CHAPTER 3

SELECTION & ASSEMBLY OF THE SENSORS PROTECTION DEVICE

3.1 INTRODUCTION

It is always a good practice to protect the monitoring sensors from local wildlife, debris and human tampering.

Four types of monitoring sensor protection devices are generally used:

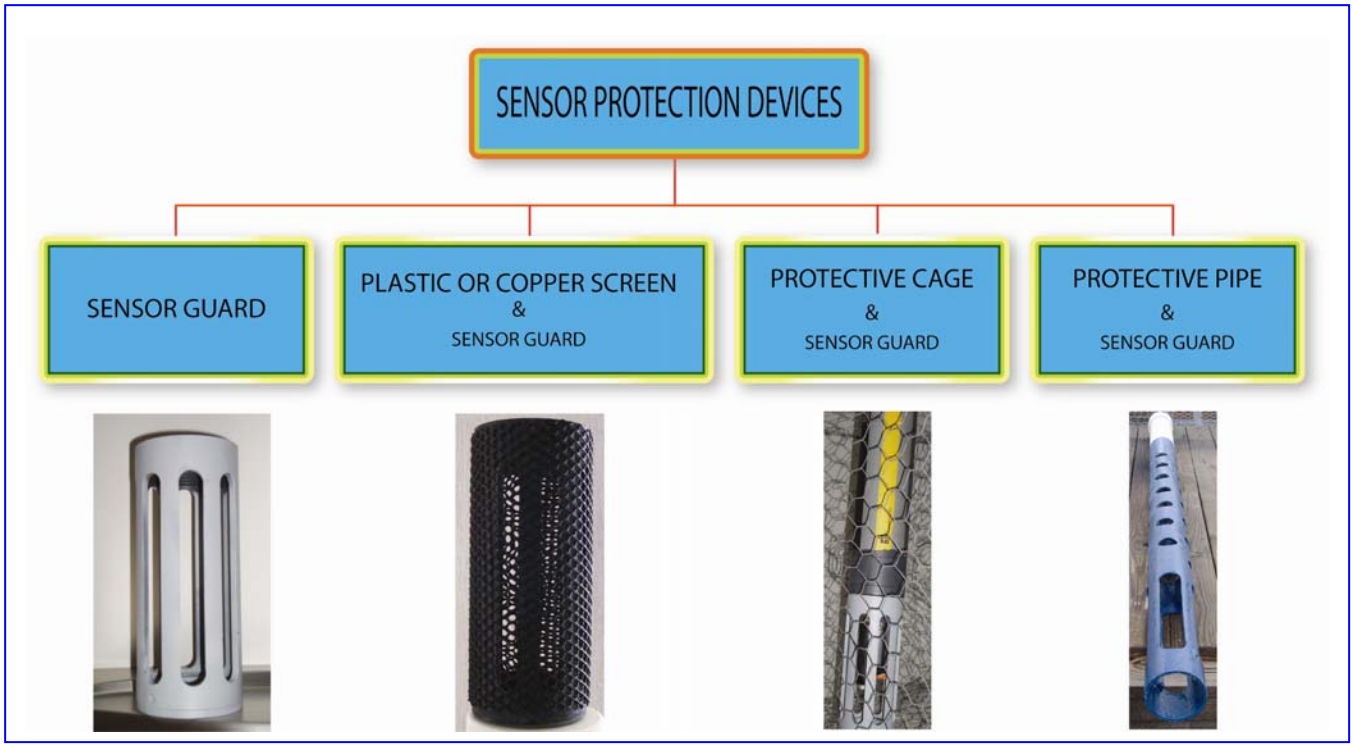


Figure 3.1 Sensor protection devices

1. Sensor or Probe guards are built in protective guards generally made of PVC or polyurethane and are recommended for use in environments with low degree of debris, wildlife or human activity. These devices come with the equipment.

2. Sensor guard wrapped with a plastic or copper screen are recommended for use in environments with large quantities of floating and/or submerged debris, particularly in rapidly moving rivers and streams. A good practice is to use a plastic (dark color, *e.g.* black) or copper screen with a mesh opening size ranging from 1/8 to 1/4 inch (3 to 6 mm). The screen is secured to the guard with rubber bands, cable ties or tape (duck or plastic electrical). The screen can be used with the protective cage or the protective pipe to provide additional shielding (CDMO, 2007). Precautions must be taken to avoid the appearance of different aquatic environmental conditions inside the screen than outside during sampling due to biofouling of the screen or physical fouling trapped on the mesh (Figure 3.2).

Figure 3.2 Fouled screens

(Source: Jacques Cousteau NERR; North Inlet-Winyah Bay NERR)

3. Protective cage has two basic designs:

- ➔ Available or modified cages (*e.g.*, crab pot, raccoon trapping cage, *etc.*)
- ➔ Special constructed cages

A protective cage can be used by itself, or can be employed with other sensor protection devices to provide additional safety. Cages can impede small animals (*e.g.* crabs) from settling into the built in protection guard and interfering with certain types of measurements. Protective cages have certain disadvantages, for example: maintenance issues due to fouling; animals can get trapped inside the cage; special water environment conditions can be created inside the cage due to fouling, trapping vegetation, or debris clogged mesh.

4. Protective Pipe

In this chapter, design guidelines to prepare a protective pipe are given. The work instructions prescribe a specific design method and it does not cover every conceivable approach.

- → For further reference, the protective pipe is referred to as the "**guard-pipe**".
- → The step-by-step instructions given in this chapter are limited to the activities necessary to construct the guard-pipe to be ready for field deployment.
- → A **specific pipe diameter** is used due to the dimensions of the monitoring sensor employed at the Reserve; other diameters and materials may be used to meet each particular need.
- → The final assembly of the guard-pipe in the monitoring station is addressed in Chapter 5 - Fixed Structure Monitoring Stations.

3.2 SENSOR PROTECTION DEVICE: GUARD-PIPE

The guidelines are written in a standard operating procedure style.

3.2.1 SUMMARY OF THE GUIDELINES

A 4 inch diameter Schedule 40 PVC pipe is utilized to protect the monitoring sensor. In order to ensure the same aquatic environmental conditions inside the pipe as outside, a set of 2 inch (5 cm) holes along the pipe, and four sets of windows (13 by 2 inches; 33 by 5 cm) at the bottom of the pipe are drilled to guarantee a good water flow. To ensure the monitoring sensor will be positioned at the windows depth when deployed, two small bolts are placed at the end of the pipe to act as stoppers. To minimize fouling, the pipe is painted with antifouling paint.

The monitoring sensor employed in this procedure is a multiparameter sonde that has a diameter of 8.9 cm (3.5 in) (type of the long term deployment sonde used at NERRS).

These design guidelines could be equally applied with any other type of pipe material or sensor diameter. It is a good practice to choose a pipe with a diameter of 1 or 2 inches (2.5 to 5 cm) larger than the diameter of the sonde, and with a length that exceeds the sonde's length by several inches (CDMO, 2007).

In this particular guard-pipe design, the pipe can be set in the monitoring station at a specific height above the substrate for fixed stations, or beneath the water level for buoyant stations.

3.2.2 QUALIFICATIONS & RESPONSIBILITIES

All users of these guidelines must be familiar with it before implementation and, if necessary, trained by personnel with previous experience in guard-pipe construction.

3.2.3 HEALTH AND SAFETY WARNINGS

The construction of the guard-pipe requires precaution in the use and handling of the tools and materials to assure safety.

- General safety precautions for working with electric and power tools must be taken.
- When using power tools safety glasses must be used.
- When drilling holes in a PVC pipe, safety precautions must be taken given that the drill bit can slip out of the hole and cause injuries.
- When painting with antifouling coating, protective gloves, glasses and clothing, and an air-purifying respirator must be used.
- Personnel engaged in the painting operations should review the paint Material Safety Data Sheets in order to acquaint themselves with the properties and hazards of the paint.

3.2.4 EQUIPMENT AND SUPPLIES

The following tables list the equipment and supplies needed to construct the guard-pipe.

EQUIPMENT		
Drill	2 in Drill Bit	Drill bits
Jig saw	Round File	Square
Measuring Tape	Straight File or Sand Paper	

Table 3.1

SAFETY EQUIPMENT	
Safety glasses	Dust mask
Vinyl gloves	Air-Purifying Respirator
Lab coat, apron or other suitable outfit to protect your clothes	

Table 3.2

SUPPLIES						
#	Supply	Description				
1	PVC Pipe	Schedule	Diameter	Length	Quantity	
		40	4 inch	16 ft	1	
2	Galvanized or stainless steel bolt (Hex Head) (recommended 316 SS)	Length	Diameter	Quantity		
		1 inch	5/16	2		
		8 inch	9/16	1		
3	Galvanized or stainless steel nuts		5/16	4		
4	4 in × 4 in PVC coupling					
5	PVC cleaner, prime and cement					
6	Padlock (*e.g.* #3 from Master Lock)					
7	Duck or Masking Tape	Small amount. To be used during the painting process.				
8	Permanent Marker	To be used to mark the PVC pipe				
9	String, a piece of soft cardboard or paper	For a 4 in pipe (15 in/ 37cm); for a 6 in pipe (22in/54cm) at least long.				
	OR					
	A piece of paper and a string	The string must be at least 16 ft long				
10	Ruler or straight stick	Preferable one meter long or longer. It will be used to mark straight lines in the PVC pipe				
11	Two pieces of 1-1½ inch PVC pipe.	Two or three ft long. Used as a helping device in the drilling process				
12	**Painting Supplies**					

There is a variety of ways to paint the inside - outside of the guard-pipe; using paint brushes and rollers, paint sprayers, paint sprayers guns, or special design paint tools. In this manual, three painting methods are briefly described:

a. Using paint brushes to paint the outside and inside

b. Using paint brushes to paint the outside and a pole with a sponge attached at one end to paint the inside

c. Using a special designed paint tub.

Table 3.3

SUPPLIES	
Antifouling coating	Micron Extra with Biolux (5696 Dark Blue) from Interlux, International Paint Inc or other similar. Choose the paint that works best under the environmental conditions the station will operate (*i.e.* fresh or salt water). Black paint is another recommended color. If black paint is selected, care must be taken if the painted pipe will stay out of the water during hot weather conditions; the black paint can cause an increase of the temperature inside the pipe. White or similar paints can not be used – they will cause reflection problems with the optical sensors.
Degreaser	PVC pipes are generally oily; it is a good practice to clean the inside and outer surfaces of the pipe with a degreaser (*e.g.* Simple Green) before painting. The cleaning improves the bonding between the coating and the PVC.

a.	Using paint brushes to paint the outside and inside
Paint Brushes	Any kind. Cheap are best to paint the outside of the pipe.
	1.5 inch wide to paint through the holes the inside of the pipe.

b.	Using paint brushes to paint the outside and a pole with a sponge attached at one end to paint the inside	
Paint brushes	Any kind. Cheap are best to paint the outside of the pipe	
Clean up sponge	Cheap is best to be used as the painting device.	
PVC or stick at least 8 ft long.	The sponge will be attached at one end (*i.e.* a ¾ in PVC pipe).	

c.	Using a special designed paint tub so the pipe can be submerged in the paint				
PVC pipe	Schedule	Diameter	Length	Quantity	
	40	6 in	8 ft	1	
PVC cap		6 in		1	
Wood	The type and quantity will depend on the type of holding structure to be designed.				

Cont. Table 3.3

3.2.5 CONSTRUCTION STEPS

One attribute that must be assured, in any type of protective pipe design, is that the aquatic environmental conditions inside the pipe are the same as the outside during sampling. In order to ensure this in the guard-pipe, four sets of 2 inch (5 cm) holes (ventilation holes) along the pipe, and four sets of windows (13 by 2 inches; 33 by 5 cm) at the bottom of the pipe are drilled to guarantee a good water flow.

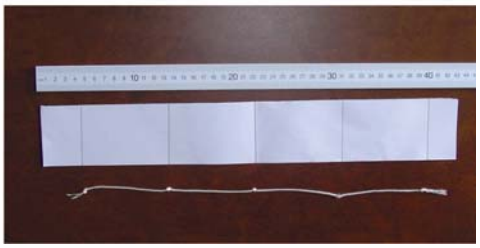
The construction of the guard-pipe is divided into three main activities:

- Drilling the ventilation holes and windows.
- Painting the guard-pipe with antifouling paint.
- Preparing the safety lock system.

1 **Subdivide the PVC pipe into 4 equal sections**

There are a variety of ways to subdivide a PVC pipe into 4 equal sections, two methods are shown here.

Using a string or a piece of paper



1 **Divide the string or paper into 4 equal sections**

→ The length of each section is shown in Table 3.4.

PVC Pipe	O. D.	Outside Perimeter	Length of each of the 4 sections
4 in (10.16 cm)	4.5 in	14.1 in	3.53 in
	11.43 cm	35.9 cm	8.98 cm

Table 3.4 Length of sections

2 **Draw a 70 inch guide-line on the PVC pipe**

→ PVC pipes come with a specification line written across the pipe. Use this line as a guide.

→ Place a ruler aligned with the specifications and draw a line from one end of the PVC pipe to a 70 inch mark.

This line is labeled "Pt 1"

If the pipe does not come with a specification line, a guide line can be drawn with a T ruler; mark a perpendicular line at one end of the pipe.

3 **Divide the PVC pipe into 4 equal sections**

→ Place the first mark of the string or paper matching Pt 1, and wrap the string or paper around the pipe

→ Using the other marks of the string or paper, draw 3 more points along the PVC circumference, Pt 2, Pt 3 and Pt 4.

→ Using the "Pt 1 line" as a guide, repeat this process three more times along the PVC pipe (to minimize drawing errors, it is convenient that the Pt 1 points are approximately 5 inches apart from each other).

→ Join the points with a ruler so three lines are created.

- → Line Pt 2 (Pt 2 - Pt 2′ -Pt 2″)
- → Line Pt 3 (Pt 3 - Pt 3′ -Pt 3″)
- → Line Pt 4 (Pt 4 - Pt 4′ -Pt 4″)

Mark additional sections along the pipe and continue to draw the three lines up to the 70 inch mark.

Using a square piece of paper

Cut a piece of paper into a square (Side = 3 1/8 in or 8 cm), and draw the two diagonals.

1 Mark four point on each end of the PVC pipe

→ Place a ruler aligned with the specifications of the pipe and draw a line from one end of the PVC pipe to a 70 inch mark.

This line is labeled "Pt 1"

→ Place the square of paper with one of the corners aligned with the Pt 1 line.

→ Mark the Pt 2, Pt 3 and Pt 4 points (meeting points PVC pipe and corners of the square of paper).

→ Repeat this process at the other end of the PVC pipe.

2 Draw four lines along the PVC pipe

→ Attach a string from Pt 2 to Pt 2′ (*e.g.* with duck tape)

→ Mark several points along the line (this will be the Pt 2 line).

→ Repeat this process with Pt 3 and Pt 4.

→ Using a ruler connect these points to create 3 lines.

If several guard pipes are going to be constructed at the same time; an option to ease the work is to use a plastic cup to mark the division points.

Once the four points are marked at one end of the PVC pipe; a plastic cup is introduced at that end and the points are marked on the cup (a guide line is marked on the cup to define the penetration depth of the cup into the pipe).

The cup is inserted in a new PVC pipe, aligning the specification line to one of the points of the plastic cup.

2 **Mark the drilling-hole points**

A set of points are marked on each line. These points identify where the ventilation holes are going to be located.

→ On each line mark the drilling-hole points as listed in Table 3.5.

Table 3.5: Drill Hole Points (Inches)

# of Hole	Pts 1	Pts 2	Pts 3	Pts 4
1	4	4	4	4
2	15	15	15	15
3	18	21	18	21
4	24	27	24	27
5	30	33	30	33
6	36	39	36	39
7	42	45	42	45
8	48	51	48	51
9	54	57	54	57
10	60	63	60	63

3 **Drill a 2 inch hole at each drilling-hole mark**

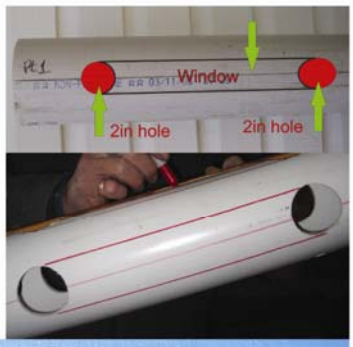
Use a 2 inch drill bit and drill a hole in each drilling-hole point.

→ Precaution must be taken when drilling holes in a round and slippery surface such as a PVC pipe. The drill could slip out of the hole and cause injuries.

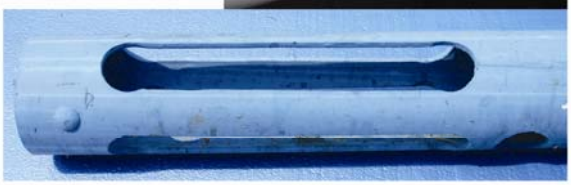
→ The drill bit can get stuck in the hole, causing the drill to rotate; wrist injuries can occur.

NOTE 1: A 1-1 1/2 inch PVC pipe, 2 to 3 foot long can be used to help the drilling process if a drill press is not being used.

4 Mark the monitoring sensor windows



- Draw two tangent lines to connect each of the 4 inch and 15 inch holes.
- Employing a jig saw or any other type of saw, cut the PVC pipe to connect the two holes.



→ Four windows will be created.

5 Smooth the hole edges

Sanding the Guard Pipe at Jordan Marina

- File and sand the holes to smooth the edges.

6 Place bolt-stoppers

To ensure the monitoring sonde will be positioned at the windows depth when deployed, two small bolts are placed at the end of the pipe to act as stoppers. The monitoring sonde will rest on these bolts when deployed.

- Drill a 5/16 inch hole at 5 cm from the bottom of the PVC pipe.

→ One hole between the Pt 1 and Pt 2 lines, and the other hole between the Pt 3 and Pt 4 lines.

→ 1 in - 5/16 galvanized or stainless steel bolts are placed inward. One or two nuts are used to tighten the bolts in place.

NOTE:

→ The pipes should have an open bottom so that if debris enters it can fall out.

→ It is a good practice to avoid using only a long bolt at the bottom of the pipe to hold the sonde in place. There are two drawbacks: first, a long stainless steel bolt may affect turbidity readings and second, a long bolt does not permit an adequate cleaning of the pipe.

7 Antifouling coating

Precautions with antifouling coating

Antifouling paint is generally toxic. Careful attention must be given to how the paint is handled and applied. Some precautions for handling and using the antifouling paint are:

Handling - Storage

READ AND FOLLOW THE MANUFACTURER'S INSTRUCTIONS AND SAFETY PRECAUTIONS.

The label displays a number of warning and safety issues which indicate those areas where particular care should be taken.

- Ensure a well ventilated working area.
- Avoid prolonged or repeated skin contact.
- Avoid contact with eyes.
- Avoid breathing in fumes vapors or over spray mist.
- Keep away from all sources of ignition.
- Do not store or use in close proximity to strong oxidizing agents (*i.e.* peroxides, hypochlorites).

Protective Clothing and Equipment

- Always wear the personal protective equipment specified on the label or in the MSDSs.
- Remove watch straps as these can trap paint particles next to the skin.
- Wear safety glasses, goggles or suitable face shield; protective gloves, suitable outfit to protect your clothes (e.g. lab coat, apron).
- Use proper respiratory protection (organic vapor respirator).
- Skin protectan cream can be helpful.

Cleaning

- Never use solvent or thinners to clean the skin.
- Remove immediately any paint that does get onto the skin by washing with warm water and soap or an approved skin cleanser.
- Wash hands after use and before eating, drinking or using the toilet.
- Wash contaminated clothing before re-use, and clean personal protective equipment before storing or re-using.
- After washing, apply a skin conditioner.

NOTE: If a power painter spray is going to be employed, it must be noted that spray painting creates additional health hazards. Spray mists should NOT be inhaled and special equipment is required. Use air-supplied respiratory protection that is NIOSH approved.

Setting up the painting area and tools

- Paint the guard pipes in open air; in a well-ventilated area.
- At the 70 inch (180 cm) tape the guard pipe with duck-tape or masking tape to mark the end of the painting section.
- Place the guard pipe in a convenient position.
- Place plastic, paper or other conventional cover on the floor to collect paint drips.

Paint the guard-pipe

Clean PVC pipe with a degreaser

Using brushes or rollers

- Paint the inside of the pipe using the long thin brush. Paint through the holes while rotating the pipe.
- Paint the outside of the pipe with a cheap brush or a roller.

Using brushes or rollers to paint the outside
Using pole and sponge to paint the inside

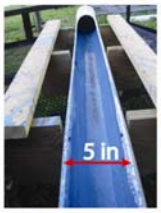
- Prepare the painting pole.
  - Cut a clean-up sponge to a convenient size.
  - Tape the sponge to one end of the pole with duck-tape.

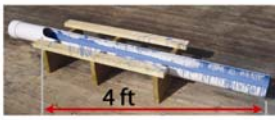
- Paint the inside of the pipe with the painting pole.
- Paint the outside of the pipe with a cheap brush or a roller.

Submerging the pipe in the paint

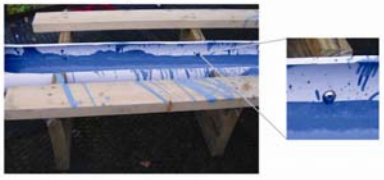
A painting tub is built with a 6 inch PVC pipe.

This is a good method to use when painting several pipes at the same time.





- Using a jigsaw make a 6 feet long 5 inches wide opening in the 6 inch pipe.
- At the close end, glue the 6 inch cap.
- Make a support structure to place the 6 in pipe and screw the pipe to the structure.



Fill the pipe with antifouling paint. Place small pieces of board at the bottom of the structure legs to level it so the paint covers the area of the guard pipe to be painted but does not leak out by the open end.

Once the pipe is painted, lift it to a vertical position and let the excess paint drip off into the 6 inch painting pipe-tub.

Given the great amount of paint employed at one time, special care must be taken to minimize spills during the whole painting process.

Usually two coats are required. Given the over coating time ranges from 8 to 15 hours, it is recommended to paint the second coat on the next day.

Dispose of all paintbrushes, gloves, papers, rollers and any other painting tool or equipment properly.

8 Preparing the safety lock system

A variety of methods exist to secure the multiparameter sensor in the guard-pipe to prevent vandalism.

The method to select will depend on the site risk factors.

Two simple safety systems are shown in this section:

Bolt-Padlock system

Drill a 3/8 inch hole at the end of the 8 in - 9/16 hex bolt.

Drill two 3/4 inch opposite holes in the 4 inch coupling.

Check that everything fits together.
The coupling will be glued to the guard-pipe during station deployment.

Cap-Bolt-Padlock system

- Cut the chain to the appropriate length.
  - During station deployment, two 3/4 inch opposite holes will be drilled in the guard-pipe to place the 8 inch bolt. The chain will be secured to the bolt. Therefore, the chain length will determine where the holes will be drilled
- Using a galvanized carriage bolt, secure a chain to the cap as shown in the figure.

- Place at the end of the chain a split link if the width of the chain is not big enough to accommodate the 8 inch bolt.

- The multiparameter sonde can be hanged from the 8 inch bolt using a rope, stainless steel wire or chain.
- Another option to hold the multiparameter sonde is to use a PVC pipe. This is a good alternative when the sonde will be placed in areas where wave action can shake the sonde at low water. A small weight is attached to the PVC pipe to provide extra mass to hold the sonde in place.
  - Make sure the rope, wire, chain or PVC pipe is long enough for the sonde to rest on the bolts-stoppers

Locking System - Nexsens Technology

- Another alternative to secure the data sonde is to hang the it from to the cap.

This is a good alternative if:

- The bolt or flat bar (where the padlock is secured) goes through the cap
- There are some safety concerns that the hanging rope can be dropped accidentally in the tube when the bolt is removed

One option to achieve this is to drill a hole at the top of the cap to place a 3-4 inch carriage bolt (*e.g.* 9/16 in diameter). A hole is drilled at the end of the bolt so a carabiner, quick link or a snap hook can be placed.

MWSS MFG, Inc.

- A flanged end-cap or a self-closing sewer cap can also be used. These type of caps have the advantage of having a good surface area around it or a handle that facilitates taking the caps off.

The National Park Service (2006) employs an eye bolt installed on the underside of the cap to hang the datasonde. The threads of the bolt are scuffed after the nut is placed as a security measure so the nut cannot be removed.

National Park Service - Southeast Regional Office

3.3 EXAMPLES OF OTHER PIPE-GUARDS

In the following, some examples of other guard-pipe designs are given for illustrative purpose only.

- → Figure 3.3 shows guard-pipes designed by AMJ Environmental, YSI Incorporated.
- → Figure 3.4 shows a guard-pipe designed by Nexsens Technology.
- → Figure 3.5 shows a guard-pipe used in the continuous water-quality sampling programs of the Province of British Columbia, Canada.
- → Figure 3.6 shows a guard-pipe used in high-flow environments.

Figure 3.3 Guard-pipe by AMJ Environmental, YSI

Figure 3.4 Guard-pipe by Nexsens Technology

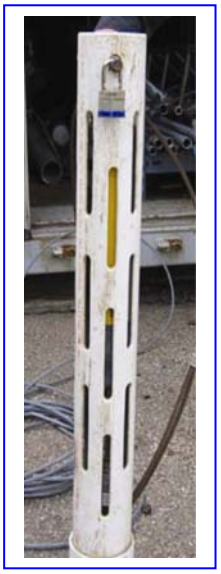


Figure 3.5 Guard-pipe by The Province of British Columbia

Even though, all the designs have different layouts and styles of holes, each one maintains the critical design factor, an adequate opening system to allow a free flow of water through the pipe.

If the monitoring site is in a high-flow environment, it is recommended to add additional protection to the sensors (BC Ministry of Environment, 2007). This can be done by cutting only two or three windows at the bottom part of the guard-pipe to guarantee a good water flow and leaving a solid part that can be faced upstream to provide the additional protection from the fast moving debris (Figure 3.6).

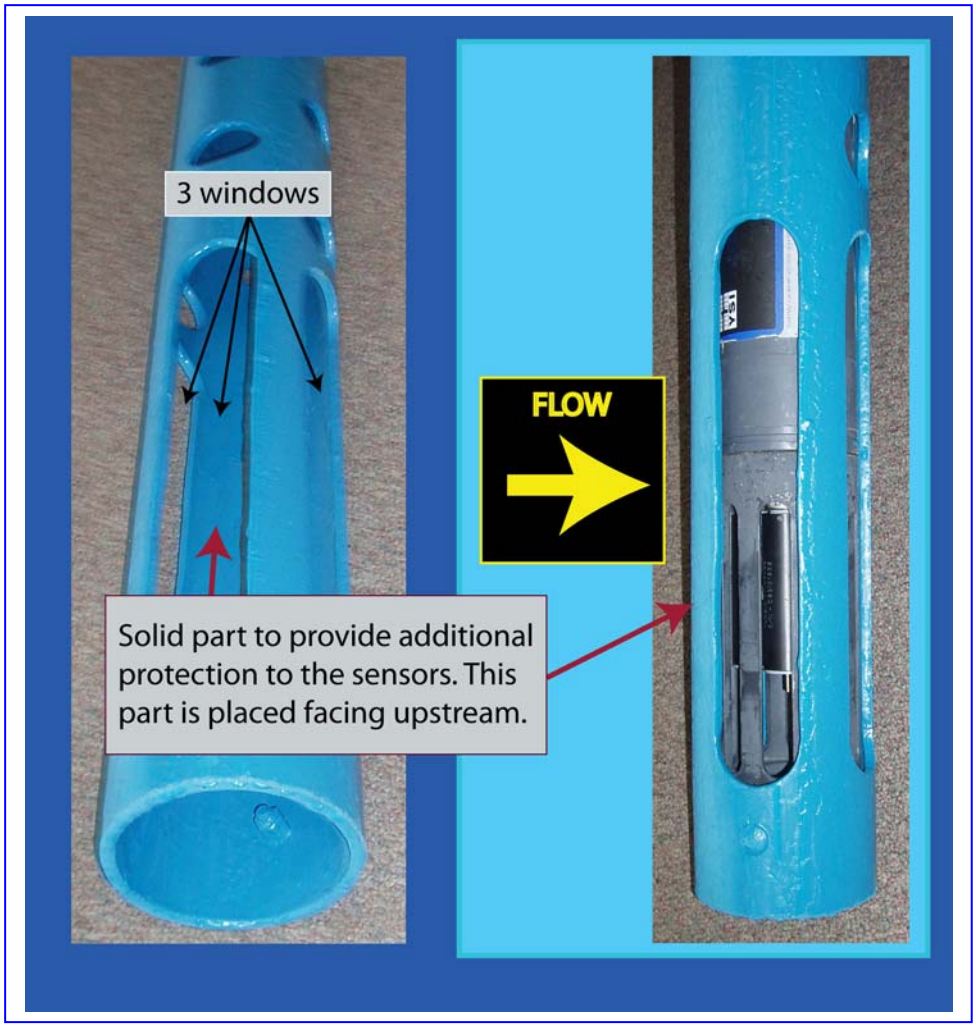


Figure 3.6 Guard-pipe for high-flow environments

3.4 PORTABLE PIPE-GUARD

Portable guard-pipes can be constructed to protect handheld multiparameter sondes (*e.g.* sondes to be used with the YSI MDS 650).

The same design principles must be applied to assure the same aquatic environmental conditions inside and outside the pipe.

For example, a portable guard-pipe for the YSI 600XL sonde is shown in Figure 3.7. This device is used to perform vertical profiling in high water flow environments.

Figure 3.7 Guard-pipe for YSI MDS 650

3.5 REFERENCE

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3.5.1 Photo Reference

Photo Locking System – Nexsens Technology, Page XX. http://www.nexsens.com/

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Photo National Park Service. Page XX. National Park Service. 2006. **Core Parameter Fixed-Station Water Quality Monitoring**. Southeast Regional Office. Natural Resource Report . PS/SER/SECN/NRR—2007/xxx. http://science.nature.nps.gov/im/units/SECN/docs/3.1._Core_Parameter_Fixed_Station_WQ.pdf

Figure 3.3 - Guard-pipe by AMJ Environmental, YSI Incorporated.

Figure 3.4 - Deployment Pipe Assemblies. Nexsens Technology. http://www.nexsens.com/products/deployment_pipe_assemblies.htm

Figure 3.5 – Photo by Frank van der Have. An Example Of A Slotted Deployment Tube. BC Ministry of Environment. 2007. Continuous Water-Quality Sampling Programs: Operating Procedures. Watershed and Aquifer Science. Science and Information Branch. The Province of British Columbia. Resources Information Standard Committee. http://www.ilmb.gov.bc.ca/risc/pubs/aquatic/waterqual/assets/continuous_waterqual.pdf