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BALATON
Power Inc.
Bringing ecology and technology together.

June 27, 2002

Mr. John Brogoitti
Chair, Fish and Wildlife Committee
Northwest Power Planning Council
851 SW 6th Ave., Suite 1100
Portland, OR 97204

200207 004

RE: Comments on ISRP's Recommendation on Innovative Funding Proposal – Project ID 34018 – to Evaluate the PISCES Fish Passage Device

Dear Mr. Brogoitti:

I'm writing to offer Balaton Power's comments in support of funding the above-listed innovative project, which was not ranked by the ISRP. In response to the ISRP's recommendations regarding this proposal, Balaton would like to submit new hydraulic and biological performance data (attached) from recent field testing that was not available at the time the application was filed, and which we believe provides additional justification on the merits of funding this proposal. Importantly, while Balaton is the developer of the PISCES intake technology we would not receive any funds under Project ID 34018.

Background on PISCES fish protection intake

"The innovative project funding category was designed to extend an open invitation to a broad array of sponsors from within and outside the basin to submit proposals to explore new methods and technologies for fish and wildlife recovery in the Columbia River Basin." Excerpt from the Northwest Power Planning Council's (NNPC) innovative proposal guidelines.

We believe the PISCES fish protection device is just the type of new technology the innovative funding category was designed to support. It has the potential to offer a simple, low cost solution to minimize fish entrainment at a water intakes across the Columbia River Basin that currently provide no fish protection.

Unlike conventional screening technologies that attempt to block migrating smolts from going with the flow of water, the PISCES intake takes a unique approach by using water flow (i.e. turbulence) to attract fish. It's based on the well-documented premise that migrating juvenile salmonids travel in the upper water column and likely use turbulence to aid them in their out migration. The floating PISCES intake is designed to take advantage of this behavior by creating

JUN 28 2002

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water flow vectors that attract fish away from the subsurface water withdrawal (see attachments for more specifics).

Balaton has been developing the PISCES system over the last four years and recently completed initial trials using juvenile fall chinook from the Yakama Nation's salmon hatchery in Prosser, WA. Preliminary results were very favorable (attached) and showed that on average the PISCES device was able to protect 4 out of 5 juvenile chinook that would have otherwise been at risk of getting entrained in the withdrawal pipe.

Response to ISRP's comments on funding PISCES research

In its recommendation to the NPPC not to fund this proposal the ISRP raised the following issues/concerns (*in italics*), which Balaton feels are inconsistent with the NPPC's innovative proposal guidelines and/or could be addressed with the additional information and comment provided below or in the attachments.

"Device is too sketchily described to facilitate review"

The attached CAD drawings of a PISCES model should provide the detailed perspective the ISRP found lacking in the original application. Also, the attached hydraulic report from Washington State University provides detailed views of the flow vectors around the PISCES unit.

"Need to put this technology in context with other technologies, laying out potential benefits to fish."

The most prevalent fish protection technologies in the marketplace that have been approved by the fisheries agencies are rotary drum screens and angled bars screens, both of which work very well at eliminating fish entrainment when properly maintained. Since both are made of finely machined steel and require major project construction, installation and maintenance costs are prohibitively high for many operators of smaller water withdrawals. Alternatively, the PISCES intake is made of a lightweight polycomposite material, is portable, and easily installed without heavy construction. While detailed pricing information on commercially produced PISCES intakes is not yet available, clearly "plastic' s cheaper than steel." Hence, the benefit of the PISCES technology in relation to current screening technologies is that while it might not preclude every fish from entering a water withdrawal, it could protect the vast majority of fish (4 out of 5 based on attached study results) that would otherwise be at risk, and at an affordable price that would allow the device to be deployed in a much greater number of unscreened diversions across the Columbia River Basin.

The PISCES is not a screen nor is it intended to displace current screening operations. Rather it's a behavioral device that attempts to use one set of flow vectors to attract fish away from, or alternatively, dissuade fish from being near another set of flow vectors that would put them at risk of being entrained.

"Other (research) should have been referenced...in this proposal"

A more extensive list of turbulence/guidance research is attached.

"While the proposal puts emphasis on potential application at hydroelectric projects, the potential application seems more in line with...irrigation intakes. Whether there is an urgent need...for that application is a question that should have been better demonstrated in the proposal."

Balaton has targeted it's initial field testing and marketing efforts at the irrigation sector, however, this is largely related to the relatively high number of irrigation withdrawals in the Basin without any fish protection and not because the technology can't be scaled to fit the circumstances at a hydropower withdrawal. Regarding the "urgency" of the need for fish protection in the irrigation sector, the NPPC has prioritized this issue in its recent letter to the Administration requesting $8 million in funding for screening Northwest irrigation diversions. In Oregon alone, the ODFW has estimated that there are over 50,000 diversions that could require some measure of fish protection.

"The comparison of costs and potential effectiveness with existing technology was not included in the presentation."

While not an exhaustive list, attached are some cost estimates on various screening alternatives from ODFW. In comparison, the custom manufactured PISCES prototype used at the Yakama Nation's hatchery for a 1 cfs withdrawal cost about $2,000. The expectation is that a commercial manufacturing process could produce PISCES units at considerably lower unit costs as production volumes increase.

"The proposal seems to be a request for the public to complete development and initial testing of this apparatus, which ultimately will remain in private ownership."

In the NPPC's solicitation for innovative proposals it states: *"the Council recognizes that some innovative proposals are based on tests of developmental technologies that would, if successful, become patented products held by private companies."*

Balaton agrees with the NPPC's position that innovative ideas to protect and restore salmon populations are not necessarily limited to the public sector. Hence, the ISRP's comments regarding the "proprietary nature of the device" seem inconsistent with NPPC policy on this issue. Many private research and development efforts, assisted by public funding, have lead to patented products that are critical to the region's salmon recovery efforts – minimum runner gap turbines and PIT technology, to name a few. Clearly, the focus should be on the overall public good, which in this case is reduced mortality at water withdrawals within the Columbia River Basin, and not whether or not a developer of a fish-friendly technology has a profit potential.

Conclusion

In closing, while Balaton has a vested interest in this proposal to study the PISCES technology, it would not receive any of the requested funds. To date, we have spent over a quarter of a million dollars on PISCES R/D efforts, and we will continue to self-finance, as investment capital is available. But because of the borrowing limitations of a small start up company, the pace of development and deployment of this fish protection technology could be greatly accelerated with NPPC's financial support in assisting the PISCES through the extensive scientific verification process required by the resource agencies. Similarly, the federal government has granted ten's of millions of dollars in public funds to fuel cell developers over the last decade because they have determined that the overall public interest would be served by accelerating the development and commercialization of an emission-free distributed generation technology. In the instance of how to spend innovative funds, the overall public interest is reducing fish entrainment at water withdrawals, and the NPPC can help serve that interest by accelerating the development and deployment of innovative fish protection technologies like the PISCES intake.

As the NPPC goes through it's deliberative process, I'd be glad to address any questions or addition information requests regarding the PISCES technology. I appreciate your consideration and respectfully request that you fund this innovative proposal.

Sincerely,

Dan Pfeiffer
Vice President of Business Development

Attachments:
[C] Graphs of entrainment rates from field tests in Prosser
[D] Hydraulic report on turbulence around PISCES prototype
[E] Cost estimates on fish screening alternatives
[F] List of citations on turbulence/guidance research
[G] CAD drawing of PISCES prototype

Figure 1.

- Highly significant difference in performance between Pisces and non-Pisces entrainment rates.
- n = number of test replicates at the fish density indicated
- No impact to fish from Pisces when entrained.
- Final 2 weeks of testing, test and non-test fish were indiscernible by size.

Figure 2.

- One week of testing at this density, where test and non-test fish were clearly discernible.
- Dawn and dusk testing only for these tests.
- Highly significant improvement on entrainment avoidance with use of Pisces.

Figure 3.

- This chart shows all test conducted, normalized to percent of fish released that did not remain in the release bucket after the 2 or 3 hours test period.
- The chart demonstrates:
  1. Consistently better performance of the Pisces at all channel flows examined (relative to unscreened pump diversion).
  2. No significant difference in entrainment among Pisces test at channel flows tested.

Figure 4.

- This figure simply demonstrates the same information as Figure 3, but perhaps in and easier to understand format. For this plot, the average percent of fish entrained at each channel flow tested is compared among and between the Pisces and non-Pisces tests. The figure demonstrates the there is no significant difference in entrainment among the Pisces tests at all of the channel flows tested, and also shows how the Pisces performs significantly better than an unscreened diversion at the flows tested to date.

Figure 5.

- Generally consistent results for increased density.
- Significantly better performance with Pisces at all fish densities tested except at 200, where no significant difference was seen (not enough tests yet).
- Only non-test fish captured at densities less then 250 fish released.
- n = number of tests at each density.

Figure 6.

- These test are normalized to percentage to reflect that some test fish remained in the release bucket after test duration was completed (2 or 3 hrs).
- Significantly better performance with Pisces at all fish densities tested except at 200, where test numbers are not yet sufficient to conclude performance specs yet.
- n = number of tests at each density.

PISCES Fish Protection Intake

Overview of Testing Procedure

- Outlet channel of Yakama Nation's Chandler Hatchery in Prosser, WA.
- Fall Chinook.
- 2 size classes:
  - >75 mm = "Test Fish"
  - < 75 mm = resident fish in channel
- Varied fish density.
- Measured > 10% of test fish before release.
- Sweep channel with block nets (2 passes), then erect during test.
- 10.6°C – 16.8°C water.
- Release test fish 15ft upstream of Pisces unit/open pipe in mid-channel (volitional from rectangular Tupperware or bucket).
- Record entrapment in capture vessel (cattle water trough) at ½ hour intervals.
- Measure length of all fish captured and compared to known test fish sizes.
- Record observations of fish behavior around Pisces during test.
- Record condition of fish following entrapment.
- Record basic water conditions: flow, temperature, and turbidity.

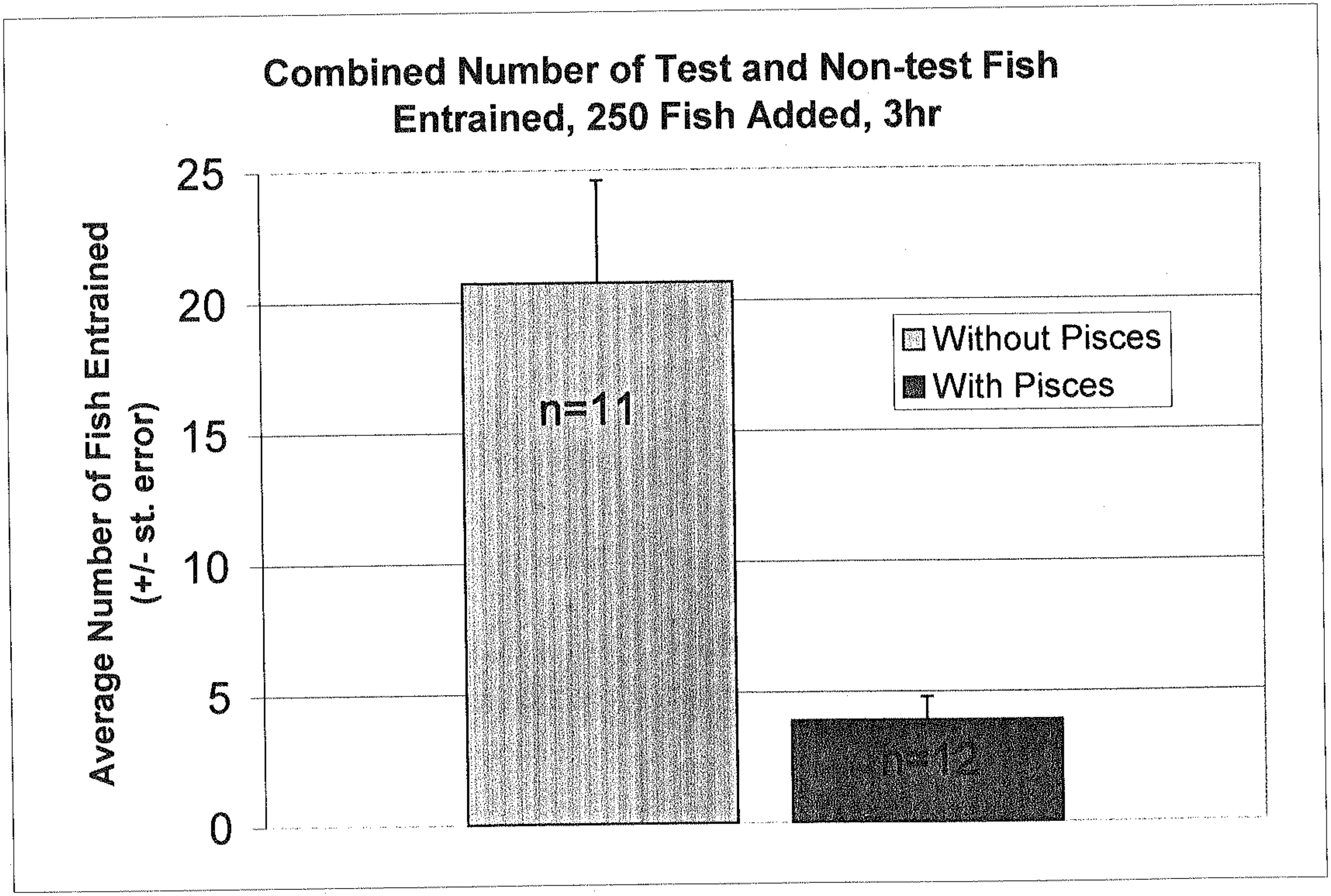
Combined Number of Test and Non-test Fish Entrained, 250 Fish Added, 3hr
Average Number of Fish Entrained (+/- st. error)
25
20
15
10
5
0
n=11
n=12
Without Pisces
With Pisces

Figure 1

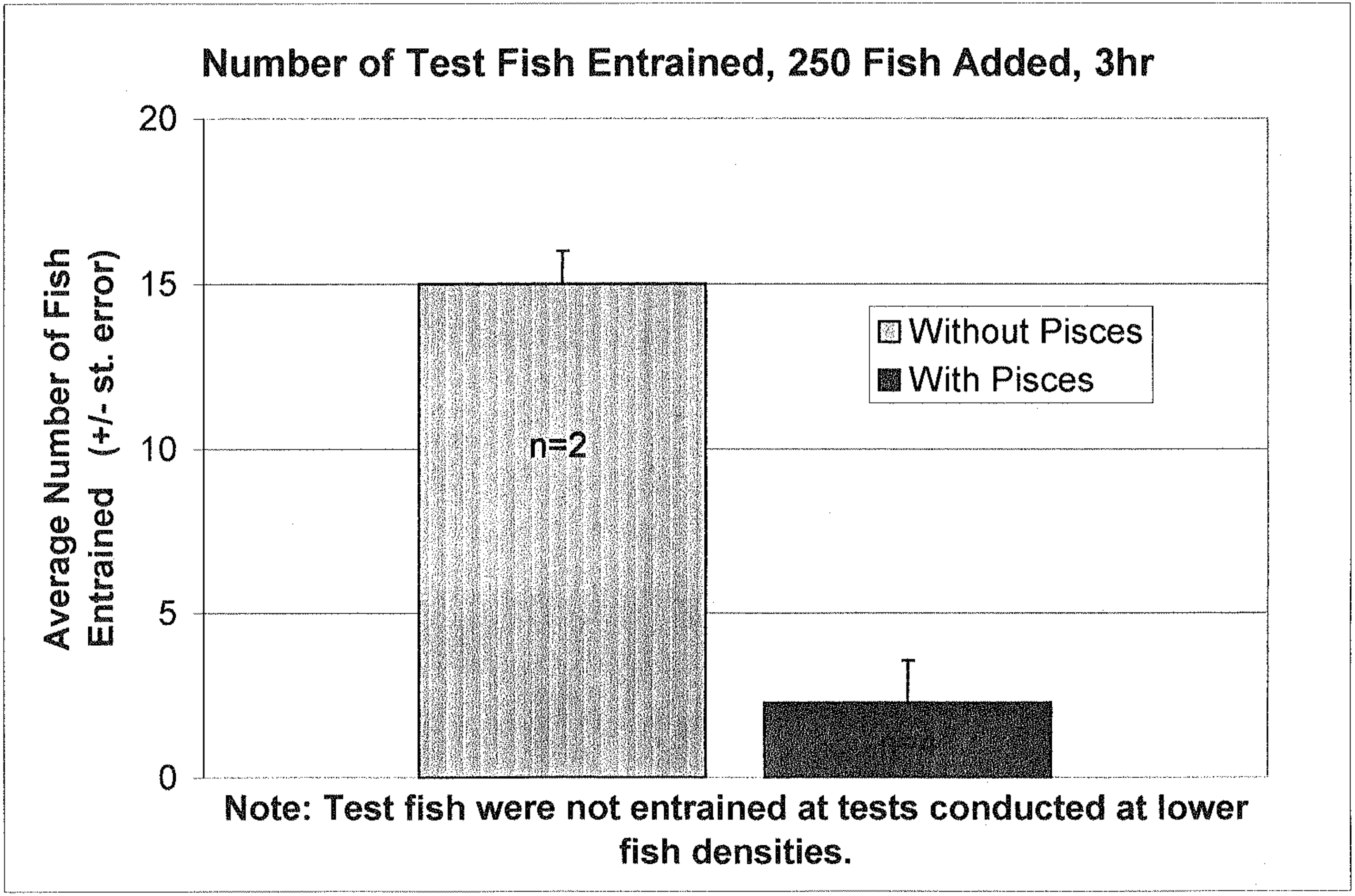
Number of Test Fish Entrained, 250 Fish Added, 3hr
Average Number of Fish Entrained (+/- st. error)
20
15
10
5
0
n=2
Without Pisces
With Pisces
Note: Test fish were not entrained at tests conducted at lower fish densities.

Figure 2

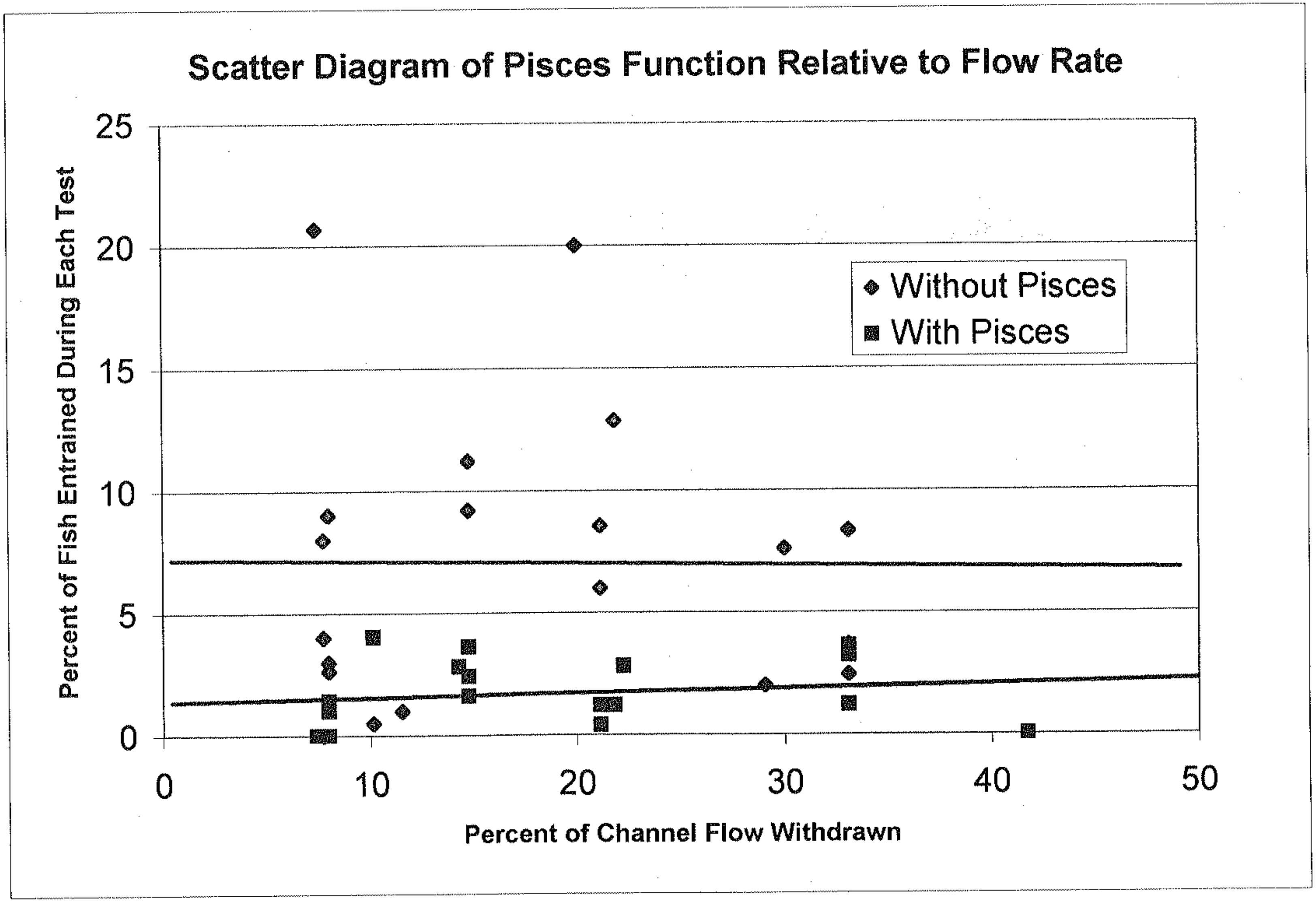
Scatter Diagram of Pisces Function Relative to Flow Rate
Without Pisces
With Pisces
Percent of Fish Entrained During Each Test
Percent of Channel Flow Withdrawn
0
5
10
15
20
25
0
10
20
30
40
50

Figure 3

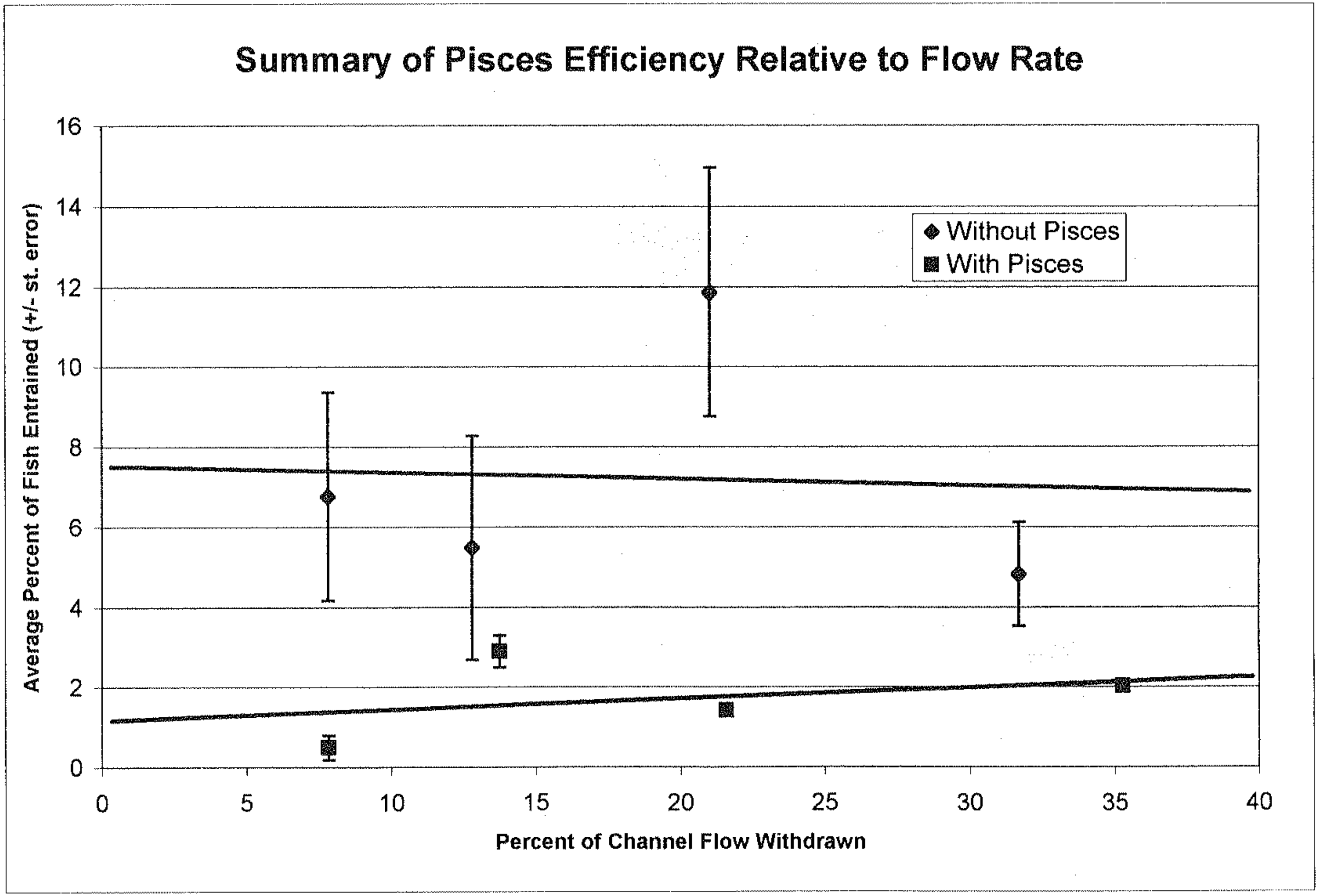
Summary of Pisces Efficiency Relative to Flow Rate
Average Percent of Fish Entrained (+/- st. error)
16
14
12
10
8
6
4
2
0
0
5
10
15
20
25
30
35
40
Percent of Channel Flow Withdrawn
Without Pisces
With Pisces

Figure 4

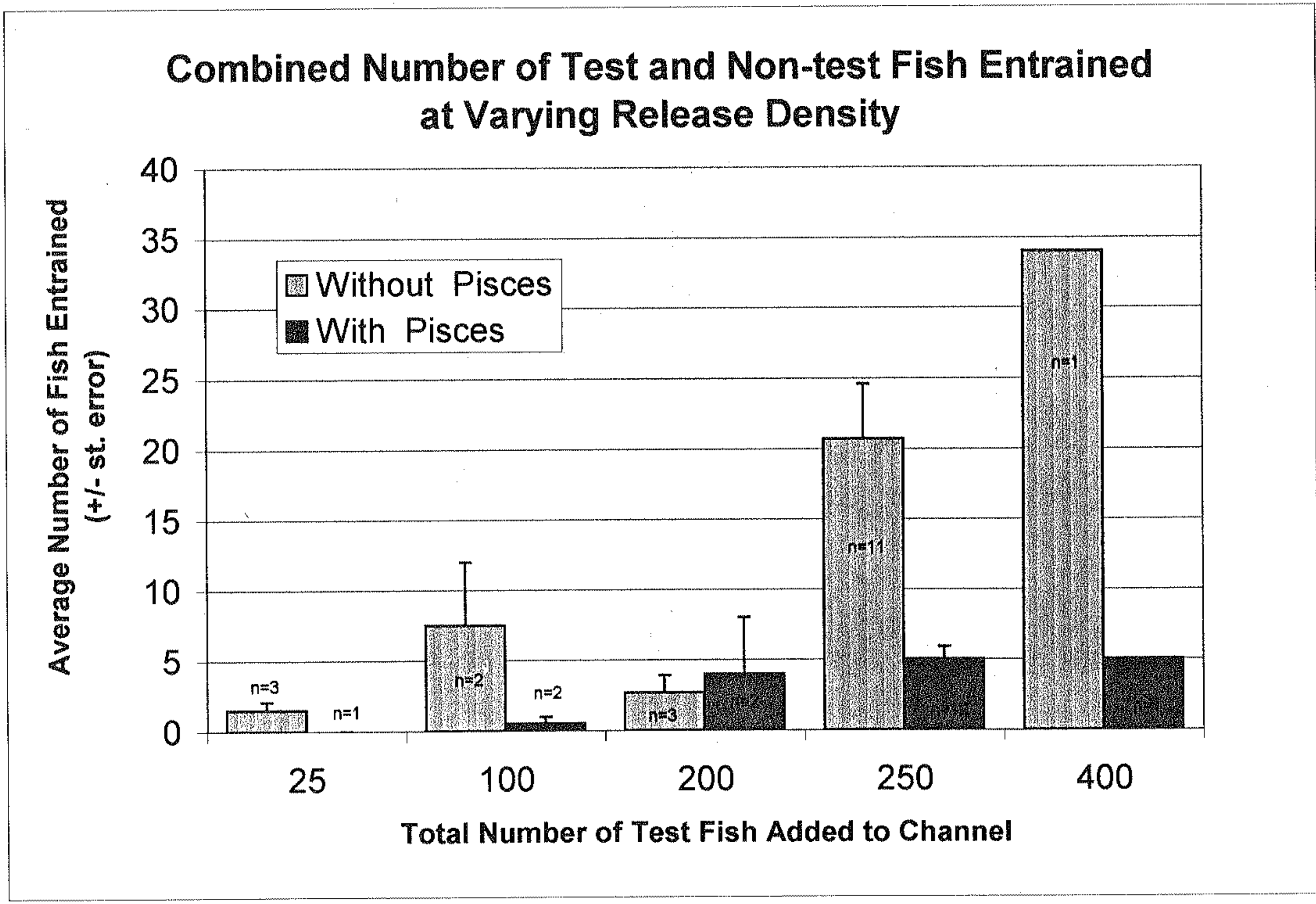
Combined Number of Test and Non-test Fish Entrained
at Varying Release Density
Average Number of Fish Entrained
(+/- st. error)
40
35
30
25
20
15
10
5
0
Without Pisces
With Pisces
n=3
n=1
n=2
n=2
n=3
n=11
n=1
25
100
200
250
400
Total Number of Test Fish Added to Channel

Figure 5

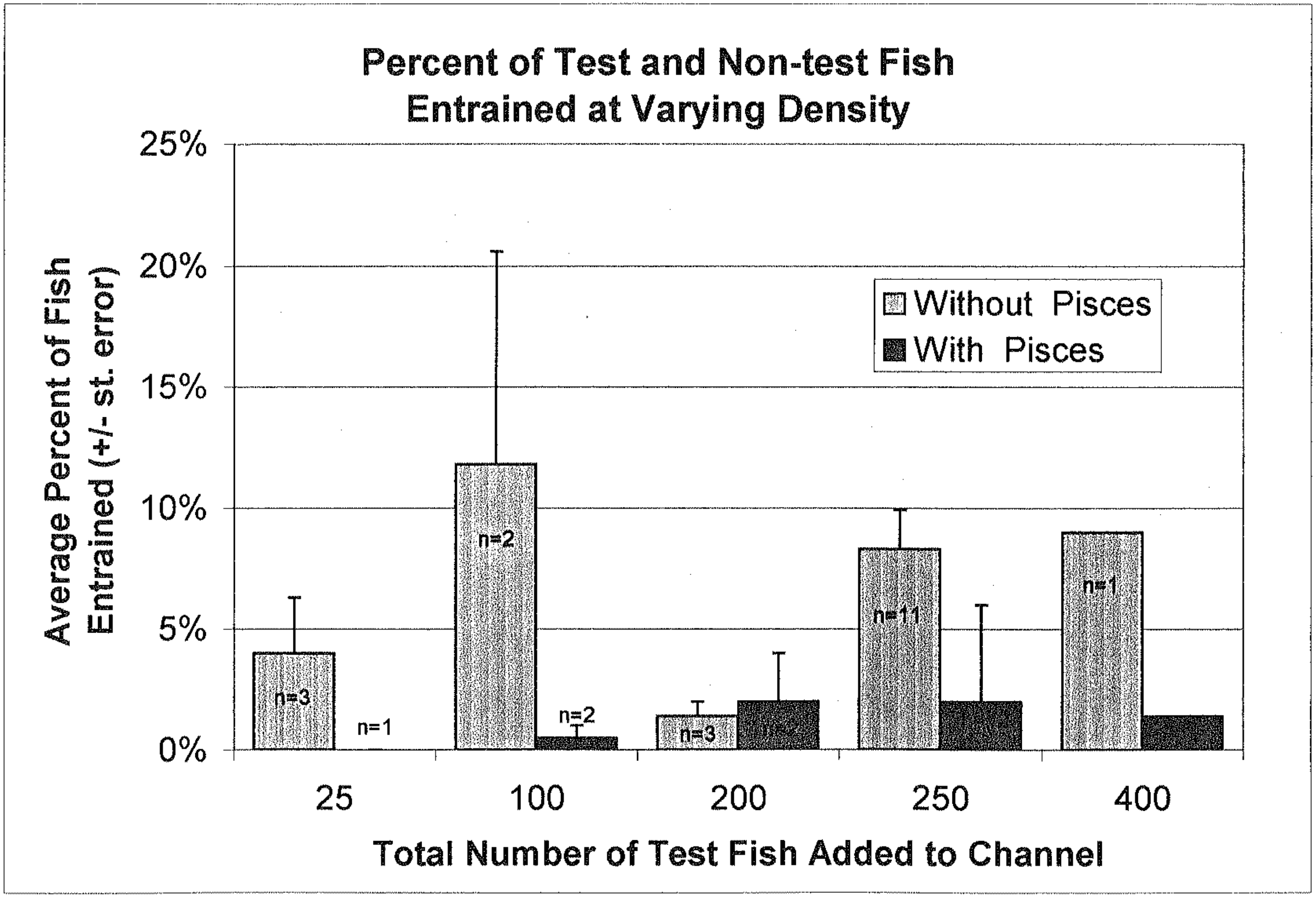
Percent of Test and Non-test Fish
Entrained at Varying Density
Average Percent of Fish
Entrained (+/- st. error)
25%
20%
15%
10%
5%
0%
Without Pisces
With Pisces
n=3
n=1
n=2
n=2
n=3
n=11
n=1
25
100
200
250
400
Total Number of Test Fish Added to Channel

Figure 6

Flow Characterization for PISCES Fish Protection Device

WASHINGTON STATE UNIVERSITY
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
ALBROOK HYDRAULICS LABORATORY

Prepared for:	Balaton Power Incorporated
Principal Investigator:	Dr. Rollin H. Hotchkiss
Date Field Work Performed:	May 20 through May 23, 2002
Location:	Prosser Fish Hatchery

Background and Purpose

Protection of fish at irrigation diversions is the focus of many regulations in the northwest. Rotating drum screens have provided relief at large scale diversion projects but many small diversion projects remain unscreened. Balaton Power is attempting to provide a cost-effective solution to fish exclusion at small diversions through the development of their PISCES Fish Exclusion Device. Towards this goal recent studies have been conducted to develop a better understanding of fish capture rates and flow field around the PISCES unit.

The purpose of this investigation was to characterize the flow field adjacent to Balaton Power's PISCES floating intake. Flow paths, capture zones, and turbulence levels around the PISCES unit were compared to the same parameters adjacent to an open intake pipe using an acoustic doppler velocimeter (ADV) and dye tracing. An ADV measures instantaneous water velocity in three directions. Results allow complicated flow patterns, called turbulence, to be described and quantified. Data were collected for the flow around an open pipe facing upstream, the PISCES unit, and the PISCES with an added flow diversion bracket referred to as the "snowplow". This report provides a summary of the flow conditions occurring for each of the three test conditions.

FIELD WORK

All measurements were collected in the raceway discharge channel of the Prosser Fish Hatchery as shown in Figure 1. The location provided a unique environment with near steady flow and a natural streambed. The channel was approximately eleven feet wide with a maximum depth of 15 inches at the test location. For all tests the flow in the channel was 7.9 cfs and was noted to be supercritical flow, while the PISCES unit was operated to remove approximately 1.1 cfs of the flow. The ADV was mounted to an adjustable platform using a wood and concrete block framing system (Figure 2). The ADV probe tip was attached to a flexible cable that in conjunction with a steel arm allowed for greater sampling flexibility around and below the PISCES unit. Sampling at each location lasted for one minute at 25 hertz (25 samples per second). A schematic diagram of the setup is shown in Figure 4. Milk was chosen as the appropriate dye due to the stream coloration and negligible effect on the natural stream. The dye was placed in a canister on the stream bank, and dispensed through a hose and dye rod. The dye rod was positioned in, around, and under the active PISCES unit to appropriately track water flow around the test structures (Figure 3). Dye was used to augment the ADV in determining mean flow paths, stagnation points, and capture zones. A Pygmy current meter, a simple instrument for measuring average water velocity, was used to verify ADV accuracy. A digital camera was used to collect instantaneous flow field images.

Figure 1. View looking upstream of Prosser Fish Hatchery discharge channel with PISCES unit and ADV sampling setup.

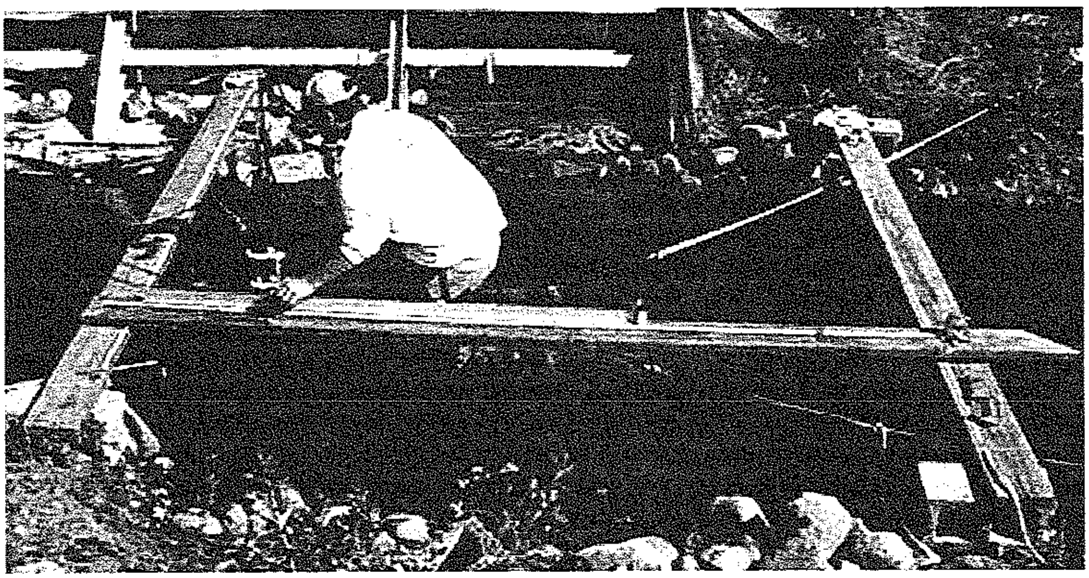

Figure 2. Side view of discharge channel during ADV sampling.

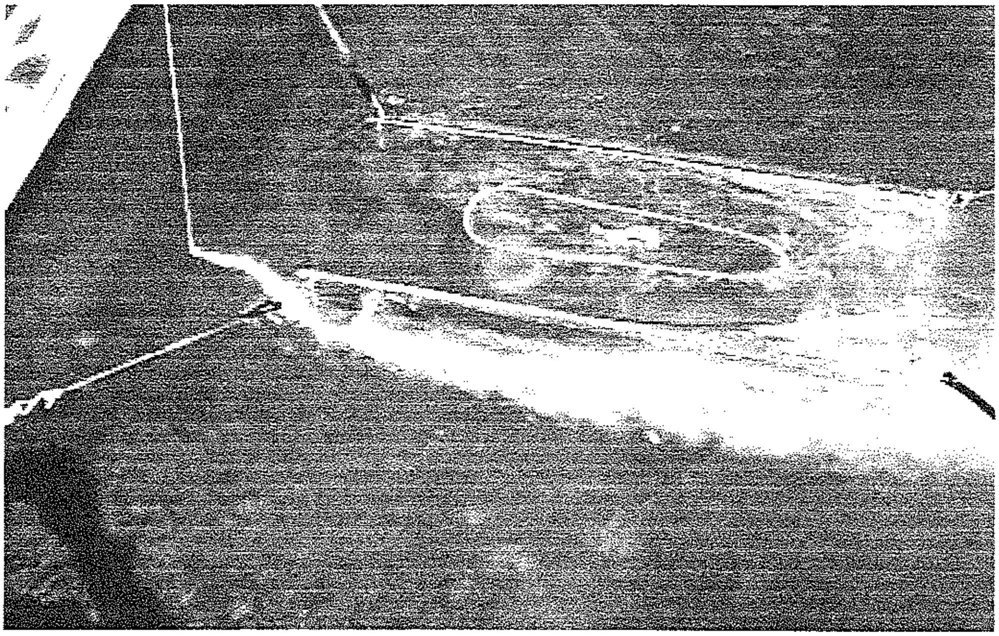

Figure 3. Dye tracing with the dye rod positioned upstream from the mouth of the Pisces unit. Milk is being released from the dye rod to allow flow to be tracked.

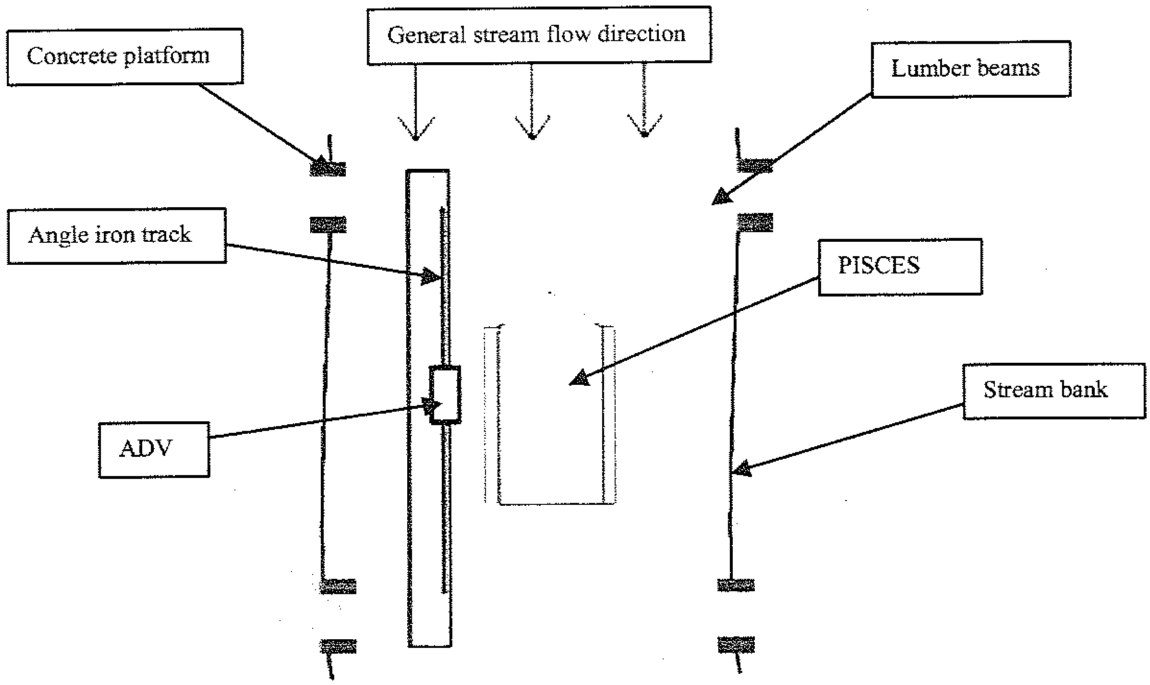

Figure 4. Overview of stream and general experimental setup

Data were collected in three cross-sections upstream from the open pipe, while velocity was characterized around the PISCES unit at nearly 100 locations including: 1) three cross-sections at two depths upstream from the unit, 2) two cross-sections downstream from the unit, 3) 8 points on each side of the unit, and 4) about 30 points beneath the unit. The data were then processed to produce three dimensional velocity vector plots for each sampling location.

RESULTS

Sufficient data were collected to characterize flow around the PISCES unit and the pipe. Figures have been produced based on the data collected from both dye tests and ADV samples.

Data were collected at two constant depths, shallow and deep, whenever possible. A depth of four inches was selected for the shallow points because this was exactly half the depth of the PISCES unit. The shallow points were used to look at flow behavior around the PISCES unit. Ten inches was selected for "deep" points because it was two inches below the PISCES, and it fit well with channel constraints at most points.

Shallow points were collected while the PISCES was in operation and flow was relatively constant. There was no major flow change as a result of the snowplow device, except for the diving flow just upstream of the unit. Figure 5 shows the shallow flow around, into, and out of the PISCES. As shallow flow approaches the PISCES from directly upstream it does one of three things: 1) a great deal of the flow is directed to the side edges of the PISCES and then downstream alongside the unit; 2) much of the flow plunges underneath the PISCES unit and is drawn into the intake; and 3) a small amount of the flow is directed into the top portion of the PISCES unit. The flow is mostly evenly divided between categories 1 and 2 with very little water entering the top of the PISCES unit. The flow that enters into the top of the PISCES is decelerated as it enters the PISCES, and then eventually is expelled out the back of the PISCES unit at a velocity slightly higher (about 0.15 ft/s) then the natural stream. The flow which exits the PISCES acts like a jet and flow downstream of the unit is characterized by vortices that spin off both sides of the jet. The constriction and flow in the top of the PISCES unit causes most of the water upstream to be forced around the side or underneath the unit. The data collected five inches upstream of the PISCES at a depth of four inches showed that water was already beginning to be directed to the outside of the unit as well as plunge everywhere in front of the unit.

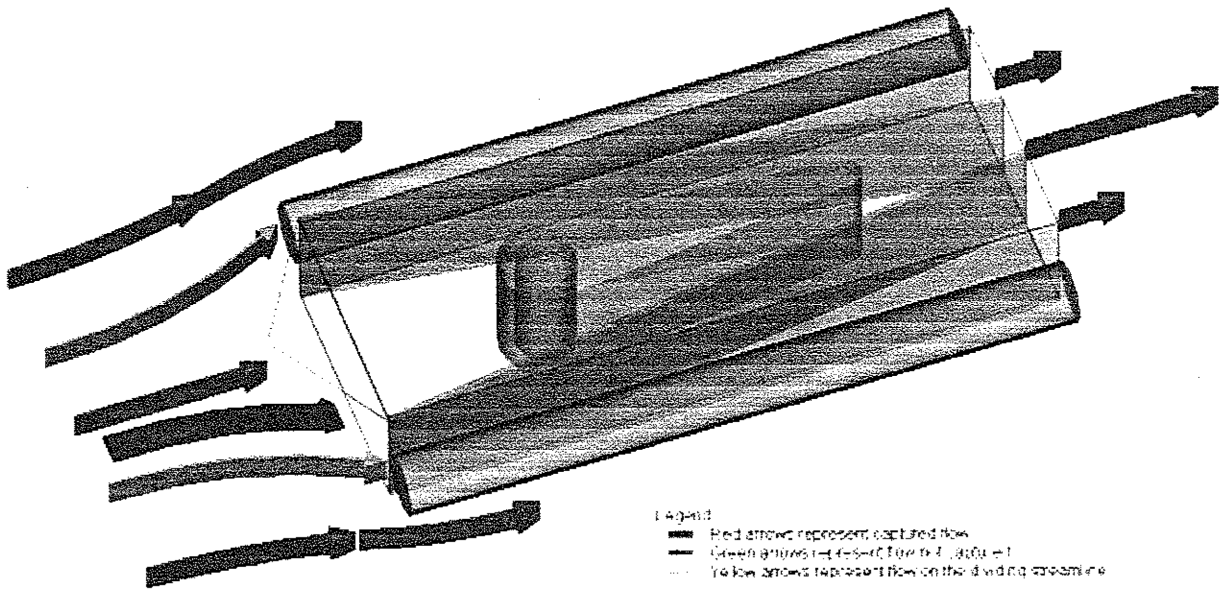

Figure 5. Isometric view of PISCES unit showing ribbons to demonstrate shallow flow patterns as water approaches and exits the unit. The ribbon length is a measure of velocity.

The data reveal that water that dives under the unit in the front was eventually drawn into the PISCES pump intake. Figure 6a shows how the water travels down from the front and into the PISCES at the bottom of the unit. With the addition of the snowplow these flow lines are changed causing the flow to travel at increased velocities, as seen in Figure 6b. For example, the flow five inches upstream of the PISCES at a four inch depth travels 1.48 ft/s without the snowplow and 1.61 ft/s with the snowplow on, or an increase of 8.7%. The flow five inches upstream of the PISCES at a depth of ten inches varies across the cross-section from 0.68 to 1.38 ft/s without the snowplow and from 1.11 to 1.46 ft/s with the snowplow on, an increase of up to 64%.

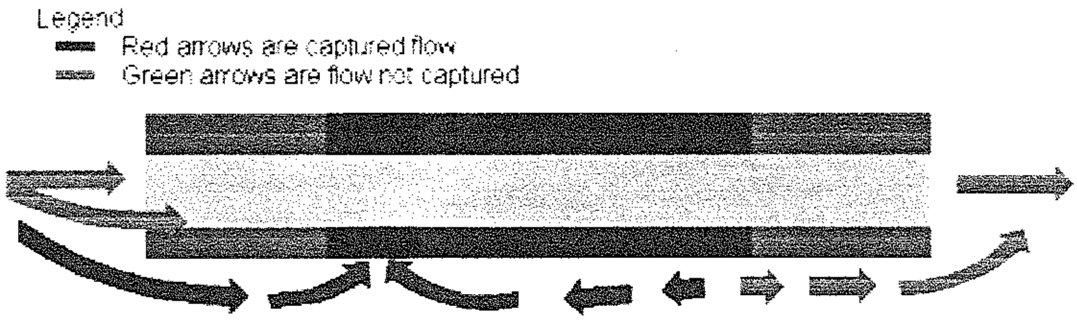

Figure 6a. Side view of the PISCES with the snowplow off with ribbons demonstrating flow patterns.

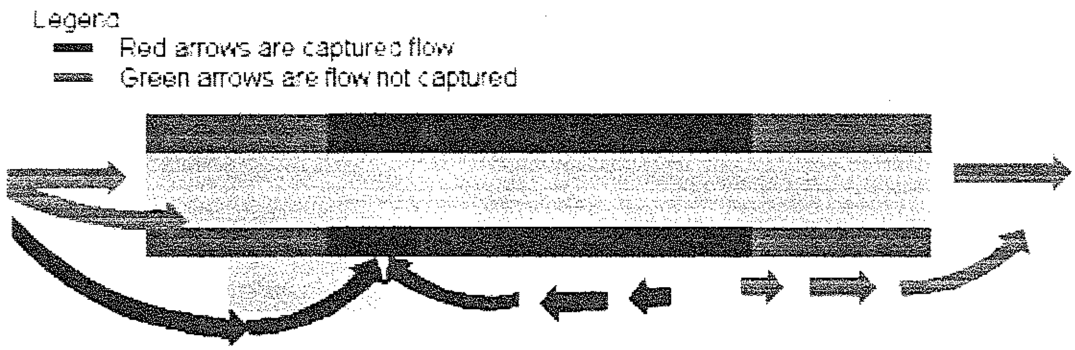

Figure 6b. Side view of the PISCES with the snowplow on with ribbons demonstrating flow patterns.

The most complicated flow patterns are underneath the PISCES unit, where the pipe, intake cavity, and snowplow all affect the flow. These complex flows can be seen in Figure 7. The Figure shows how all flow inside the capture zone eventually moves towards the upstream end of the intake cavity and is drawn into the pipe. The capture zone moves upstream and widens when the snowplow is attached. The variation in capture zones for the snowplow off and the snowplow on are shown in Figure 7 using an orange line (snowplow off) and a blue line (snowplow on). The flow inside the capture zone is also made more chaotic and asymmetric when the snowplow is on compared to when the snowplow is off. The snowplow also increased velocities at certain points beneath the unit, but a trend is impossible to define due to the very complex flow.

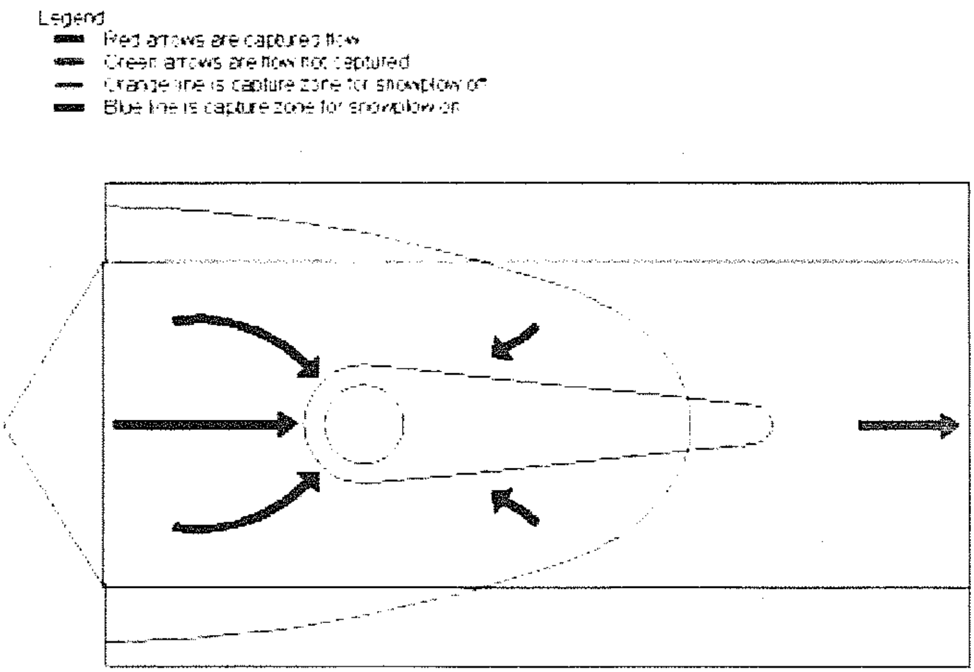

Figure 7. Bottom plan view looking up at the PISCES using ribbons to demonstrate flow patterns. The capture zone of the bottom intake is represented by the orange line for the no snowplow test and the blue line for the snowplow on test.

Three dimensional velocity vectors around the unit are shown in Figures 8 and 9. The greatest magnitude vectors are seen to be closest to the intake, and are as high as 2.82 ft/s for without the snowplow and 3.16 ft/s when the snowplow is on.

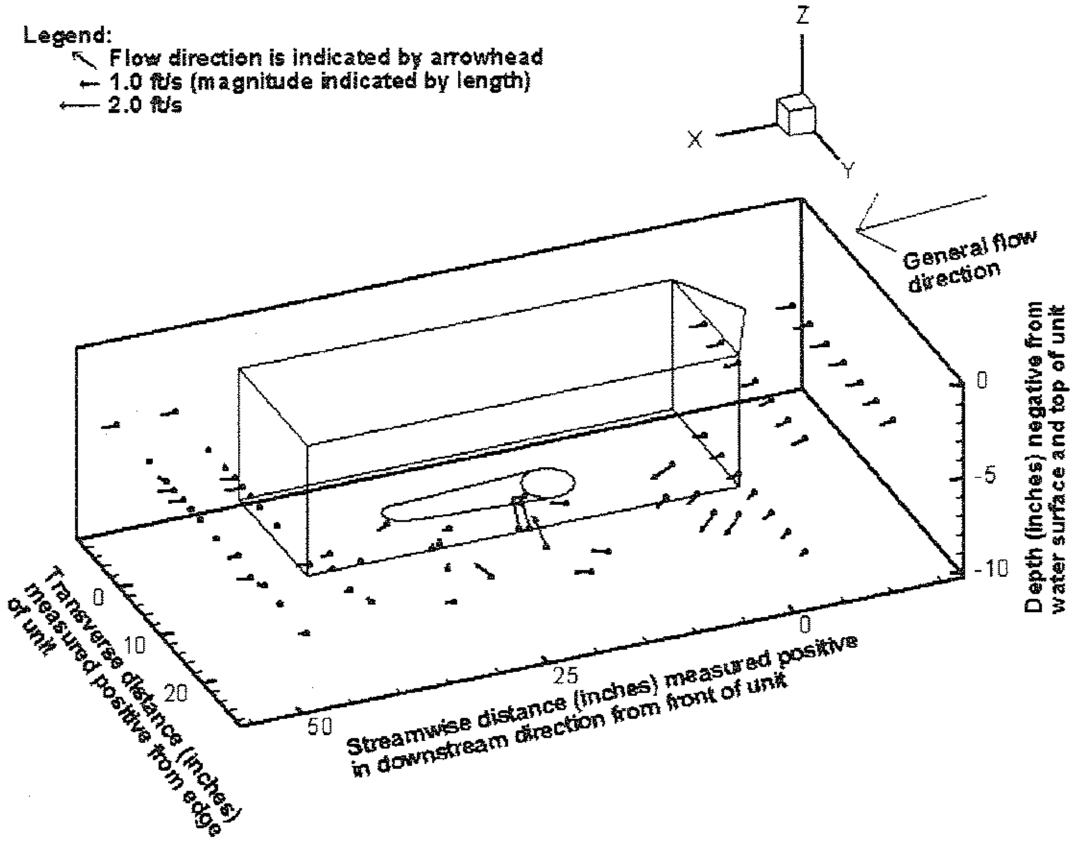

Figure 8. Isometric view of velocity vectors showing flow magnitude and direction for upstream, downstream and underneath the PISCES unit with the snowplow off.

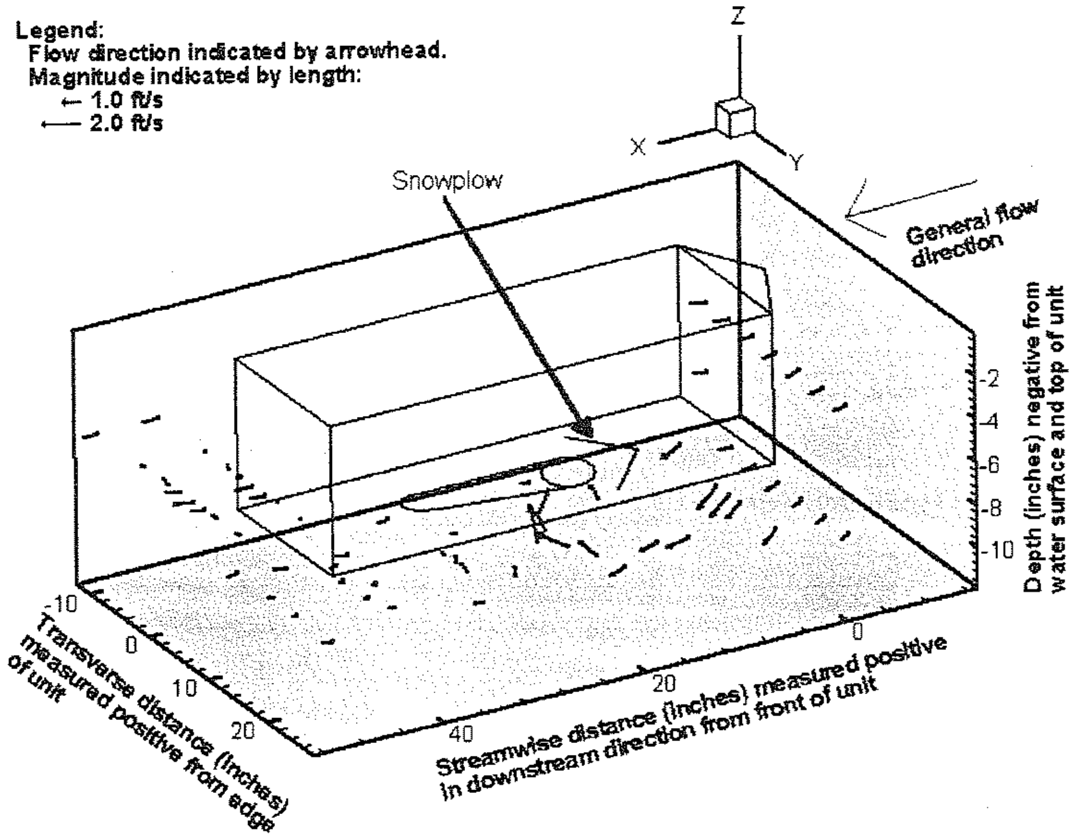

Figure 9. Isometric view of velocity vectors showing flow magnitude and direction for upstream, downstream and underneath the PISCES unit with the snowplow on.

Dye and ADV data were also collected for an open pipe facing upstream and withdrawing at approximately the same rate as for the PISCES tests. The capture zone for the open pipe is shown in Figure 10, and is based upon data collected at the center of the pipe mouth shown in Figure 11. The maximum velocity recorded was 3.04 ft/s three inches upstream of the mouth. This reveals that the PISCES without the snowplow attached draws in flow slower than the open pipe.

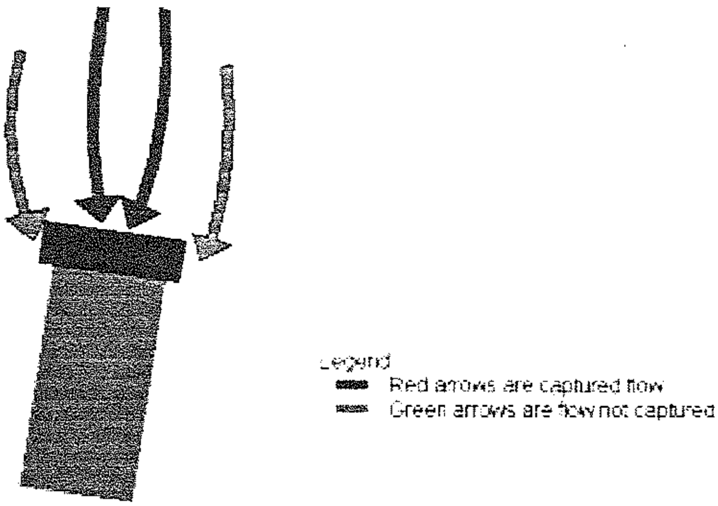

Figure 10. Plan view of the open pipe with ribbons demonstrating flow patterns.

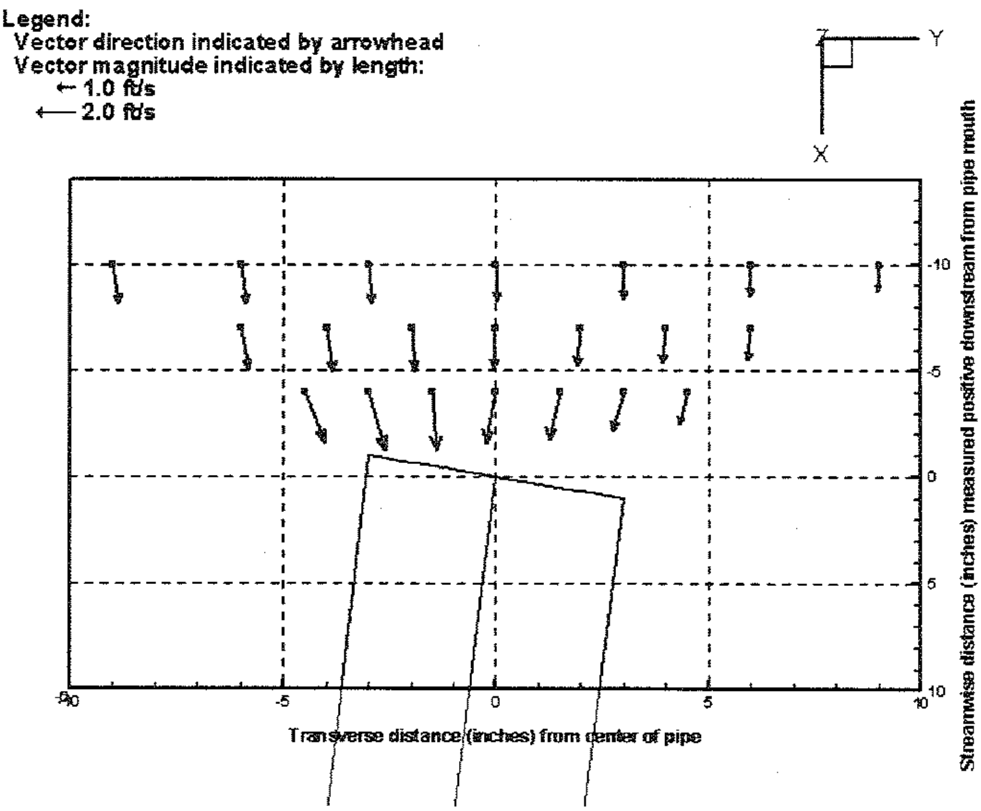

Figure 11. Plan view of the open pipe with vectors showing flow magnitudes and directions.

TURBULENCE

The turbulent kinetic energy (TKE) is a measure of the intensity of fluctuation of flow and is the most widely accepted method for determining the intensity of turbulence. Figure 12 shows the distribution of TKE along cross sections upstream and downstream of the PISCES. As can be seen from Figure 12 the TKE directly upstream of the PISCES is relatively uniform and is comparable to background levels of TKE further upstream. The TKE levels directly downstream of the PISCES are much more dynamic and are generally two to three times the intensity found upstream of the PISCES and in background samples. The large peaks in TKE downstream from the PISCES occur at the edges of the jet coming out the nozzled portion of the PISCES.

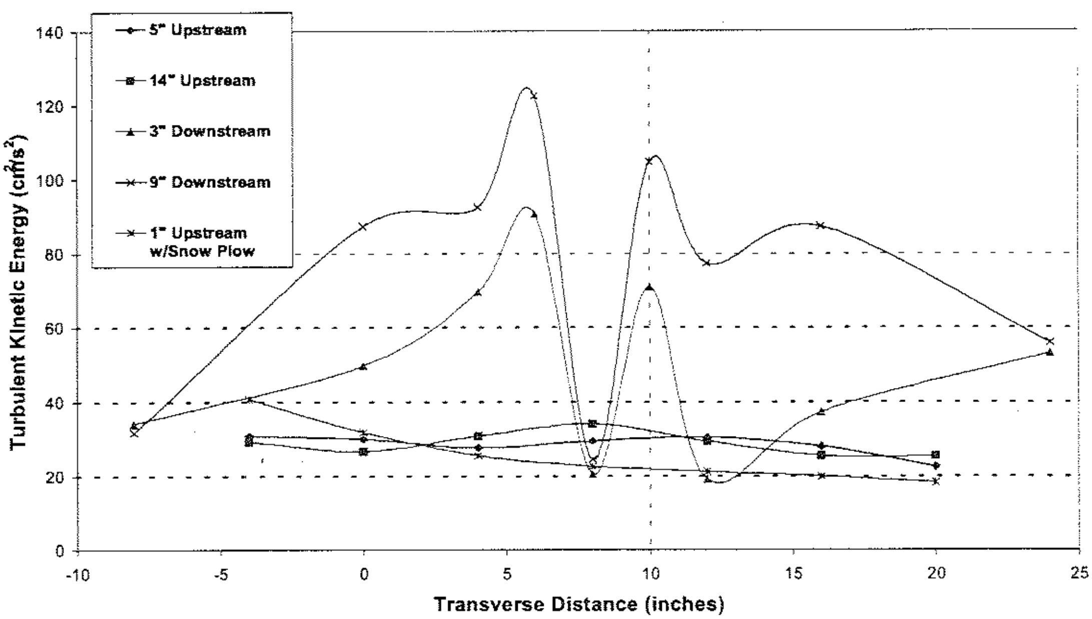

Figure 12. Turbulent Kinetic Energy Upstream and Downstream of the Pisces Unit at a Depth of four inches from the Water Surface

CONCLUSIONS

The flow field around the PISCES unit was successfully characterized using ADV measurements and dye testing. Results showed that very little flow passed through the upper portion of the PISCES unit, while most flow was forced around the outside or dove below the unit. Velocities increased around the edges of the unit as a result of flow constriction. Vorticies were shed from the corners of the unit. A jet of water was created downstream of the unit by the constricting walls within the PISCES. This jet caused vortex shedding and increased turbulence in the wake of the unit. The capture zone extended from the front corners of the unit to just upstream from the inlet cavity. The snowplow caused flow velocities to increase and become more chaotic below the unit, while moving a wider capture zone upstream.

OREGON DEPARTMENT of FISH and WILDLIFE

Fish Screening Program

Fish Screen Costs

Fish Screen Type*	N	Flow Rate (cfs)	Cost ($)	Cost/cfs ($)
Rotary Drum	12	0.4 - 25.0	4,500 - 45,000	1,309 - 11,250
Rotary Drum, Prefab (All 18" d drums)	4	0.8 - 2.0	7,392 - 7,834	3,859 - 9,358
Belt	3	10.0	23,135 - 31,608	2,313 - 3,161
Panel	2	12.0 - 30.0	36,926 - 85,000	2,833 - 3,077
Pump, Low Velocity	10	0.5 - 1.8	801 - 1,662	801 - 1,915
Pump, Clemons	10	0.6 - 4.2	1,000 - 3,441	520 - 2,220
Pumps, Sure Flo	10	0.5 - 6.0	1,029 - 2,856	476 - 2,450

* All fish screens are self-cleaning except for Low Velocity pump screen.

bmk
11/14/2000
Costs, Screens (ODFW).doc

References on Turbulence as it relates to Fish

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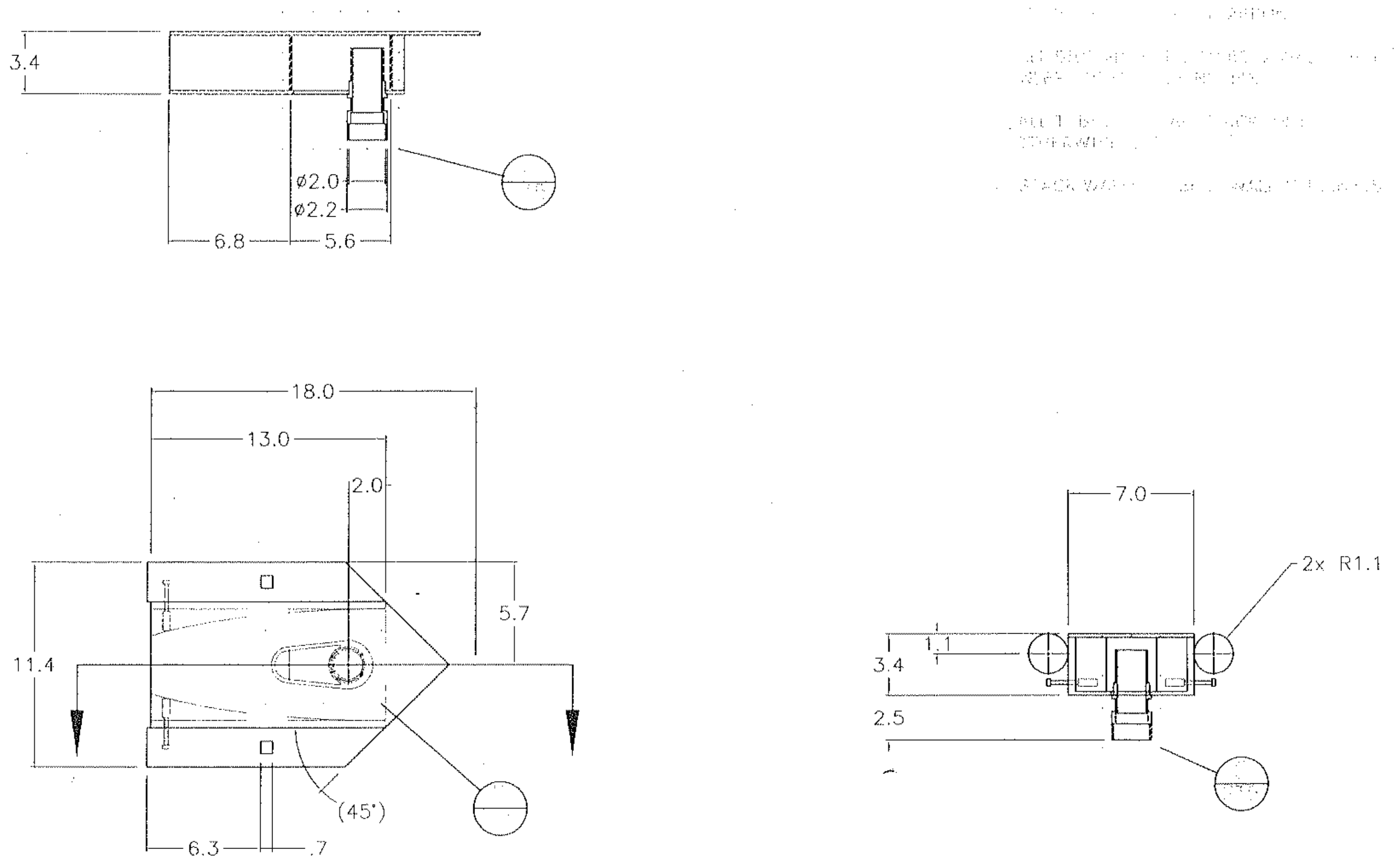

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