D. W. KELLEY, *Aquatic Biologist*
323 FORUM BUILDING
1107 - 9TH STREET
SACRAMENTO, CALIF. 95814

PHONE (916) 443-3781

October 5, 1978

Mr. J. Dietrich Stroeh
General Manager
Marin Municipal Water District
220 Nellen Avenue
Corte Madera, CA 94925

SUBJECT: Report- "The Relationship Between Streamflow and Salmonid Rearing Habitat in Walker and Lagunitas Creeks, Marin County".

Dear Diet;

We wrote this report to help you negotiate the stream releases from Kent Reservoir, and to renegotiate those from Soulajule. Our intent was to produce two curves relating streamflows to spawning runs, ocean, and river catch of salmon and Steelhead from Lagunitas and Walker Creeks. Our first draft did that, but Keith Anderson and other biologists convinced us that we did not have enough data to do it with confidence and the lack of confidence reduced its value as a negotiating tool. Therefore, we have retreated to a set of curves describing how the quantity and quality of juvenile salmonid rearing habitat is affected by changes in flows on both streams. Our data here is as good as the state of this art will allow. Since the quantity and quality of rearing habitat is the limiting factor on both streams, these curves should be useful tools for negotiation.

The last curve, which is Figure 10, summarizes all the data and suggests two key points:

1. Increasing streamflows above about 3 cfs on Lagunitas Creek does not really add much to the quality or quantity of salmonid rearing habitat there. This situation will change if Walker Creek's ability to remove the sand and its bedload was reduced. If that happens, the quantity

and quality of rearing habitat at any given streamflow would be less than it is now. It will cost higher releases of water to accomplish the same thing.

2. On Walker Creek, the efficiency of flow releases in providing juvenile salmonid rearing habitat is low - mainly because of bank erosion. I believe that the District's leadership or participation in a bank erosion control program is a sound approach to renegotiating the Soulajule Agreement. If you agree in principle, I suggest the fist step is a meeting with the US Soil Conservation Service personnel who have much experience in organizing and financing this sort of project.

Sincerely,

Don W. Kelley

enclosures
DWK:lk

D. W. KELLEY, *Aquatic Biologist*
323 FORUM BUILDING
1107 - 9TH STREET
SACRAMENTO, CALIF. 95814

PHONE (916) 443-3781

RELATIONSHIP BETWEEN STREAMFLOW AND SALMONID REARING HABITAT IN WALKER AND LAGUNITAS CREEKS, MARIN COUNTY

Prepared by

Don W. Kelley

and

Rollin C. Reineck, Jr.

For
Marin Municipal Water District

October 4, 1978

LIST OF FIGURES

LIST OF TABLES

The Marin Municipal Water District is completing the Soulajule Reservoir on Arroyo Sausal and is proposing to enlarge its Kent Reservoir on the headwaters of Lagunitas Creek. The District has an existing agreement with the California Department of Fish and Game to operate the Soulajule Reservoir in a way that is expected to restore the salmon and Steelhead runs in Walker Creek, and it is their desire to operate an enlarged Kent Reservoir on Lagunitas Creek in a way that will enhance the small runs that now spawn in that stream. The degree of enhancement on both streams will depend to a large extent upon the special releases of stored water into the streams. The purpose of this report is to provide a quantitative assessment of the relationship between the size of salmon and Steelhead runs that can be maintained in those streams and the volume of streamflow, part of which would need to be released from storage.

WHAT CONTROLS THE SIZE OF SALMON AND STEELHEAD RUNS?

Past investigations have led us to believe that in both streams the size of the salmon and Steelhead runs are now limited by the amount and quality of available rearing area for juvenile fish during their first summer and fall when the streamflows are low (Kelley, 1976 and 1978). One of the most important aspects of the existing agreement over the Soulajule Reservoir operation is that flows ranging from 0.5 to 5 cfs will be maintained during this period in Walker Creek - a significant enhancement over the last several decades when Walker Creek has ceased to flow at all each mid-summer. Lagunitas Creek flows do not completely cease, but upstream from its junction with Nicasio Creek, the flows do become less than 0.5 cfs in most summers. Augmentation of that low flow is contemplated as part of enlarging Kent Reservoir.

MEASUREMENT OF REARING HABITAT

Young silver salmon and Steelhead trout must remain in the stream for at least one full year before they can move down into salt water in the ocean. The amount and quality of suitable rearing habitat for these fish varies not only with streamflow, but with differences in channel shape, substrate composition, gradient, and riparian plant cover.

It is easy to point out and measure parts of the stream that are entirely unsuitable for rearing habitat. During the day, neither silver salmon nor rainbow trout will ordinarily be found in water less than about one-half foot deep unless it is a riffle or a glide with a rough cobble bottom. Neither will they ordinarily be found in those areas of pool that are less than a foot deep unless there is some sort of cover, such as cobble, logs, or tree roots on the bottom.

We measured and assessed the quality of rearing habitat on representative reaches of Walker and Lagunitas Creeks as flows declined during the late spring and summer of 1978 (Figure 1). Using these measurements we developed indices of "rearing habitat" that combined both the quantity and quality of habitat in these reaches, at different stream-flows. Wading up the stream in each of these reaches, we made two or three measurements of the width of each pool, glide, and riffle, and measured its length to compute *a* surface area at that particular flow. We estimated what percentage of the surface area was rearing habitat, and graded that habitat as poor, fair, good, or excellent, giving it a quantitative rating of 1, 2, 4, or 8. The total area of each pool, riffle, or glide was then multiplied by the rating to provide a rearing habitat index. When the quality of the habitat within an individual pool, glide, or riffle varied much, it was subdivided for this assessment.

The individual indices of rearing habitat were then summed and divided by the total length of the stream reach being assessed to provide a total index which considers both the quantity and quality of rearing habitat in a particular reach at a given flow. These indices, which are theoretically comparable between reaches, different streams, and different flows, are plotted as a function of streamflow on Figure 2.

LAGUNITAS CREEK

Two reaches were selected as representing most of the habitat on the 12 miles of Lagunitas Creek from Kent Reservoir downstream to tidewater (Figure 3). The first, a 751 foot reach 1.5 miles downstream from the

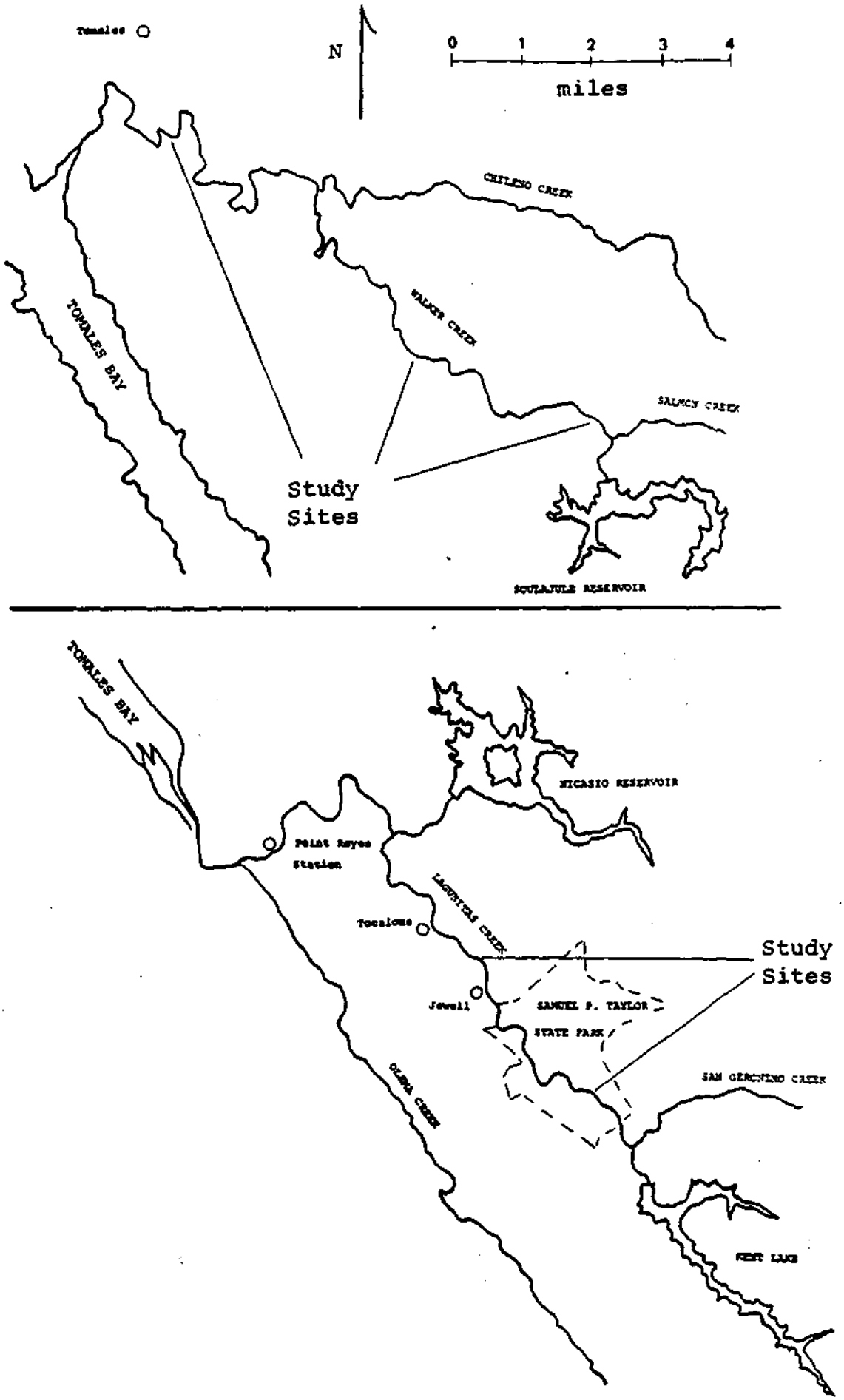

Figure 1. Location of rearing habitat study sites on Walker Creek (above), and Lagunitas Creek (below).

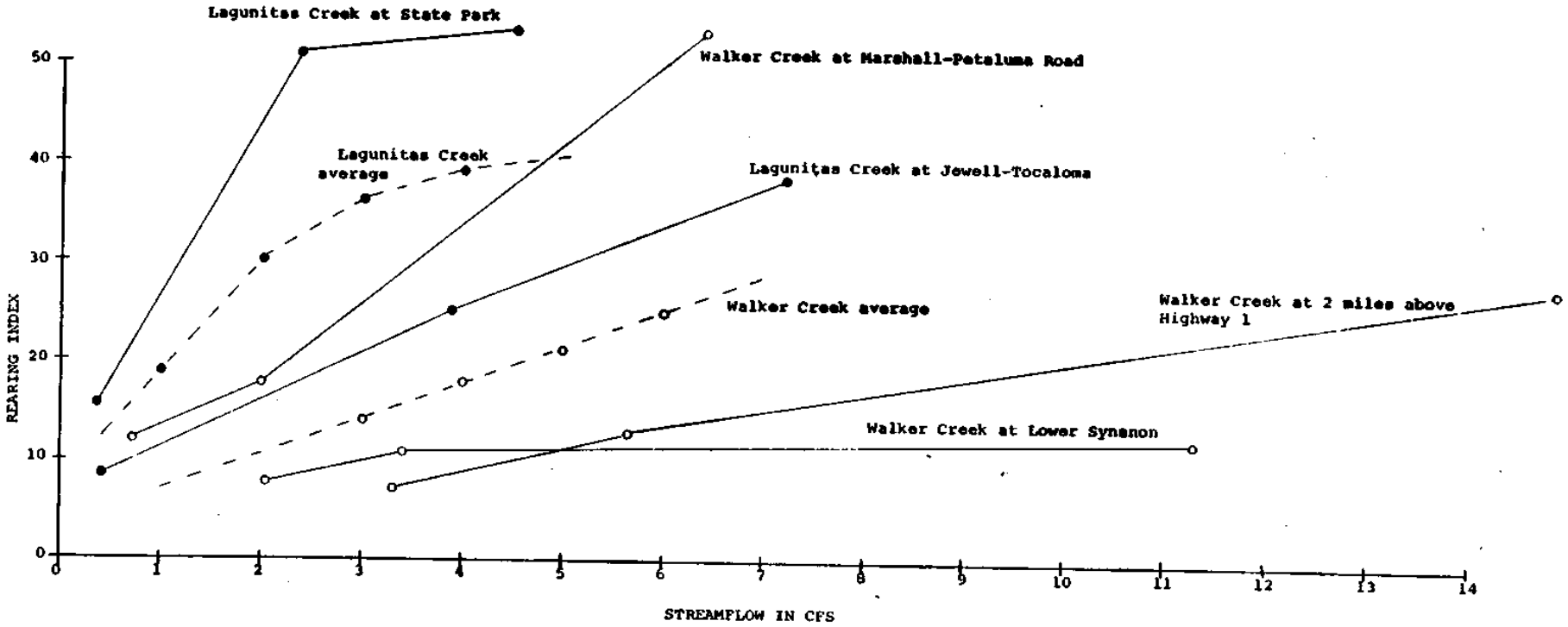

Figure 2. Rearing habitat indices as a function of streamflow in each section measured.

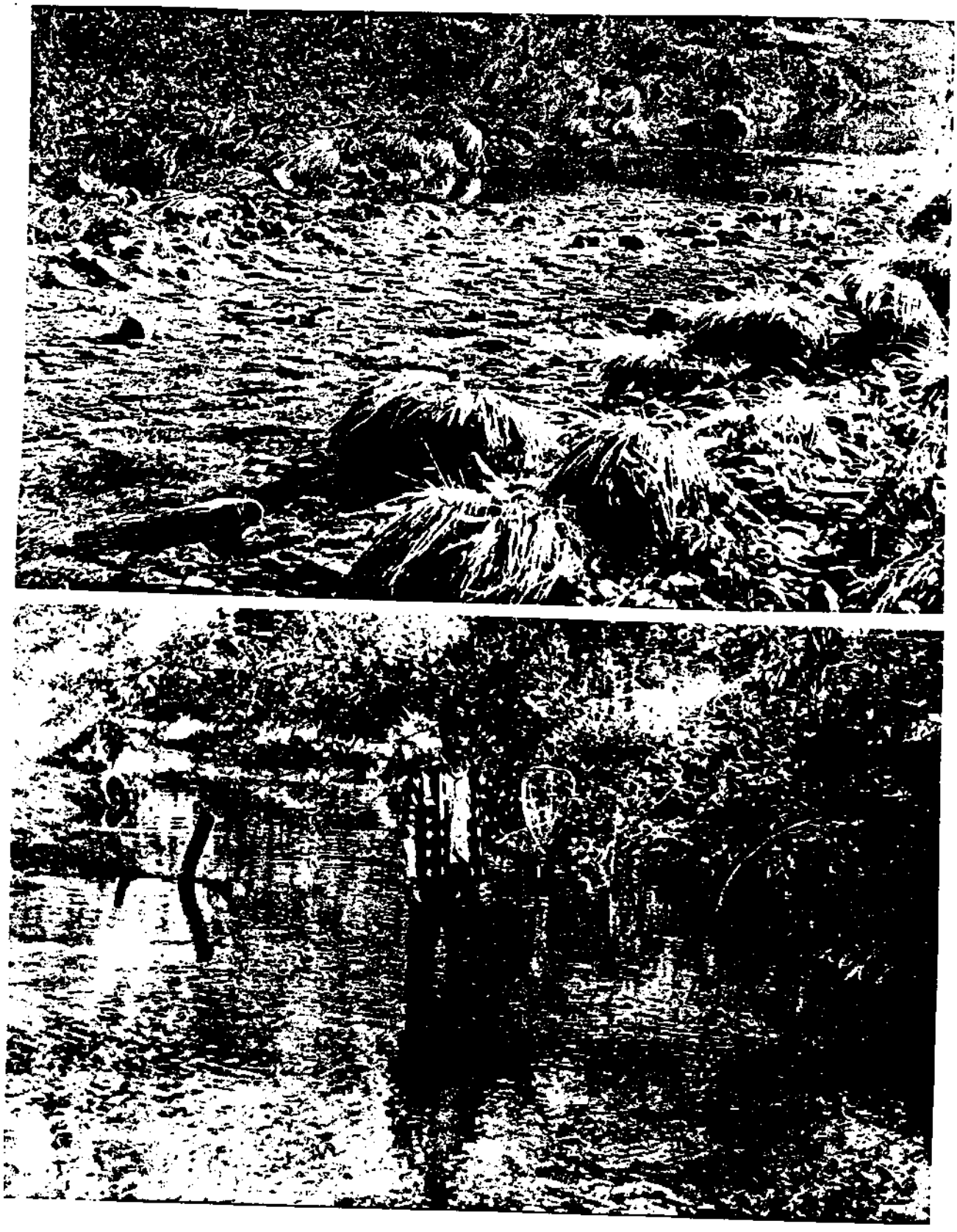

Figure 3. Representative rearing habitat on Lagunitas Creek. Upper photo was taken in Taylor Park at a stream-flow of 3.0 cfs; the lower photo, a mile below Jewell at 5.7 cfs. Changes in flows influence rearing habitat differently in each reach.

junction of Lagunitas Creek and San Geronimo Creek, was chosen to represent the high quality of habitat that is predominant throughout Taylor State Park (Figure 3). The stream here flows over bedrock ledges and boulder through the redwood forest. The channel is confined between high banks and there are frequent bedrock ledges which prevent the stream from degrading.

This is a reach of long pools, the bottom ends of which break off into short glides, then form riffles which enter the pool below.

We found more sediment in the lower end of the pools than desirable, but in spite of that, we judged about half of the stream to be suitable rearing habitat for juvenile salmonids. This did not change much with changes in streamflow (Figure 4). Increases in flows above the present summer flows of about 0,5 cfs would very rapidly increase the quality of the salmonid rearing habitat here. As flows fell below 2.3 cfs, significant decreases in both width and habitat quality caused our rearing index to fall rapidly. As flows increase above about 2.5 cfs, both the quality of the rearing habitat and the width of the stream increases slowly, but the percentage of the surface area that is rearing habitat decreases slightly, and the combined result is that the stream does not really gain much in terms of the total rearing index at those higher flows.

In this upper reach, which is similar to about half of Lagunitas Creek above tidewater, increases in summer flows above about 2.5 cfs do not provide major increases in rearing habitat.

A 674 foot reach of Lagunitas Creek between Jewell and the Tocaloma Bridge was chosen to represent the flatter and lower half of Lagunitas Creek where the channel is wider and substrate more sandy. The pools here have been partially filled with small gravel and sand and at the low summer flow, the stream meanders about in a wide channel.

In this reach, the pools and riffles are small and between 60 and 75% of the reach consists of glides.

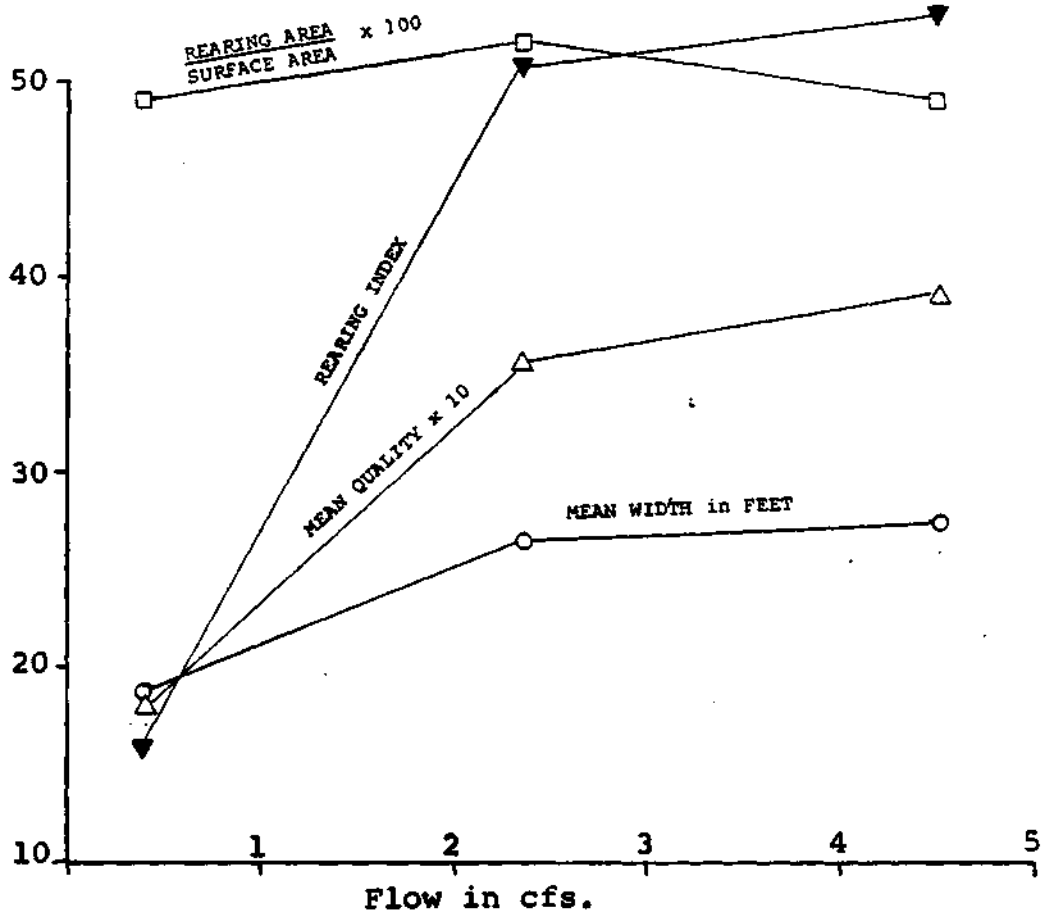

Figure 4. Measurements on Lagunitas Creek in Taylor Park as affected by streamflow.

Increases in flow from the low summer level will not increase the quality of rearing area as rapidly as they do through Taylor Park (Figure 5). As flows fell below the maximum 7.23 cfs at which we measured the habitat, the quality of the rearing habitat and the percent of the surface area that is rearing habitat, rather steadily declined. The combination made the rearing index fall even faster. In this reach, which is similar to about one-half of Lagunitas Creek, increases in minimum flows well beyond those being proposed would continue to provide major benefits.

WALKER CREEK

Because surface flows cease by mid-summer each year, Walker Creek sustains only a remnant run of Steelhead and a few stray silver salmon. The Soulajule Project is designed to restore those runs with summer releases ranging from 0.5 cfs to 5 cfs depending upon the availability of stored water. Restoration to the extent described in the District's Soulajule reports also assumes that the streambank erosion will be reduced, the destruction of the remaining riparian vegetation halted, and riparian vegetation restored over about one-third of the creek where it has been washed away. This in turn, is expected to reduce the amount of sand and fine gravel now accumulated in the stream.

Three reaches were selected to represent the 14.2 miles of stream between the Soulajule Dam and tidewater (Figure 6). A 1357 foot long reach on Walker Creek, along the Marshall-Petaluma Road, was selected as representative of the better salmonid habitat that remains. Sections similar to this are also found in the Walker Creek canyon and at several places between there and tidewater. About one-third of the stream is similar habitat. In these reaches, substrate contains a large amount of exposed cobble and boulders, and there are long, deep pools, separated by short riffles which themselves are often paved with large gravel. The low water channel is well contained between banks, and although riparian vegetation is clearly threatened by bank erosion, it has not yet been destroyed. These sections are about half shaded by old alders.

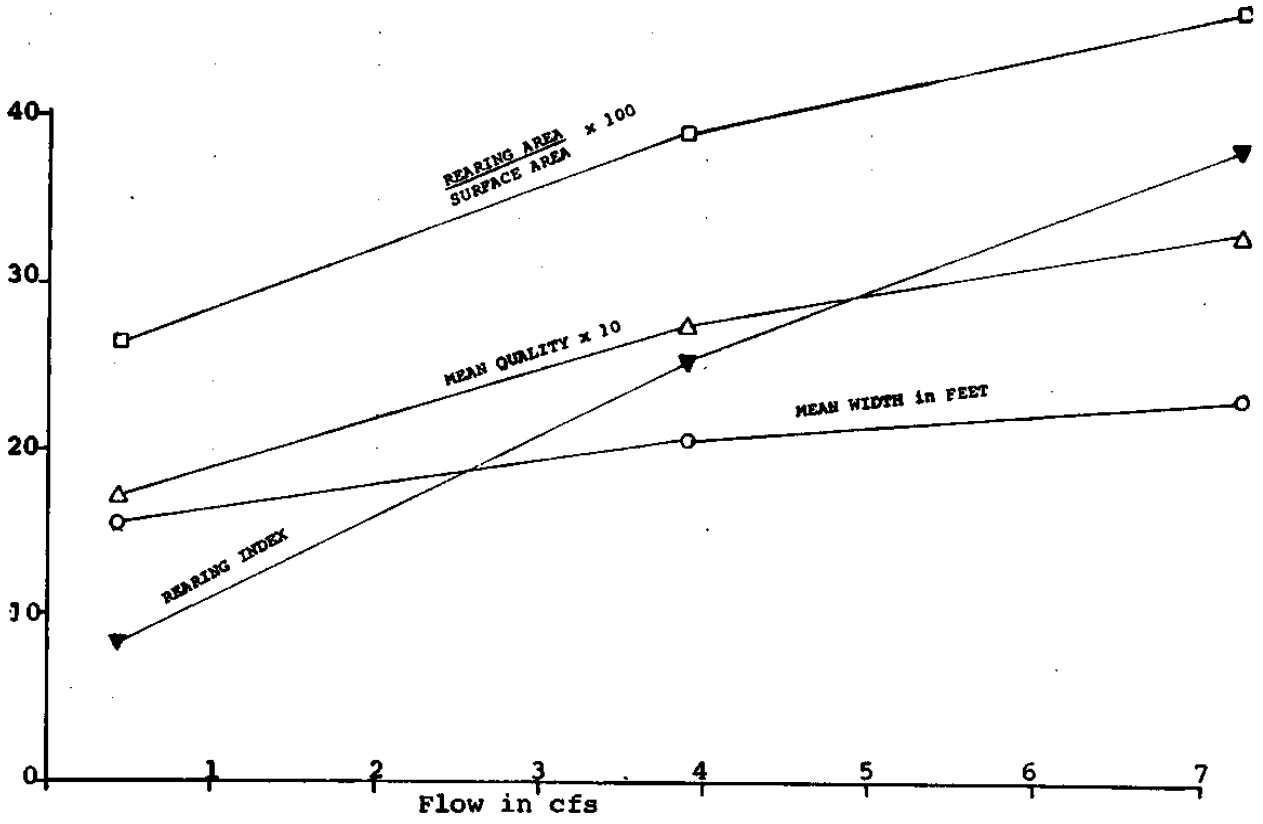

Figure 5. Measurements on Lagunitas Creek below Jewell as affected by streamflow.

Figure 6. Walker Creek, along the Marshall-Petaluma Road (top); at the lower end of Synanon Ranch (center); and 2 miles above Highway 1. All flows near 3 cfs.

Our measurements at the low flows were confounded by dredging and sedimentation in part of this Marshall-Petaluma reach in early May. For that reason we believe the comparisons of conditions at 1.99 and 0.72 cfs are not valid. We believe that reduction in flows below 1.99 would have reduced the habitat more than shown on Figure 7.

The data does illustrate that while the quality of habitat in this reach of Walker Creek is high, at low flows the stream is narrow and the percentage that can be counted as rearing habitat is also small. With increasing flows/ the stream would steadily improve up to the maximum 6.4 cfs that we measured. Because the channel is wide and largely covered with cobble, we expect it would do so until the flows exceeded 10, or even 15, cfs.

A 962 foot reach on the south end of the Synanon Ranch, adjacent to the entrance of Frink Canyon Creek, was selected as being representative of that one-third of Walker Creek which is wide and flat, and the poorest salmonid habitat. The bedload deposits of sand and gravel have filled pools here so that most of the stream is shallow glides and riffles over sandy or pea gravel substrate. The quality of rearing habitat in these reaches at low flows is poor, and increases in flow simply spread the stream in a thin sheet over fine gravel (Figure 8). If proposed stream-flow releases are to be utilized to create rearing habitat for salmonids in these reaches, the sandy bedload must be moved out.

The remaining third of Walker Creek was represented by a 1340 foot reach 2 miles upstream from the Highway 1 Bridge. It is a reach of glides and riffles, but unlike the lower Synanon section, does contain some pools. At low flows, this reach is relatively low quality, but at flows above 6 cfs the quality improves significantly and probably continues to do so beyond the highest flows that we measured (Figure 9).

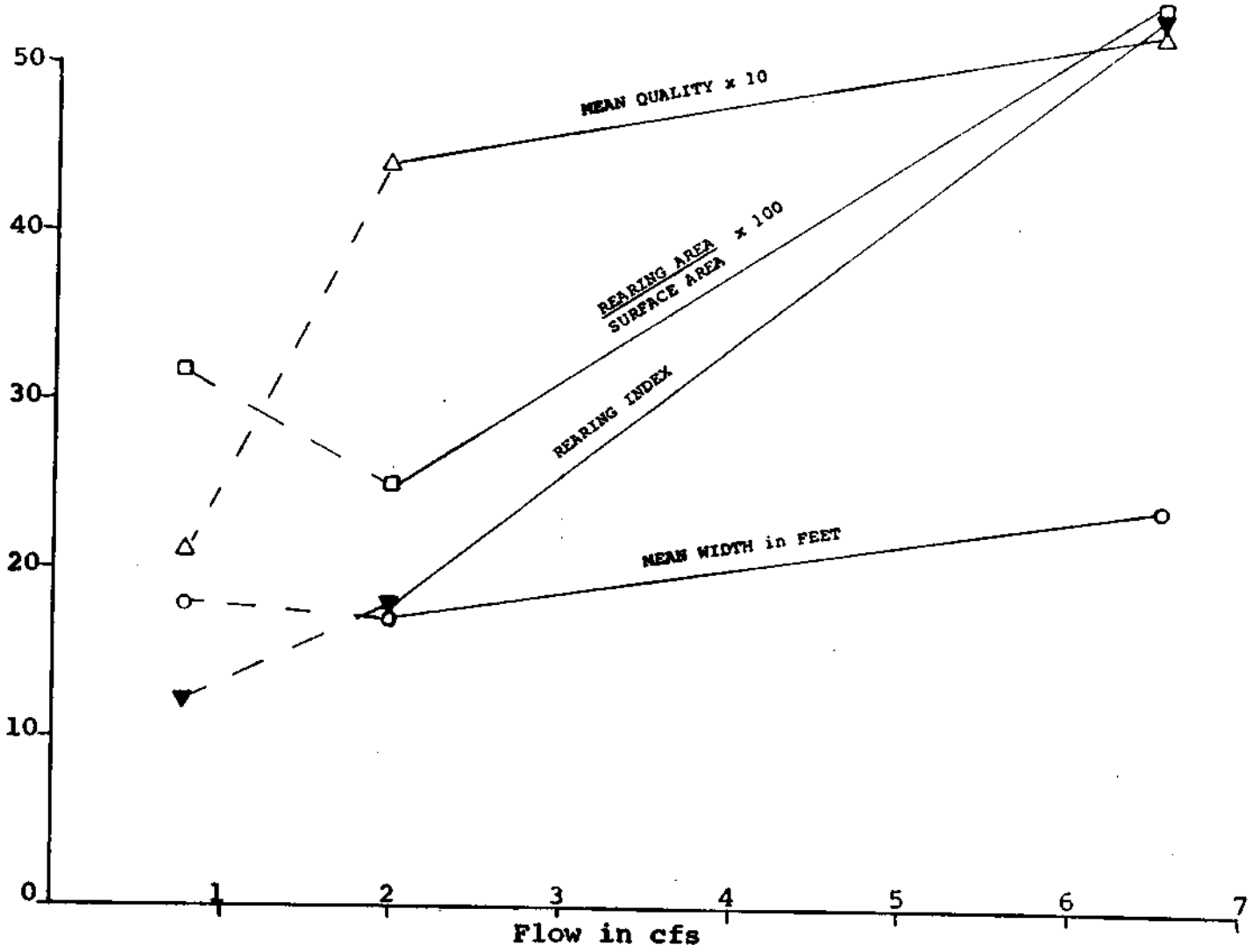

Figure 7. Measurements on Walker Creek, Marshall-Petaluma Road section, as affected by streamflow.

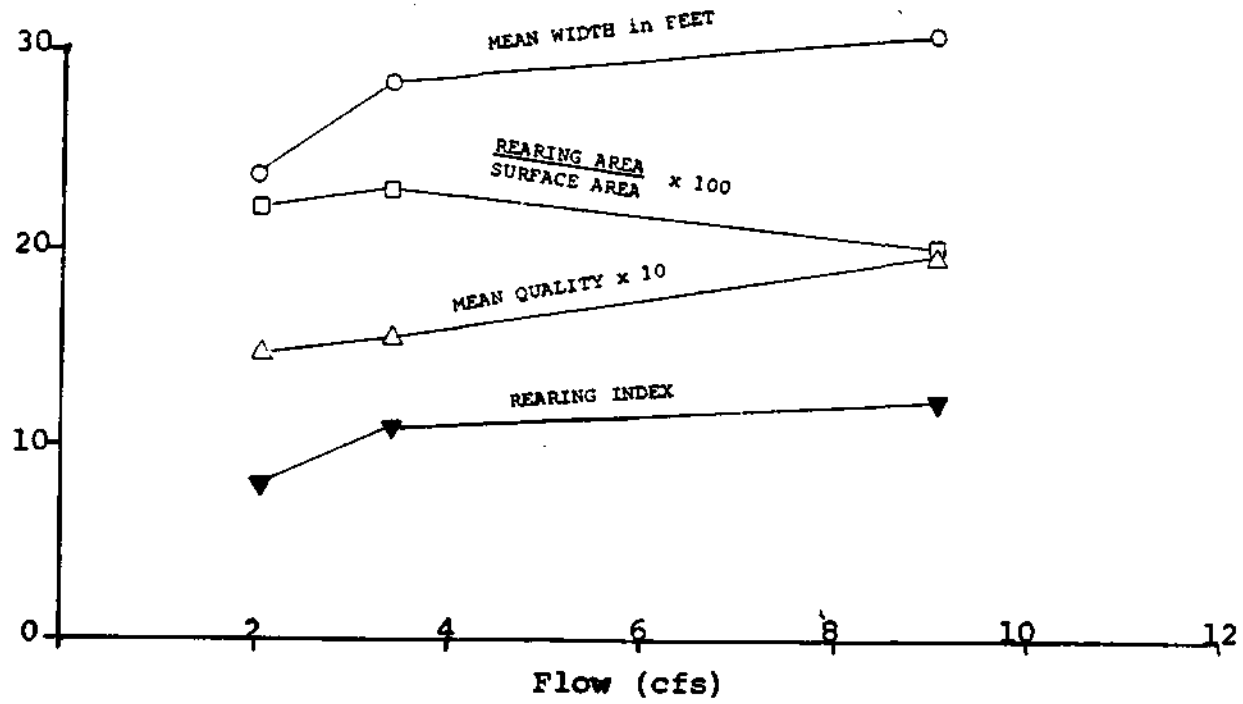

Figure 8. Physical conditions on lower Synanon section, as affected by streamflow.

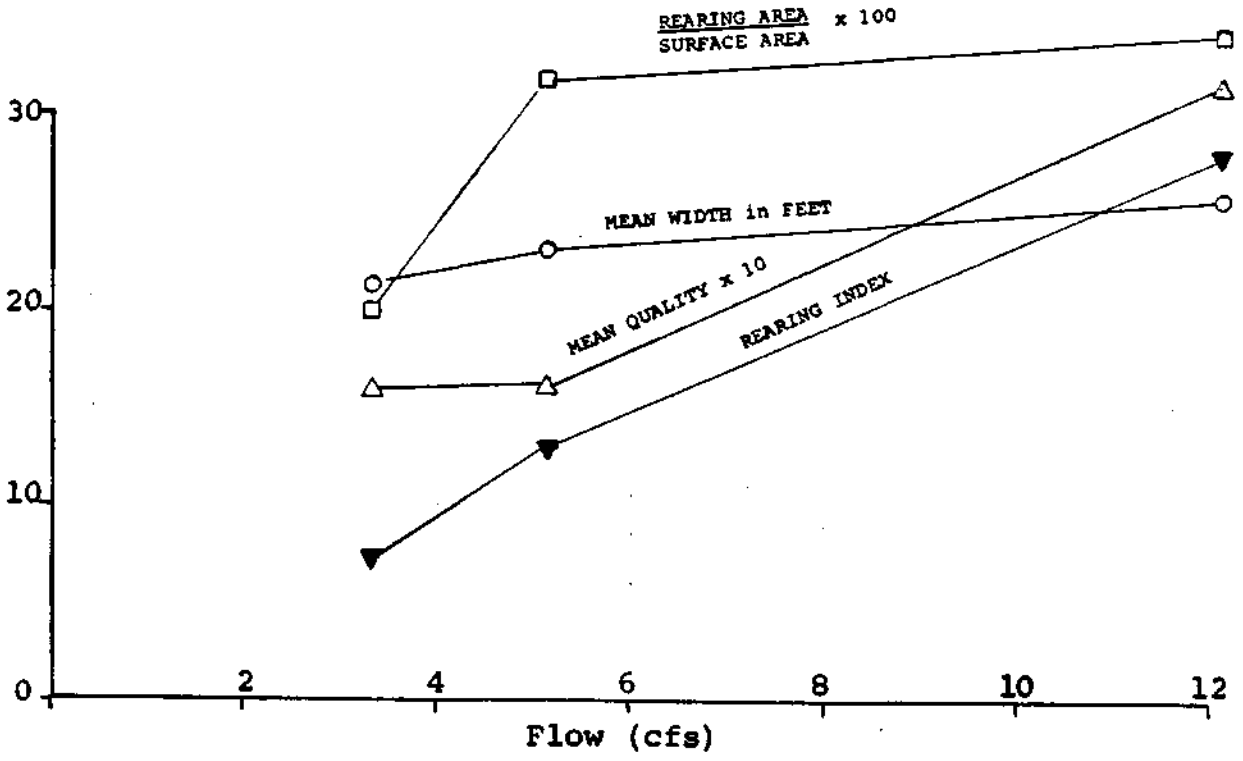

Figure 9. Physical conditions on section 2 miles above Highway 1.

COMPARISON OF LAGUNITAS AND WALKER CREEKS

The principal purpose of our making the various measurements described in this report was to provide a tool for rationally negotiating how much water will be released from Kent Reservoir if it is raised, and for renegotiating the existing agreement between the Marin Municipal Water District and the Department of Fish and Game. We intended to convert the curves describing rearing indices at various flows into juvenile, and finally, adult salmon and Steelhead populations and catch, but we have not succeeded. Keith Anderson, biologist for the Department, reviewed our first draft that contained these estimates. He convinced us that we simply do not have enough data on either existing fish populations or the survival rates from one life history stage to the next, to convert the rearing indices to numbers of fish. To do so would imply that we can predict the future more accurately than is really possible,

We have agreed that the most valid tool for negotiation is a graph showing the mean rearing index calculated for each stream adjusted by the length of the stream. Since the rearing index is a measure of the quantity and quality of the rearing habitat per lineal foot, we have multiplied the mean rearing indices by the number of miles of stream to tidewater (Table 1). This is the best information currently available for comparing the two streams and the different flow releases. We believe that the adult populations produced by both Walker and Lagunitas Creek are, and will continue to be, proportional to these adjusted rearing indices, but we do not have the data to calibrate them in terms of numbers of fish.

The curves drawn from these data illustrate primarily that the present value of a streamflow release in Lagunitas Creek is approximately double that of Walker Creek (Figure 10). The main reason for this, is that bank erosion has filled many reaches of the Walker Creek channel with sand and small gravel and has destroyed riparian vegetation that offers shade and shelter. In such reaches the rearing habitat increases very slowly and sometimes not at all as streamflows increase.

Table 1. 1978 rearing indices x lengths of Walker and Lagunitas Creeks (adjusted rearing index) .

1978 Indices of Salmonid Rearing Habitat x miles Lagunitas and Walker Creeks above tidewater.

Streamflow in cfs	1	2	3	4	5	Source of information
Lagunitas Creek						
mean rearing index	19.0	30.3	36.2	39.4	---	Figures 2, 4, and 5
miles of stream	12.0	12.0	12.0	12.0		USGS map
adusted rearing index	228	364	434	473		
Walker Creek 1978				.		
mean rearing index	6.1	10.0	14.0	17.9	23.1	Figures 2, 6 ,1 , and 8
miles of stream	14.2	14.2	14.2	14.2	14.2	USGS map
adjusted rearing index	87	142	199	254	328	
Walker Creek-Estimated Potential						
mean rearing index-Marshall-Petaluma Rd.		18.0	25.6	33.3	41.1	Figure 7
miles of stream		14.2	14.2	14.2	14.2	USGS map
adjusted rearing index		256	363	472	584	

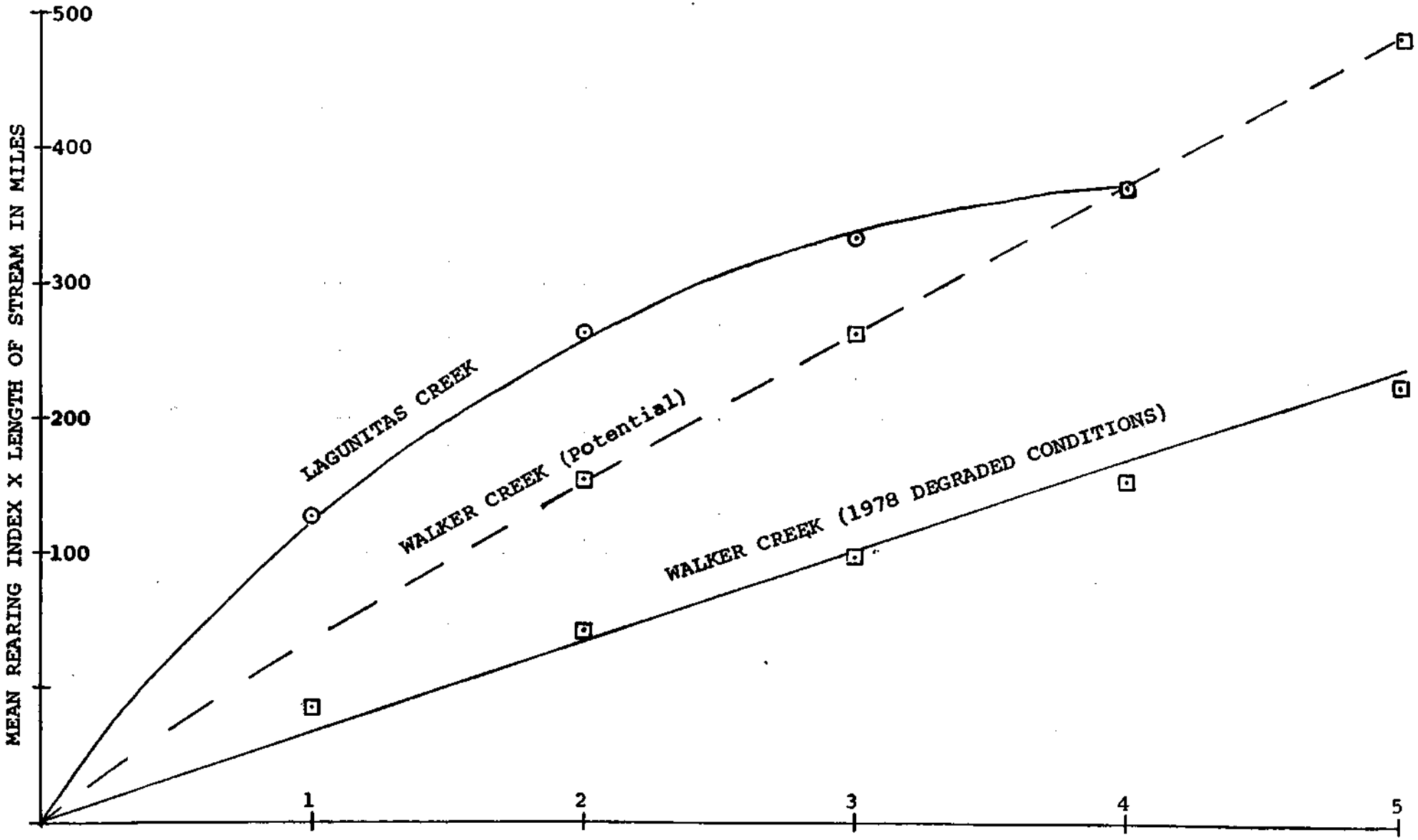

Figure 10. 1978 Mean Rearing Indices x Miles of Stream at various flows. This is the best information available for comparing the two streams.

During 1976, estimates that the streamflow releases scheduled with the Soulajule Project would produce a mean spawning run of about 1200 adult salmon and Steelhead, were based on a very rough model and an assumption that significant stream improvement would occur. The following is quoted from our report to the District.

> "The reduction of flood flows . . .is expected to reduce bank erosion and cause some changes in substrate conditions. Flood flows will reach caving banks less frequently with a project in operation, and when they do the water will have less velocity, be less erosive, and have less capacity to pick up loose soil that has fallen into the high flood channel. The contribution of sand and silt to the stream will be reduced.
>
> "Winter bedload movement rates will also be reduced. The stream velocities needed to transport silt and sand will be less affected than those required to move gravel and rubble. The net result is that in time, the substrate of Walker Creek will be composed of more rubble and gravel and less sand and silt. This will be of great benefit to both spawning and young salmon and Steelhead.
>
> "The establishment of a permanent streamflow in the Walker Creek channel will encourage the invasion of riparian vegetation, particularly willow. The provision . . .of summer waters is also expected to benefit and strengthen established riparian vegetation now threatened by root desiccation as the stream degrades and meanders.
>
> "The combination of permanent summer flow and reduced bank erosion will encourage willows and alders along the stream. Riparian vegetation that now provides reasonably good shade for two-thirds of the stream's length, above tidewater, will benefit. We believe that willow growth will shade the now unshaded portion about five years after the project is completed. In some places it may be necessary to protect young growth from browsing. "

The great variation in the quality of rearing habitat in different, widely scattered sections of Walker Creek is evidence that if the existing sand can be successfully removed, and if bank erosion can be controlled, the rearing habitat in Walker Creek will be significantly improved. There are a few reaches in Walker Creek where rearing habitat is fully as good as the best to be found in Lagunitas Creek, but those reaches are not representative of large portions of the stream. About one-third of Walker Creek is similar to the reach where we measured habitat along the Marshall-Petaluma Road. We believe that many parts of the stream can be restored to look like that. Accordingly, we suggest that our measurement of the rearing Indices In the Marshall-Petaluma reach is a good estimate of the maximum potential for Walker Creek (Figure 10).