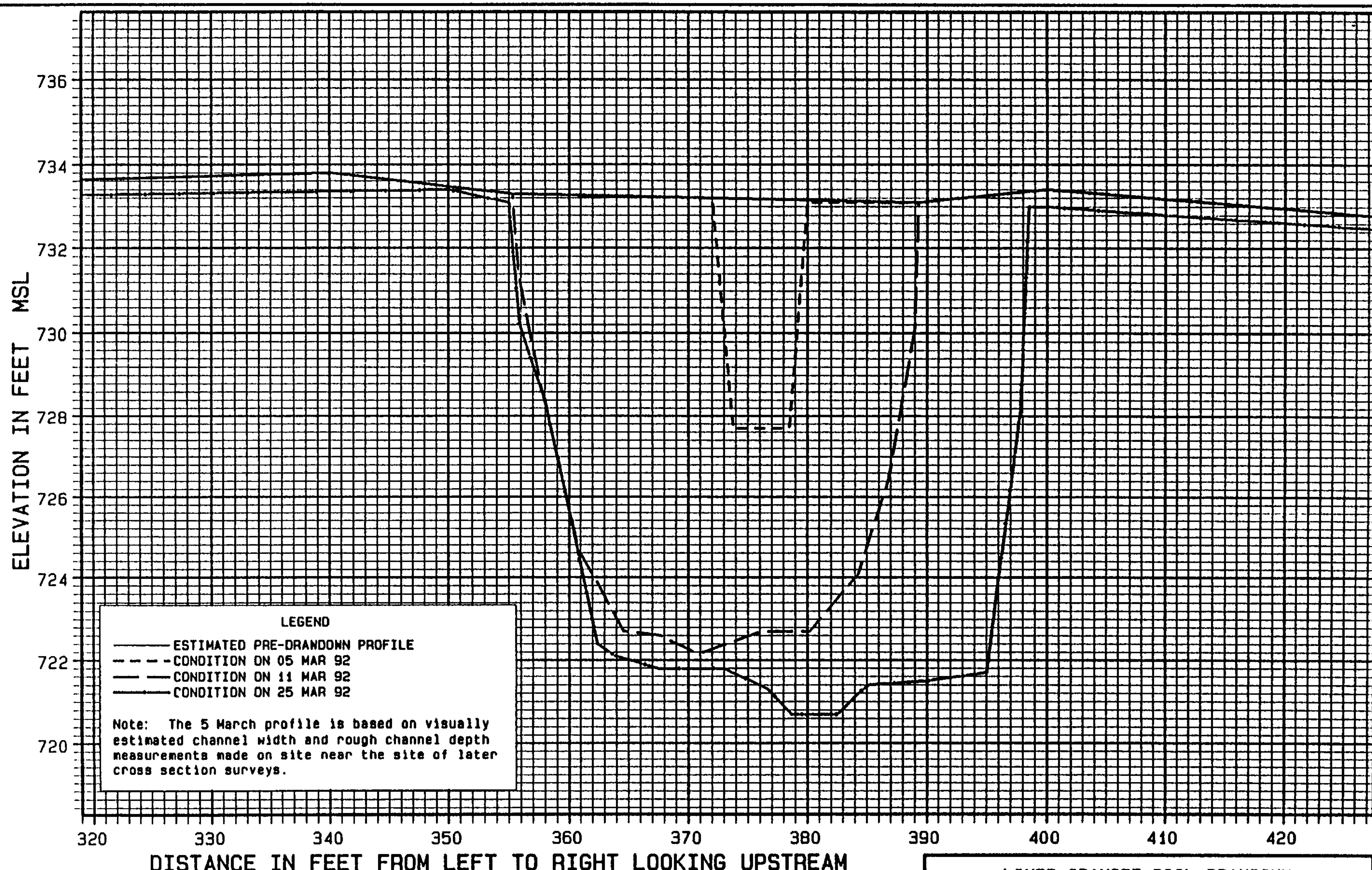
SECTION A2

ALPOWA CREEK DELTA EROSION

U. S. Army Corps of Engineers
Hydrology Branch

L. CUNNINGHAM 15 APRIL 92

PLATE 30



LOWER GRANITE POOL DRAWDOWN

SECTION A2 LEFT CHANNEL

ALPOWA CREEK DELTA EROSION

U. S. Army Corps of Engineers
Hydrology Branch

L. CUNNINGHAM 15 APRIL 92

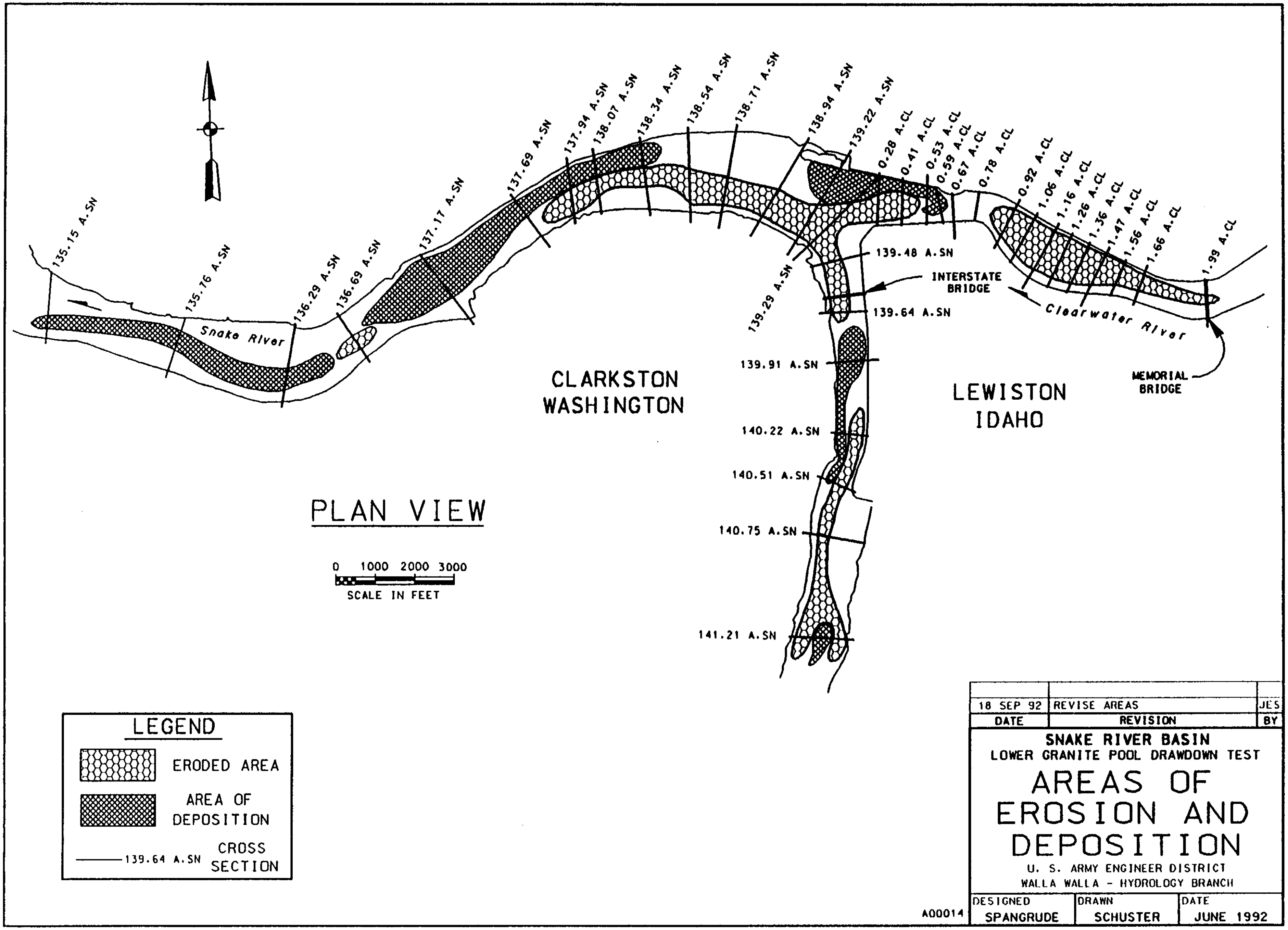

135.15 A.SN
135.76 A.SN
136.29 A.SN
136.69 A.SN
137.17 A.SN
137.69 A.SN
137.94 A.SN
138.07 A.SN
138.34 A.SN
138.54 A.SN
138.71 A.SN
138.94 A.SN
139.22 A.SN
139.29 A.SN
139.48 A.SN
139.64 A.SN
139.91 A.SN
140.22 A.SN
140.51 A.SN
140.75 A.SN
141.21 A.SN
0.28 A.CL
0.41 A.CL
0.53 A.CL
0.59 A.CL
0.67 A.CL
0.78 A.CL
0.92 A.CL
1.06 A.CL
1.16 A.CL
1.26 A.CL
1.36 A.CL
1.47 A.CL
1.56 A.CL
1.66 A.CL
1.99 A.CL
Snake River
Clearwater River
INTERSTATE BRIDGE
MEMORIAL BRIDGE
CLARKSTON WASHINGTON
LEWISTON IDAHO
PLAN VIEW
0 1000 2000 3000
SCALE IN FEET
LEGEND
ERODED AREA
AREA OF DEPOSITION
139.64 A.SN CROSS SECTION
18 SEP 92 | REVISE AREAS | JES
DATE | REVISION | BY
SNAKE RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST
AREAS OF EROSION AND DEPOSITION
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH
DESIGNED SPANGRUDE
DRAWN SCHUSTER
DATE JUNE 1992
A00014

PLATE 16

APPENDIX M2: CROSS-SECTIONAL VELOCITIES

BASED ON ACOUSTIC DOPPLER PROFILER VELOCITY MEASUREMENTS

AVERAGE PREVAILING AZIMUTH FOR VELOCITY PROFILES SURVEYED BY USGS
(BASED ON ADP AZIMUTH)

SECTION	USGS FILE NAME	POOL CAT.	STUDY FILE NAME	DATE	TIME (HRS)	FOREBAY USED (FT-MSL)	DISCHARGED USED (CFS)	ADP AZIMUTH (DEG.)	GEOMETRIC AZIMUTH (DEG.)	DIFF. (DEG.)	BEGIN NO. POINTS	POINTS IN ADP AVERAGE	PERCENT POINTS USED
0.41	LP5-0.41B	LOW	57	18-Mar	1052	715.00	10,100	247.28	271.55	24	99	91	92%
0.41	MP1-0.41A	MID	61	06-Mar	1018	723.01	11,100	282.04	271.55	10	190	173	91%
0.41	FP1-0.41C	FULL	01	26-Feb	1200	737.19	8,200	281.13	271.55	10	421	319	76%
1.26	LP4-1.26C	LOW	50	18-Mar	0831	719.00	1,400	293.33	294.27	1	13	12	92%
1.26	LP4-1.26E	LOW	51	18-Mar	0856	721.00	5,100	305.06	294.27	11	33	31	94%
1.26	FP1-1.26B	FULL	02	26-Feb	0922	736.95	6,400	297.34	294.27	3	376	280	74%
2.34	MP4-2.34B	MID	73	06-Mar	1050	725.28	10,000	244.83	228.12	17	55	43	78%
2.34	LP4-2.34A	LOW	56	17-Mar	1516	725.00	7,700	289.66	228.12	62	52	45	87%
2.34	FP1-2.34A	FULL	04	25-Feb	1553	736.01	9,400	252.51	228.12	24	179	148	83%
70.90	GP3-70.9A	FULL	18	12-Mar				351.19	262.00	89	61	11	18%
70.90	GP3-70.9A&B	FULL	18&74	12-Mar	1645	636.24	30,000	297.37	262.00	35	123	28	23%
70.90	GP3-70.9B	FULL	74	13-Mar				203.07	262.00	59	30	21	70%
79.20	GP3-79.2A	FULL	75	13-Mar				223.73	202.00	22	41	32	78%
79.20	GP3-79.2B	FULL	19	12-Mar				336.22	202.00	134	323	206	64%
79.20	GP3-79.2A&B	FULL	19&75	12-Mar	1447	636.16	30,400	334.07	202.00	132	388	205	53%
91.00	GP3-91.0A	FULL	20	12-Mar	1348	636.14	25,500	328.31	268.00	60	406	357	88%
101.00	GP2-101.0A	FULL	16	12-Mar	1047	636.17	26,500	309.38	230.00	79	527	368	70%
106.00	GP2-106.0B	FULL	17	12-Mar	1015	636.19	35,500	346.78	337.20	10	242	188	78%
107.73	LLP3-107.73H	LOW LOW	28	26-Mar				255.56	304.16	49	67	6	9%
107.73	LLP-107.73C	LOW LOW	27	25-Mar				316.86	304.16	13	70	24	34%
107.73	LLP3-107.73O	LOW LOW	31	26-Mar				351.30	304.16	47	65	26	40%
107.73	LLP3-107.73M	LOW LOW	30	26-Mar				324.39	304.16	20	677	553	82%
107.73	LLP3-107.73K	LOW LOW	29	26-Mar				316.09	304.16	12	740	438	59%
107.73	LLP3-107.73A	LOW LOW	26	25-Mar				310.85	304.16	7	764	529	69%
107.73	LLP3-107.73M&O	LOW LOW	30&31	26-Mar	1136	699.30	90,000	324.74	304.16	21	742	569	77%
107.73	LLP3-107.73H&K	LOW LOW	28&29	26-Mar	0942	700.04	25,500	315.65	304.16	11	807	450	56%
107.73	LLP3-107.73A&C	LOW LOW	26&27	25-Mar	1409	700.82	26,600	311.21	304.16	7	834	551	66%
108.31	FP3-108.31A	FULL	08	27-Feb				289.94	283.40	7	120	97	81%
108.31	MP3-108.31A	MID	69	07-Mar				278.64	283.40	5	291	242	83%
108.31	FP3-108.31B	FULL	09	27-Feb				232.96	283.40	50	13	9	69%
108.31	MP3-108.31B	MID	70	07-Mar				268.86	283.40	15	197	39	20%
108.31	LLP3-108.31C	LOW LOW	33	26-Mar	1017	700.06	26,600	329.21	283.40	46	703	415	59%
108.31	LLP3-108.31A	LOW LOW	32	25-Mar	1324	700.64	26,700	330.67	283.40	47	701	402	57%
108.31	LP3-108.31D	LOW	47	20-Mar	1216	705.98	26,000	332.12	283.40	49	792	519	66%
108.31	MP3-108.31A&B	MID	69&70	07-Mar	1400	720.55	36,000	278.83	283.40	5	512	277	54%
108.31	FP3-108.31A&B	FULL	08&09	27-Feb	1437	735.30	85,200	288.80	283.40	5	139	100	72%
113.90	LLP3-113.9A	LOW LOW	34	25-Mar	1252	700.89	29,600	349.28	319.00	30	344	318	92%
113.90	LLP3-113.9C	LOW LOW	35	26-Mar	1240	700.90	36,200	251.47	319.00	68	332	322	97%
119.00	LLP2-119.0D	LOW LOW	22	17-Mar	1317	700.06	55,100	338.89	316.55	22	389	362	93%
119.00	LLP2-119.0A	LOW LOW	21	25-Mar	1128	700.98	28,000	341.23	316.55	25	450	405	90%
119.00	LP3-119.0A	LOW	48	20-Mar	1023	705.99	28,700	342.51	316.55	26	270	231	86%
119.00	MP3-119.0B	MID	71	08-Mar	1227	718.52	38,700	309.60	316.55	7	408	366	90%
119.00	FP3-119.0A	FULL	10	28-Feb	1232	734.37	30,500	297.61	316.55	19	567	519	92%
120.46	FP3-120.46A	FULL	11	27-Feb				221.39	329.51	108	120	53	44%
120.46	FP3-120.46B	FULL	12	27-Feb				190.58	329.51	139	209	9	4%
120.46	LLP3-120.46B	LOW LOW	36	26-Mar	1437	700.79	11,600	338.94	329.51	9	211	155	73%
120.46	LLP2-120.46B	LOW LOW	23	25-Mar	1055	701.03	28,800	333.77	329.21	5	478	447	94%
120.46	LP3-120.46A	LOW	49	20-Mar	0931	706.00	31,100	333.56	329.51	4	273	247	90%
120.46	MP3-120.46B	MID	72	07-Mar	1137	720.64	34,900	320.29	329.51	9	365	296	81%
120.46	FP3-120.46A&B	FULL	11&12	27-Feb	1120	735.18	1,000	215.36	329.51	114	329	57	17%
126.07	LLP2-126.07A	LOW LOW	24	25-Mar	1016	701.06	30,400	344.01	344.74	1	415	383	92%

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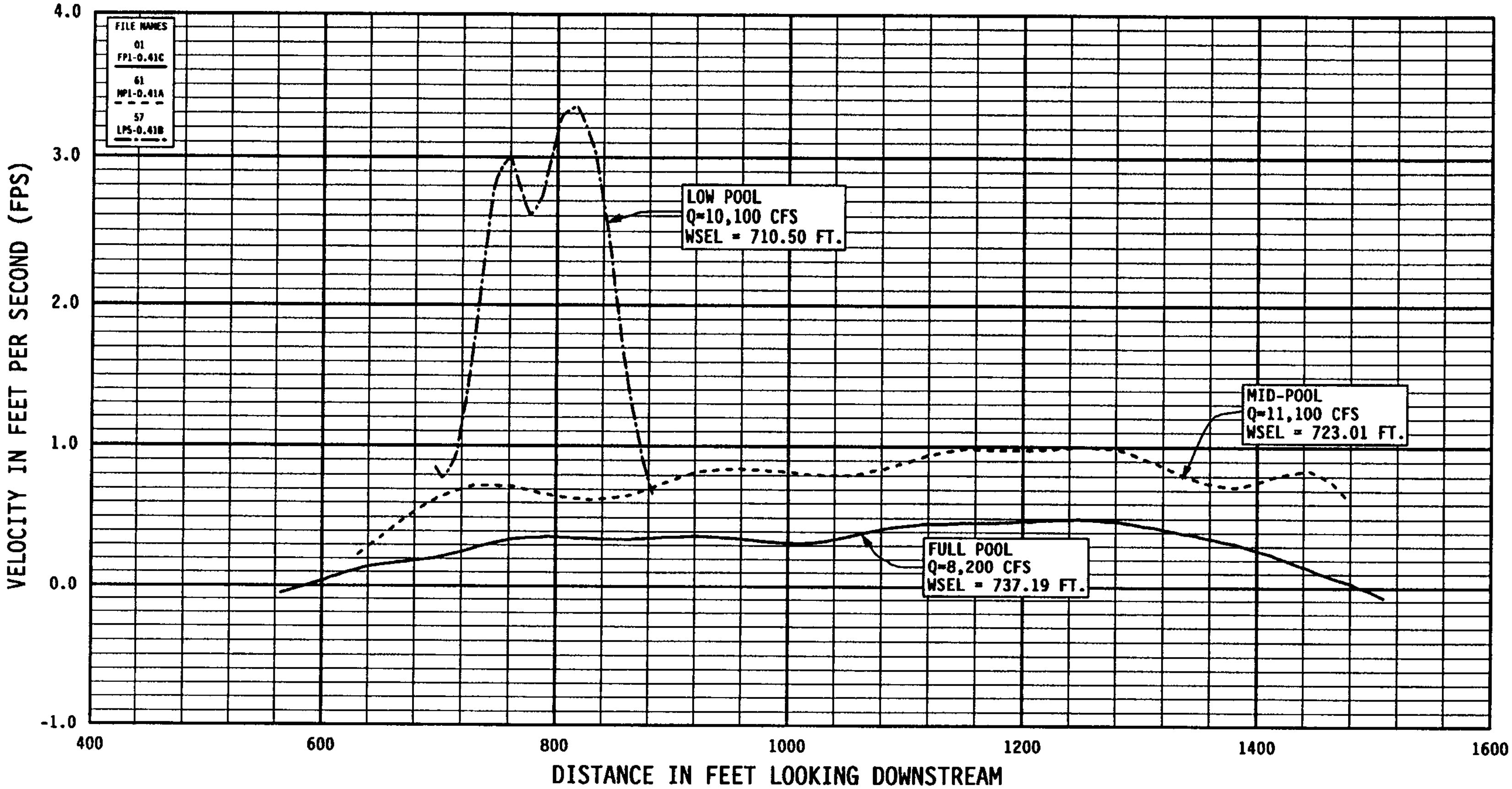
AVERAGE PREVAILING AZIMUTH FOR VELOCITY PROFILES SURVEYED BY USGS
(BASED ON ADP AZIMUTH)

SECTION	USGS FILE NAME	POOL CAT.	STUDY FILE NAME	DATE	TIME (HRS)	FOREBAY USED (FT-MSL)	DISCHARGED USED (CFS)	ADP AZIMUTH (DEG.)	GEOMETRIC AZIMUTH (DEG.)	DIFF. (DEG.)	BEGIN NO. POINTS	POINTS IN ADP AVERAGE	PERCENT POINTS USED
130.66	LP2-130.66F	LOW	44	20-Mar	0835	706.00	30,000	336.07	286.93	49	263	242	92%
130.66	LP2-130.66A	LOW	42	18-Mar	1247	709.00	34,700	336.88	286.93	50	264	252	95%
130.66	LP2-130.66D	LOW	43	19-Mar	1247	706.01	43,600	330.72	286.93	44	240	230	96%
130.66	MP1-130.66A	MID	64	07-Mar	1438	724.00	37,000	287.68	286.93	1	472	432	92%
130.66	MP2-130.66D	MID	65	07-Mar	1005	720.75	40,000	288.14	286.93	1	443	414	93%
130.66	FP3-130.66B	FULL	13	27-Feb	1621	734.84	51,500	283.02	286.93	4	401	291	73%
132.05	LLP2-132.05A	LOW LOW	25	25-Mar	0948	701.10	27,300	312.37	234.91	77	155	146	94%
132.05	LP2-132.05E	LOW	46	19-Mar	1209	704.65	58,300	295.37	234.91	60	183	173	95%
132.05	LP2-132.05B	LOW	45	18-Mar	1232	706.01	35,100	314.06	234.91	79	198	187	94%
132.05	MP2-132.05B	MID	66	06-Mar	1412	722.60	41,000	246.92	234.91	12	343	338	99%
132.05	FP3-132.05B	FULL	14	26-Feb	1436	736.59	37,000	261.31	234.91	26	258	220	85%
132.05	FP3-132.05	FULL	15	27-Feb	0910	736.96	37,100	255.65	234.91	21	240	222	93%
137.17	LP1-137.17F	LOW	38	19-Mar	0914	701.18	32,600	261.79	285.80	24	177	156	88%
137.17	LP1-137.17A	LOW	37N	17-Mar	1607	704.00	27,500	232.63	233.60	1	155	126	81%
137.17	MP2-137.17B	MID	67N	05-Mar	1401	724.75	33,700	309.85	285.80	24	290	265	91%
137.17	FP2-137.17A	FULL	05	25-Feb	1445	736.38	36,000	251.75	268.32	17	417	384	92%
138.34	LP1-138.34A	LOW	39	17-Mar	1646	704.00	15,700	320.94	261.73	59	80	69	86%
138.34	LP5-138.34A	LOW	58	18-Mar	1008	705.97	25,000	292.15	261.73	30	175	168	96%
138.34	MP2-138.34B	MID	68	05-Mar	1537	724.49	35,400	323.72	261.73	62	246	219	89%
138.34	FP2-138.34A	FULL	06	26-Feb	1034	737.70	36,800	275.33	261.73	14	431	395	92%
139.43	LP5-139.43	LOW	59	18-Mar	1035	709.91	20,600	319.51	346.70	27	175	163	93%
139.43	LP4-139.43B	LOW	52	19-Mar	0817	710.11	22,700	319.97	346.70	27	173	158	91%
139.43	LP1-139.43A	LOW	40	17-Mar	1038	710.20	22,200	320.92	346.70	26	90	86	96%
139.43	MP1-139.43B	MID	62	05-Mar	1000	724.93	27,500	342.04	346.70	5	269	259	96%
139.43	FP2-139.43B	FULL	07	25-Feb	0948	737.25	27,100	312.50	346.70	34	243	223	92%
141.21	LP1-141.21A	LOW	41	17-Mar	1100	713.00	20,600	345.13	2.96	18	46	41	89%
141.21	LP4-141.21A	LOW	53	17-Mar	1112	713.00	1,600	330.59	2.96	32	20	13	65%
141.21	MP1-141.21A	MID	63	05-Mar	1044	724.86	26,000	3.99	2.96	1	240	212	88%
141.21	FP1-141.21A	FULL	03	25-Feb	1110	737.06	25,300	342.70	2.96	20	540	478	89%
142.05	LP5-142.0A	LOW	60	19-Mar				293.42	18.60	85	197	187	95%
145.15	LP4-145.0B	LOW	54	19-Mar	0624	731.00	24,700	305.94	315.70	10	194	170	88%
148.09	LP4-148.09	LOW	55	19-Mar	0552	739.00	23,900	337.41	354.93	18	153	137	90%



NOTE:

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2. INDICATED VELOCITIES REPRESENT THE COMPONENT OF VELOCITY IN THE PREDOMINANT FLOW DIRECTION, FOR EACH PROFILING RUN, AS MEASURED BY THE ADP. VELOCITIES AT EACH HORIZONTAL STATION WERE AVERAGED OVER THE DEPTH OF THE SECTION THEN THE PLOT WAS SMOOTHED BY CALCULATING RUNNING AVERAGES OVER GROUPS OF 2 DATA POINTS.

3. THE TOTAL DISCHARGE (Q) WAS CALCULATED FROM ADP DATA WHICH OMITTED SMALL AREAS ALONG EACH SHORELINE WHICH COULD NOT BE REACHED BY THE SOUNDING BOAT. THIS USUALLY REPRESENTED LESS THAN 1 PERCENT OF THE TOTAL DISCHARGE.

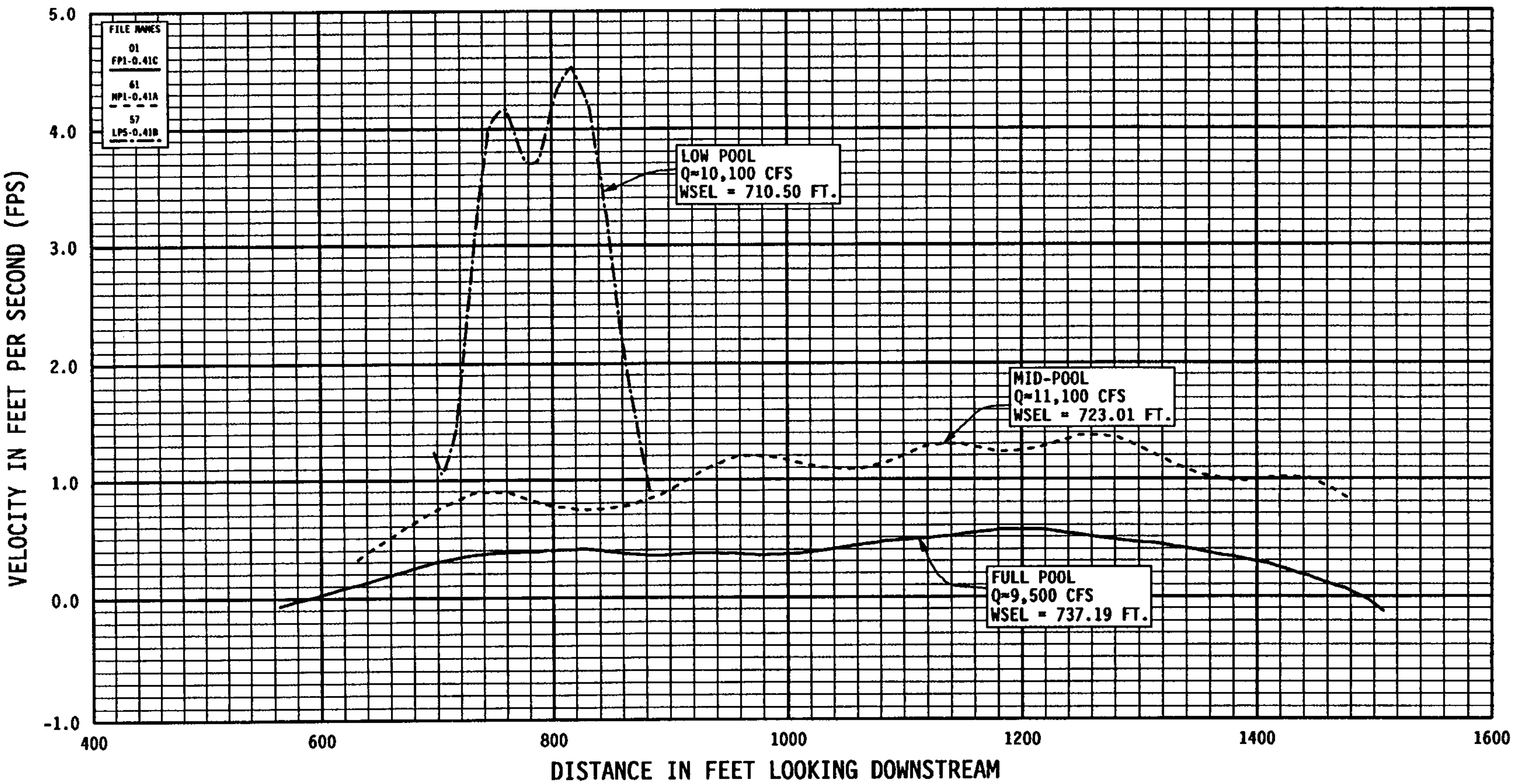
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

CLEARWATER RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

AVERAGE VELOCITY PROFILES
RANGE 0.41

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	5 OCTOBER 1992



NOTE:

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2. "SURFACE" VELOCITIES WERE MEASURED WITHIN 3 TO 6 FEET OF THE SURFACE DEPENDING ON THE POOL DEPTH.
3. INDICATED VELOCITIES REPRESENT THE COMPONENT OF VELOCITY IN THE PREDOMINANT FLOW DIRECTION FOR EACH PROFILING RUN AS MEASURED BY THE ADP. THESE VALUES WERE THEN SMOOTHED BY CALCULATING RUNNING AVERAGES OVER GROUPS OF 2 DATA POINTS. NEGATIVE VALUES REPRESENT UPSTREAM FLOW.
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

CLEARWATER RIVER BASIN

LOWER GRANITE POOL DRAWDOWN TEST

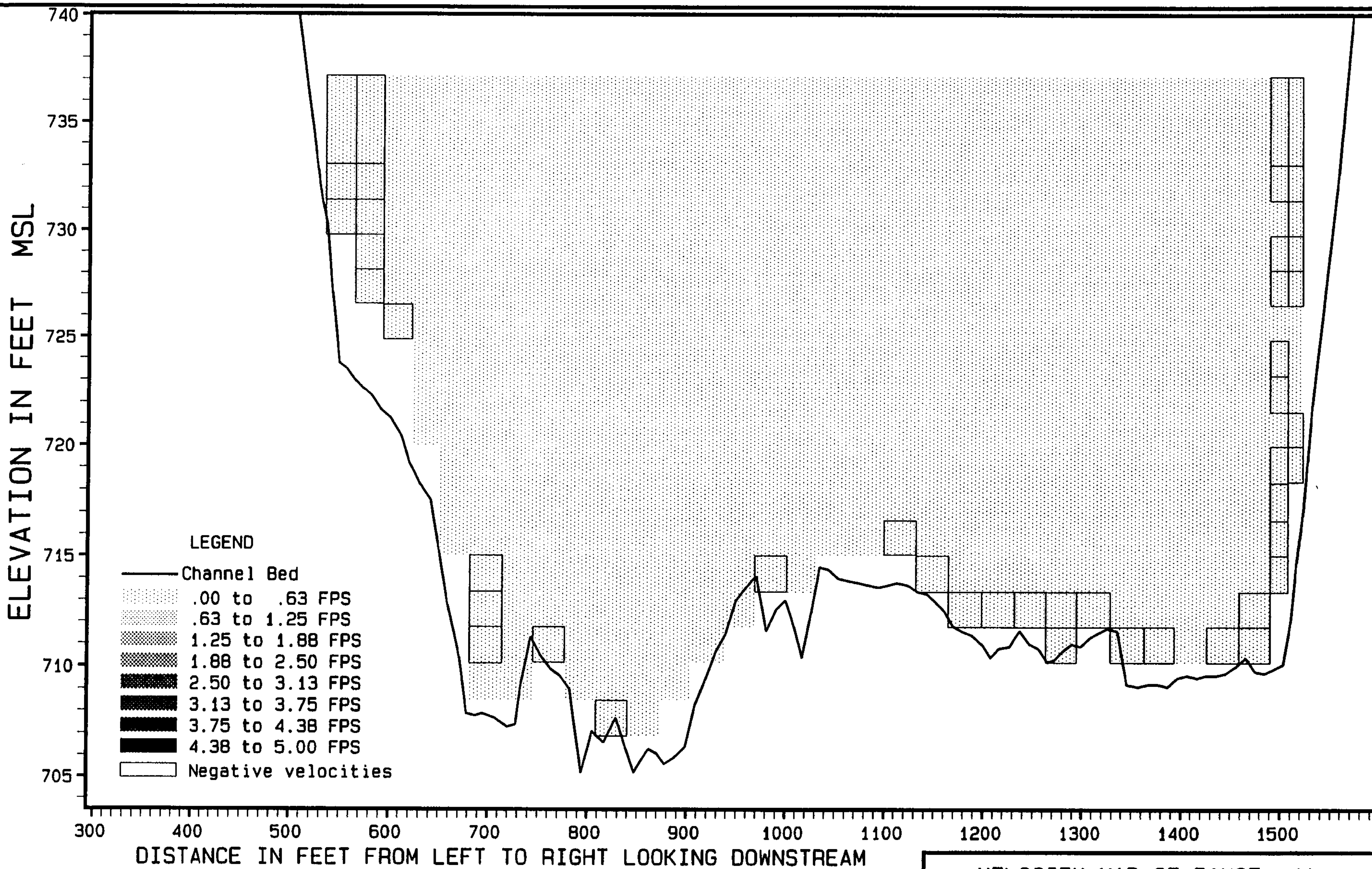
SURFACE VELOCITY PROFILES

RANGE 0.41

U.S. ARMY CORPS OF ENGINEERS

WALLA WALLA DISTRICT - HYDROLOGY BRANCH

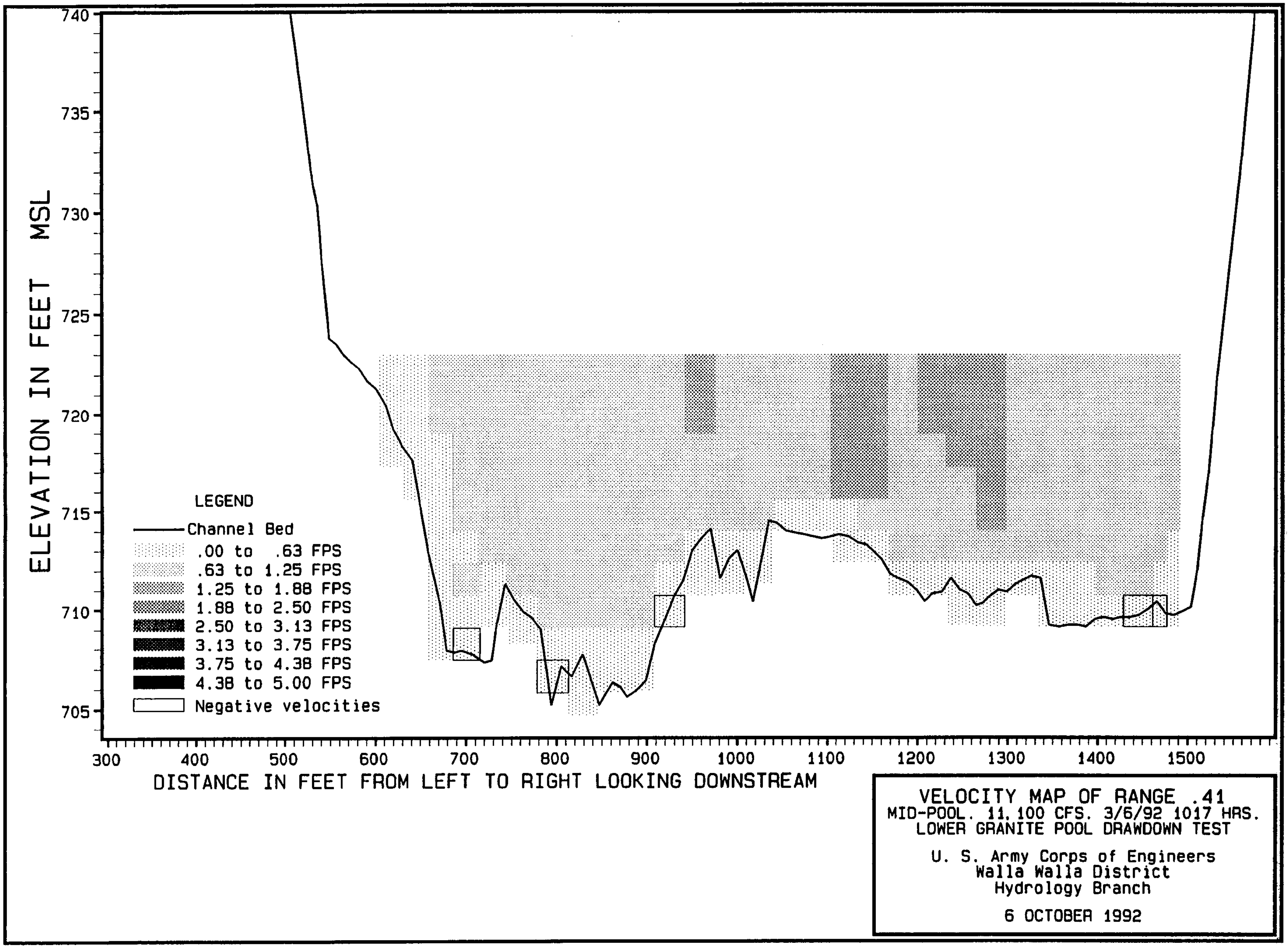
DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	5 OCTOBER 1992

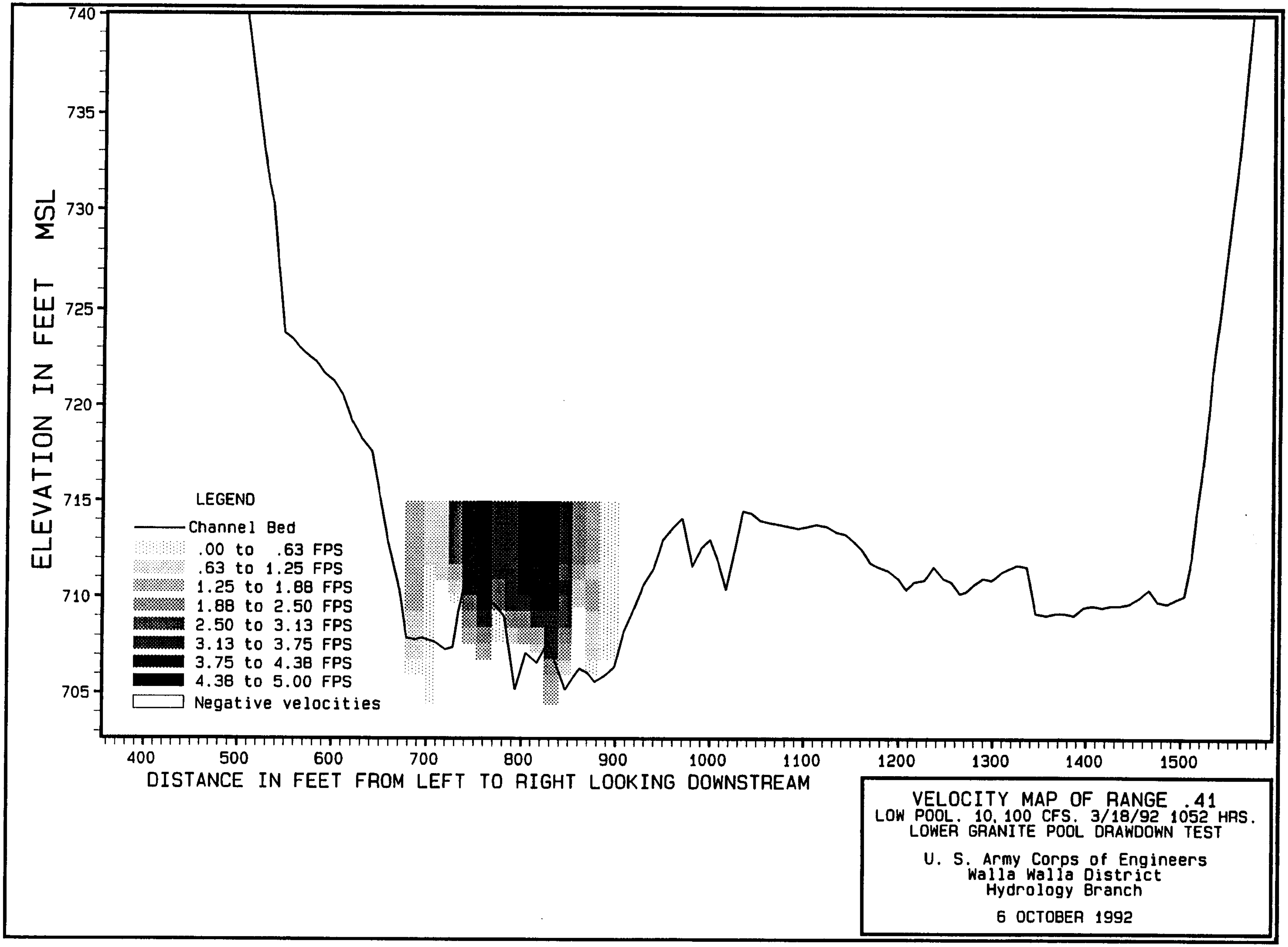


VELOCITY MAP OF RANGE .41
FULL POOL. 9,500 CFS. 2/26/92 1200 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

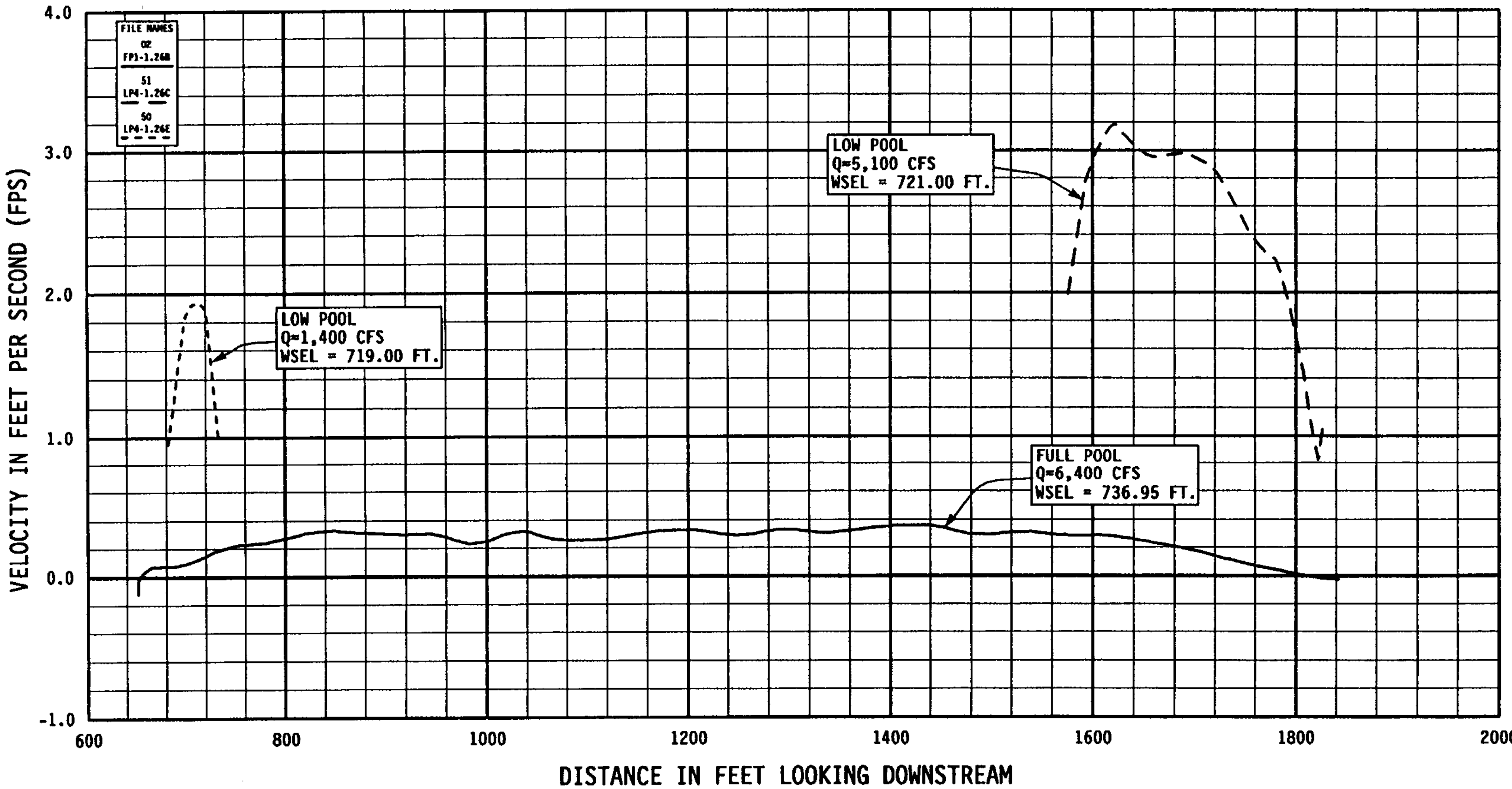
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

6 OCTOBER 1992


ELEVATION IN FEET MSL
740
735
730
725
720
715
710
705
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
DISTANCE IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM
LEGEND
Channel Bed
.00 to .63 FPS
.63 to 1.25 FPS
1.25 to 1.88 FPS
1.88 to 2.50 FPS
2.50 to 3.13 FPS
3.13 to 3.75 FPS
3.75 to 4.38 FPS
4.38 to 5.00 FPS
Negative velocities
VELOCITY MAP OF RANGE .41
MID-POOL. 11,100 CFS. 3/6/92 1017 HRS.
LOWER GRANITE POOL DRAWDOWN TEST
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch
6 OCTOBER 1992



740
735
730
725
720
715
710
705
ELEVATION IN FEET MSL
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
DISTANCE IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM
LEGEND
Channel Bed
.00 to .63 FPS
.63 to 1.25 FPS
1.25 to 1.88 FPS
1.88 to 2.50 FPS
2.50 to 3.13 FPS
3.13 to 3.75 FPS
3.75 to 4.38 FPS
4.38 to 5.00 FPS
Negative velocities
VELOCITY MAP OF RANGE .41
LOW POOL. 10,100 CFS. 3/18/92 1052 HRS.
LOWER GRANITE POOL DRAWDOWN TEST
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch
6 OCTOBER 1992



NOTE:

1. VELOCITY DATA WAS COLLECTED BY AN ACOUSTIC DOPPLER PROFILER (ADP) MANUFACTURED BY RD INSTRUMENTS.
2. INDICATED VELOCITIES REPRESENT THE COMPONENT OF VELOCITY IN THE PREDOMINANT FLOW DIRECTION, FOR EACH PROFILING RUN, AS MEASURED BY THE ADP. VELOCITIES AT EACH HORIZONTAL STATION WERE AVERAGED OVER THE DEPTH OF THE SECTION THEN THE PLOT WAS SMOOTHED BY CALCULATING RUNNING AVERAGES OVER GROUPS OF 1 DATA POINTS.
3. THE TOTAL DISCHARGE (Q) WAS CALCULATED FROM ADP DATA WHICH OMITTED SMALL AREAS ALONG EACH SHORELINE WHICH COULD NOT BE REACHED BY THE SOUNDING BOAT. THIS USUALLY REPRESENTED LESS THAN 1 PERCENT OF THE TOTAL DISCHARGE.
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

CLEARWATER RIVER BASIN

LOWER GRANITE POOL DRAWDOWN TEST

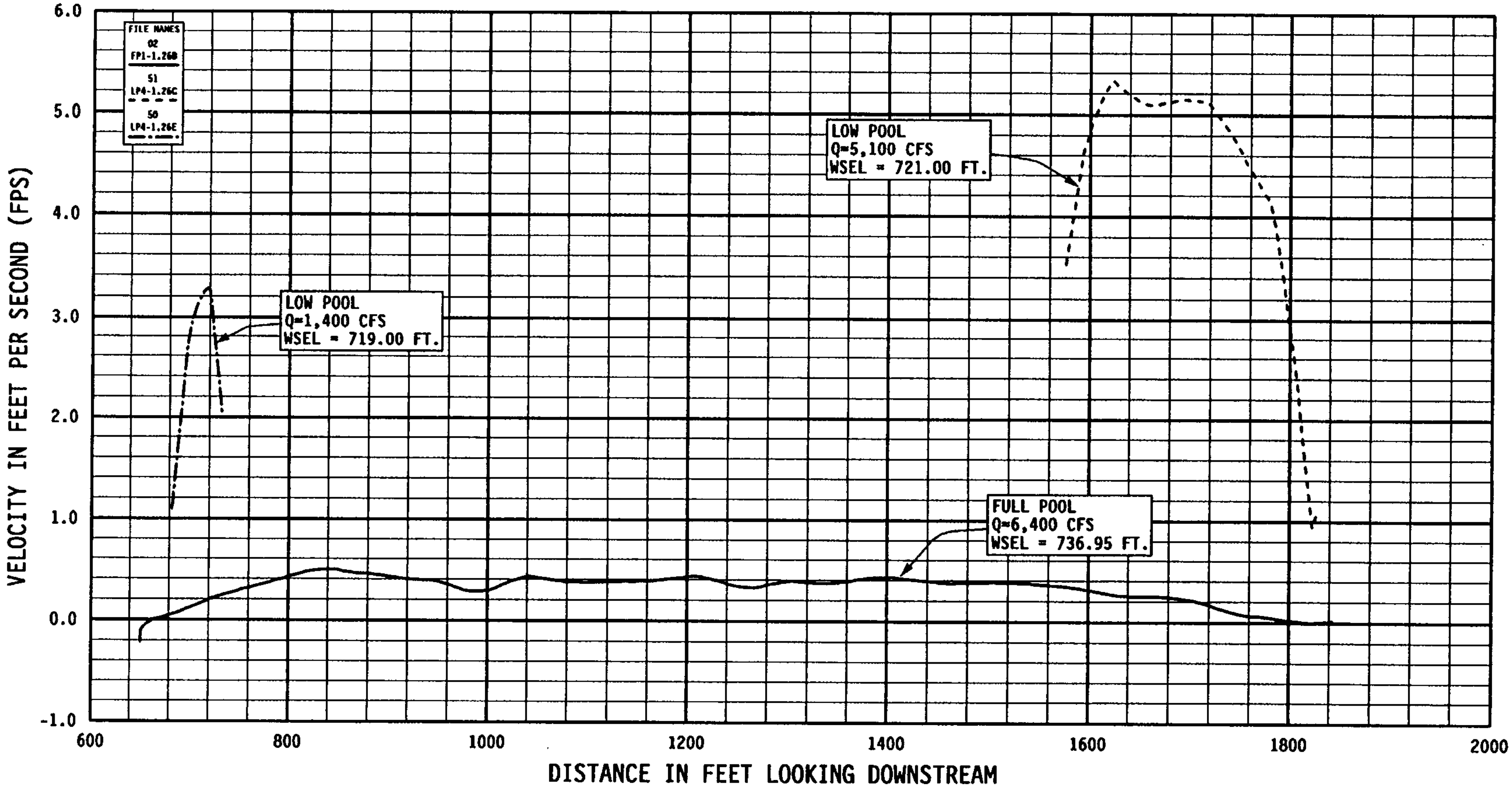
AVERAGE VELOCITY PROFILES

RANGE 1.26

U.S. ARMY CORPS OF ENGINEERS

WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	6 OCTOBER 1992



NOTE:

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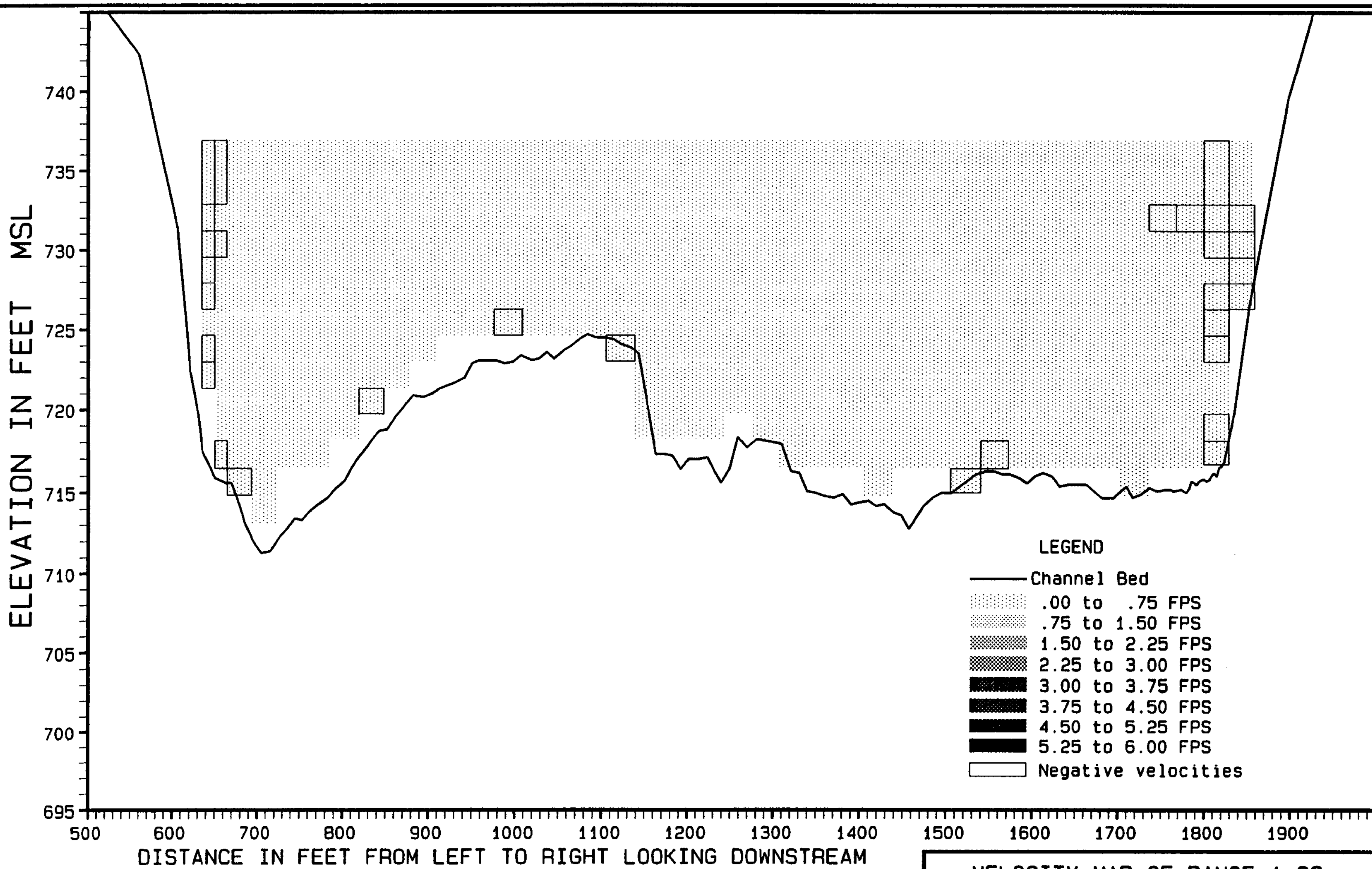
CLEARWATER RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

SURFACE VELOCITY PROFILES RANGE 1.26

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

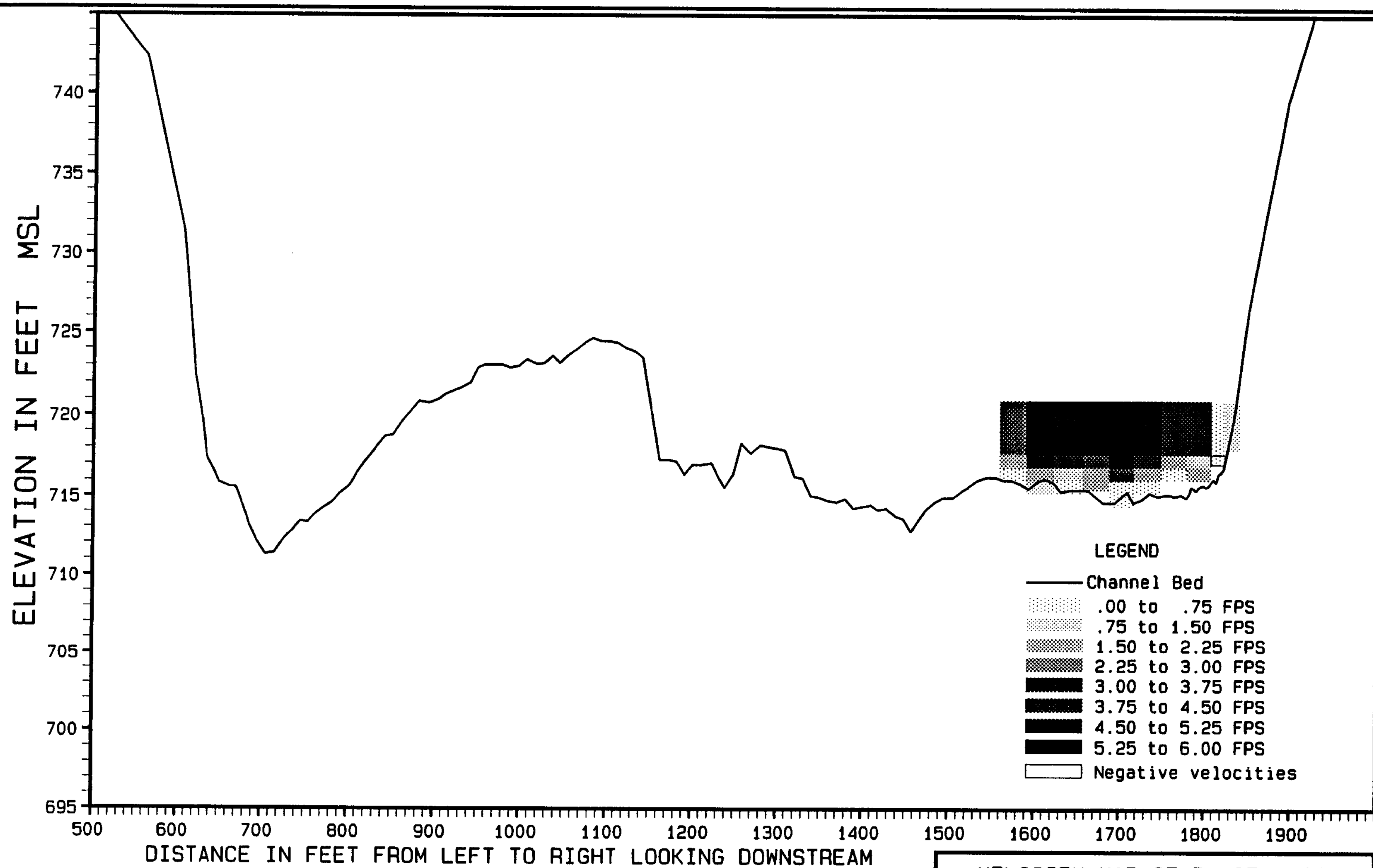
DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	6 OCTOBER 1992



VELOCITY MAP OF RANGE 1.26
FULL POOL. 6,400 CFS. 2/26/92 0922 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

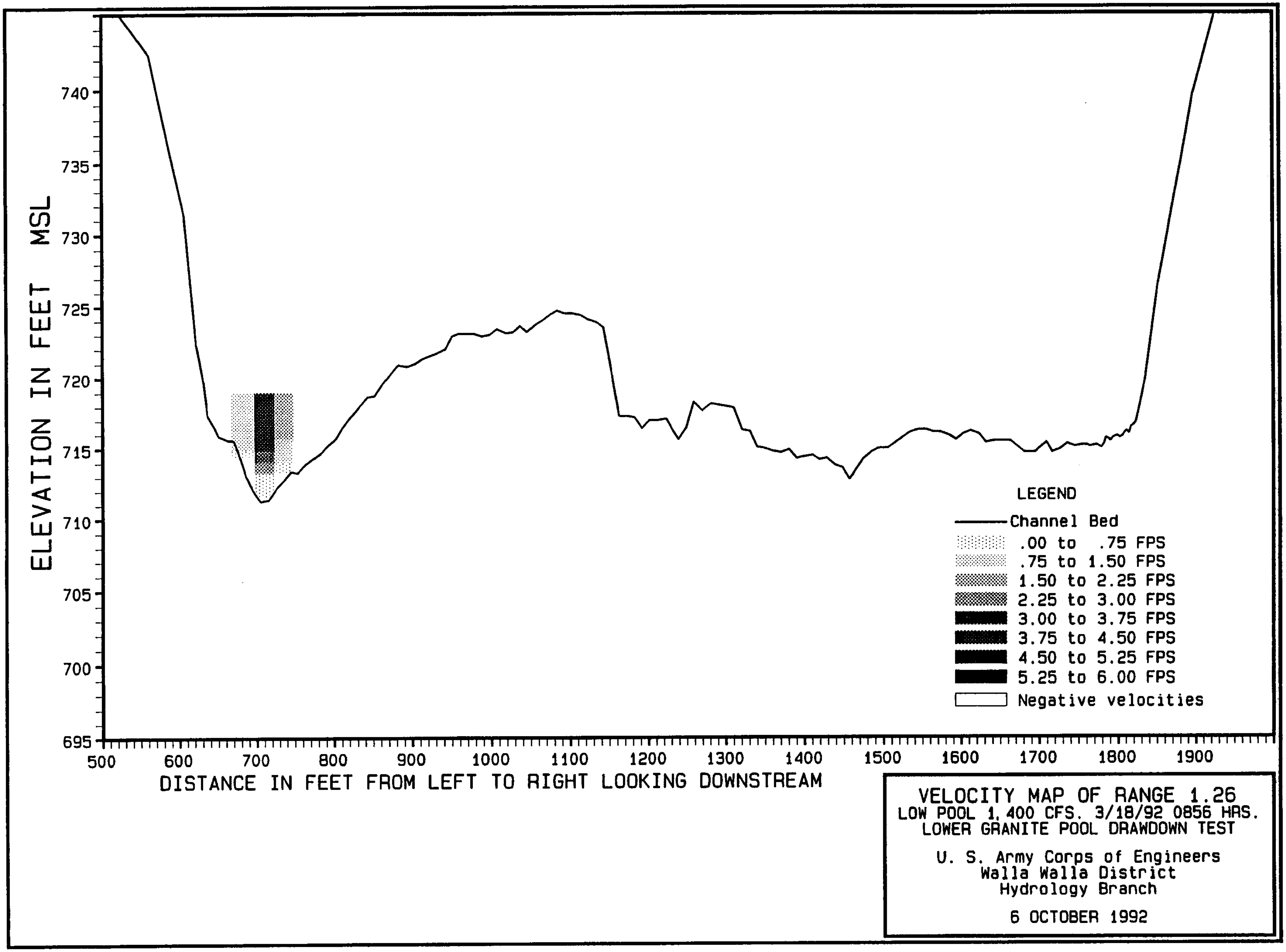
20 OCTOBER 1992

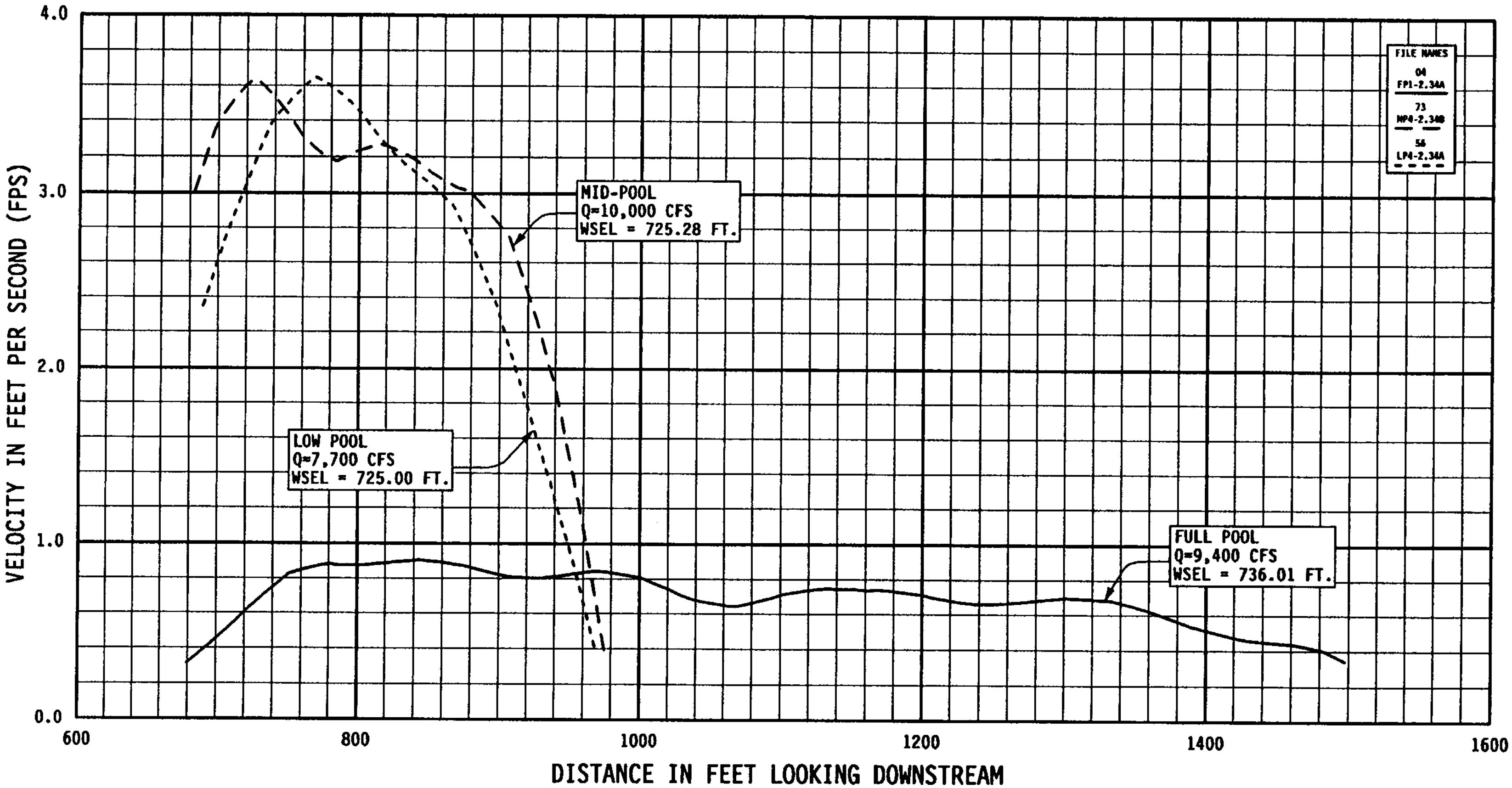


VELOCITY MAP OF RANGE 1.26
LOW POOL. 5,100 CFS. 3/18/92 0856 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

6 OCTOBER 1992


ELEVATION IN FEET MSL
740
735
730
725
720
715
710
705
700
695
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
DISTANCE IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM
LEGEND
Channel Bed
.00 to .75 FPS
.75 to 1.50 FPS
1.50 to 2.25 FPS
2.25 to 3.00 FPS
3.00 to 3.75 FPS
3.75 to 4.50 FPS
4.50 to 5.25 FPS
5.25 to 6.00 FPS
Negative velocities
VELOCITY MAP OF RANGE 1.26
LOW POOL 1,400 CFS. 3/18/92 0856 HRS.
LOWER GRANITE POOL DRAWDOWN TEST
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch
6 OCTOBER 1992



NOTE:

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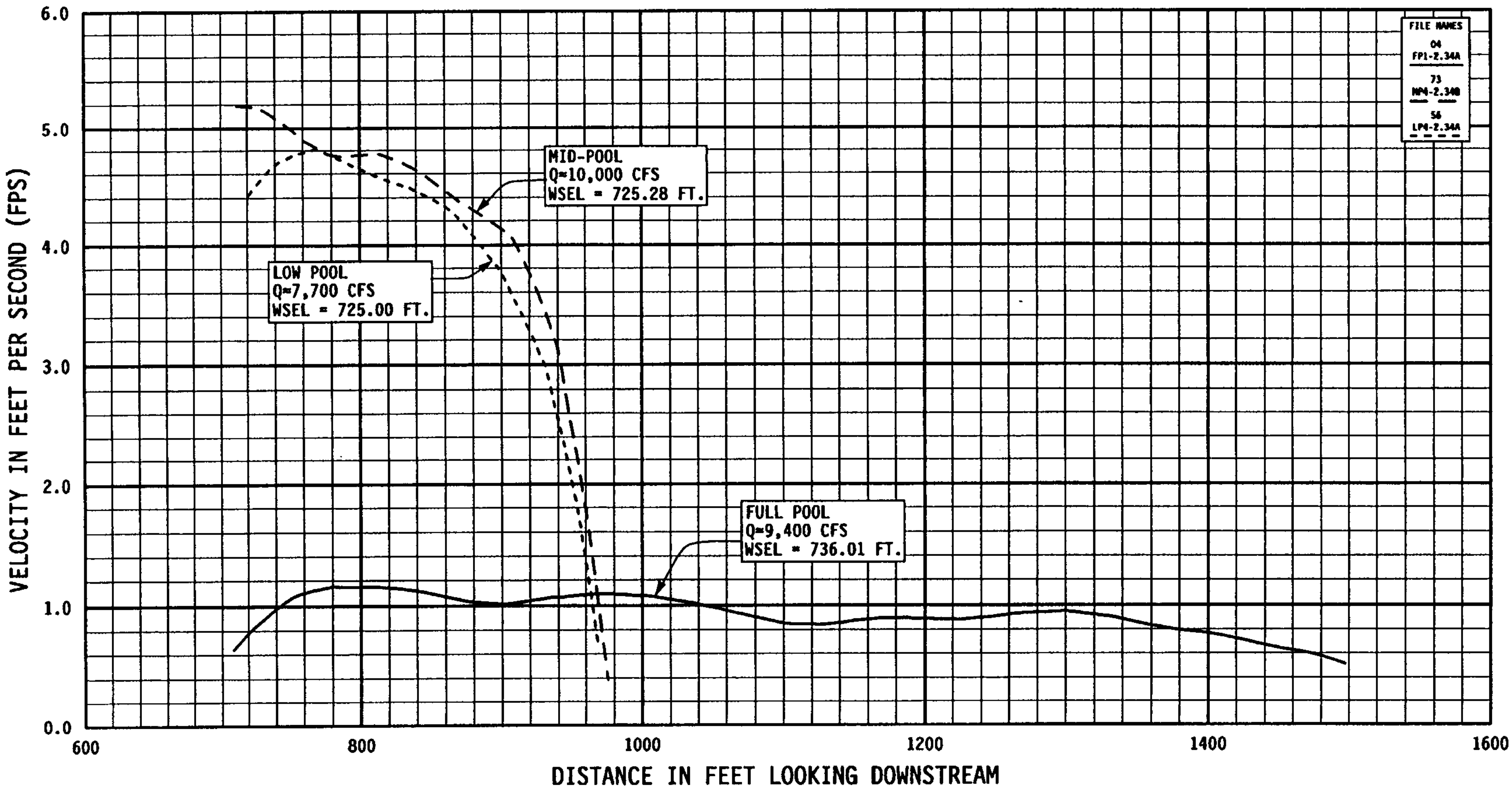
3. THE TOTAL DISCHARGE (Q) WAS CALCULATED FROM ADP DATA WHICH OMITTED SMALL AREAS ALONG EACH SHORELINE WHICH COULD NOT BE REACHED BY THE SOUNDING BOAT. THIS USUALLY REPRESENTED LESS THAN 1 PERCENT OF THE TOTAL DISCHARGE.
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

CLEARWATER RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

AVERAGE VELOCITY PROFILES
RANGE 2.34

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	6 OCTOBER 1992



NOTE:

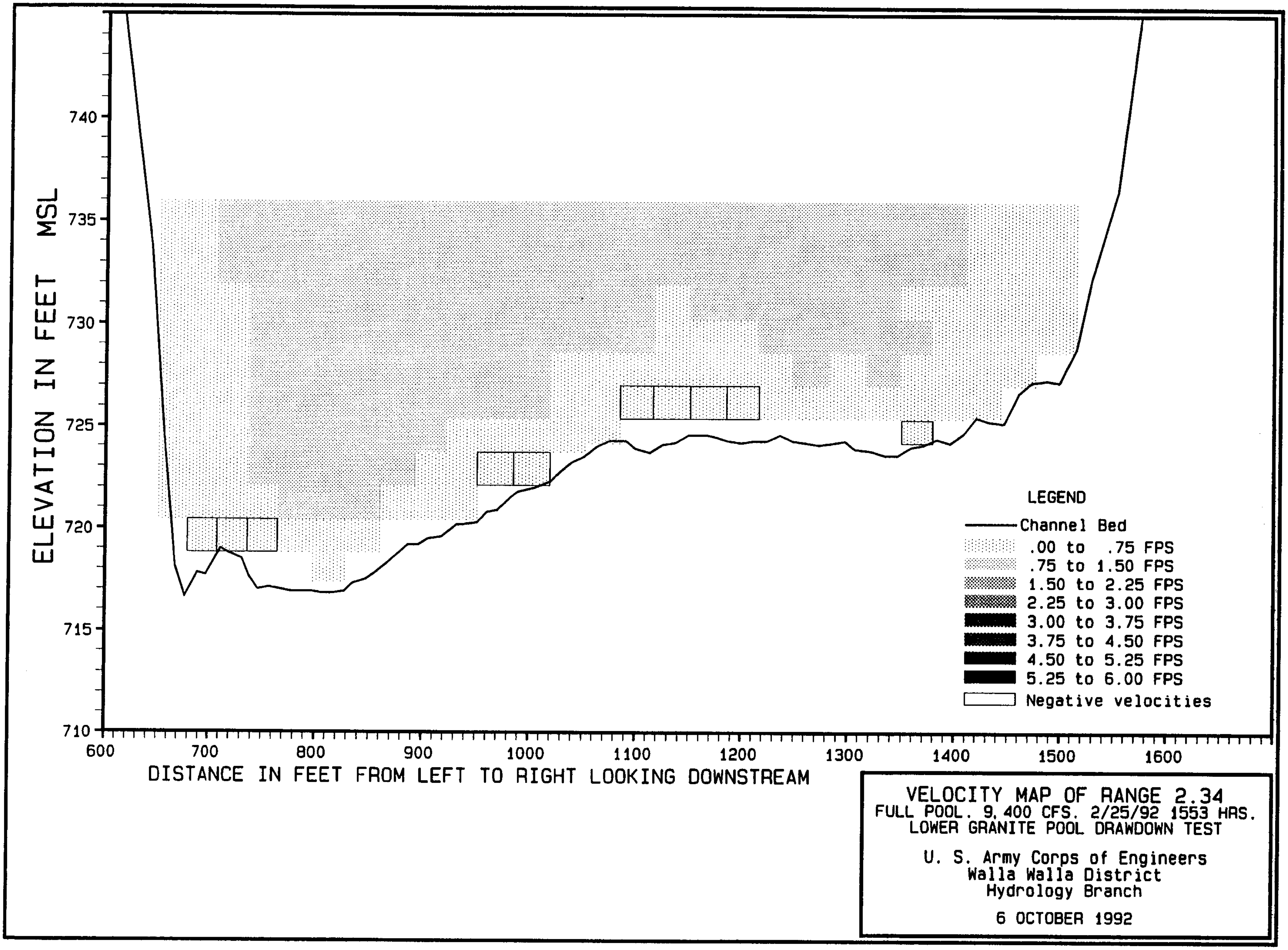
1. VELOCITY DATA WAS COLLECTED BY AN ACOUSTIC DOPPLER PROFILER (ADP) MANUFACTURED BY RD INSTRUMENTS.
2. "SURFACE" VELOCITIES WERE MEASURED WITHIN 3 TO 6 FEET OF THE SURFACE DEPENDING ON THE POOL DEPTH.
3. INDICATED VELOCITIES REPRESENT THE COMPONENT OF VELOCITY IN THE PREDOMINANT FLOW DIRECTION FOR EACH PROFILING RUN AS MEASURED BY THE ADP. THESE VALUES WERE THEN SMOOTHED BY CALCULATING RUNNING AVERAGES OVER GROUPS OF 2 DATA POINTS. NEGATIVE VALUES REPRESENT UPSTREAM FLOW.
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

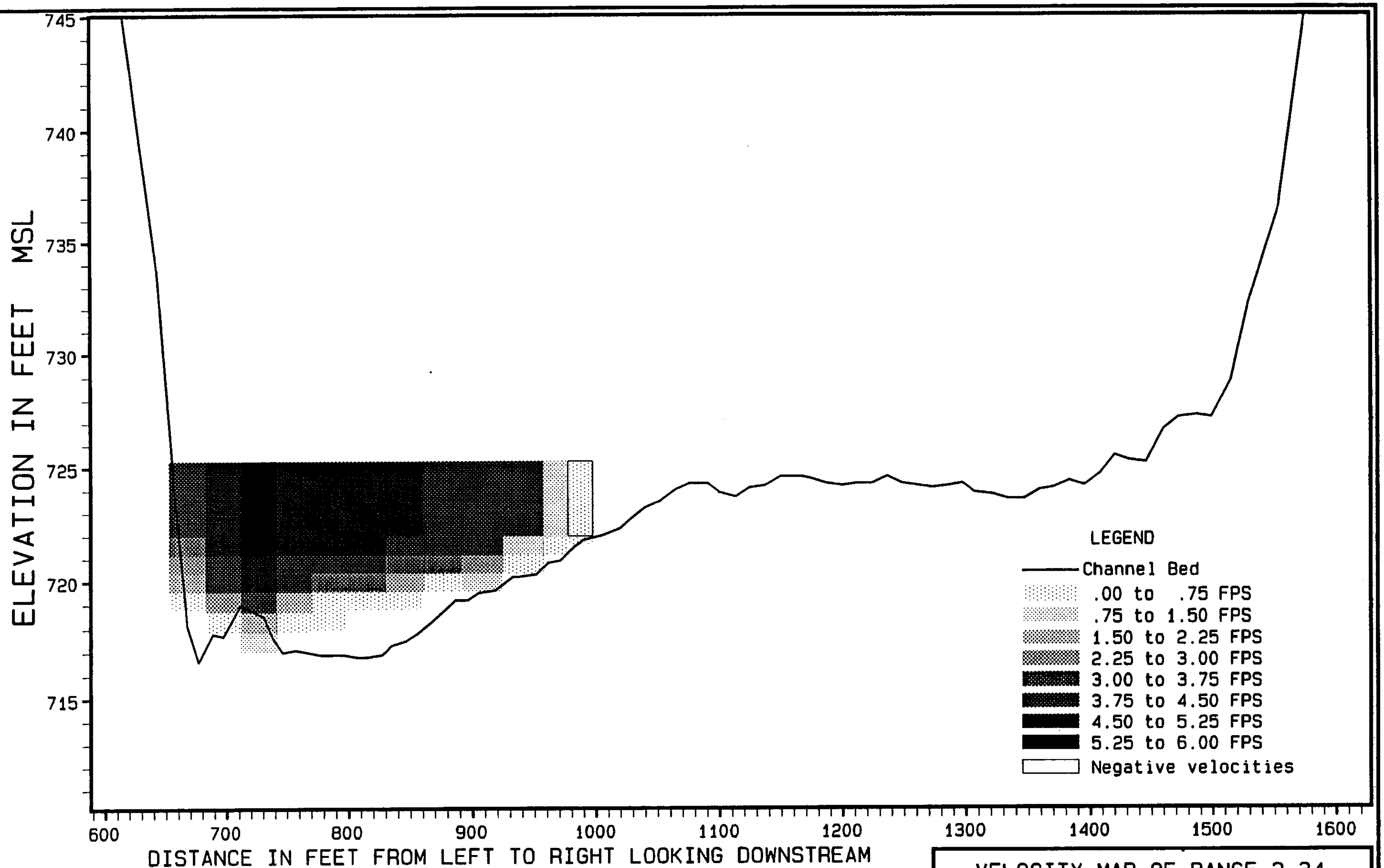
CLEARWATER RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

SURFACE VELOCITY PROFILES
RANGE 2.34

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	6 OCTOBER 1992

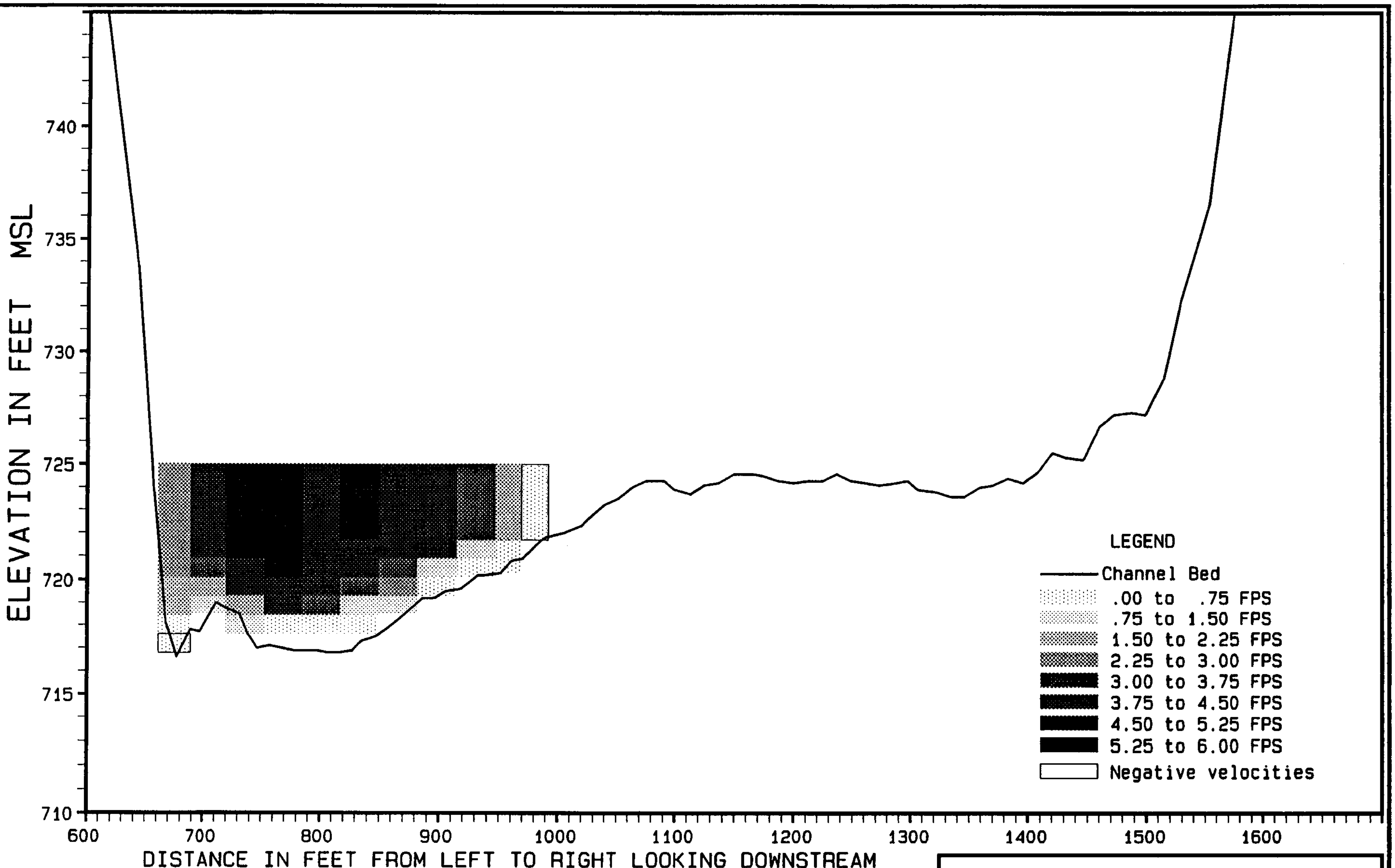

ELEVATION IN FEET MSL
740
735
730
725
720
715
710
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
DISTANCE IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM
LEGEND
Channel Bed
.00 to .75 FPS
.75 to 1.50 FPS
1.50 to 2.25 FPS
2.25 to 3.00 FPS
3.00 to 3.75 FPS
3.75 to 4.50 FPS
4.50 to 5.25 FPS
5.25 to 6.00 FPS
Negative velocities
VELOCITY MAP OF RANGE 2.34
FULL POOL. 9,400 CFS. 2/25/92 1553 HRS.
LOWER GRANITE POOL DRAWDOWN TEST
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch
6 OCTOBER 1992



VELOCITY MAP OF RANGE 2.34
MID-POOL. 10,000 CFS. 3/6/92 1050 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

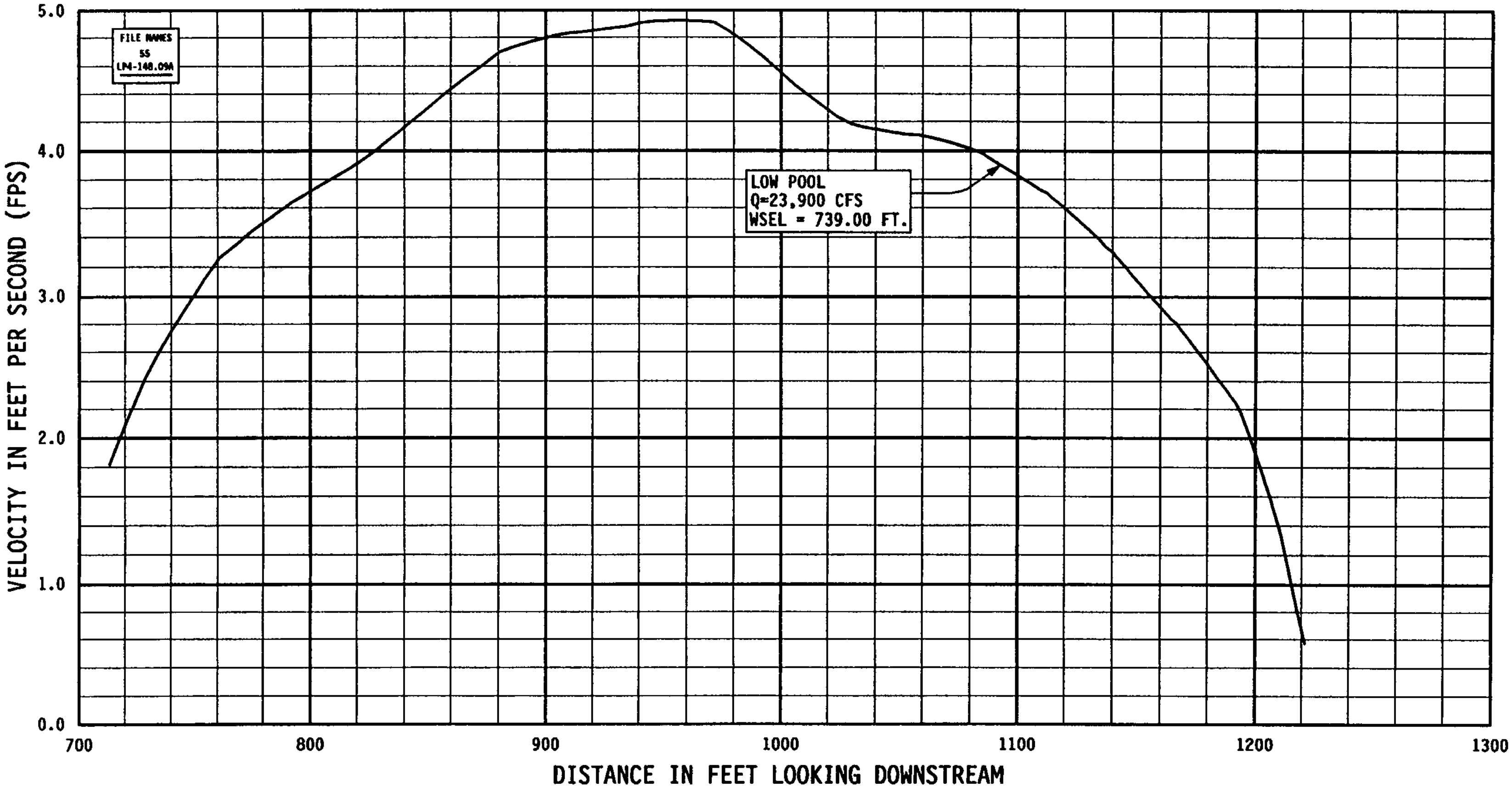
2 NOVEMBER 1992



VELOCITY MAP OF RANGE 2.34
LOW POOL. 7,700 CFS. 3/17/92 1516 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

6 OCTOBER 1992



NOTE:

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4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

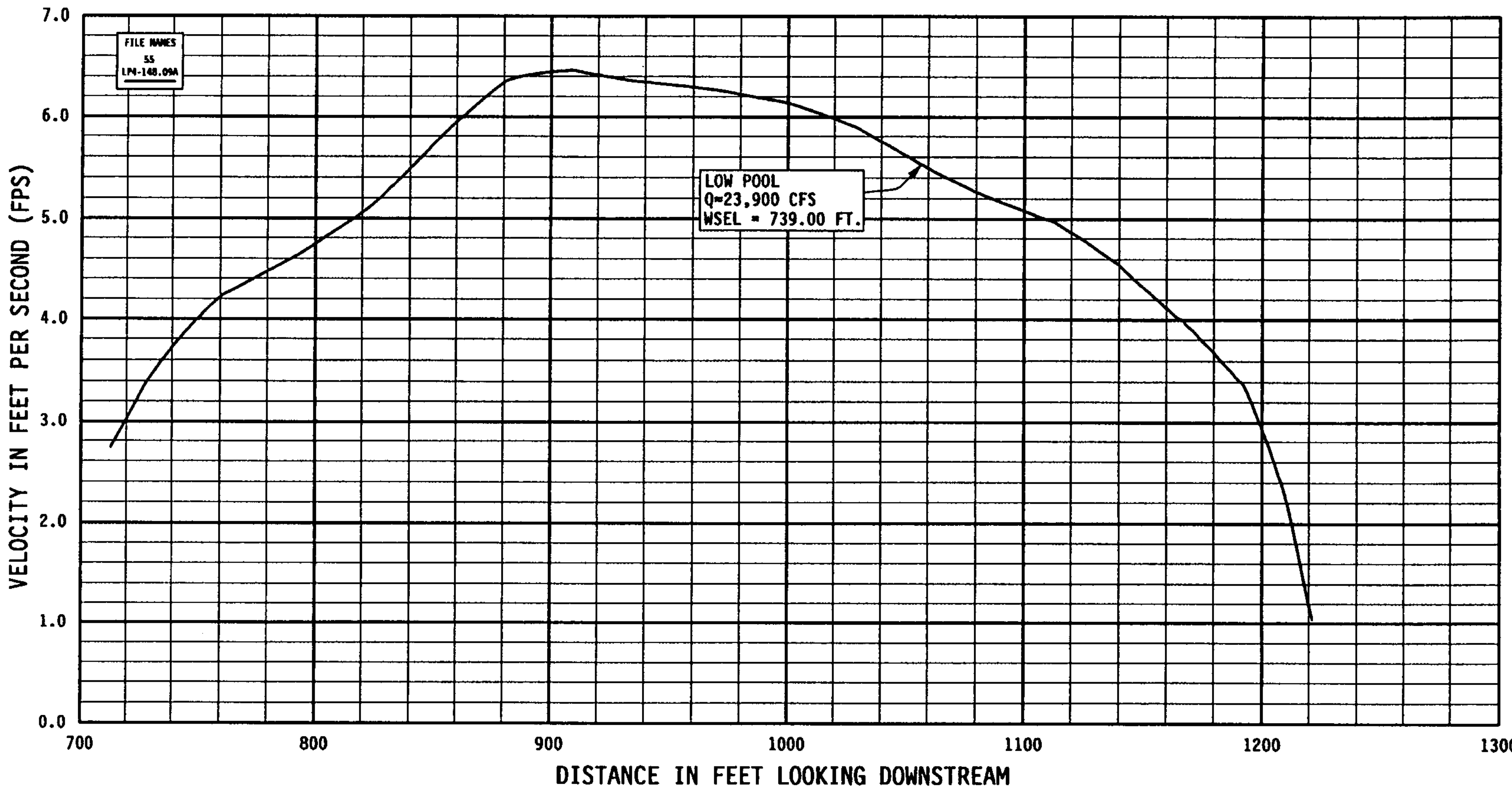
SNAKE RIVER BASIN
LOWER GRANITE RESERVOIR

AVERAGE VELOCITY PROFILES

RANGE 148.09

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	12 OCTOBER 1992



NOTE:

1. VELOCITY DATA WAS COLLECTED BY AN ACOUSTIC DOPPLER PROFILER (ADP) MANUFACTURED BY RD INSTRUMENTS.
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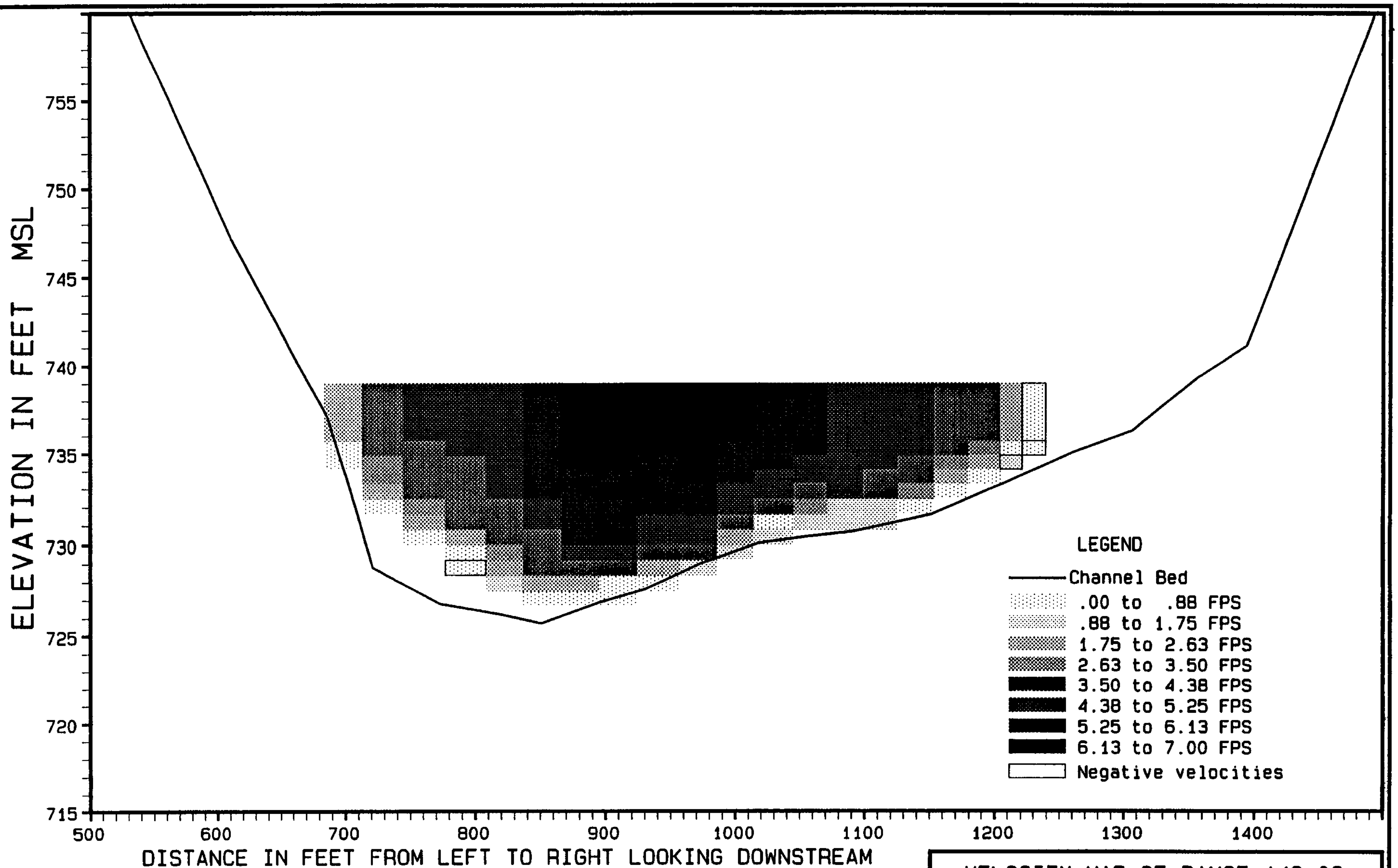
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

SNAKE RIVER BASIN
LOWER GRANITE RESERVOIR

SURFACE VELOCITY PROFILES RANGE 148.09

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

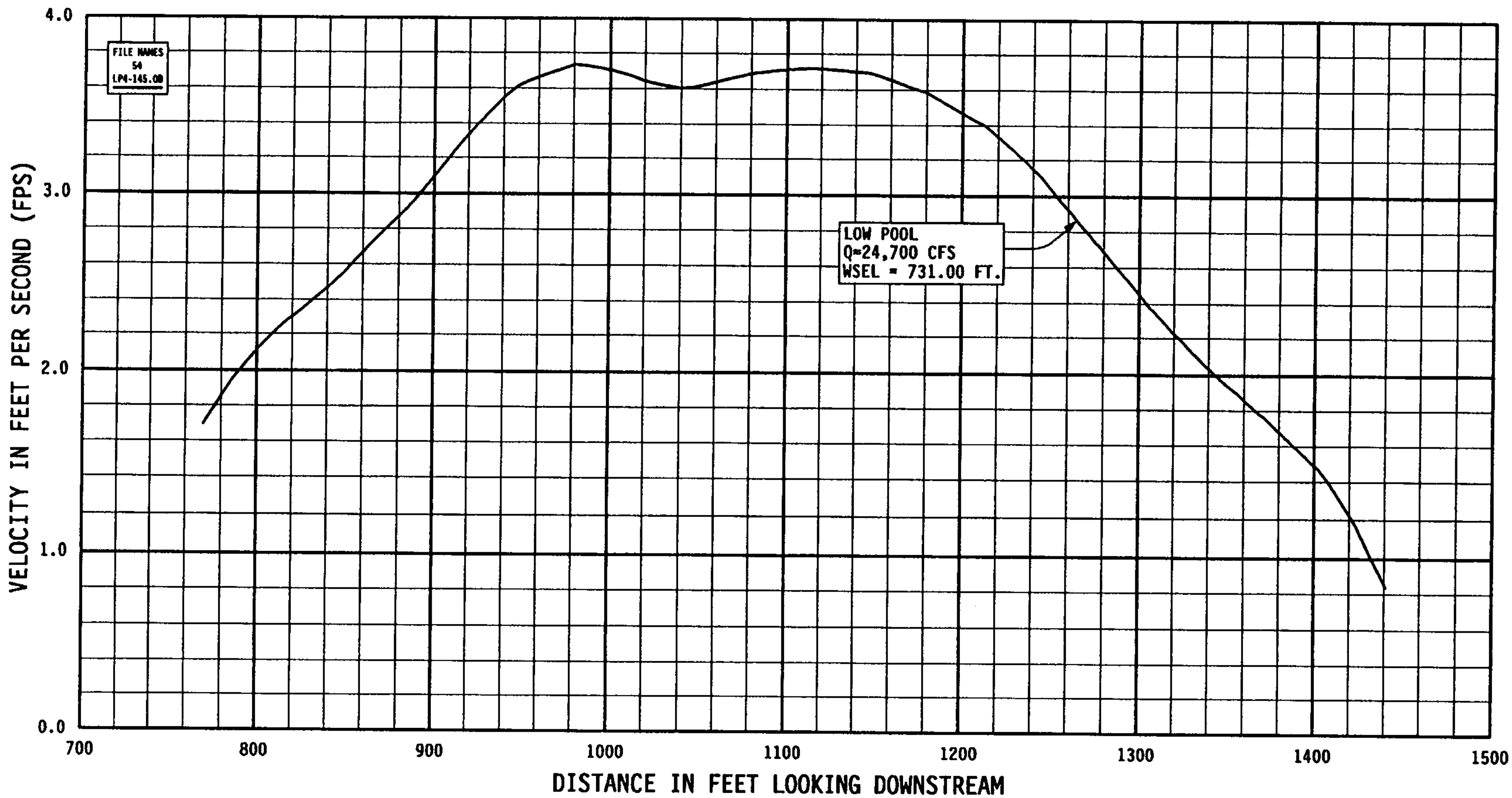
DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	6 OCTOBER 1992



VELOCITY MAP OF RANGE 148.09
LOW POOL. 23,900 CFS. 3/19/92 0552 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

6 OCTOBER 1992



NOTE:

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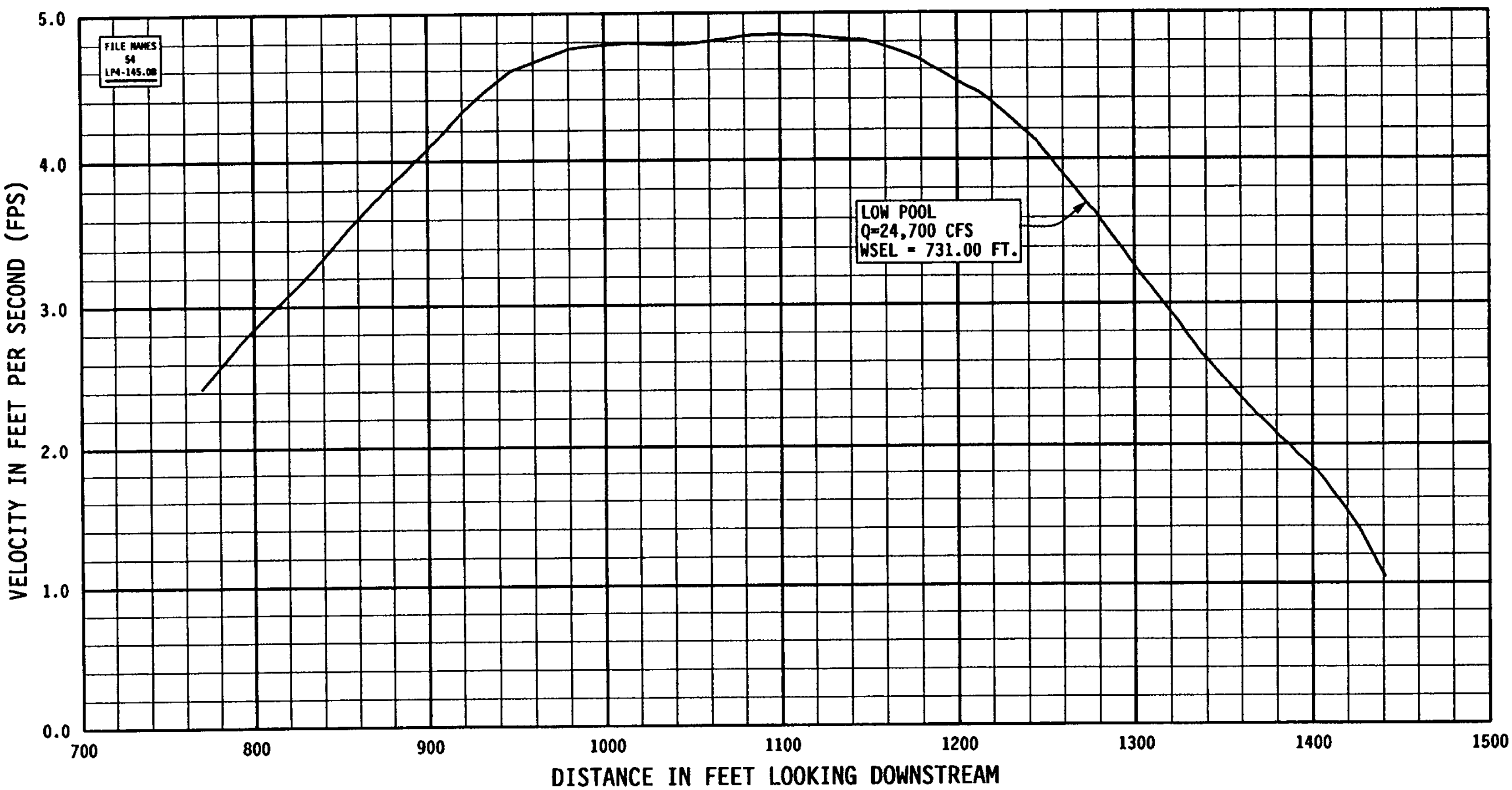
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

SNAKE RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

AVERAGE VELOCITY PROFILES
RANGE 145.15

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	7 OCTOBER 1992



NOTE:

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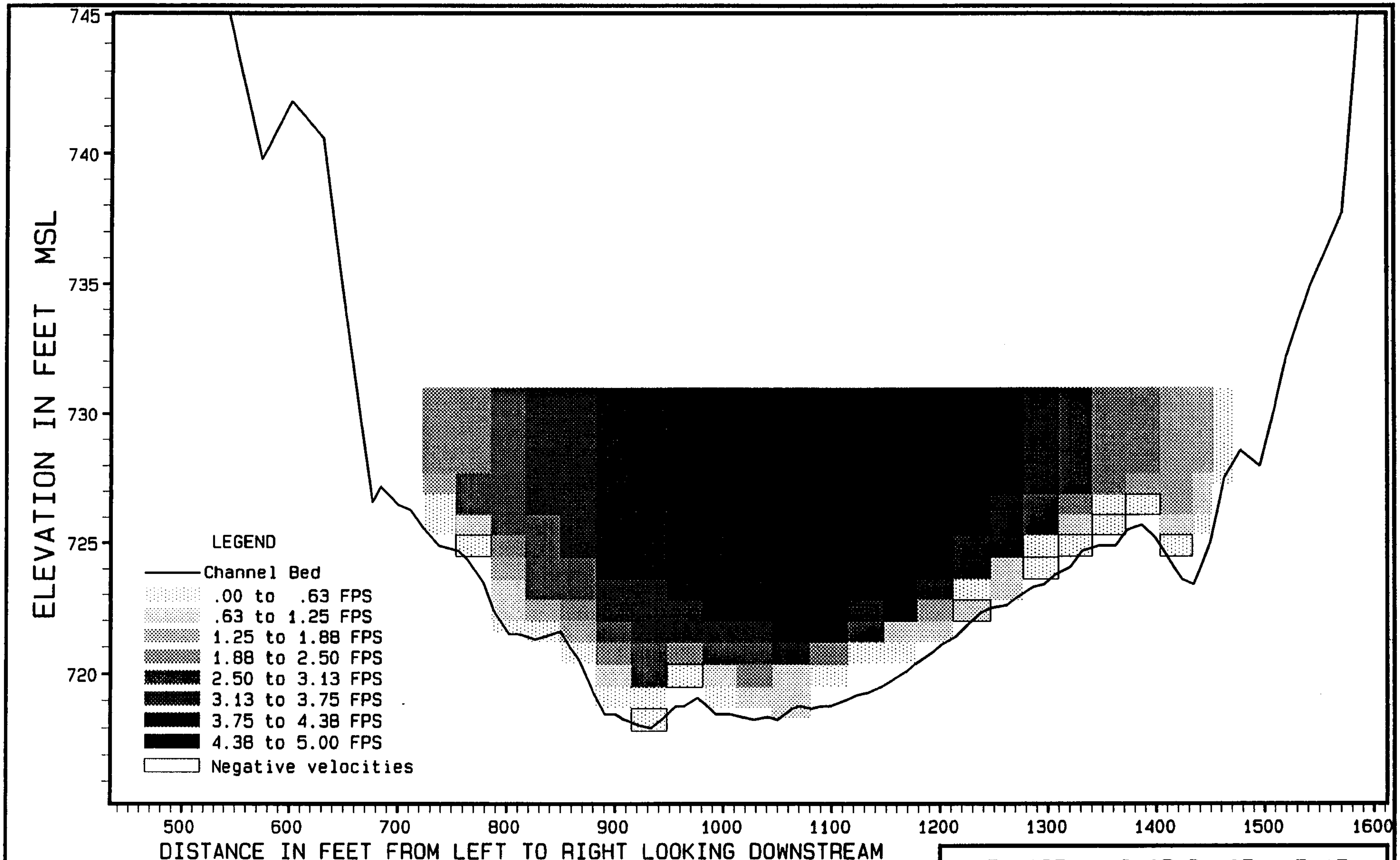
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

SNAKE RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

SURFACE VELOCITY PROFILES
RANGE 145.15

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

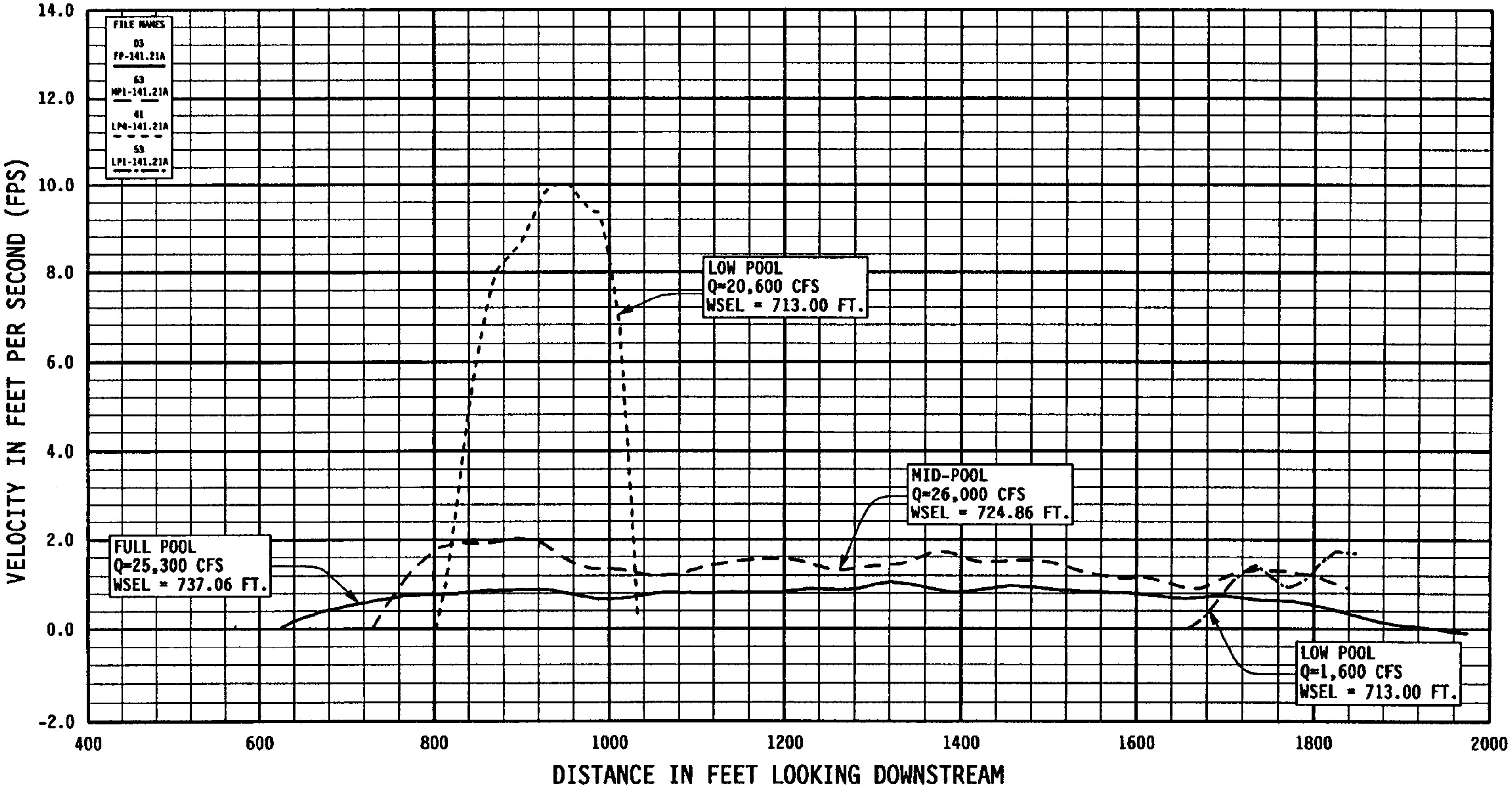
DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	7 OCTOBER 1992



VELOCITY MAP OF RANGE 145.15
LOW POOL. 24,700 CFS. 3/19/92 0624 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

7 OCTOBER 1992



NOTE:

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4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

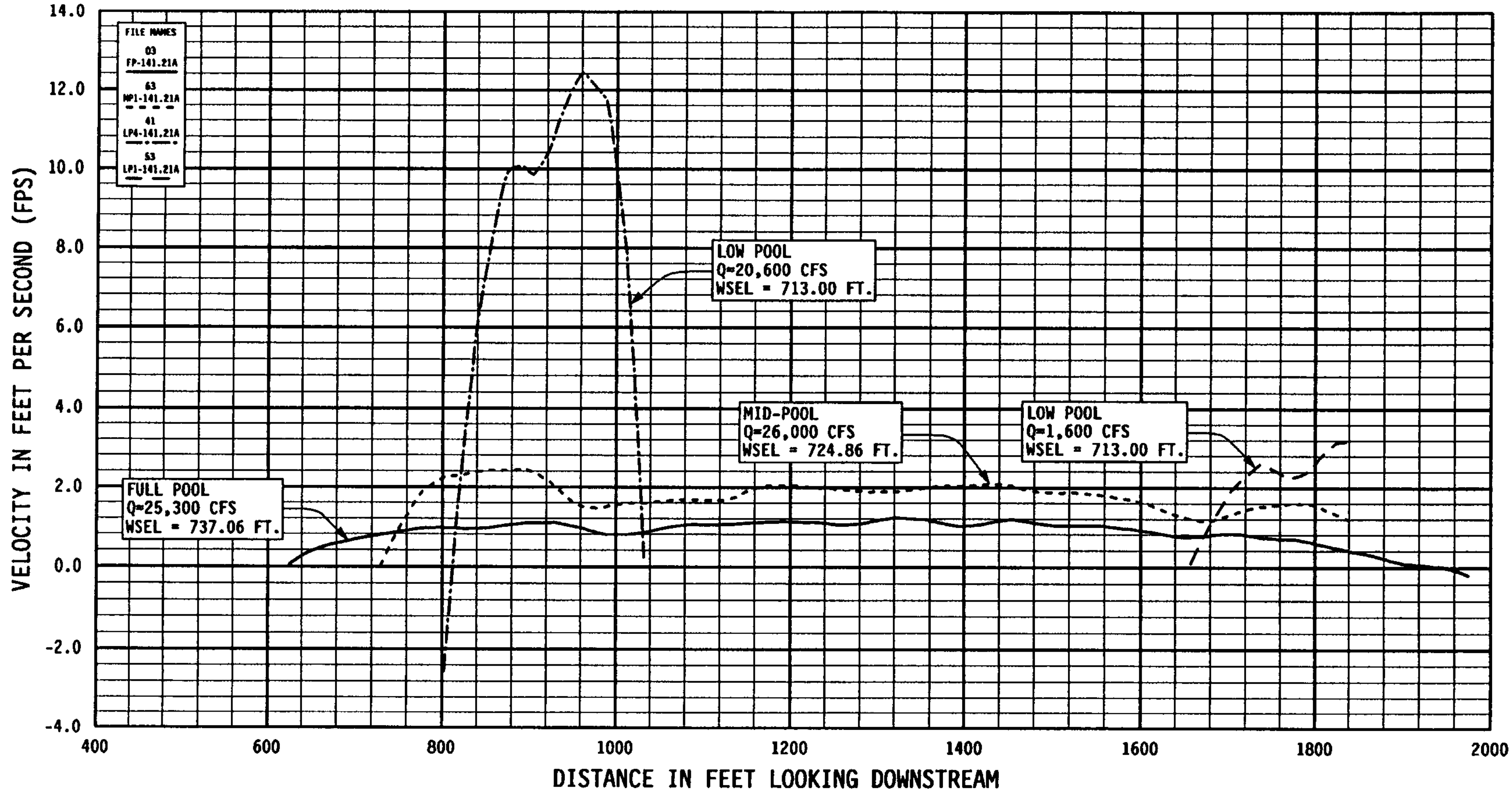
SNAKE RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

AVERAGE VELOCITY PROFILES

RANGE 141.21

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	7 OCTOBER 1992



NOTE:

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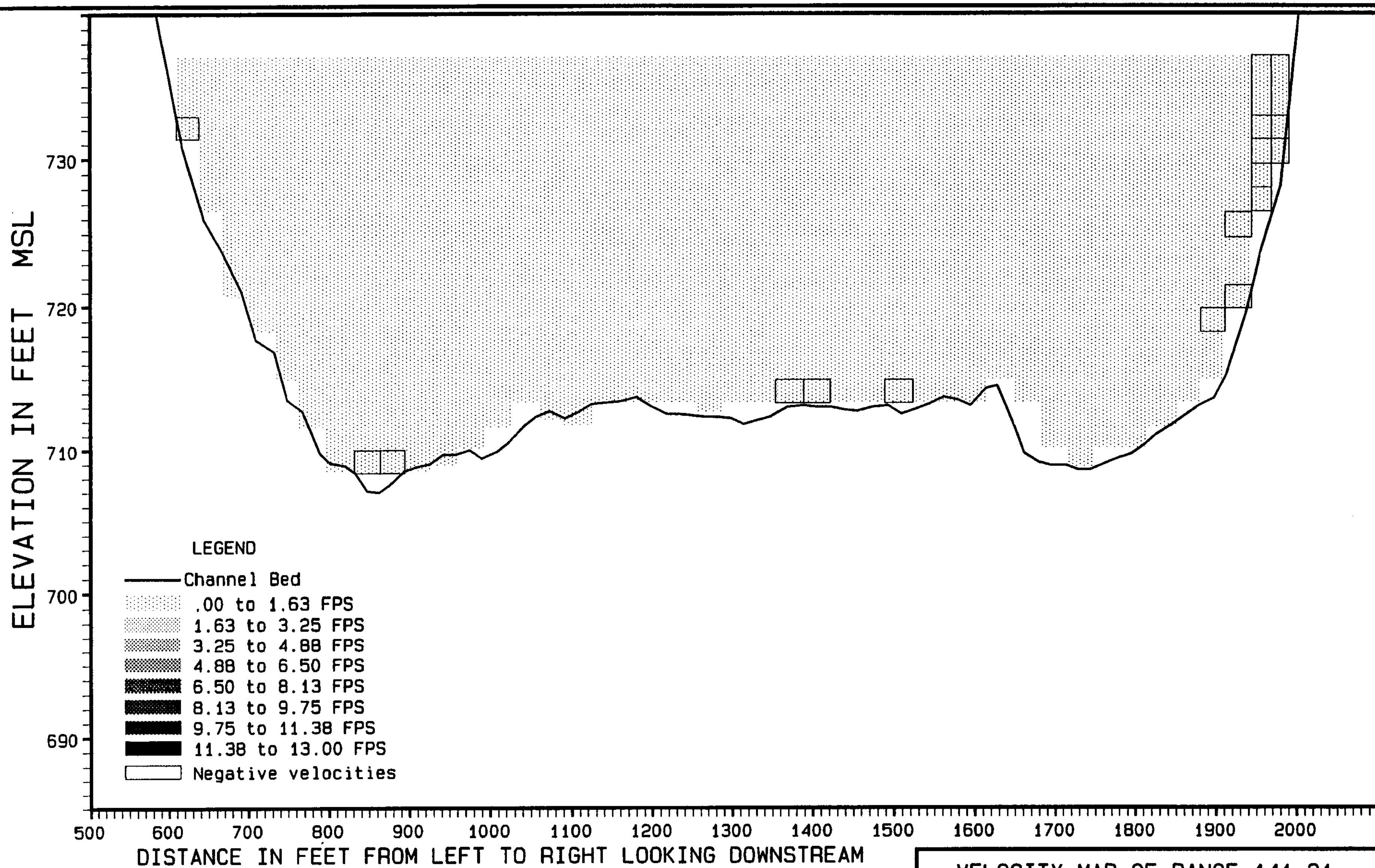
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

SNAKE RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

SURFACE VELOCITY PROFILES RANGE 141.21

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

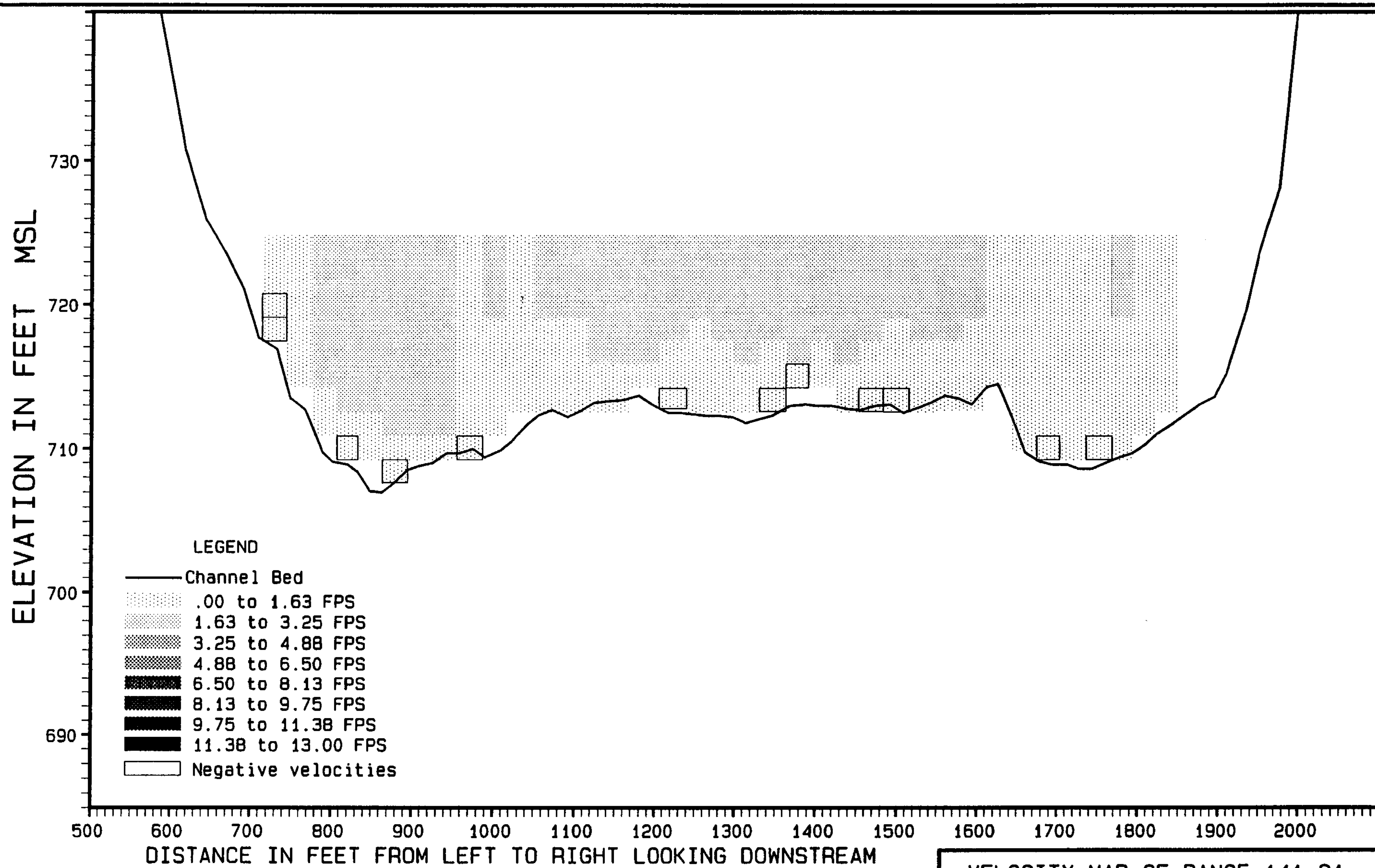
DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	7 OCTOBER 1992



VELOCITY MAP OF RANGE 141.21
FULL POOL. 25,300 CFS. 2/25/92 1110 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

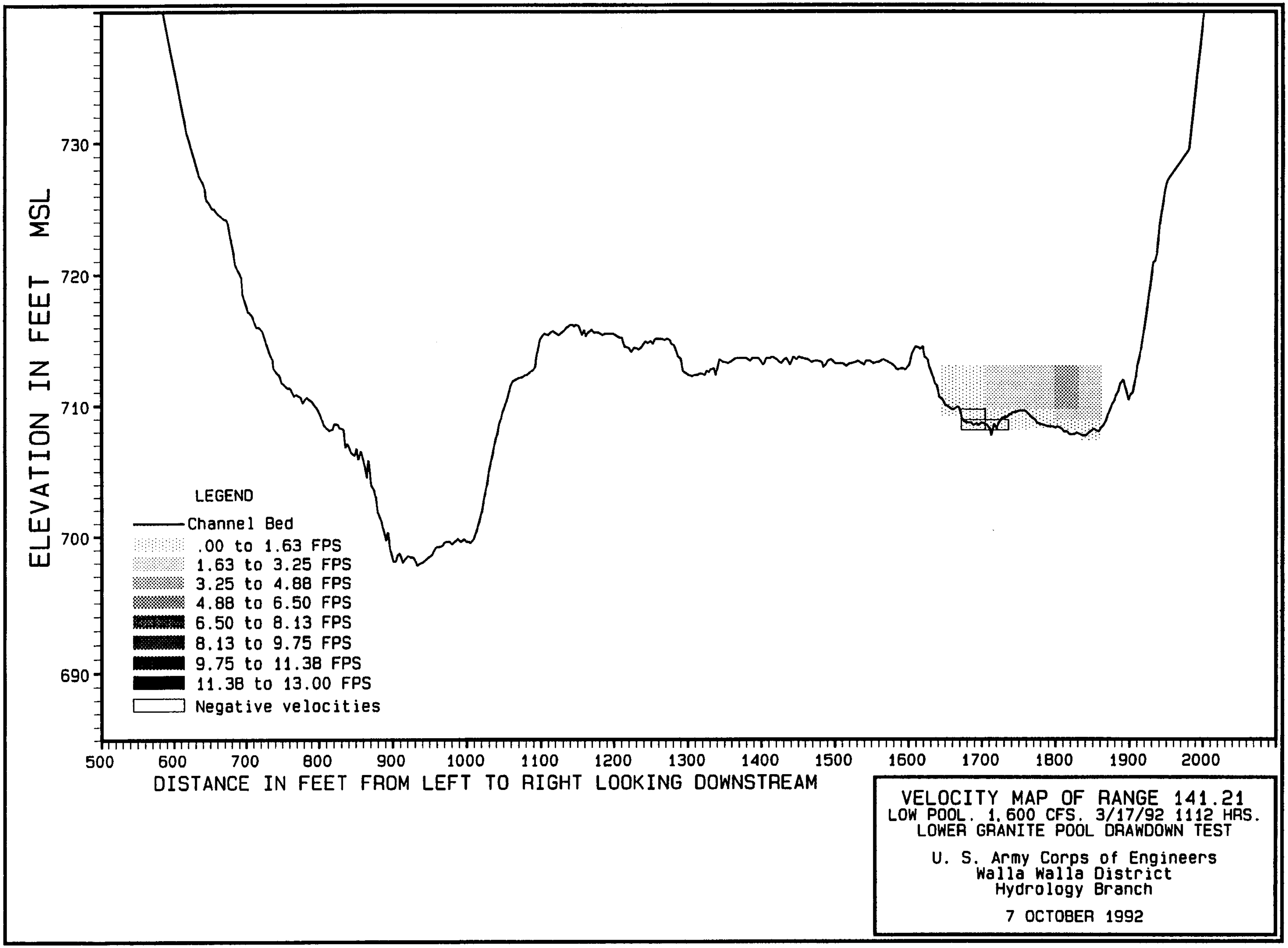
7 OCTOBER 1992

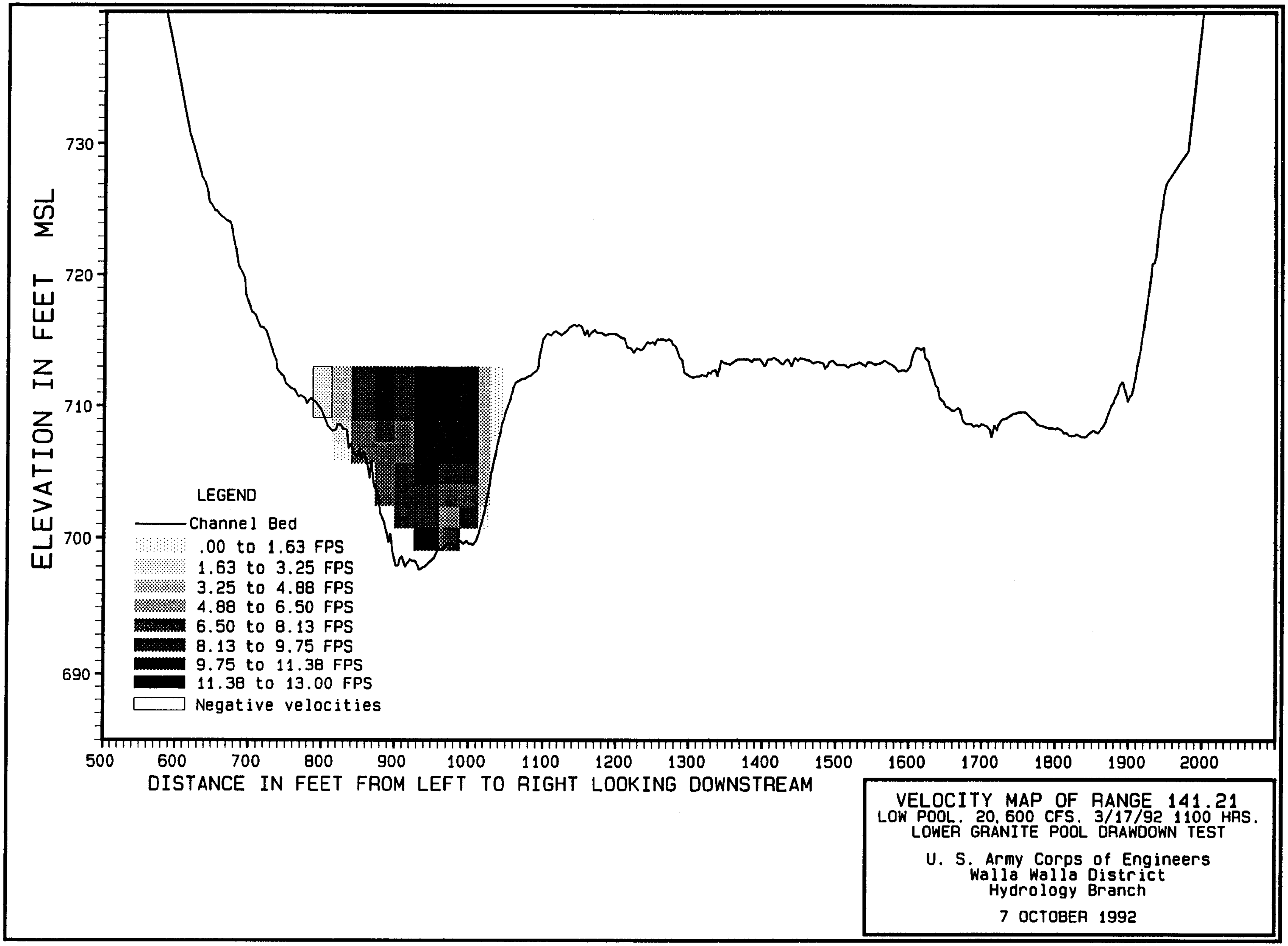


VELOCITY MAP OF RANGE 141.21
MID-POOL. 26,000 CFS. 3/5/92 1044 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

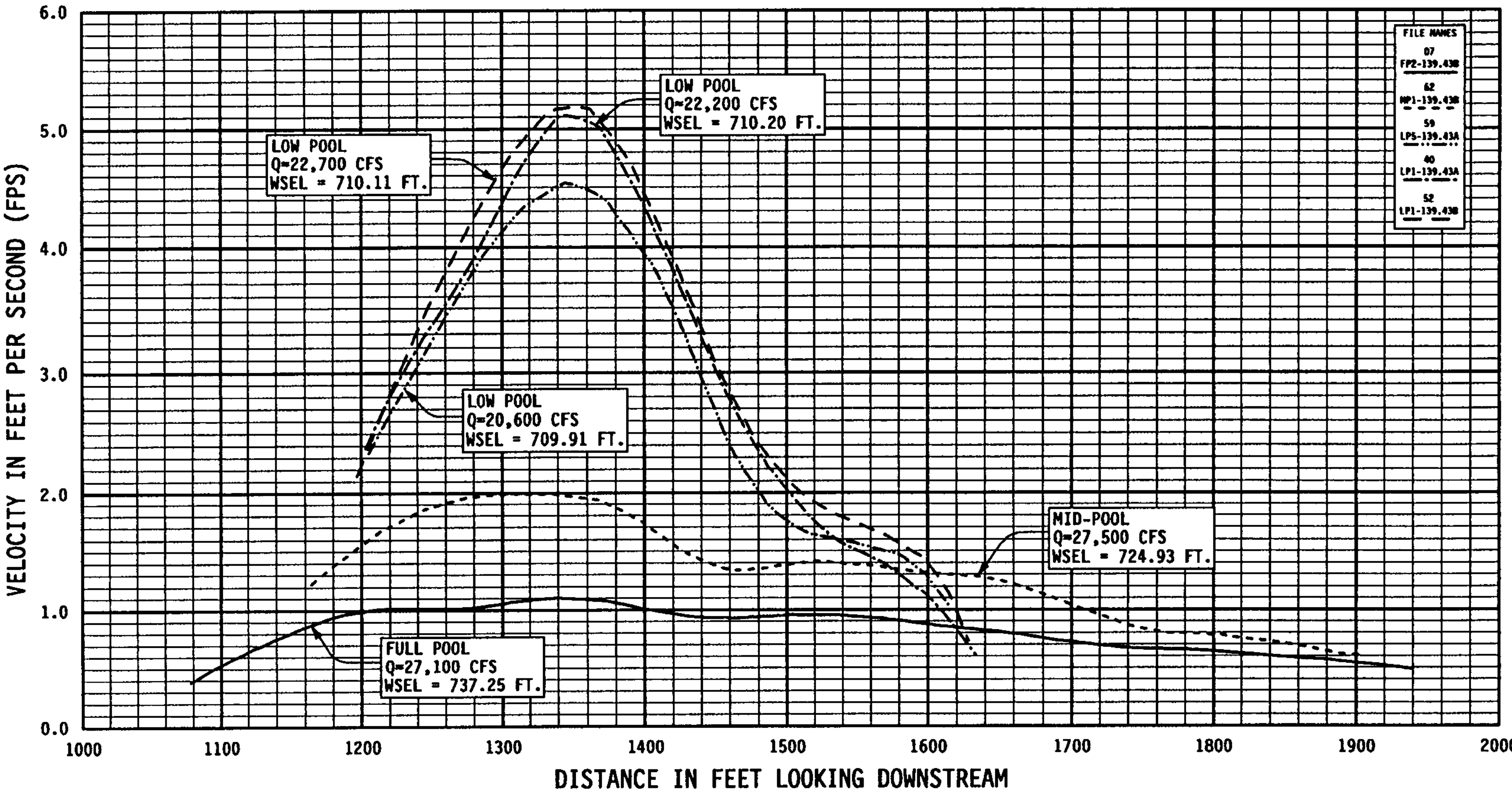
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

7 OCTOBER 1992


ELEVATION IN FEET MSL
730
720
710
700
690
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
DISTANCE IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM
LEGEND
Channel Bed
.00 to 1.63 FPS
1.63 to 3.25 FPS
3.25 to 4.88 FPS
4.88 to 6.50 FPS
6.50 to 8.13 FPS
8.13 to 9.75 FPS
9.75 to 11.38 FPS
11.38 to 13.00 FPS
Negative velocities
VELOCITY MAP OF RANGE 141.21
LOW POOL. 1,600 CFS. 3/17/92 1112 HRS.
LOWER GRANITE POOL DRAWDOWN TEST
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch
7 OCTOBER 1992



730
720
710
700
690
ELEVATION IN FEET MSL
LEGEND
Channel Bed
.00 to 1.63 FPS
1.63 to 3.25 FPS
3.25 to 4.88 FPS
4.88 to 6.50 FPS
6.50 to 8.13 FPS
8.13 to 9.75 FPS
9.75 to 11.38 FPS
11.38 to 13.00 FPS
Negative velocities
500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
DISTANCE IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM
VELOCITY MAP OF RANGE 141.21
LOW POOL. 20,600 CFS. 3/17/92 1100 HRS.
LOWER GRANITE POOL DRAWDOWN TEST
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch
7 OCTOBER 1992



NOTE:

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4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

SNAKE RIVER BASIN

LOWER GRANITE POOL DRAWDOWN TEST

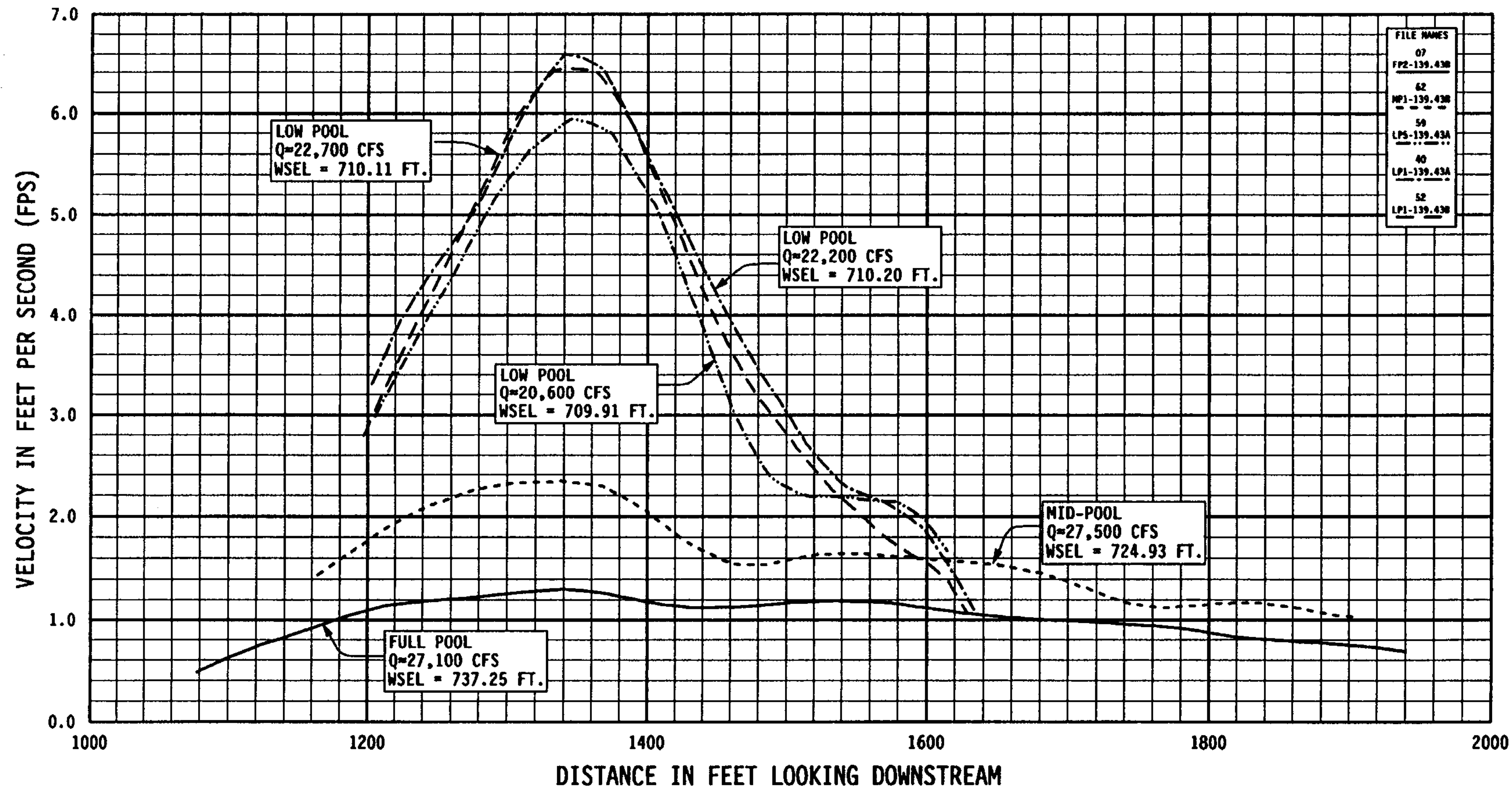
AVERAGE VELOCITY PROFILES

RANGE 139.43

U.S. ARMY CORPS OF ENGINEERS

WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	7 OCTOBER 1992



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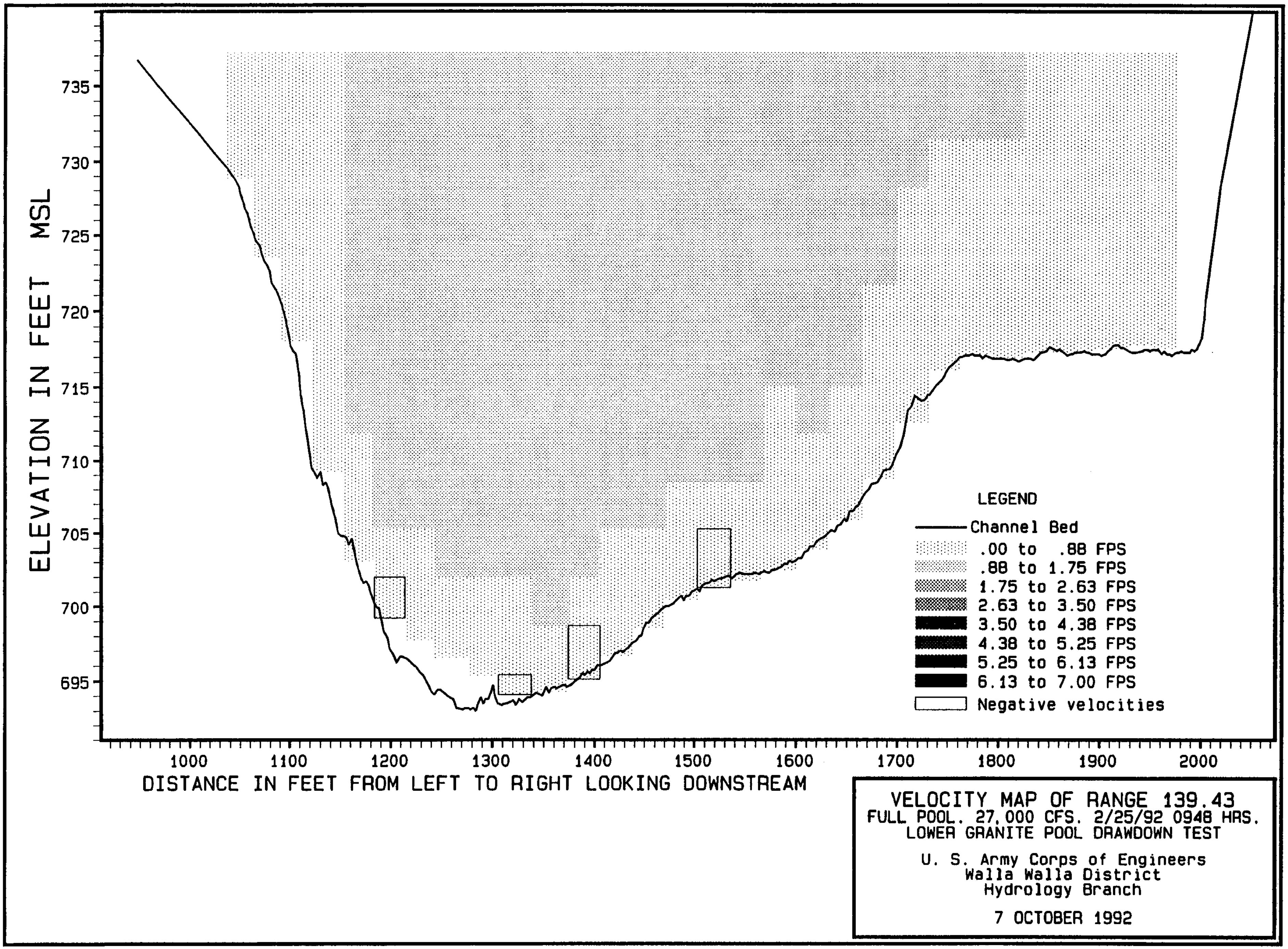
4. WATER SURFACE ELEVATION (WSEL) WAS MEASURED FROM MEAN SEA LEVEL (MSL).

SNAKE RIVER BASIN
LOWER GRANITE POOL DRAWDOWN TEST

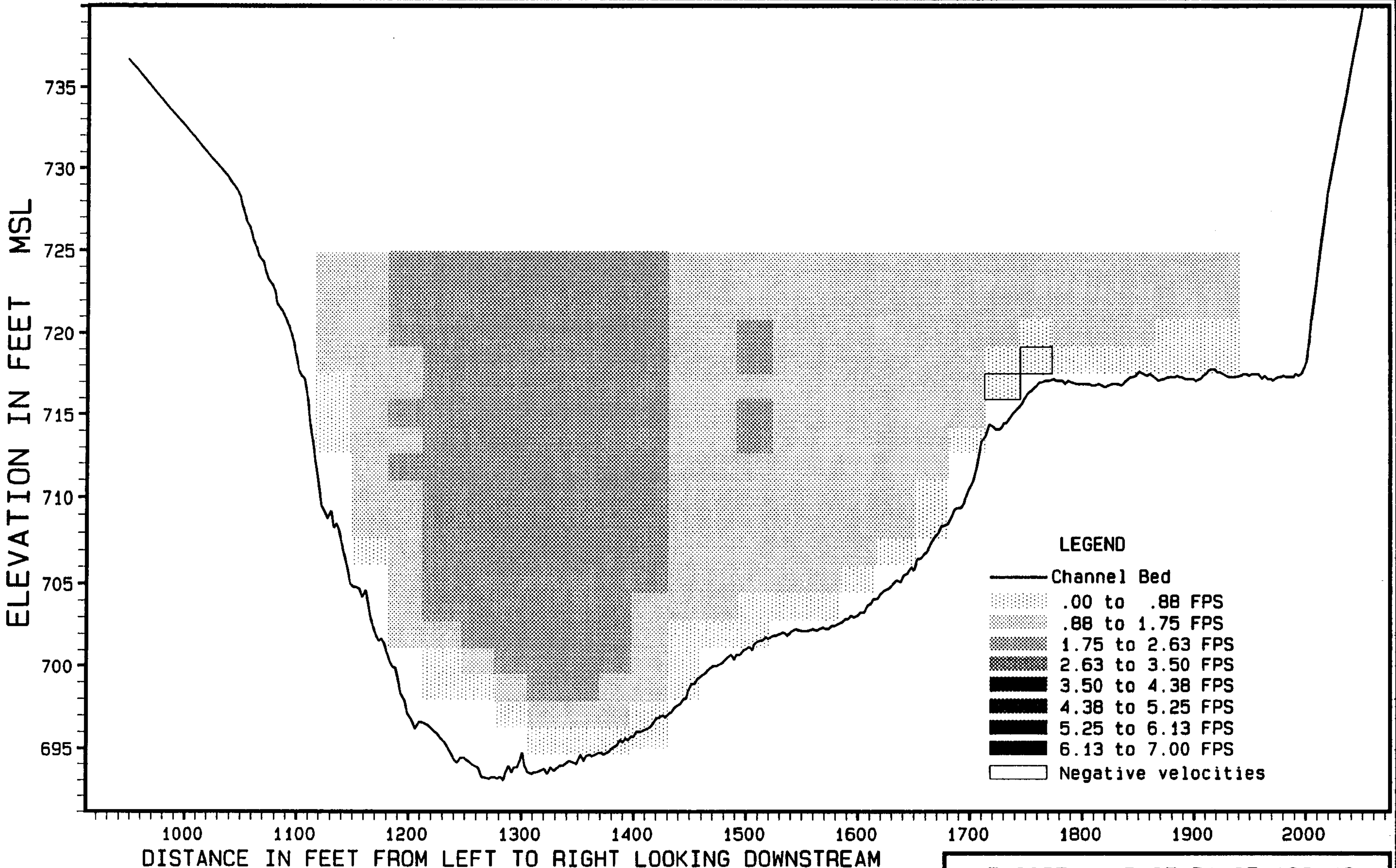
SURFACE VELOCITY PROFILES
RANGE 139.43

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT - HYDROLOGY BRANCH

DESIGNED BY:	DRAWN BY:	DATE
L. CUNNINGHAM	G. HARDIN	7 OCTOBER 1992



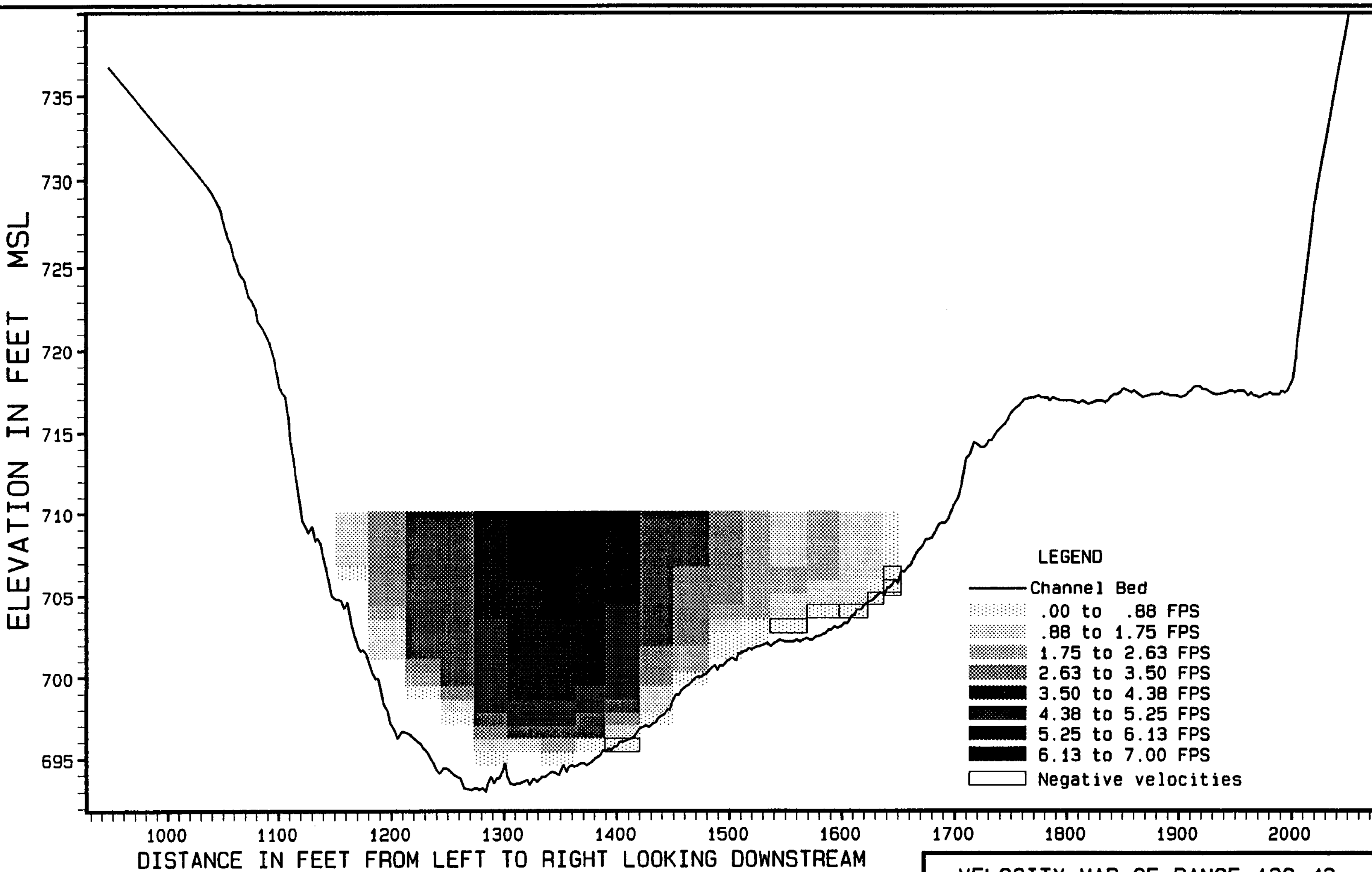
ELEVATION IN FEET MSL
735
730
725
720
715
710
705
700
695
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
DISTANCE IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM
LEGEND
Channel Bed
.00 to .88 FPS
.88 to 1.75 FPS
1.75 to 2.63 FPS
2.63 to 3.50 FPS
3.50 to 4.38 FPS
4.38 to 5.25 FPS
5.25 to 6.13 FPS
6.13 to 7.00 FPS
Negative velocities
VELOCITY MAP OF RANGE 139.43
FULL POOL. 27,000 CFS. 2/25/92 0948 HRS.
LOWER GRANITE POOL DRAWDOWN TEST
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch
7 OCTOBER 1992



VELOCITY MAP OF RANGE 139.43
MID-POOL. 27,500 CFS. 3/5/92 1000 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

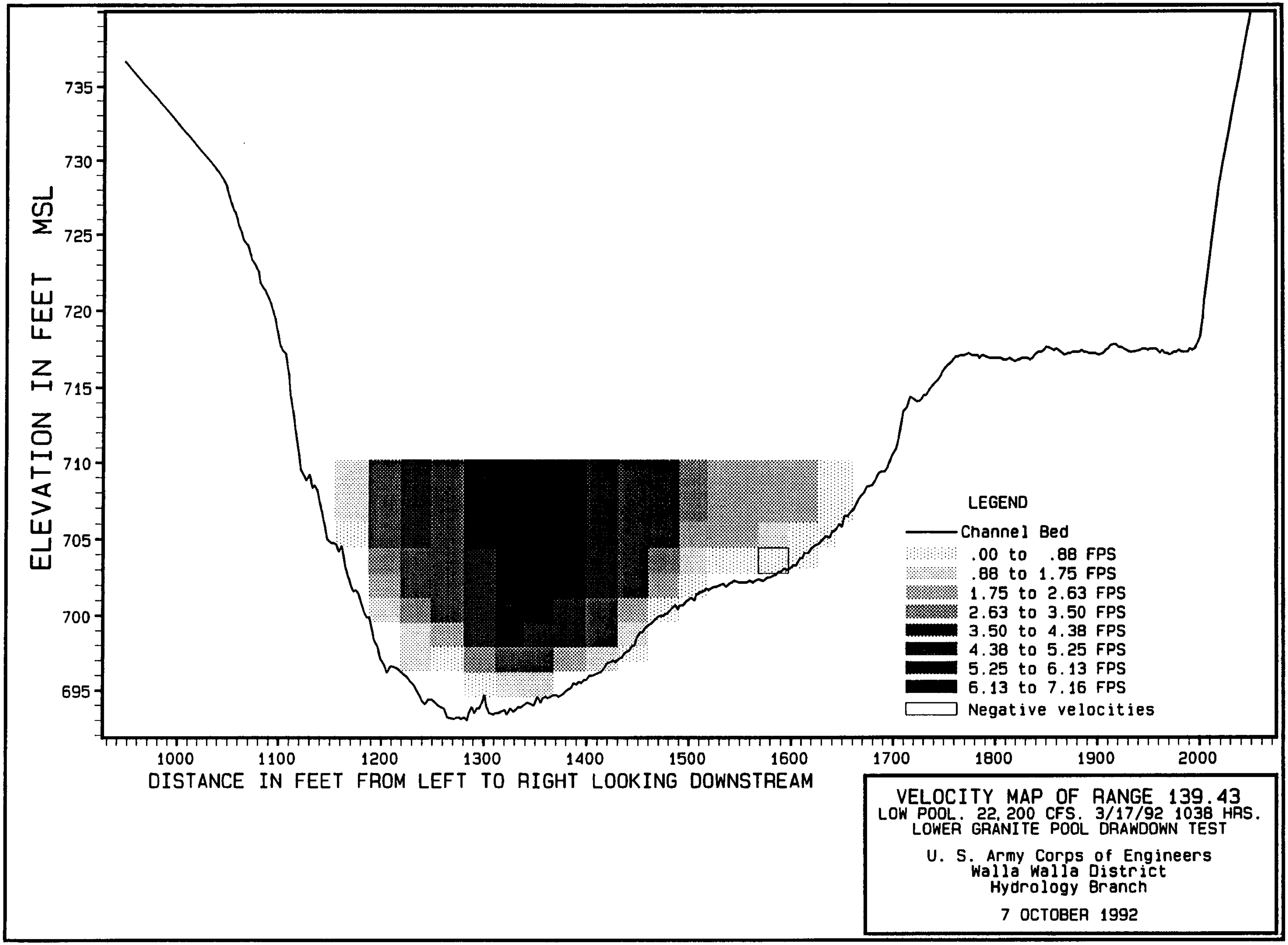
7 OCTOBER 1992

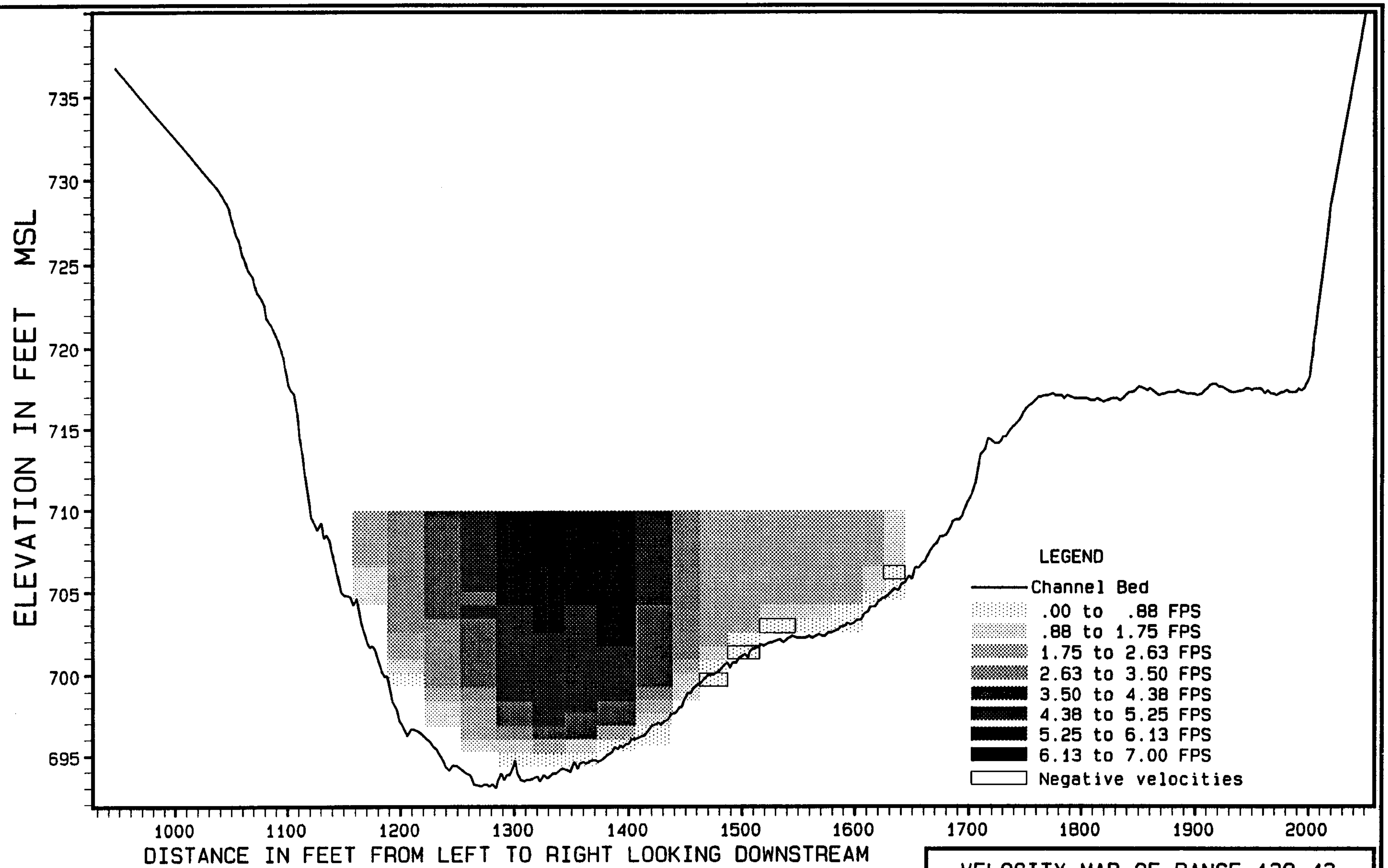


VELOCITY MAP OF RANGE 139.43
LOW POOL, 22,700 CFS, 3/19/92 0817 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

7 OCTOBER 1992


ELEVATION IN FEET MSL
735
730
725
720
715
710
705
700
695
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
DISTANCE IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM
LEGEND
Channel Bed
.00 to .88 FPS
.88 to 1.75 FPS
1.75 to 2.63 FPS
2.63 to 3.50 FPS
3.50 to 4.38 FPS
4.38 to 5.25 FPS
5.25 to 6.13 FPS
6.13 to 7.16 FPS
Negative velocities
VELOCITY MAP OF RANGE 139.43
LOW POOL. 22,200 CFS. 3/17/92 1036 HRS.
LOWER GRANITE POOL DRAWDOWN TEST
U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch
7 OCTOBER 1992



VELOCITY MAP OF RANGE 139.43
LOW POOL. 20,600 CFS. 3/18/92 1035 HRS.
LOWER GRANITE POOL DRAWDOWN TEST

U. S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

7 OCTOBER 1992