MANATEE PROTECTION STUDY

I. Introduction:

In 1988 the FWS Manatee Recovery Plan indicated that the entrapment of manatees in flood gates and navigation locks was the second largest cause of human-related manatee deaths. As a result, an interagency task force consisting of members from the FWS, ACOE, SFWMD, DEP and Dade County was formed to examine the problem. The results of the task force formulation has been a an extensive environmental and engineering study to investigate potential technological solutions to this problem. The studies have taken place in a two-phase approach.

II. Part One: flood control structures (studies conducted by SFWMD in partnership with ACOE).

There are two types of flood control spillways; elevated and non-elevated. At the elevated spillways barriers have been installed to completely prohibit the passage of manatees due to the threat posed to them by the ensuing plummet. At the non-elevated gates, or tidal gates, barriers are not acceptable because we need to ensure and not prohibit safe passage. It is at these tidal gates that we are experimenting with pressure sensitive devices. The Phase one studies developed the following three goals more thoroughly.

1. Implement new operational protocol. 2. Design and Install Pressure Sensitive Device on the gates 3. Determine feasibility of Barriers

A. *Operational Protocols*.

During the early eighties a minimum 2.5 ft. gate opening criteria was established to eliminate the potential for pinning manatees against the upstream side of the spillway gate. This was intended to eliminate the possibility of death by drowning. Since the new protocol was established no deaths have been attributed to drowning. But again, structure related mortalities did not decline significantly, hence the continued efforts to develop gate protection devices.

B. *Pressure Sensitive Device's (Pad's).*

1. Magnetic Plunger/Reed Switch. The SFWMD conducted research to develop a plunger-type gate reverse sensor device which has been installed along the lower edge of the vertical gates at S-27 in Jan '93 and S-29 in March '94. This mechanical device is designed to immediately stop and then reverse the lowering of a vertical water control gate when an object is detected under the closing gate. The sensing device consists of a series encapsulated reed switches and pressure sensitive plungers on the bottom of the water control gate which transmit a signal used to reverse the gate direction when resistance is encountered. If a manatee activates the sensors during gate closing, the gate will open and allow the manatee to pass. After the gate re-opens it will fully close provided that nothing remains beneath the gate.

To date there have been some problems with the plunger systems. The plungers require a complex control circuitry which experienced failures such that manatee deaths have still occurred since installation. The system also presents befouling problems due to the use of submersed moving parts. And finally, the system has no sensitivity to discriminate passage of debris from manatees and, therefore, can cause false signals. This system has improved the protection level at the structures as is evidenced by successful triggerings by manatees, however, it has not been completely successful and has required a high level of maintenance effort. The technology requires further refinements or the development of an alternative system (see below). 2. Piezo-Electric Film Sensor. In August 1995, Harbor Branch Oceanographic Institute introduced a new technology, the piezo-electric sensor, that could be utilized to detect the presence of a manatee under a closing gate. The sensor uses Piezo film, a thin flexible material manufactured from polyvinylidene fluoride plastic, which converts mechanical energy to an electrical response. When the film is stressed, a charge is generated on the surface of the film proportional to the applied stress. The piezo electric sensor for the lift gates uses a long piezo strip in place of mechanical plungers. The piezo film is sandwiched within a rubber block. A strip is installed immediately upstream and downstream of the gate. If the sensors detect the presence of a manatee in the spillway, the gates are stopped and reset themselves at 2.5 feet to allow the manatee to pass. This technology is applicable for both the vertical spillway structures and the sector gates.

C. *Barriers*:

A barrier was developed that was designed to be located 6 to 8 feet in front of elevated and lock associated spillway structures within the needlebeam recesses. The limited use of barriers is designed to ensure that the manatee are not denied access to potentially important feeding grounds. Currently barriers are in place on the Ortona and the St. Lucie spillways as well as most of the elevated spillways. The most significant problems with the barriers to date has been the need to keep them free of vegetation, a task that has proven to be extremely labor intensive. Plans are under way currently to break the barriers down into 3-piece units for greater ease during maintenance.

III. Phase II - Navigation Lock structures (studies performed by ACOE).

The purpose of Phase Two is to design and implement measures to reduce mortalities at navigation locks. The study resulted in the development of: recess screens, new operational protocols, various pressure sensitive devices, and new hydroacoustic detection devices.

A. The earliest efforts to reduce deaths at sector gates included recess screens and new operational protocols.

1. Recess Screens: Manatee protection recess screens were installed at many of the sector gate locks. The purpose of the screens is to prevent manatee access to sector gate bottom recesses where there is a possibility of manatees becoming crushed while the gates are in motion. The screens are similar to chain link fencing and they begin approximately six inches from the bottom of the lock chamber and cover the recess all the way to the top of the water column.

2. Operational Protocol. These lock operating procedures are designed to place the manatees at less risk while they are in the vicinity of the locks. The locks have been modified so that the rate of gate closure is reduced during the final few feet to reduce the possibility of entrapment. Furthermore, the lock tenders have been educated regarding the importance of manatees and these new protocols, and now maintain sighting logs. Additionally, volunteer observer programs have been developed at high-use localities.

B. Pressure Sensitive Devices. The USACE and the SFWMD are in the process of evaluating three pressure activated systems for the sector gates: the hinge plate switch, j-seal piezo electric film contact sensor, and the hydraulic tube system.

1. Hinge Plate Switch. This system was developed by SFWMD. The hinge plates are intended to be located at the leading and trailing edges of the sector gate's contact edges. If a manatee is caught in a closing gate, a spring-loaded "hinge-plate" activates a limit switch and stops gate motion. An audible alarm and visible light are activated to alert the operator, who then opens the gate to a required distance and allows the manatee to pass through.

The "hinge-plate" assembly consists of a stainless steel backer plate with a quarter-inch thick stainless steel "hinge". The "hinge-plate" assembly may be twenty or more feet in length depending on the lock water depth. The assembly can be lowered into place with a crane. Divers are required to guide and fasten the assembly underwater while other workers fasten the assembly at the surface. The estimated average cost to install is $50,000.

The prototype hinge-plate system was installed on S-193/Taylor Creek Lock by the SFWMD. They are functioning as anticipated on the structure, however there were some problems. After some additional fine tuning however, the system seems to be working very well. In the four years prior to installation there were six fatalities at S-193, in the two years since the hinge plates were installed there have been zero. Unfortunately, it has been determined that the hinge plates are not feasible for use on the OWW structures due to the fact that the hinge plates protrude such that the open gates may no longer be swung within the recess of the lock chamber wall. This does not pose a problem at structures like S-193 where the only traffic tends to be small recreational vehicles. However, this would pose a significant problem on the OWW due to the passage of much larger traffic, including barges, which would likely damage the hinge plates.

2. Hydraulic Tube Sensor: This PSD was developed by the USACE, Jacksonville District. A flexible tube filled with biodegradable hydraulic fluid is installed at the J-seal and/or the bumper block line. The static pressure of the tube is set at 10psi. Compression of the tube by contact with a manatee would increase the contained fluid pressure. When the pressure reaches 12psi it activates an electrical device that sends a signal to control sector gate action. A microswitch is activated which relays a signal to detect manatee presence and stops the gate. The lock operator is alarmed by visual and audio display, and he may then open the gates farther to allow the manatee to pass through. As a system check , low pressure (8psi) alerts the operator of a possible leak condition. The cost of installation is around $40,000 per structure.

The prototype hydraulic tube system was installed in 1995 on the Port Myaca Structure. Installation of the system required the use of divers to guide the tube into place and bolt it onto the structure. There have been some problems with maintaining the static pressure due to leaks. Also, the tubes seem to be vulnerable to damage from passing boat traffic and water turbulence. Due to these problems, the system requires a high level of maintenance and is not believed at this time to be a preferred alternative. 3. Piezo-Electric: The most promising possibility for the use of the Piezo in a PSD on sector gates seems to be a J-Seal Contact Sensor Design. It has been designed and tested by HBOI. The j-seal sensor was fabricated by sandwiching the piezo film between the j-seal and a protective neoprene cover layer. This j-seal would replace the original on the gates. The sensor would connect to junction box assemblies that contain the gate trip and alarm connections. This junction box would contain the sensor condition module used to report contacts over a cable run to the control room. A control room junction box would contain the gate trip and alarm connections, in addition to the hardwired connections to the present gate closure circuitry. The detected presence of a manatee in contact with the j-seal would stop the gate closure and activate the alarm, at which point the gate operator could open the gates and allow the manatee to pass. Also, an override switch would allow the system to be bypassed and restore operator control. The average cost of the system on both gates of a structure would be $50,000. The ACOE hopes to initiate testing of this device by FY98.

C. Hydroacoustic Device Systems. The USACE Jacksonville District enlisted the aid of the Waterways Experiment Station (WES) in evaluating the feasibility of several acoustic systems for detecting manatees in the lock chamber. During 1995 eleven devices were tested, and all but one proved to be unacceptable for use in the lock chamber environment. Both imaging systems (those that showed an image of manatees on a monitor) and non-imaging systems were tested. Most of the imaging devices proved problematic due to cost of implementation, susceptibility of the devices to damage from boat traffic, and the unusual nature of the lock environment which causes the sonar beams to scatter and images to be unreadable. The non-imaging devices which functioned under the concept of interrupted beam sensors were the most promising. Three of these devices were tested. One of these, the AMP Piezo-electric Acoustic Ladder Array was found to be feasible and will be tested on the St. Lucie Lock during F.Y. 97. This system uses AMP piezo electric copolymer tiles as 'beam breaking' emitter-receiver pairs set up to form an acoustic ladder array. The acoustic emitter-receiver pairs are made by imbedding piezo-electric copolymer tile in hard rubber silicon. The co-polymer tiles will be formed into circular bands that will be hard back mounted on the outside of a stainless steel tube at the selected interval. The sensor array tubes encapsulated in polyurethane and PVC would be the only components that would be placed in the water. This ladder-type set up of emitters on one gate and receivers on the other gate would have the emitter/receivers spaced approximately eight inches apart. The system will be installed on the I-beams of each gate. The beams of these transducers would range from four to nine degrees so as to protect the manatee within the critical zone of the closing gates. A manatee swimming between closing gates would interrupt at least two beams to activate an alarm and stop the gate.

The AMP Piezo-electric Acoustic Ladder array system is "fail safe" since a transducer failure results in a false trigger. The system is inherently separated into multiple independent channels with yes/no outputs so trouble shooting and diagnostics are simplified. The system is self-diagnostic and well suited for simple "replace the module" repairs. The system is micro controller based and readily lends itself to data logging applications. Data can be stored in nonvolatile memory and connected to a PC to allow logging of statistical information, such as number of potential manatee targets, date, time and location of a manatee within the critical zone. The system could also be used to temporarily trigger video recorders or other devices. The average costs for implementation is $20,000 per structure.

III. Future Plans.

Phase I - At the flood control structures the preferred alternatives appear to be piezo-electric strips for the non-elevated structures and barriers for the elevated. Once the testing phase is completed for the piezo strips, the USACE and the SFWMD intend to retrofit all non elevated C&SF flood control structures with this manatee detection device. The system will be installed on the remaining unprotected non-elevated spillways in the order of the highest to the lowest mortality levels.

Phase II - At the navigation locks the most promising technologies seem to be the j-seal piezo sensor and the piezo acoustic ladder array. Installing both systems on each structure will provide a backup system of protection in the event that one system is temporarily malfunctioning. The acoustic system will be installed and tested on the St. Lucie Lock during 1997. If the tests are successful, then the phased installation of the system can be expected to begin by early 1998. Plans for the further testing of the j-seal contact sensor are awaiting approval from USACE Headquarters.

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