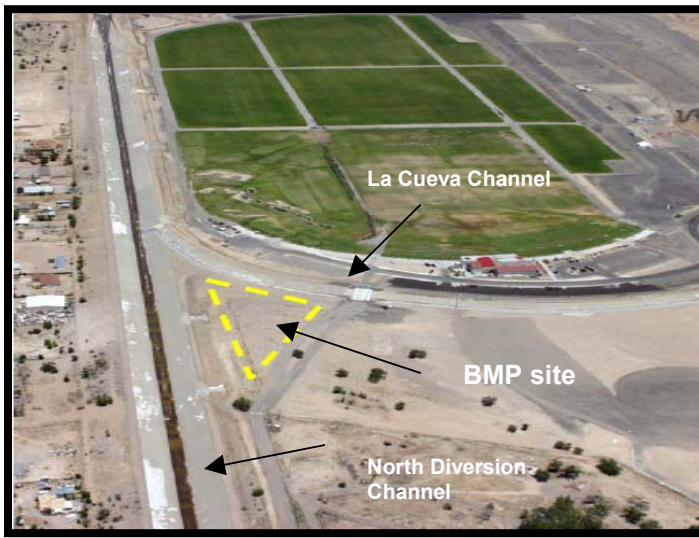


Debris Removal Structure at La Cueva Arroyo

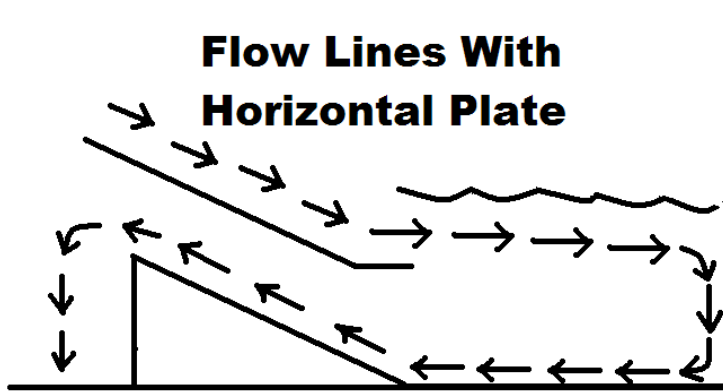
AMAFCA is currently planning a debris removal structure at the La Cueva channel prior to its discharge into the North Diversion Channel. The size is limited due to the agency having only about 1/3 of an acre of land available for use. Normally water would be diverted into a BMP structure and pass into a sedimentation pond however, water will most likely be diverted directly into the North Diversion Channel from the BMP structure.⁶



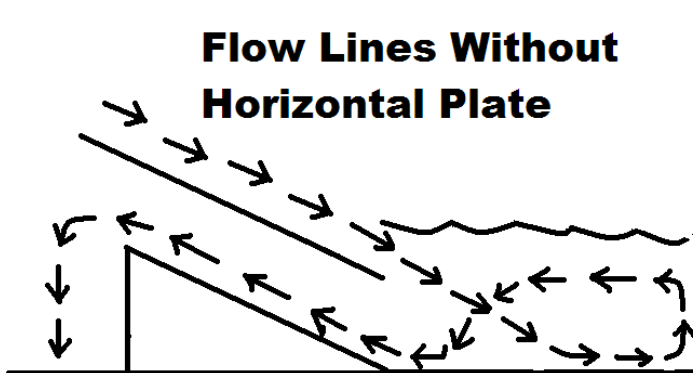
La Cueva Channel BMP site
(top grassy area is Balloon Fiesta Park)

The La Cueva Channel has a 20 yr storm flow of approximately 150 cfs and AMAFCA wants to divert this flow into the BMP structure for treatment. The velocity of the channel water is a very high 20-25 ft/s. AMAFCA prefers simple hydraulically driven systems with little or no grating. They also prefer BMP's that are easy to maintain and clean. Designing a structure of this nature is no easy task, but through the use of fluid mechanics a suitable design was made.

The Reverse Flow Debris Filter or RFDF uses the concept of reversing flows to create dead zones, and manipulate water currents so that most of the storm water can only leave the structure through a certain path. To remove floatables and neutrally buoyant material, the current would need to be manipulated so that the upper 2/3's of the water cannot pass through the structure since this is where these materials lie. In doing this the bottom current would speed up as water exits, being that dense matter and sedimentation do not need to be removed then the structure basic theory would be adequate.

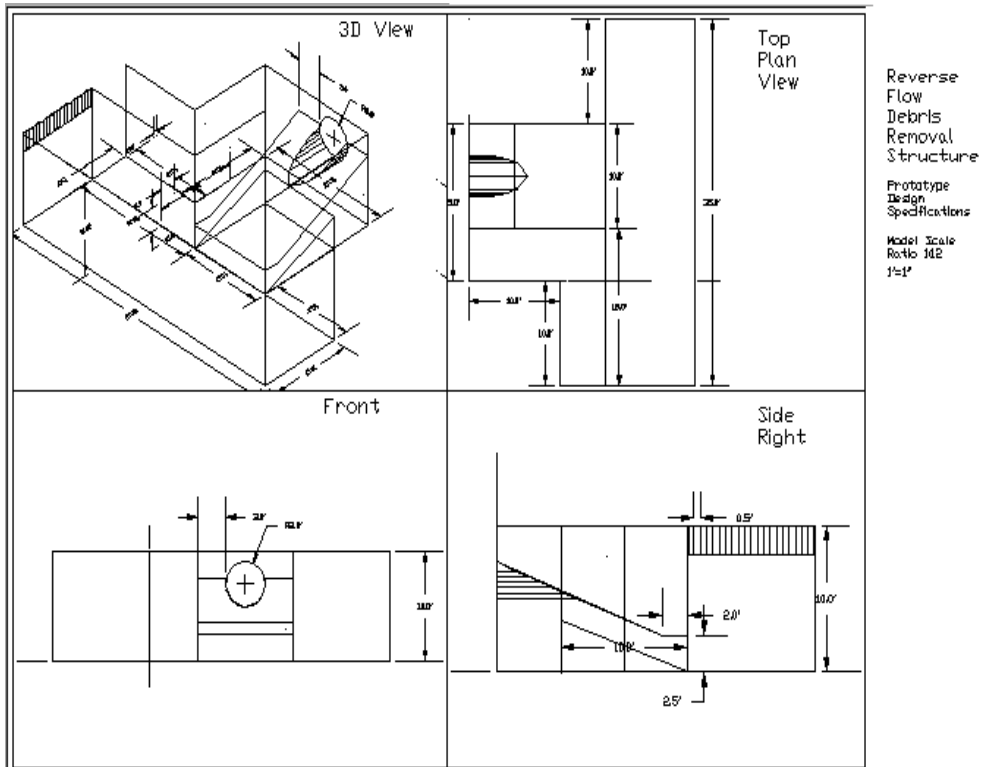


The above diagram shows elementary flow lines that describe the general flow of the system. At the bottom of the ramp is a horizontal plate that pushes flow away from the discharge point by creating a hydraulic jump. Only water and debris entering the bottom current can leave the structure.

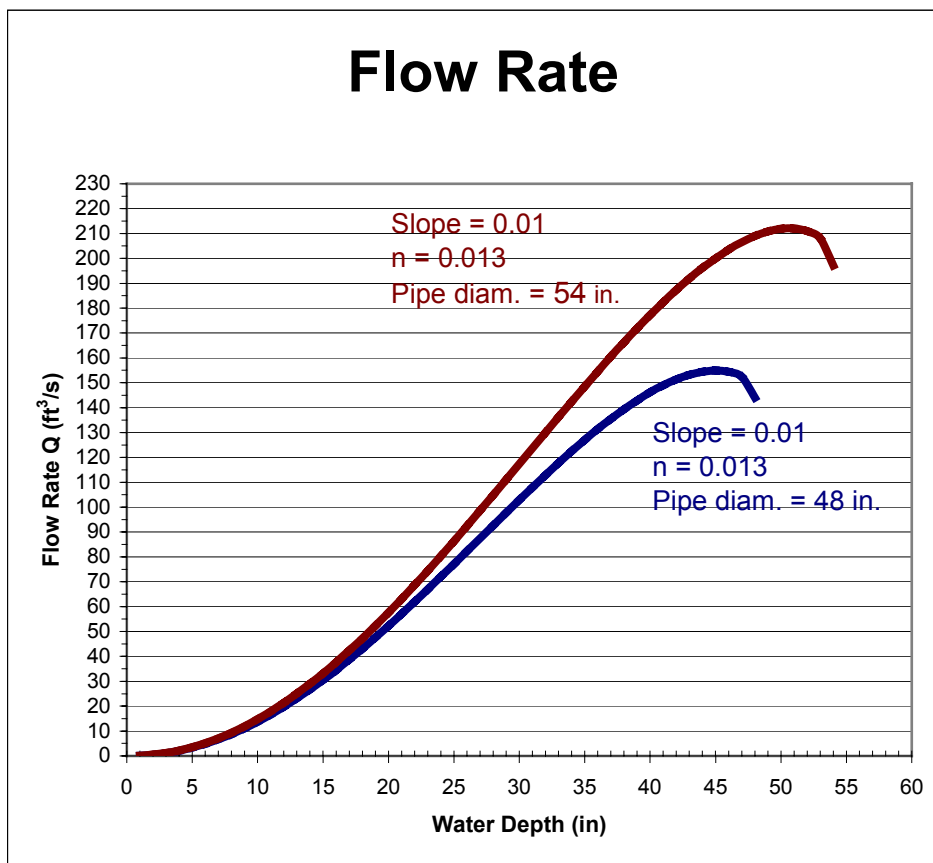


Without the horizontal plate installed the water flows in a circular channel which creates a strong current in the top and middle water zones. Debris would be pulled toward the discharge and although the floatables would not be able to sink and exit, neutrally buoyant material would be pulled right through the structure.

RFDF Design



Manning's equation for flow was used to determine the pipe diameter needed to handle the 150 cfs flow rate. Different standard pipe sizes were modeled in excel and are graphed below.



Manning's Equation for Flow

$$Q = (A * R^{2/3} * S^{1/2}) / n$$

A = Area of flow segment of circle

$$R = A/P$$

P = Wetted Perimeter = wetted arc of circle

D = depth of flow

n = coefficient of roughness

S = Slope

Using a slope of 1 to 100 and a roughness coefficient of 0.13 for concrete lined channels, a 48 in. pipe with a max Flow Rate Q = 158 cfs of was selected for the prototype structure.

The model scale was selected to be a 1:12 scale for simplicity and size. The collection tank was sized according to a 20s flow.
 $(150 \text{ cfs} * 20 \text{ s}) = 3000 \text{ ft}^3$.

Froude's equation of similitude was used to select appropriate flow rates for testing.

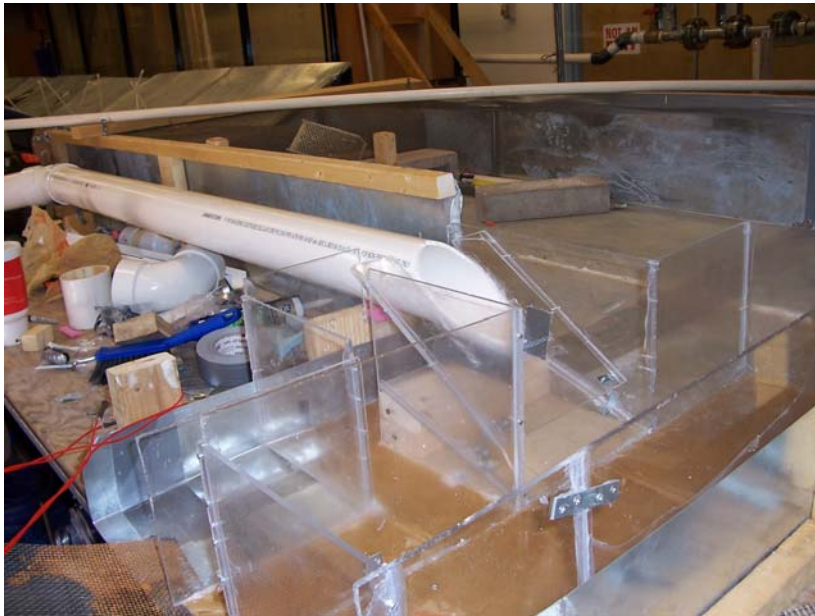
$$F_r = V/(gl)^{1/2}$$

$$V_p/(gl_p)^{1/2} = V_m/(gl_m)^{1/2}$$

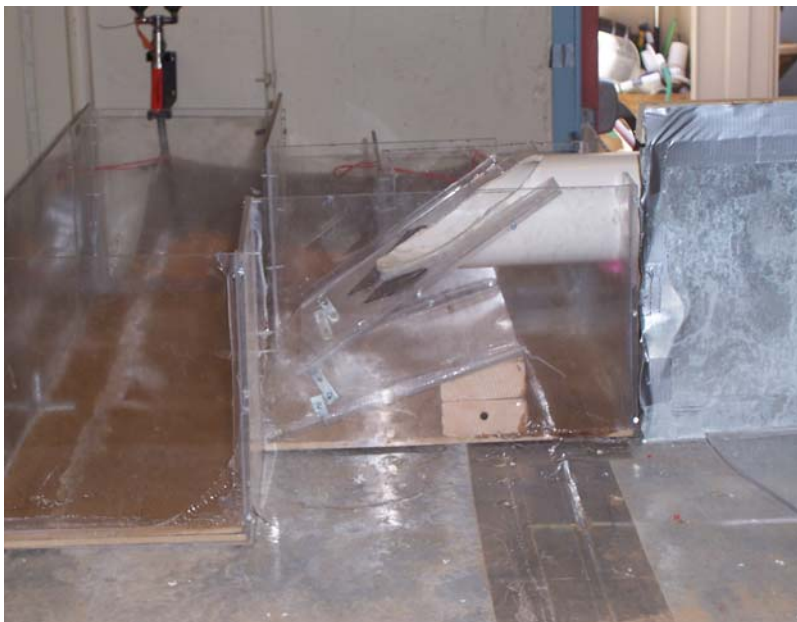
V = velocity

g = gravity

l = length



The model was built out of Lexan so that the water and debris flow could be easily seen.



Test Procedures

Two tests were run at different flow rates using 3 different material types to simulate floatable, neutrally buoyant, and dense materials. The first test was run without a horizontal plate at the end of the flow ramp. (Figure 2) The second test was run with a horizontal plate installed at the end of the ramp. (Figure 1) Both tests consisted of five pieces from each group being placed within the RFDF for 5 minutes at 5 different flow rates. After the 5 minutes the flow was dropped and the number of material from each group retained was counted. This test was then repeated 3 times.



Floatable Debris



Neutrally Bouyant



Dense Material

Results

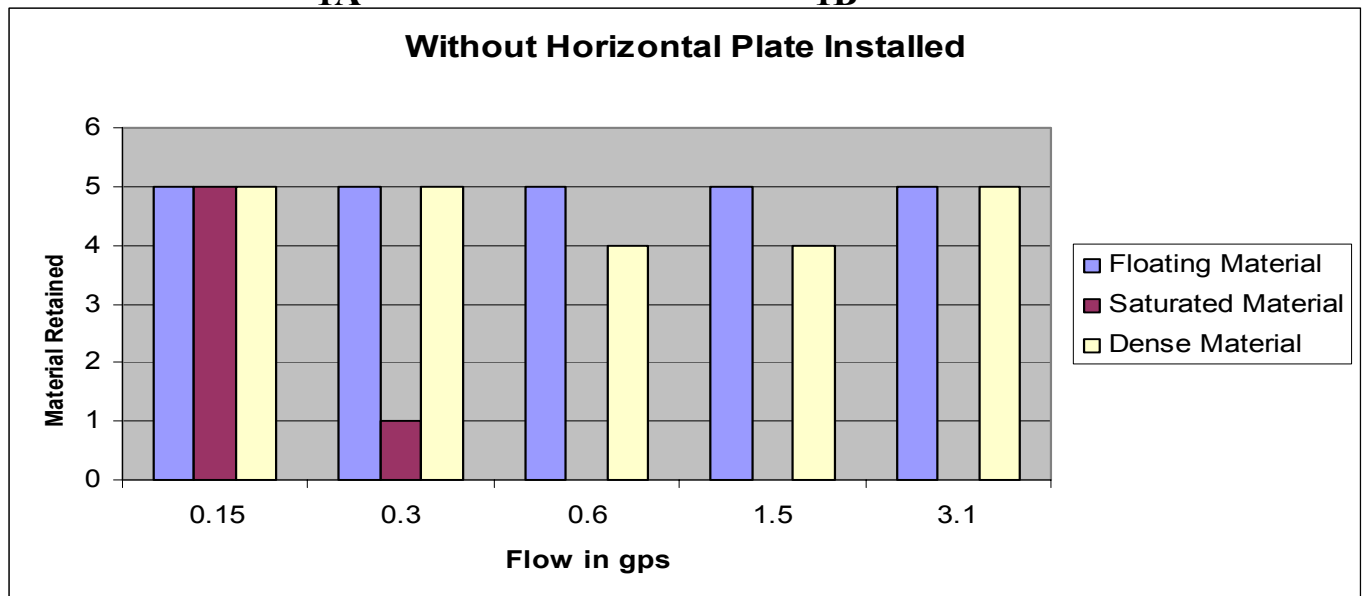
Test 1



1A



1B

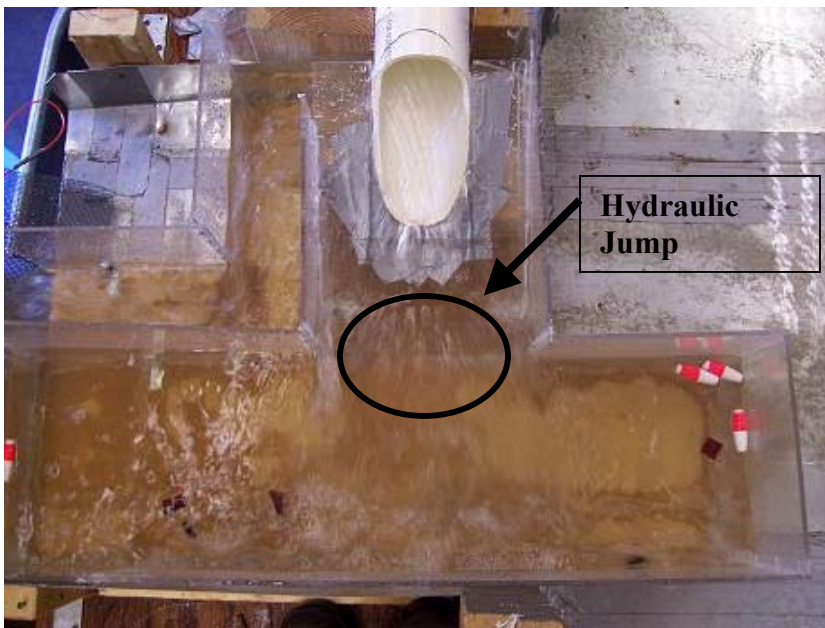


Without the horizontal flow and hydraulic jump at the end of the ramp, floatable material collected near the water entrance/exit point as can be seen in picture 1A and B. Neutrally buoyant material passed through the structure at nearly all flow rates. This design is not adequate because it did not meet 2 of the AMAFCA standards. It did not separate neutrally buoyant material, and it did not collect debris in a manner that would be easily cleaned.

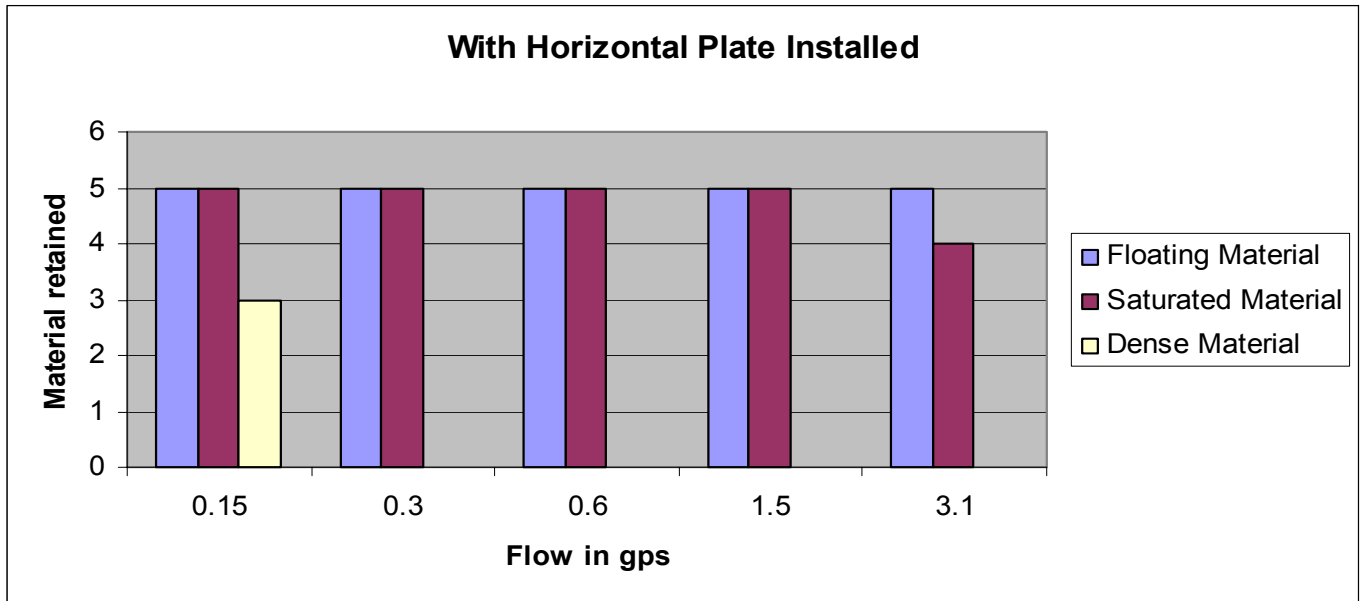
Test 2



2A Models Horizontal Plate at end of Ramp



2B



With the horizontal plate installed the RFDF retained all floatable debris as well as almost all neutrally buoyant material at all flow rates. The hydraulic jump created by the flow also pushed the debris into the edges of the holding chamber as can be seen in picture 2B. The model performed better than expected and met all AMAFCA design preferences.

Recommendations

The test model performed very good and if the model was used a plate at the bottom of the ramp would be required to remove floatables and neutrally buoyant material. If higher removal was desired the RFDF could be linked in a series with flow entering the system at different angles. If two were linked in series 1 with the horizontal flow and one with the angled flow, it would be expected that the removal performance would be very high. In the same respect a grate could also be added at the discharge point to remove 100% of material smaller than the apertures. Since most debris won't be introduced to the screen to begin with, clogging would not be expected. In addition, since water will flow back into the structure when flow stops, the grate will self clean between storm events.

References

¹www.epa.org

²www.freshcreek.com

³www.cdstechnologies.com

⁴www.springsgov.com

⁵www.lastormwater.org

⁶www.amafca.org