## Book B

## Bathymetry and Survey Line Locations

**By**
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The Silverman et al. (1971) bathymetry and line locations map lists Arnold Silverman, David Pevear, and Sidney Prahl as the "compilers" of the map. I believe that Sidney Prahl was the primary compiler for the map, and I will refer to the map as the Prahl map.

Prahl's original map was apparently never published though it was clearly prepared with that formality in mind. Marian Lankston did the final artwork of the map during the summer of 1972 using a draft provided by Prahl. The final artwork was probably rendered on drafting film, and I will come back to that later. Prahl's probable objective was to include the map as a large plate in his master's degree thesis. One might expect the Prahl thesis to describe the sources of the bathymetric data in some detail. However, Prahl apparently did not complete his degree work. The University of Montana, Maureen and Mike Mansfield Library does not have a Prahl thesis in its catalog.

Wold (1982) referenced Prahl's post-acquisition processing of the seismic data. However, Wold did not reference the Prahl bathymetry and track line map explicitly. The unpublished Prahl map has two components, i.e., the bathymetry of the lake and the locations of the Wold-Crosby seismic lines, both of which Wold needed for his paper. Wold's (1982) Figure 1 references the bathymetry that was presented in the Kogan (1980) thesis, but Wold does not reference his source for the survey lines. Wold must have had some resource for the seismic survey lines, though, because he shows them on his Figure 1, and his interpretations are drawn along the respective lines. As I mentioned in the narrative for Book A, Wold's (1982) map did not show the locations of Lines A and B. In the context of Book A, Lines A and B related to data on the USGS magnetic tape. Wold's (1982) published map also did not show some of the lines in the southern part of the lake.

Kogan likely did have a copy of the original Prahl map, and he used Prahl's bathymetry as the base on which to show his 1980 survey lines. The Kogan thesis map references an unpublished map with Silverman, Pevear, Prahl, and Crosby as authors. I believe that Kogan chose to reference the four individuals who were named on the Prahl map as the "sources" of information not those listed as the map "compilers", i.e., Silverman, Pevear, and Prahl.

The Prahl map credits two sources of bathymetric data, i.e., Silverman's traverses of the mid-1960's and traverses from the 1970 Wold-Crosby seismic survey. Silverman was on the faculty of the University of Montana (UM), Department of Geology. David Pevear was a UM graduate student in the mid-1960's. Prahl, of course, was also a UM graduate student, though later than Pevear in the late 1960's and early 1970's.

Based on an attribution on the map and my correspondence with Pevear, the Silverman phase of the bathymetric work was conducted in 1965 and 1966. Pevear offered this recollection in an email to me dated May 11, 2011:

*The echo sounder was a huge, military surplus thing; the sender (source), called a "magnetostrictor", was at least a foot in diameter and was bolted thru the hull. It produced a relatively small strip chart, but the source was apparently powerful, for we saw what looked like sub-bottom reflectors that resembled the images on your website. We made quite a few profiles over much of the lake; I was worried that we would run aground in the delta area. Unfortunately, our navigation was by crude dead reckoning.*

The "delta area" mentioned by Pevear is the delta of the Flathead River that is forming at the north end of the lake. The "website" mentioned above was a predecessor of this site on a commercial web server. However, the images to which Pevear refers are now in Books C and E of this collection. The bathymetry profiles in Book D were recorded during the Wold-Crosby program in 1970. The "strip charts" to which Pevear referred are likely lost. However, some of the bathymetry profiles from the Wold-Crosby survey do show the sorts of features to which Pevear was probably referring.

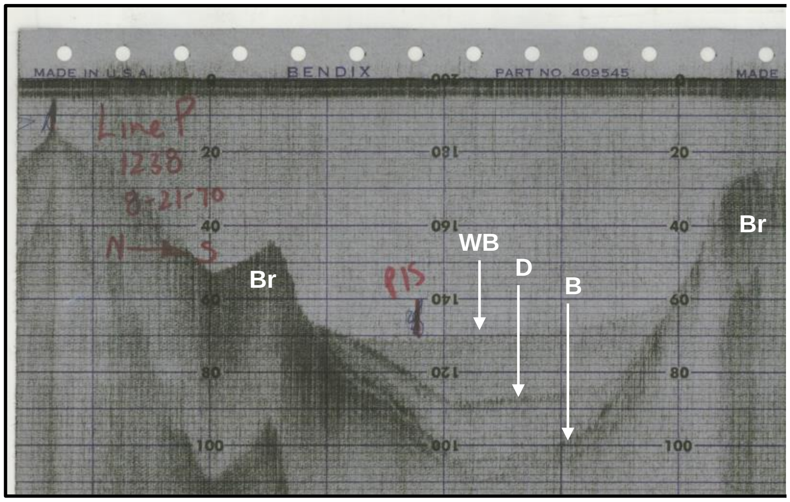


**Figure 1. North Half of Line P Bathymetry.** This section extends from near Dayton to near the northwest tip of Wildhorse Island. I added labels for the water bottom (WB) and units using the nomenclature of Hofmann (2005).

Figure 1 is an example from Line P of the Wold-Crosby survey in which sedimentary reflections were particularly well indicated on the depth sounder's recorder. The depth sounder's purpose was to detect the water bottom, i.e., the unconsolidated sediment or the bedrock under the lake water. In general, the source's signal strength was not sufficient to penetrate below the water bottom.

However, in the case of Line P in Figure 1, the water bottom reflection near the red, handwritten mark "P1S" is weak suggesting only a slight density contrast between the water and the sediment, i.e., the sediment was fine grained and was fully saturated, i.e., its porosity was probably just slightly below critical porosity. The low reflection coefficient at the water bottom allowed more energy to penetrate into the sediments. The water bottom near P1S is the top of Hofmann's (2005) Unit F, which Hofmann interprets to be a thin layer draping over lake bottom sediments and the Precambrian bedrock alike. Unit D is the top of the Mt. Mazama tephra as interpreted by Hoffman, and B is another significant unit in Hofmann's analysis. Br is the Precambrian bedrock. Hofmann uses the example of Line P in making his definitions because the Wold-Crosby and Kogan surveys followed almost identical tracks west of Wildhorse Island

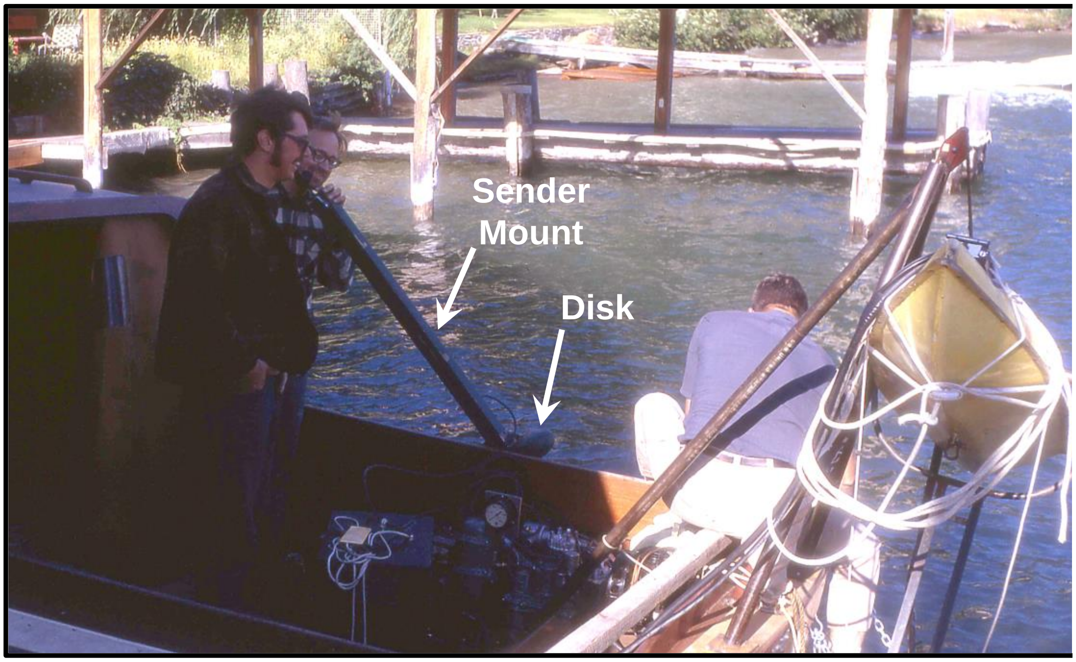


**Figure 2. Magnetostrictor Disk.** Pictured (from left) are Carl Brzozowy, Ronald Friedel, and Gary Crosby. I have labeled the sender mount and the magnetostrictor source disk. *(Photo used with permission of Richard Wold)*

and, therefore, the respective sections are complementary in terms of sediment and bedrock identification.

Until my 2023 phase of maintenance on the files in this archive, I had not realized that the set of slides that Richard Wold provided to me in 2006 contained images that serendipitously captured elements of the depth sounding equipment that was employed in parallel with the Wold-Friedel seismic system. The features of the depth sounding system were not central features of the respective images and were easily overlooked.

For example, Pevear, above, mentions that the "sender" unit was a "military surplus" disk approximately one foot in diameter. Figure 2 shows University of Wisconsin-Milwaukee technician, Ronald Friedel, holding one end of a 2x4 board, painted Army green. I will call this board the sender mount. Resting on the starboard gunwale and attached to one end of the sender mount board is an Army green disk approximately one foot in diameter. With the mount and the disk being a dark color and in the shadow in this view, I had not focused on the significance of what Friedel was holding until my 2023 editing. Nevertheless, the Disk in the photo is, likely, the source for the depth sounding equipment that generated the sections in Book D of this archive and, likely, is the same equipment that Silverman and Pevear had used in previous summers. As I will show later, the mounting arrangement would appear to be different from what Pevear described.

Figure 3 shows the scene in Figure 2 from a different angle. In both views, Professor Crosby is working to detach a 2x4 (or similar) board from the transom of the survey boat. Except for the two field recorded sections for Line B in Book C, each section has a date and at least a starting and ending time handwritten on it. The two sections labeled Line B have times but no dates. I captured the dates and times for each line and sorted them in a spreadsheet. Line J was

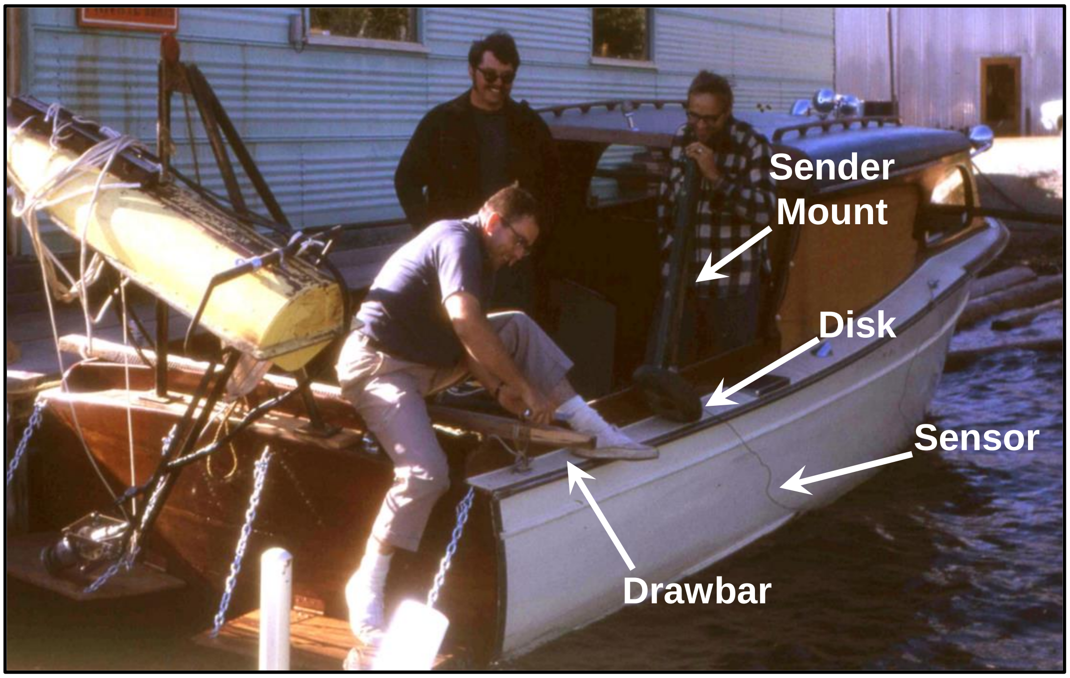

**Figure 3. Removal of Broken Drawbar.** This shows Professor Crosby removing the broken wooden beam to which the hydrophone, the air gun assembly, and the depth sounding source had been attached during recording of the initial line. The magnetostrictor source (Disk) and the Sender Mount are hard to see in the poor light. The small wire along the gunwale is interpreted to connect to the sensor for the depth sounding system. *(Photo used with permission of Richard Wold)*

apparently the first line traversed. Near the end of the field recording from Line J, a handwritten notation indicates that the drawbar board, referred to as "pole", broke. The board was subsequently replaced by a steel pipe. The board and, later, the pipe were the attachment points for the air gun source and the hydrophone of the seismic system and the depth sounder source.

Line J was recorded on a Sunday. No data were collected on the following Monday. Monday may have been spent replacing the wooden drawbar with the steel pipe and making a new attachment point for the sender mount. Production seismic shooting appears to have resumed on Tuesday.

Figure 4 shows enlargements of small areas of three of Wold's photographs in which the depth sounding equipment is not the central feature of the frame. Panel a in Figure 4 shows the sender mount. The disk in Panel a is sitting on the floor of the boat and is out of sight. The steel drawbar is also labeled (Pipe). In Panel b, the steel plate to which the sender mount would be attached can be seen, and in Panel c, the sender mount has been connected to the steel plate. This method of deployment of the magnetostrictor source is different from that described by Pevear above.

Wold's set of photos includes one of an oscilloscope (Figure 5). This was not part of the Wold-Friedel seismic system, and I presume that it was related to the depth sounding equipment. However, it could simply have been on hand for testing circuits. The device was a Tektronix model 321. That model was discussed by Jaski (1961). The oscilloscope was mostly solid

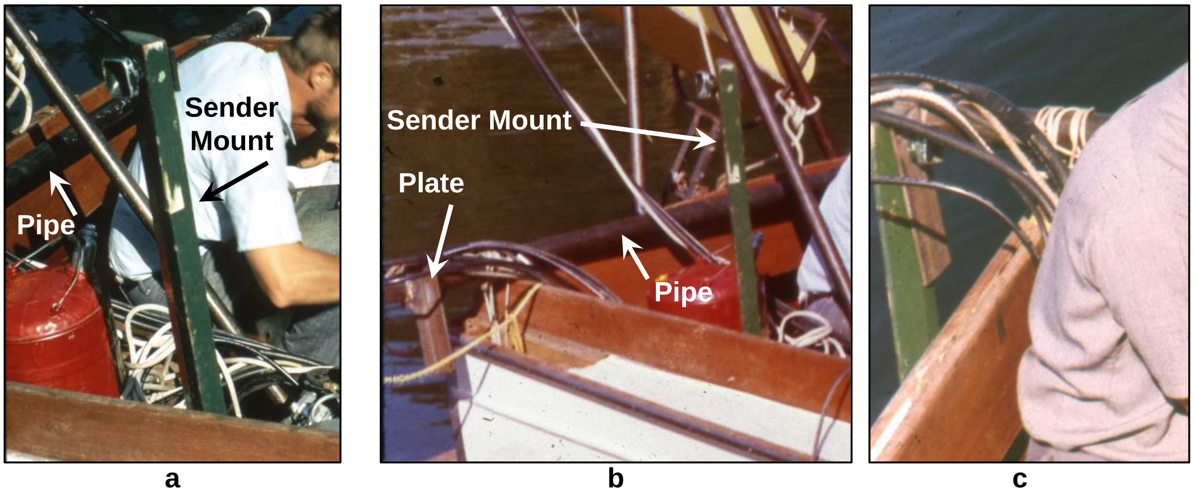


**Figure 4. Depth Sounder Deployment.** a) Drawbar steel pipe and the end of the 2x4 that supported the sender unit. b) Welded to the steel pipe is the plate to which the sender mount was attached. c) The sender mount bolted to the steel plate with the depth sounder source deployed in the water alongside the survey boat. *(Photos used with permission of Richard Wold)*

state, having just two vacuum tubes other than the CRT. In addition to operating on standard 110 Vac power, the unit could be powered by internally mounted flashlight batteries, by an external 12 Vdc automotive or marine battery, and so forth. The Jaski (1961) article shows the oscilloscope being used to check a “depth indicator” on a boat.

This book includes two map file images:

a) an image of the only known surviving print of the original artwork
b) an enhanced version of the image of the surviving print.

The surviving Prahl map, like all of the surviving documents of the 1970 project, is available to view in the K. Ross Toole archive of the Maureen and Mike Mansfield Library at the University of Montana. The surviving paper map is a black line, diazo-style copy from an original that was probably prepared on drafting film. Whether or not the original artwork still exists is not known. Folklore among some University of Montana geology students of the early to mid-1970’s era hints that the original artwork was severely damaged by an accident involving the science building’s janitorial staff during cleaning in the geophysics lab.

I mention in the narrative for Book A that the Prahl map was lost from 2008 to 2011. Fortunately, the map was found. Through the years since it would have been made, circa 1972, the surviving paper map has faded, and some features have bled into other parts of the document as the map lay folded for long periods of time. Considering the map’s probable age, one should not be surprised that the map has water stains or stains from other liquids, that it is torn, and that it has tacky spots where tape has been removed in addition to the wear along the folds. When it was found in 2011, it was in desperate need of being archived. Marc Hendrix and I transferred the paper map to the library shortly after it was found. The library scanned the map and encased it in polyester film.

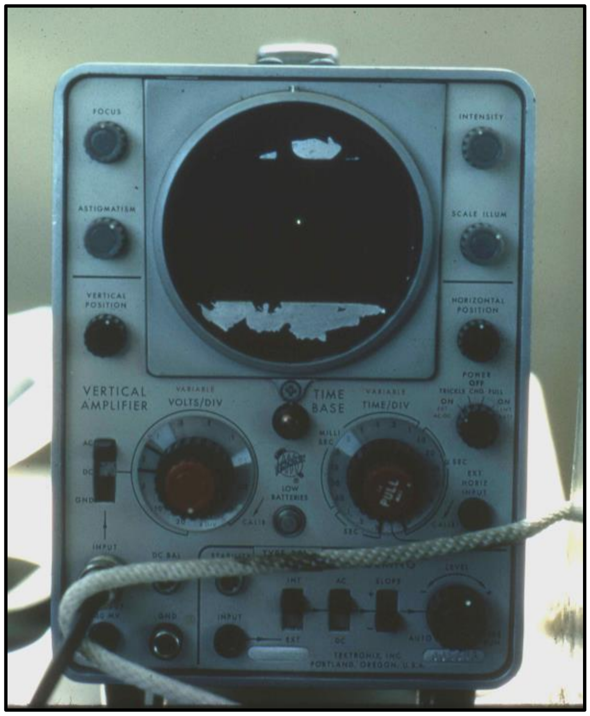


**Figure 5. Tektronix 321 Oscilloscope.** I do not know the significance of the image on the screen. *(Photo used with permission of Richard Wold)*

In the fall of 2015, I learned that an archival group at the Montana Bureau of Mines and Geology (MBMG) in Butte, MT, had resources to enhance images of old drawings, e.g., geologic maps of mining claims. The staff at MBMG offered to do what they could to enhance the image of the Prahl map. The second file in this book is the result of their efforts.

The following is from Margaret Delaney, Program Administrator for Data Preservation of the MBMG, Mining Archives Department, after the first phase of the MBMG enhancement (October 29, 2015):

> *Montana Bureau of Mines and Geology, Mining Archives Department, updated the Bathymetry map of Flathead Lake by scanning the USGS 7.5 minute quadrangle maps (see below) of the bathymetry coverage area. The maps were scanned at a resolution of 600 dpi and combined into a composite base map using Photoshop and resized to the original Bathymetry map scale. Certain features of the new base map (e.g., islands) were removed to preserve the integrity of the original report's map features.*
>
> *Seismic information from the high-resolution digital copy of the original report's map, obtained from the Maureen & Mike Mansfield Library at the University of Montana, was overlain on the base map and sharpened to give a crisp look to the bathymetry lines. All layers were double-checked for accuracy and merged into a single image.*

*<u>USGS Quadrangle Maps used to create new base map:</u>*

*Elmo Quadrangle*
*Wild Horse Island Quadrangle*
*Rollins Quadrangle*
*Bull Island Quadrangle*
*Woods Bay Quadrangle*
*Somers Quadrangle*
*East Bay Quadrangle*
*Polson Quadrangle*
*Big Fork Quadrangle*
*Buffalo Bridge Quadrangle*

"Seismic information" referenced above is just the Silverman and the Wold-Crosby track lines, i.e., no actual seismic data were involved in the enhancement. Delaney was not clear as to what islands were removed from the "new base map".

After the delivery of the MBMG enhanced image of the bathymetry map, I asked Delaney if the content of the map, i.e., the contours, line locations, and title block, could be easily overlain on a base that comprised the 1960's vintage topographic maps. MBMG agreed to make a new base map using files from the US Geological Survey's historical map collection and drop the previously enhanced content onto the new base. This new base obviated the need to remove features such as the "islands" referenced above. The new base is essentially identical to the base that the original compiler would have made circa 1970. The only difference in the resulting map is that the new base map is in color.

The work at MBMG in assembling a new base map was analogous to the process that the compiler in the early 1970's, nominally Sidney Prahl, would have gone through. The difference being that the later effort was able to use all digital tools. Both base map assembly efforts started with the 7.5 minute (1:24,000) USGS topographic quadrangle maps. The MBMG assembled the maps digitally in an image editor while the earlier compiler had to be more manual.

In 1970-71, the quadrangle sheets would have been physically trimmed of margins and edge annotations and taped together to form a large composite. That composite sheet would have been photographed by a reprographics firm. A positive print on drafting film, nominally, Mylar[1], would have been made by projecting the negative to the scale desired by the compiler. This is the stage at which the original quadrangle scale was reduced by 50% to the scale noted on the Prahl map, i.e., 1:48,000. These were common map generating practices in that era. The photography would have been black and white, losing any color that might have been on the original quadrangle sheets. Losing the color was not an issue in the early 1970's. Copies of the Mylar base map and its subsequent bathymetric and seismic line contents would have been copied using a diazo process and, therefore, would have been monochrome. A paper copy of the Mylar base map would have been used to draft the contours and line locations, layout the title block, and so forth. The paper draft would have been given to the professional drafter a a guide for generating the final map on the polyester film. I can imagine that the film on which Marian Lankston drew the contours and line locations was the only Mylar copy of the initial base that was made, i.e., a cost saving measure.

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[1] Mylar is a registered trademark of DuPont Teijin Films for a form of polyester film.

The enhanced image prepared by the MBMG maintains the green of forested areas, the blue of the lake water and tributary rivers, the red of major highways and section numbers, and so forth. I think that these color features soften the starkness of the original monochrome map and make the bathymetric and track lines content easier to read. Important to note in the enhancement is that nothing has been re-entered into the graphic in terms of text in the title block or labels on contour and seismic survey lines.

The map from the initial MBMG enhancement is not on this site. A paper copy was printed on a modern large-scale plotter and is available to view in the Toole archive of the Mansfield Library at the University of Montana. The file that is in this book is the MBMG version that used the 1960's era color quadrangle maps.

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