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3D NUMERICAL INVESTIGATION ON SETTLING BASIN LAYOUT

A case study on Mai Khola Hydropower Project, Nepal

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FOREWORD

This report titled "3D Numerical Investigation on Settling Basin Layout" is a master thesis for the Master of Science in Hydropower Development and submitted to the Department of Hydraulics and Environmental Engineering, Norwegian University of Science and Technology, Trondheim, Norway.

The main aim of this thesis work is to do three dimensional numerical investigations on settling basin layout for finding optimum layout and geometry with respect to hydraulic, sediment distribution and trap performance by using the SSIIM model. In this thesis work, a case study on settling basin of Mai Khola Hydropower Project of Nepal has carried out.

The required data for this thesis work was collected from Sanima Hydropower (P) Limited (developer of project) and Hydro Lab (P) Limited. The study is carried out from January 2012 to June 2012 and this report is an outcome of the study during my thesis work.

I certify that the work and result presented in this report is my own and that all source of information, any significant outside inputs and contributions have been fully acknowledged.

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EXECUTIVE SUMMARY

This study is about 3D Numerical Investigation of Settling basin layout by using numerical modeling program SSIIM. This study is carried out by using SSIIM windows version 1 (SSIIM 1.0). SSIIM is numerical modeling software, developed at NTNU by Professor Nils Reidar B. Olsen. This program has been used for investigation numerical modeling of hydraulic and sediment transport for different layouts geometry of settling basin.

In this study a case study has carried out on settling basin layout of Mai Khola Hydropower Project, Nepal. Hydraulics performance of proposed layout and one alternative layout with shorter approach is numerically investigated by water and sediment flow computation. For the Numerical investigation structured grid for settling basin layout has developed with the help of drawing provided and excel spread sheet program. Hydraulics performance is investigated for design discharge with constant flow. The hydraulic performance of closing of one chamber and operation of remaining chamber with design discharge of power plant is also investigated. Based on water flow computation result, sediment computation was carried out for one settling chamber, proposed, alternative and modifications of proposed layouts. Effect of approach geometry on distribution of sediment on four chambers of settling basin and sediment trap performance were studied by sediment flow simulation. Effects of closing of chamber on distribution of sediment concentration were also investigated with the help of sediment simulation. Trapping efficiency is evaluated for one settling chamber, proposed alternative and modification layouts and closing mode models. Trap efficiency of one settling chamber model is compared with trap efficiency by analytical method.

Based on hydraulic performance, sediment distribution performance and trap efficiency performance; recommendation of modification on approach geometry has made. Also, studied result shows that SSIIM 1.0 version can be used for investigating performance of hydraulic structures and settling basin.

CONTENTS

ANNEXURE

Annexure-A
Drawing

Annexure-B
Grid Generation

Annexure-C
Result

APPENDIX

Appendix-A
Inputs files for SSIIM Model

Appendix-B
Trap Efficiency Calculation by SSIIM Model

Appendix-C
Trap Efficiency Calculation by Analytical Method

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATIONS

c	Sediment concentration
CFD	Computational fluid dynamics
ε	Epsilon
Γ	Turbulent diffusion coefficient
HPP	Hydropower Project
i	i direction
j	j direction
k	Turbulence kinetic energy
km	kilometer
km^2	kilometer square
kg/s	Kilogram/second
m	meter
m/s	meter per second
M	Striker's roughness value
m^3/s	Cubic meter per second
masl	meter above sea level
MW	Mega watt
NTNU	Norwegian University of Science and Technology
PPM	Parts per million
PSD	Particle Size Distribution
Sediment size 0	All size of sediment Size 1 to Size 5
Sediment Size 1	Sediment size of 0.3mm
Sediment Size 2	Sediment Size of 0.2 mm
Sediment Size 3	Sediment Size of 0.15 mm
Sediment Size 4	Sediment Size of 0.1 mm
Sediment Size 5	Sediment Size of 0.06 mm
s	second
SSIIM	Sediment Simulation in Intake with Multiblock option
u	Velocity on X direction

1. INTRODUCTION

All of the Himalayan Rivers have problem of sedimentation. Sediments are fragments of rock and minerals, loosened from the surface of the earth due to weathering processes and the impact of rain and snow, blowing winds, flowing water and moving glaciers. When fragmented material is carried by water motion, wind and other means, sediment transport occur.

Himalayan rivers have huge potential of power generation because of Himalayan rivers are originated from the snowcapped mountains, glaciers, regular monsoon rain and with high river gradient which provided substantial head for power generation. In spite of enormous power production potential of Himalayan Rivers, the rivers provide some of the greatest challenges in power project and other water resource development. An important challenge of developing power project in Himalayan Rivers is the difficulty of operation and maintenance of the plant due to large quantity of sediment inflow with hard and abrasive minerals. Most of power plants in the Himalayan Rivers are affected by excessive sediment which decrease capacity of reservoir and cause erosion of turbine components. Also sediment decreases the efficiency of turbine which reduces the power production. Erosion of turbine components mostly depends upon mineral content, shape and size of sediment particle flow through turbine. Power plants in Himalayan Rivers are typically high head so turbines are more affected by sediment.

Due to higher inflow and adverse effect on power production, sediment should be trapped before flow for feeding power plant. Most of power plants in river with sediment problem, there must be sediment trapping system. Generally, in the Himalayan river headworks, settling basin is built for trapping suspended sediment particle. Settling basin is one of major component in such river with respect to cost and energy generation. The performance of settling basin is depended upon its ability to trap suspended sediments and its ability to remove the trapped deposits from the basin. Performance of settling basin can be studied by Physical modeling and Numerical modeling before implementation.

It will be never be possible to trap all suspended sediment in trapping system. However, most of sand fractions of suspended sediment should be removed before flow to power generation to maintain the hydraulic transport capability of the waterways, reduce the sediment load on turbine and minimize wear and efficiency loss and obtain the require power generation regularity.

1.1 Background

Due to high sedimentation problems in Himalayan Rivers especially in Nepalese rivers, sustainability of project is in questioned. In Nepalese hydropower projects, sediment can have a detrimental effect on the life of the various components. Due to high concentration and hard mineral sediment, wear and tear of turbine components is very high which reduce turbine efficiency and increases operational and maintenance cost. Energy production is cut during maintenance period. This will affect overall economic of project. On other hand, most of project in Himalayan River have high head. High head plants which are subjected to more vulnerable with sediment. To ensure good performance of plant, sediment should be trapped as much as possible before feeding to power plant.

To minimize sediment flow to power plant, there are different intake arrangements have been practiced. However, all suspended sediment could not be bypass by such efficient headworks arrangement. Efficient settling basin should be provided for trapping fine sediment.

The trap efficiency of settling basin is mainly governed by the geometry of basin, i.e. size, shape. Larger basin will have more capacity to trap sediment while shape is important with respect to flow distribution. Due to economic and space restriction of site large settling basin may not possible to build. A good shape will produce an even flow distribution in the basin and maintain optimum trapping efficiency. So the hydraulic design of settling basin arrangement should secure an even flow distribution for various discharges, efficient of deposits during flushing of basin.

It is very important to know performance of headworks and settling basin during planning phase. Performance of headworks and settling basin can be checked by Physical modelling and Numerical modelling test. Computational fluid dynamic (CFD) model is developed for numerical modelling practice. In practice, Physical modelling has been used to find the performance of prototype. However, Physical model test is more expensive and time consuming. Due to advancing in computer technology, there is several numerical modelling software. The software has been used for numerical modelling test. Due to complex nature of flow dynamics of water, it is very difficult to developed numerical model. However, numerical model test is less time consuming and also cheaper than physical modelling test. Numerical model can be idle solution for small project where funding is less and physical modelling test may not feasible due to cost and shortage of time. On other hand physical model test has its own limitation. It is very difficult to do physical modelling test for suspended and small size particles. It is very hard to find natural material to model such suspended and small size particle. Settling basin is generally subjected to suspended particle. In such case numerical model gives more reliable results. On other hand it will be more costly and time consuming to investigate by physical modelling for different shapes and geometry of structures. Numerical Modelling will be best solution of such studies in planning of large projects.

1.2 Objectives

Among the civil work at Hydropower project, headworks arrangement, settling basin is one major component with respect to cost and performance. It is very important to optimize size of settling basin for a hydropower project. Especially for small hydropower project the cost variation for settling basin might be substantial.

The objective of this thesis work is to use numerical model for investigating hydraulics of settling basin. Here SSIIM[1] is used for investigation performance of settling basin layout of Mai Khola hydropower project of Nepal. Effect on hydraulics and sediment distribution on settling chambers with different modification on approach culvert will be investigated.

Here simulation will be done for prototype and performance of settling basin will be investigated with different respects such as Hydraulic performance, flow distribution, turbulence, sediment distribution and trapping efficiency will be checked. After investigation, reliability of SSIIM will be accessed.

1.3 Limitation of Study

The physical model studies only included headworks. So lack of physical modelling study of settling basin, it is not possible to verify the result of this numerical investigation. Also this study does not include flushing performance of settling basin. Study of gravel trap also not included in this investigation.

Due to lack of particle size distribution of suspended sediment of river, PSD of suspended sediment is adopted as Khimti River.

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[1] *SSIIM: SSIIM is an abbreviation for Sediment Simulation In Intakes with Multiblock option. The program is designed to be used in teaching and research for hydraulic / river/ sedimentation engineering. It solves the Navier-Stokes equations using the control volume method with the SIMPLE algorithm and the k-epsilon turbulence model. It also solves the convection-diffusion equation for sediment transport, using van Rijn's formula for the bed boundary. Also, a water quality module is included. The program is developed by Professor Dr. Nils Reidar Olsen. [Olsen, SSIIM User's Manual]*

2. SETTLING BASIN

Water resources are nature's gift to human in Himalayan region. However, it is very challenging to use water resources in Himalayan Rivers due to extreme sediment loads. Reliable and efficient systems for sediment control and removal of sediment from withdrawn water will be needed for successful use of water resource in Himalayan Rivers. So sediment settling basin is one of the most important component for efficient use of water resource in Sediment River especially in hydropower projects.

2.1 Settling Basin Design

2.1.1 Design Principle

It is very important to trap sediment before feeding power plant. However, it is not possible to trap all sediments. The objective of a settling basin is to reduce the turbulence level in the water flow to allow suspended sediment particles to settle out from the water body and deposit on the bottom of the basin. Most of the particles bigger than 0.15 to 0.3 m must be excluded to minimize costs related to turbine wear and generation losses during maintenance of turbines. It is therefore required to control the sediment content in the water released for power generation .The deposits are then removed from the basin by use of the flushing system or through excavation is the amount of sediments is small. In recent year there are different sediment removal techniques has been developed. [Sediment control, D.K]

Settling basin design is guided by the fall velocity of the sediment particle which shall be excluded. The fall velocity is dependent on density, size, shape and concentration of particles and some extent of water temperature. Turbine wear generally cause by hard mineral sediment like quartz and feldspar. The water with high concentration of quartz and feldspar has high rate of erosion rate of steel. Sediment also reduce turbine efficiency and may cause blockage of water way. Settling basin design should have following objectives:

- Uniform flow distribution in both plane, vertical plane and horizontal plane.
- No dead pocket in basin at entrance or exit, and eddies should avoid
- An even flow distribution if there are more than one basins.
- Efficient removal during flushing of settling basin.

2.1.1.1 Particle fall velocity

The fall velocity is an important parameter for the understanding of sediment motion. The turbulence motion of the flow tends to detach and lift the particles but the falling motion is counteracting this effect as soon as the particles are free of the bed. The fall velocity of different size particles are shown in Figure 2.1. [Hydraulic Design, Dagfinn etl.]

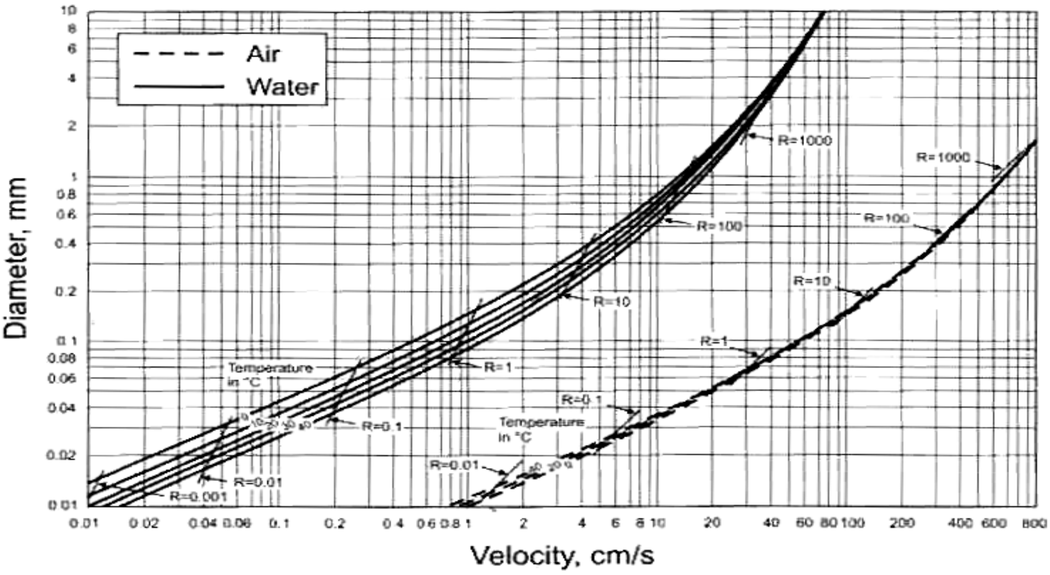

Figure 2.1 Fall velocity of quartz spheres in water and air after Rouse

2.1.1.2 Drag, lift and gravity

The water exerts force on sediment particle is referred as drag and lift. The drag force acts in the main direction of flow while lift acts transversally to the flow direction. The drag and life forces are given by following expressions.

$$F_D = C_D.A.\rho.\frac{u^2}{2} \qquad 1$$

$$F_L = C_L.A.\rho.\frac{u^2}{2} \qquad 2$$

F stands for force and C for correction coefficient, which D and L stand for drag and lift.

The third element in the stability analysis is the gravity force, which in suspended transport is balanced by the forces of the turbulent current, and in bed load motion also causes resistance due to friction against the stationary bed.

2.1.1.3 Shear stress and turbulence

Sediment transport theory is generally studied with shear stress and turbulence as determining factors for the bed because it is impossible to deal with each individual particle.

The shear stress is the average force per area exerted by the water on the bed while turbulence is defined as irregular flow motion resulting from eddies that are carried by the flow and swirling in an irregular manner. Shear stress depends on rate of change of velocity from bed to free surface above the bed level. Shear stress is result of turbulence, transferring momentum towards the bed.

Practically, direct measurement of turbulence is impossible. However if the average velocity in two points near the bed is known, it is possible to assess the effect of turbulence and calculate the bed shear stress by using following expressions.

$$u_* = 0.17 \frac{u_1 - u_2}{\log(z_1 - z_2)} \qquad 3$$

$$\tau_0 = u_*^{\ 2}.\rho_w \qquad 4$$

Where, u_* is fictitious parameter, shear velocity, and u_1 and u_2 are the two measured velocities, z_1 and z_2 are corresponding distance from the bed, τ_0 is bed shear stress, and ρ_w is the density of water.

In uniform flow, i.e. when bed and surface are parallel, the bed shear stress is found directly by combining slope, S fluid density and hydraulic radius, R. [Hydraulic Design, Dagfinn etl.]

$$\tau_0 = g.\rho_w.R.S \qquad 5$$

2.1.1.4 Start of motion

Shields combined expressions for the destabilizing forces, drag and lift, against weight or friction as the stabilizing force into a general formula for the equilibrium of particles:

$$C_s = \frac{\tau_0}{(\rho_s - \rho_w).g.d} \qquad 6$$

The famous Shield's diagram is shown in Figure 2.2. Values of C_s below the curve indicate stability against motion and values on curve indicates start of motion also labeled as critical Shield value, C_c corresponding shear stress is critical shear stress while value above the cure indicates particles are in motion.

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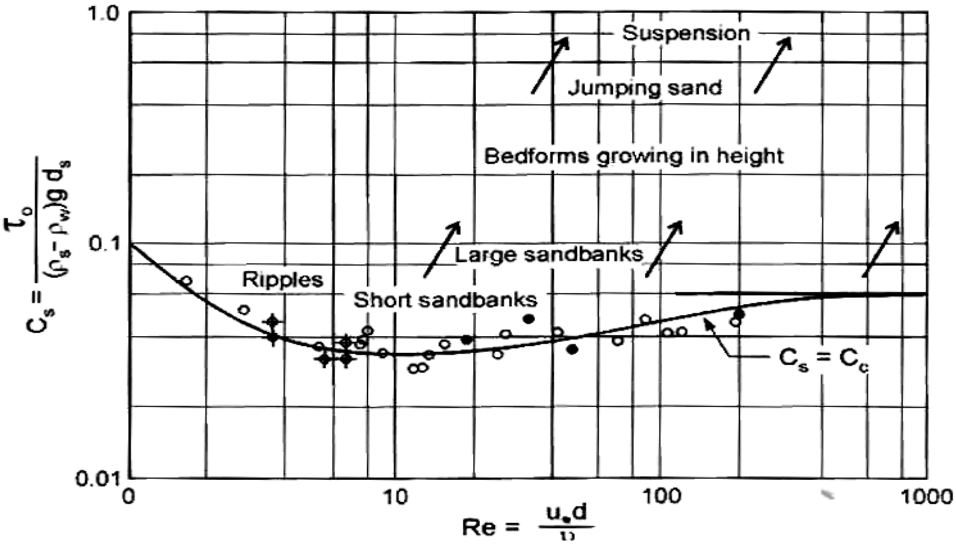


Figure 2.2 Shield's diagram for start of motion

2.1.1.5 Erosion and deposition

When the flow current able to carry material away from area than it is called erosion and if the flow current is not able to carry the sediment transport then deposition will occur.

2.1.1.6 Concentration of particle on suspension

Concentration of particle on suspension generally depends upon fall velocity of the suspension particles. Particles in suspension tend to settle down due to gravity force but due to upward component of turbulence particles remains tend to in suspension. The concentration gradient is affected mainly by the fall velocity of the particle and by the turbulence intensity. In a stable flow the concentration of particle decrease upward.

2.1.1.7 Calculation of sediment transport

<u>Bed load transport</u>

There are many formulae have developed for calculation of bed load transport. Generally following formulae are used for calculation bed load transport.

$$g_s = 10.q.S.\frac{\tau_0 - \tau_c}{\left(\left(\rho_s - \rho_w\right)/\rho_w\right)^2.d_{50}} \quad 7$$

The Meyer-Peter and Müller formula was developed to fit data from step flumes, and is therefore useful in many hydropower cases with Step Rivers.

$$g_s = \sqrt{\left(\frac{g.\rho_w.S.R.(k/k') - 0.047.g(\rho_s - \rho_w).d_{50}}{0.25.\rho_s^{\frac{1}{3}}((\rho_s - \rho_w)/\rho_s)^{2/3}} \right)} \qquad 8$$

g $_s$ is the bed load by weight per unit of time and width.
q is the unit discharge of water, i.e. flow per m width
S is the slope of the energy line.
k/k' is a bed-form correction of the bed-friction
k/k'=1 for flat bed and k/k'=0.5 for a rough bed due to bed-form etc.
ρ_s and ρ_w is the density of particles and water respectively
τ_0 and τ_c is bed shear stress and critical shear stress respectively .

Calculation of suspended load

If sufficient sampling data are available, it is possible to apply following formula to compute the suspended load Q_s passing the area A at the time of sampling.

$$Q_s = \int^{A} c(y,z).u(y,z).dz.dy \qquad 9$$

Where c is the concentration of suspended sediments and u is the velocity in same point.

2.1.1.8 Velocity in the settling chamber

According to T.R. Camp, the critical velocity can be determined by following relation.

$$V = a\sqrt{d} \qquad 10$$

Where,

V = flow through velocity in m/s
d = diameter of particle up to which sediment load is desired to be removed
a = constant which is 0.36 for d> 1 mm, 0.44 for 1mm>d>0.1 mm and 0.51 for 0.1 mm>d

2.1.1.9 Dimension of the settling chamber

Generally, preliminary dimension of settling chamber is calculated by the particle approach. It is based on simple relation. If there is no turbulence inside the basin, the ratio between the particle fall velocity, w and the horizontal transit velocity in the basin is vt must be the same ratio between the fall distance.

If depth of basin is D, width B, flow through velocity 'vt' the discharge passing through the settling chamber is

$$Q = B.D.v_t \qquad (11)$$

If w is settling velocity, settling time't' is

$$t = \frac{D}{w} \qquad (12)$$

Then length of basin is calculated as:

$$L = v_t.t \qquad (13)$$

From equation 12 and 13

$$L.w = D.v_t \qquad (14)$$

From equation 11 and 14 we can find length of basin by selecting values of D, Q, vt and w.

2.1.1.10 Trapping efficiency

The trapping efficiency of a settling basin is mainly governed by the geometry. Generally size and shape are main dominating parameters. Larger settling basin will facilitate exclusion of more suspended sediment while the shape of basin is very important to produce an even flow distribution in the basin. Even flow distribution is very important to maintain optimum trapping efficiency and reduce turbulence.

It is very important to have good design of inlet and out let geometry to obtain evenly distributed flow over the depth and width of settling basin. It is very difficult to find space to obtain optimum design of inlet so guide wall or tranquillizer at inlet of settling basin might be introduced to obtain evenly flow distribution.

In preliminary studies, Camps diagram, shown in Figure2.3 may be used to find trapping efficiency.

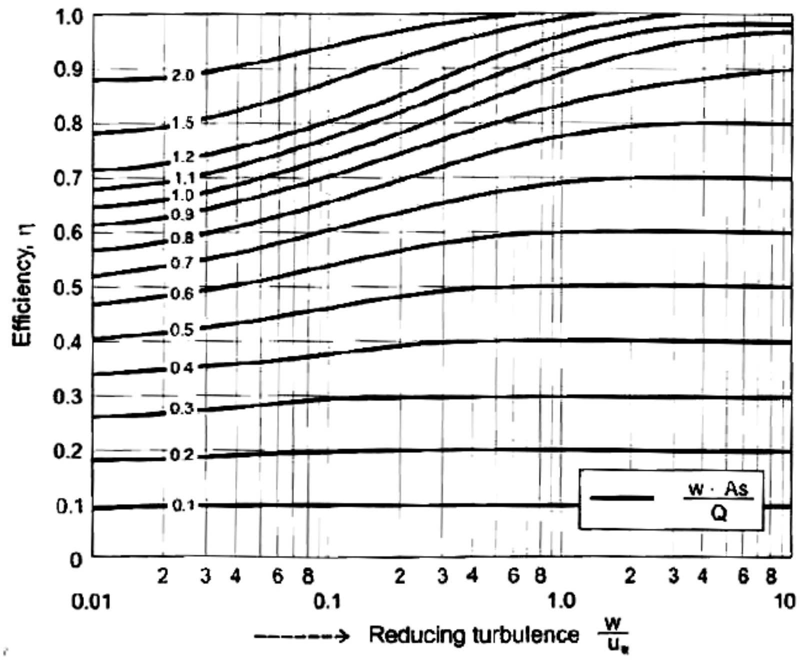


Figure 2.3 Camps diagram for trap efficiency

The trap efficiency η is found based on following parameters.

$$\frac{w}{u^*} \text{ and } \frac{w.A_s}{Q} \qquad 15$$

Where, u* is the shear velocity, w is settling velocity, As is surface area and Q discharge and shear velocity can be found using Mannings' formula for the energy gradient S_e. R is the hydraulic radius.

$$u^* = \sqrt{g.R.S_e} \text{ and } S_e = \left(\frac{Q}{M.A.R^{\frac{2}{3}}} \right)^2 \qquad 16$$

For simplified calculation of trapping efficiency Vetter method, simplified version of Hazen method also is used.

$$\eta = 1 - e^{-\left(\frac{w.As}{Q}\right)} \qquad 17$$

By applying computational fluid dynamics, it is possible to include the effect of the inflow and out flow condition in the computation of the trapping efficiency. Here, SSIIM model is used to discuss about performance of settling basin of Mai khola Hydropower project of Nepal.

2.1.2 Sediment Removal Techniques.

Deposited sediment can be removed from the basin while the basin is in operation or while the basin is out of operation. When basin is out of operation; mechanical means or different kinds of flushing systems may be used to remove settle sediment deposits.

2.1.2.1 Removal while the Basin is out of Operation

The basin is taken out of operation and de-watering of basin is taken. Deposited sediment can be removed by mechanical means or lowering water level inside the basin generating a swift flowing free surface gravity flow throughout the basin. This type of basin also called as “Conventional flushing system”. The main disadvantage of this type of flushing system is generation loss or construction of additional settling basin to avoid generation loss. However, flushing is straight forward and easy to monitor flushing process.

2.1.2.2 Removal while the Basin is Operational

Deposited sediment in settling basin is continuously flushed while basin also in operation. This can be done in two way i.e continuous flushing and intermittent flushing. However, water level and water flow must be maintained in the basin throughout the flushing period to order to maintain power generation.

Continuous flushing

Flushing flow to settling basin is abstracted continuously from the bottom of settling basin to avoid sediment deposition at the bottom of basin. About 20 to 30 % of design discharge will be required for such system. Also it is necessary to generate a current close to the particles to erode and carry the sediment particles away with the flushing flow.

Intermittent flushing

This system is same as continuous flushing. Main advantage of this system with respect to continuous is; there is no loss of water during the time between two flushing.

2.1.2.3 Serpent sediment sluicing system

It is also known as S4[2]. This has also been subjected to international patent investigations and it is protected internationally.

The “serpent” (a heavy-duty rubber tube) seals a longitudinal slit between the settling basin and a flushing canal along the bottom of the basin when it is filled

[2] *S4 system patent rights are held by SINTEF and the investor Dr. Haakon Støle.*

with water. There is a flushing gate downstream end of the flushing canal and an operation valve facilitating filling the serpent with water or dewatering the serpent so it becomes buoyant. The S4 system works in two modes. i.e closing mode and opening mode. in opening mode the serpent is gradually lifted from the slit along the bottom of basin to the surface while in closing mode the serpent gradually close the slit over the flushing canal in the bottom of the basin as it is filled with water and subjected to the suction from the flushing canal. The flushing water consumption is 10 % during flushing only. Figure 2.4 shows the S4 system. [Hydraulic design. Dagfinn ele]

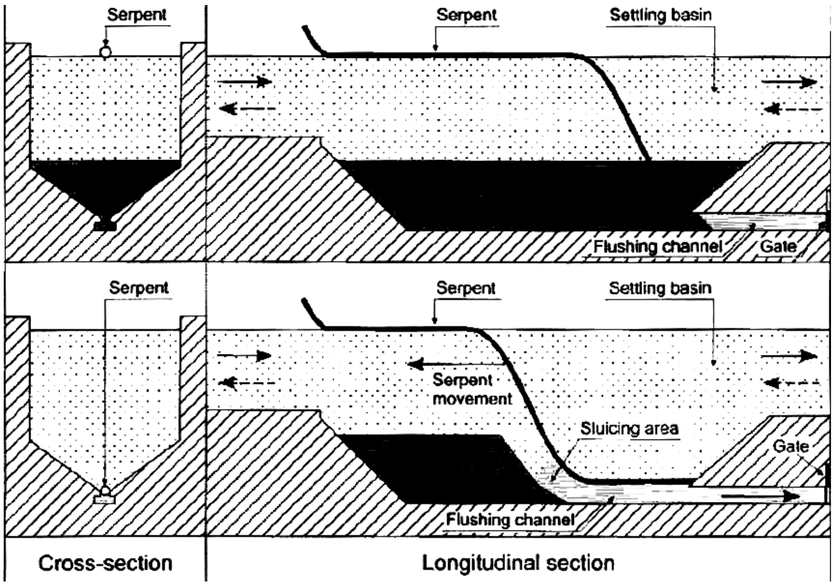


Figure 2.4 Serpent Sediment Sluicing System (S4)

3. SSIIM MODEL

3.1 Introduction

SSIIM is an abbreviation for Sediment Simulation In Intakes with multiblock option. First SSII program was developed in 1990-1991 by Dr. ing. Nils Reidar B. Olsen during his dr. ing degree at the division of Hydraulic Engineering, Norwegian Institute of Technology.

The main strength of SSIIM compared to other CFD program is the capability of modeling sediment transport with moveable bed in a complex geometry. This includes multiple sediment sizes, sorting, bed load and suspended load, bed forms and effect of sloping beds. [SSIIM User manual, Olsen]

The program is developed for teaching and research for hydraulics/river/sedimentation engineering.

3.2 Model Overview

The SSIIM program solves the Navier- Stockes[3] equations with the k-ε model on a three-dimensinal almost general non-orthogonal grid. A control volume method is used for the discretization, together with the power-law scheme or the second order upwind scheme. The SIMPLE method is used for the pressure coupling. An implicit solver is used, producing the velocity field in the geometry. The velocities are used when solving the convection-diffusion equations for different sediment sizes. This gives trap efficiency and sediment deposition pattern. [SSIIM User manual, Olsen]

3.3 Theoretical basis

The Navier-stokes equations for turbulence flow are solved to obtain the water velocity.

The k-ε turbulence model is used for calculating the turbulence shear stress.
The Navier-Stokes equations for non-compressible and constant density flow can be modeled as follow:

[3] *The Navier Stokes equations are set of coupled differential equations and could , in theory, can be solved for a given flow problem by using methods from calculus. But, in practice, these equations are too difficult to solve analytically. Presently, fast computers are being used to solve approximations to the equations using variety of techniques like finite difference, finite volume, finite element and spectral methods. The Navier Stokes equations describe how the velocity, pressure, temperature and density of moving fluid are related. The equations were derived independently by G.G.Stokes and Navier.*

$$\frac{\partial U_i}{\partial t} + U_i \frac{\partial U_i}{\partial x_j} = \frac{1}{\rho} \frac{\partial}{\partial x_j} \left(-P\delta_{ij} - \rho \overline{u}_i \overline{u}_j \right) \quad 18$$

The left term on the left side of equation is transient term; the second term is convective term while first term and second term on right side is pressure and Reynold stress term respectively.

3.3.1 The k-ε turbulence model

The eddy viscosity concept is introduced with Boussineq approximation to model the Reynolds stress term:

$$\overline{u_i u_j} = v_T \left(\frac{\partial U_i}{\partial x_j} + \frac{\partial U_i}{\partial x_j} \right) + \frac{2}{3} k \delta_{ij} \quad 19$$

The first two terms on the right side of the equation form the diffusive term in the Navier-Stokes equation. The third tem on the right side is incorporated into the pressure. The eddy viscosity in the k-ε is as:

$$v_T = c_\mu \frac{k}{\varepsilon^2} \quad 20$$

K is turbulent kinetic energy, defined as:

$$k = \frac{1}{2} \overline{u_i u_j} \quad 21$$

k is modeled as:

$$\frac{\partial k_i}{\partial t} + U_j \frac{\partial k_i}{\partial x_j} = \frac{\partial}{\partial x_j} \left(\frac{v_t}{\sigma x_j} \frac{\partial U_i}{\partial x_j} \right) + P_k - \varepsilon \quad 22$$

Where P_k is given by:

$$P_k = v_T \frac{\partial U_i}{\partial x_j} \left(\frac{\partial U_j}{\sigma x_i} + \frac{\partial U_i}{\sigma x_j} \right) \quad 23$$

The dissipation of k is denoted ε, and modeled as:

$$\frac{\partial \varepsilon}{\partial t} + U_j \frac{\partial \varepsilon}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\frac{\nu_T}{\sigma_k}\frac{\partial \varepsilon}{\partial x_j}\right) + C_{\varepsilon 1}\frac{\varepsilon}{k}P_k + C_{\varepsilon 2}\frac{\varepsilon^2}{k} \qquad 24$$

In all above equations 'c' are different constants. The k-ε model is used as default turbulence model in SSIIM.

3.3.2 Wall laws

The wall law in SSIIM is given as default by Schilichting(1979)

$$\frac{U}{u_x} = \frac{1}{k}\ln\left(\frac{30y}{k_s}\right) \qquad 25$$

The roughness, k_s is equivalent to a diameter of particles on the bed.

3.3.3 Sediment flow Calculation

In SSIIM model sediment transport is calculated by size fraction. Sediment transport generally divided in to bed load and suspended load. The suspended load can be calculated with the convection –diffusion equation for sediment concentration Equation 26.

$$\frac{\partial c}{\partial t} + U_j \frac{\partial c}{\partial x_j} + w\frac{\partial c}{\partial z} = \frac{\partial}{\partial x_j}\left(\Gamma \frac{\partial c}{\partial x_j}\right) \qquad 26$$

In equation 26, 'w' denotes the fall velocity of the sediment, and Γ diffusion coefficient, which is taken from the k-ε model.

$$\Gamma = \frac{\nu_T}{S_c} \qquad 27$$

Where, Sc is the Scmidth number, set to 1.0 as default in model. However, different value can be adopted in model.

In equation 26, the first term is for convection of sediments and the second term is due to the fall velocity of sediments and can be said as extra convection term added to the velocities in the vertical direction. On other hand side term is for diffusion of sediments. Γ is diffusion coefficient due to the mixing by turbulence in the water. It depicts amount of sediments transported through the walls of the finite volume because of turbulence and the difference in concentration between the two sides of the wall.

For this in SSIIM van Rijn's formula is used.

$$c_{bed} = 0.015 \frac{D_{50}}{a} \frac{\left[\dfrac{\tau - \tau_c}{\tau_c}\right]^{1.5}}{\left\{D_{50}\left[\dfrac{(\rho_s - \rho_w)g}{\rho_w \upsilon^2}\right]^{\frac{1}{3}}\right\}^{0.03}} \qquad 28$$

Where D_{50} = Sediment particle diameter

τ = bed shear stress

τ_c = critical bed shear stress for movement of sediment particles

ρ_s = density of sediment

ρ_w = density of water

v = viscosity of water

g = acceleration due to gravity

a = reference level set equal to the roughness height

The influence of sediment concentration on the water flow is still a matter of discussion and possess different opines.

3.3.4 Different version of SSIIM

OS/2 version and Windows version are available for users. In OS/2 version, the main user interface consists of a dialog box and a menu bar while windows version consist only one window with one menu. Here for studies, windows version is used.

In the starting of simulation, SSIIM model needs length of initial channel, width of initial channel and water depth. Figure 5.6 shows the initiation of SSIIM model. Hydraulic performances for these layouts have been compared.

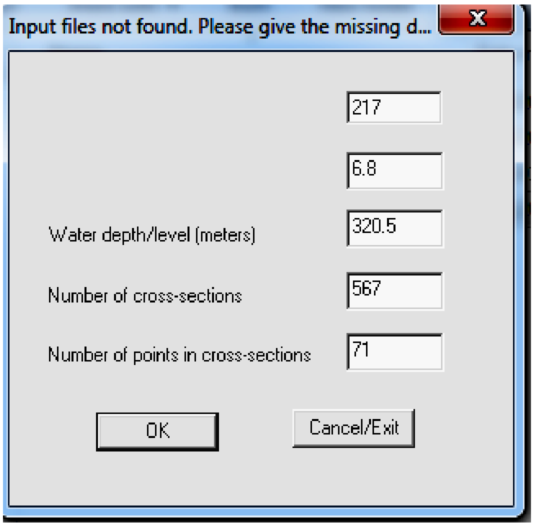


Figure 3.1 Input parameters for SSIIM Model Starting

The content of the window can be changed by choosing different sub option in the view menu. Picture of window version is shown on Figure 3.2.

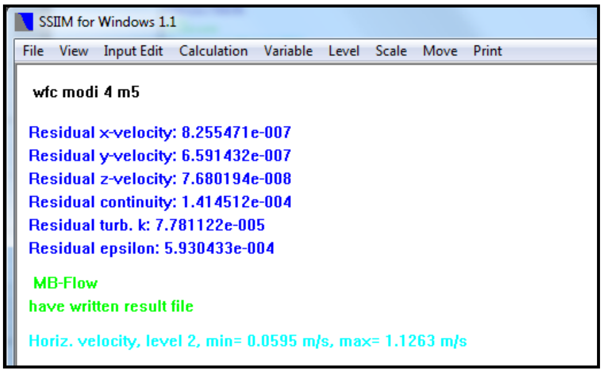


Figure 3.2 Windows version of SSIIM

3.3.5 Inputs and outputs files

Following flow chart shows different inputs and outputs files used in SSIIM 1.

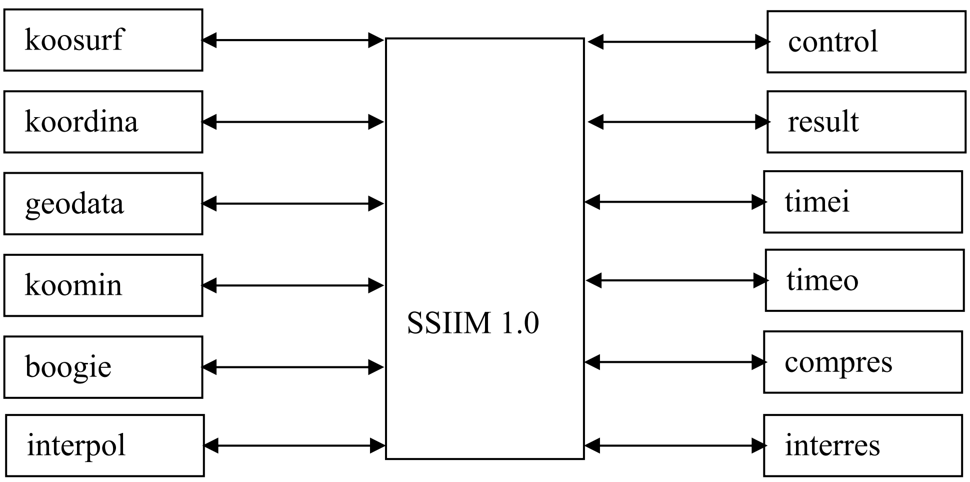
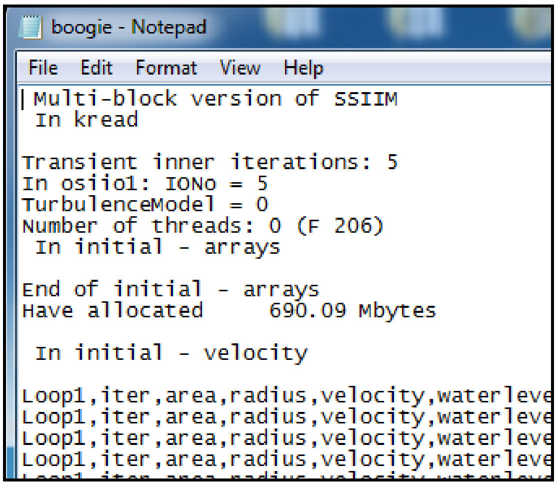


Figure 3.3 Input and output files

The boogie file

This is a file that shows a printout of intermediate results from the calculations. It also shows parameters as average water velocity, shear stress and water depth. Trap efficiency and sediment grain size distribution is also written in this file. If errors occur, an explanation is also written to this file. [SSIIM User manual, Olsen]


boogie - Notepad

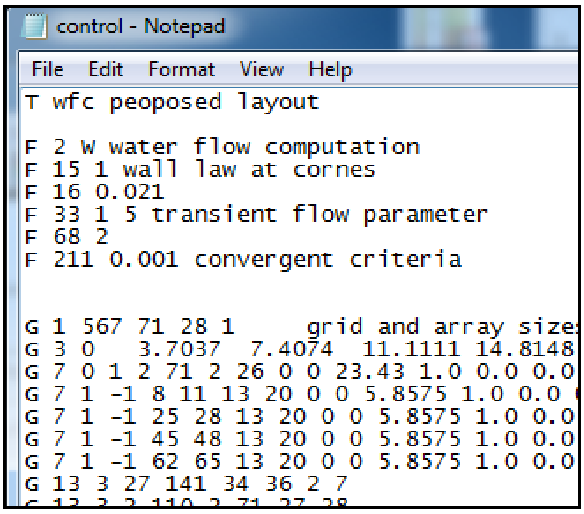
File Edit Format View Help

```
Multi-block version of SSIIM
 In kread

Transient inner iterations: 5
In osiio1: IONo = 5
TurbulenceModel = 0
Number of threads: 0 (F 206)
 In initial - arrays

End of initial - arrays
Have allocated     690.09 Mbytes

 In initial - velocity

Loop1,iter,area,radius,velocity,waterleve
Loop1,iter,area,radius,velocity,waterleve
Loop1,iter,area,radius,velocity,waterleve
Loop1,iter,area,radius,velocity,waterleve
```

Figure 3.4 Sample of Boogie file

The control file

The control file gives most of the parameters the model needs. Control file also contains most of the other data necessary for the program. The parameters are given as different data sets. For example F data sets , G data sets etc. It is an important input file of SSIIM.


control - Notepad

File Edit Format View Help

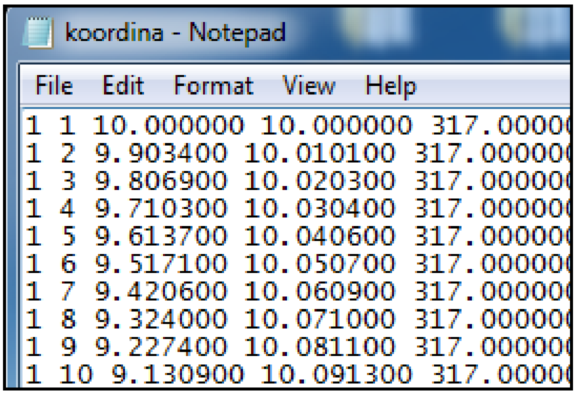
```
T wfc peoposed layout

F 2 W water flow computation
F 15 1 wall law at cornes
F 16 0.021
F 33 1 5 transient flow parameter
F 68 2
F 211 0.001 convergent criteria


G 1 567 71 28 1      grid and array size
G 3 0    3.7037  7.4074  11.1111 14.8148
G 7 0 1 2 71 2 26 0 0 23.43 1.0 0.0 0.0
G 7 1 -1 8 11 13 20 0 0 5.8575 1.0 0.0
G 7 1 -1 25 28 13 20 0 0 5.8575 1.0 0.0
G 7 1 -1 45 48 13 20 0 0 5.8575 1.0 0.0
G 7 1 -1 62 65 13 20 0 0 5.8575 1.0 0.0
G 13 3 27 141 34 36 2 7
```

Figure 3.5 Sample of control file

The koordina and koomin files

The koordina file describes the bed of the geometry with structured grid. The main input data for koordina file is x, y and z coordinate of the point and the format of the data is given as: i j x y z.

The data on the koordina file defines a surface. It is possible to make a file with exactly the same format and called as koomin. This surface is then used as a minimum elevation surface for bed changes. The bed will be stable on this surface and will not be lowered under this surface.

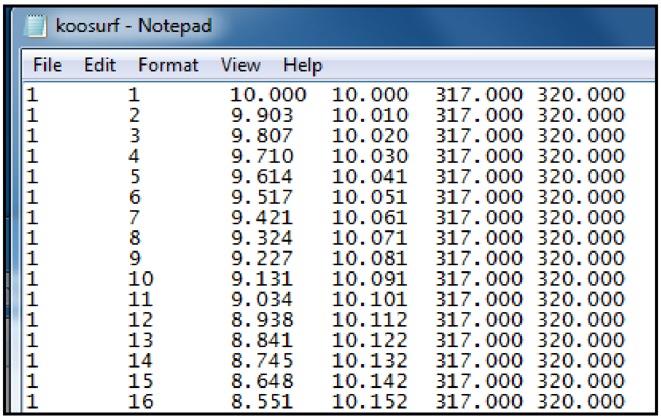

koordina - Notepad
File Edit Format View Help

```
1 1 10.000000 10.000000 317.0000
1 2 9.903400 10.010100 317.00000
1 3 9.806900 10.020300 317.00000
1 4 9.710300 10.030400 317.00000
1 5 9.613700 10.040600 317.00000
1 6 9.517100 10.050700 317.00000
1 7 9.420600 10.060900 317.00000
1 8 9.324000 10.071000 317.00000
1 9 9.227400 10.081100 317.00000
1 10 9.130900 10.091300 317.0000
```

Figure 3.6 Sample of Koordina file

The xyzc and koosurf files

The two files xyzc and koosurf files contain the geometry of grid. The koosurf file is similar to koordina file, except that the surface elevation also written for each line and similar to koordina file for tunnel option. The xyzc file contains the x, y, and z values of all the grid intersections.

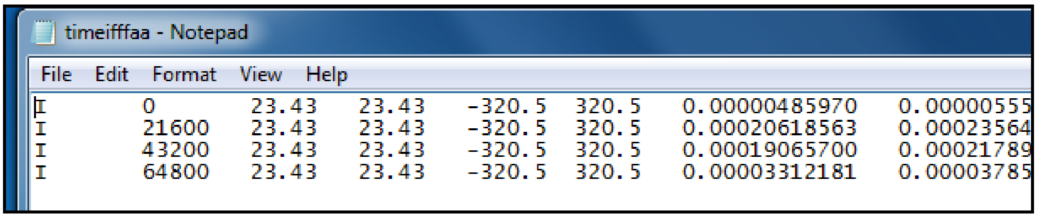

koosurf - Notepad
File Edit Format View Help

```
1    1     10.000  10.000  317.000 320.000
1    2     9.903   10.010  317.000 320.000
1    3     9.807   10.020  317.000 320.000
1    4     9.710   10.030  317.000 320.000
1    5     9.614   10.041  317.000 320.000
1    6     9.517   10.051  317.000 320.000
1    7     9.421   10.061  317.000 320.000
1    8     9.324   10.071  317.000 320.000
1    9     9.227   10.081  317.000 320.000
1    10    9.131   10.091  317.000 320.000
1    11    9.034   10.101  317.000 320.000
1    12    8.938   10.112  317.000 320.000
1    13    8.841   10.122  317.000 320.000
1    14    8.745   10.132  317.000 320.000
1    15    8.648   10.142  317.000 320.000
1    16    8.551   10.152  317.000 320.000
```

Figure 3.7 Sample of Koosurf file

The timei and timeo files

There are two files that are used for time series calculations. The timei file is input file for time series of discharge, water level, sediment concentration and control for output and the timeo file is an output file with time series from the model.




```
I      0      23.43   23.43   -320.5   320.5   0.00000485970   0.00000555
I      21600  23.43   23.43   -320.5   320.5   0.00020618563   0.00023564
I      43200  23.43   23.43   -320.5   320.5   0.00019065700   0.00021789
I      64800  23.43   23.43   -320.5   320.5   0.00003312181   0.00003785
```

Figure 3.8 Sample of timei file

The tecplot and paraview files

The tecplot files are result files used for graphics representation in the Tecplot program. The file have the format that makes them directly importable into the Tecplot program.

The result file

This file contains the results from the water flow calculations. The file is written when the prescribed numbers of iterations have been calculated or when the solution has converged. The results are velocities in three dimensions, k,ε, pressure and the fluxes on all the walls of the cells. The data from this file is used as input for the sediment flow calculations.

4. CASE STUDIES ON MAI KHOLA HPP

4.1 Introduction

Mai Hydropower project (MHP) is located in IIam District in Eastern Development Region of Nepal. The project area is bounded by Soyak/ Chisapani/Danabari VDCs between 26° 46' 00" and 26° 50' 00" latitude north and between 87° 52' 30" and 87° 55' 00" longitude east. The installed capacity of the Mai Hydropower project was 15.6 MW but it was increased to 22 MW during the model study.

Mai Khola is one of the tributary of Kankai Mai River. The river is monsoon as well as spring fed perennial type originating at an altitude of 3600 m from Mahabharat[4] range.

The average gradient of this river is 0.0216, whereas within the project area, it is 0.01. The river bed within the proposed headworks area has alluvial deposit and average particle size of the armoured layer is about 75 mm. Location map of Mai khola hydropower project is show in Figure 4.1.

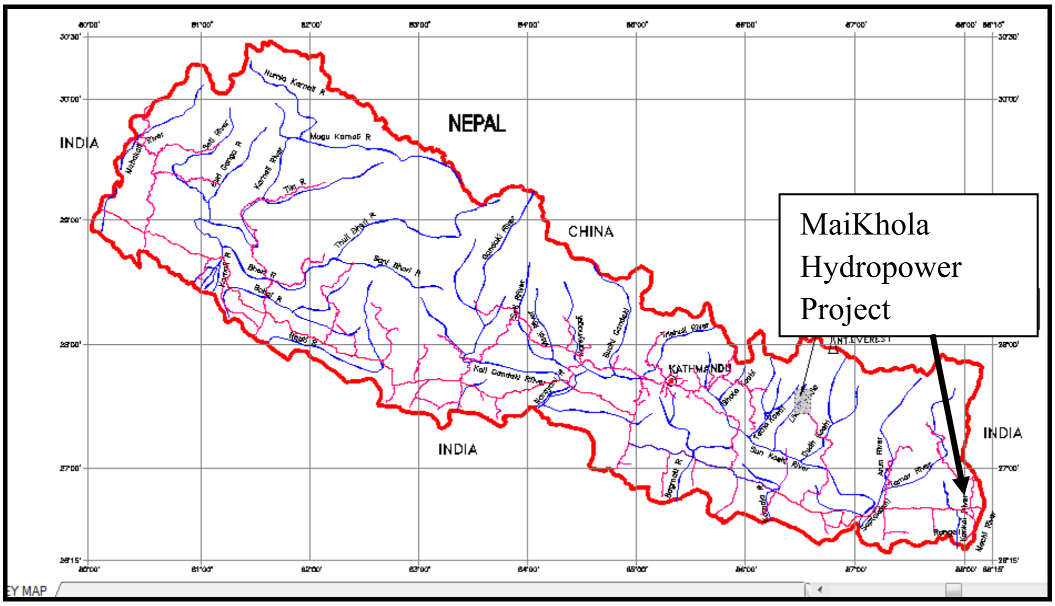


Figure 4.1 Location of Mai Khola hydropower Project

[4] **Mahabharat Range:** A complex system of mountain range in elevation form 8000 feet to 14000 feet. Hilly are of Nepal is lied in this range.

4.2 Salient feature of Mai Khola Hydropower Project

Salient feature of Mai Khola Hydropower Project is shown on Table 4.1 .

Table 4.1 Salient feature of Mai Khola Hydropower project

Descriptions	**Parameters**
Location: Project Area	Danabari & Chisapani Village Development Committee, Ilam District in Eastern Development Region , Nepal
Hydrology:	
Catchment area of Mai Khola	589.0km^2
Design flow	23.43 m3/s (for 22 MW)
Long term annual average flow	32.66 m3/s
Design flood at intake (1 in 100 years)	2352.0 m3/s
Headworks	
General Hydraulics:	
Gross Head	122.1 m
Net Head	108.93 m (for 22 MW)
Installed capacity	22 MW
Diversion weir:	
Type	Concrete gravity Dam
Shape	Ogee profile
Crest elevation	321.1 masl
Crest length	82.7 m
Maximum flood level	325.6 masl.
Intake:	
Type	Frontal intake, over the under sluice
No of orifice	3
Sill elevation	319.0 above masl
Design discharge	23.43 m3/s
Under sluice:	
Invert level	314.5 m above masl
Width	4.0 m
Height	2.0 m
Number	3
Approach culvert to gravel trap:	
Type	RCC pressure culvert
Width	6.8 m
Height	3.0 m
Gravel trap:	
Type	RCC
Number of chamber	1
Width	6.8 m

Depth	11.4m
Gravel flushing pipe	
Type	Mild steel encased by RCC
Number of conduit	1
Inner Diameter	1.2
Length	37.6 m
Approach Culvert to settling basin:	
Type	RCC pressurized conduit
Number	2
Size	35.82 m longX3.4 m wideX3.0 m height
Settling Basin:	
Type	Conventional flushing
Number of chambers	4
Size (parallel section)	75.0 m longX 9.5 wide X 5.85 masl
Top wall level	321.0 masl

4.3 Sediment Data

4.3.1 Bed material

From modeling aspect, it is very important to have information on bed material composition with respect to grain size distribution and suspended sediment loads. Bed stability and development of armored layers are important for the performance of headworks structure and thalweg control.

4.3.2 Suspended Sediment

Suspended sediment is very important while studying settling basin. A filed measure suspended sediment sample has taken from physical modeling report of Mai Khola Hydropower Project. Figure 4.2 shows suspended sediment data with respected discharge at Mai khola River. Sediment flow to settling basin was calculated by scaling the discharge to settling basin with respect to discharge in river. Measure sediment data is listed in Appendix-A.

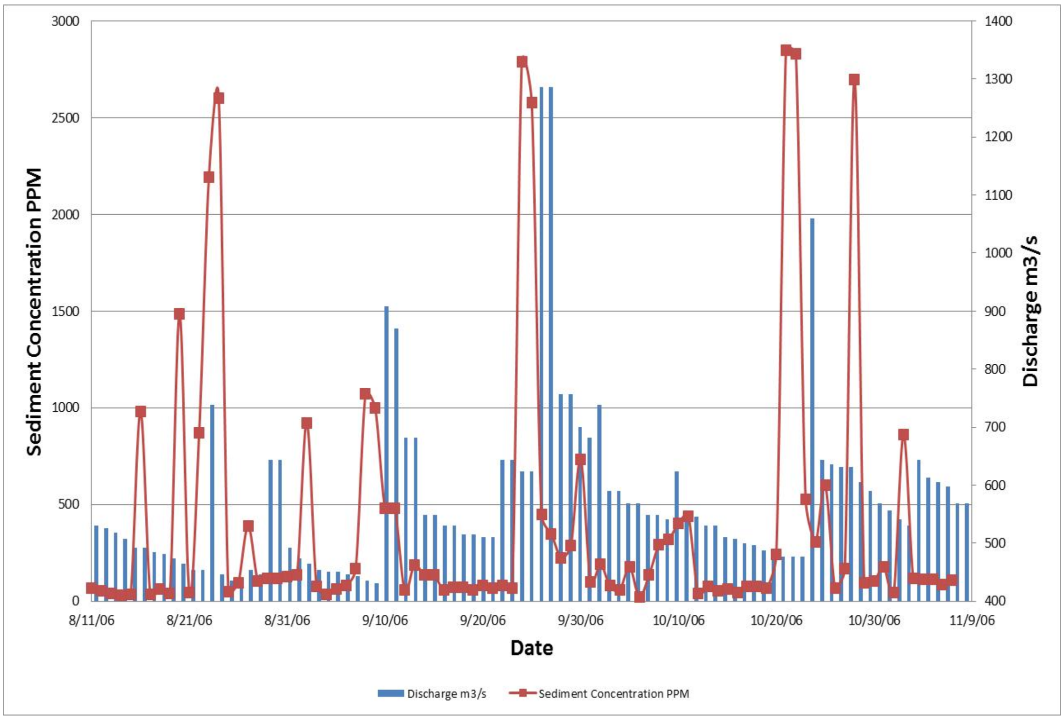


Figure 4.2 Sediment Concentration and discharge in Mai Khola

4.4 Headworks Arrangement

The head works includes major components like concrete ogee weir, stilling basin, frontal intake, with bed load sluicing arrangements, gravel trap, approach culvert and settling basin.

4.4.1 Settling basin layout

Settling basin in Mai khola hydropower project is conventional type. Settling basin contains four chambers with equal sizes. Settling basin followed inlet culvert, gravel trap, approach culvert. The length of settling basin is 75 m, width is 9.5 m and depth is 5.85 m. The arrangement of settling basin is listed in Annexure- A, provided by Sanima Hydropower (owner). In Numerical modeling, inlet culvert, gravel trap, approach culvert and settling basin are included. However, modeling of gravel trap has not done in this study. It is assumed that flow from inlet culvert is only containing suspended sediment. Also for optimization, different arrangement of settling basin with inlet and approach geometry was modeled and results are compared. In this study two layouts were studied i.e proposed and alternative layout. Alternative layout has made with shorter length and larger curve angle with respect to proposed layout. Due to shorter length than proposed layout, the alternative layout will save cost of settling basin. The length of main part of settling basin is kept same as proposed layout. However, approach geometry is changed. Figure 4.3 shows comparison of plan view of alternative layout with respect to proposed layout.

Table 4.2 shows the main feature of proposed settling basin. Water flow computation was done for constant design discharge of 23.43 m^3/s because it is assumed that sediment problem is occurred during wet season while the sufficient discharge available for power production.

Table 4.2 Feature of Settling basin

Type	Conventional type
Design discharge	23.43 m3/s
Effective Length	75 m
Width of one chamber	9.5 m
Depth	5.85 m
Water level at settling basin	320.5 masl
Number of settling chamber	4

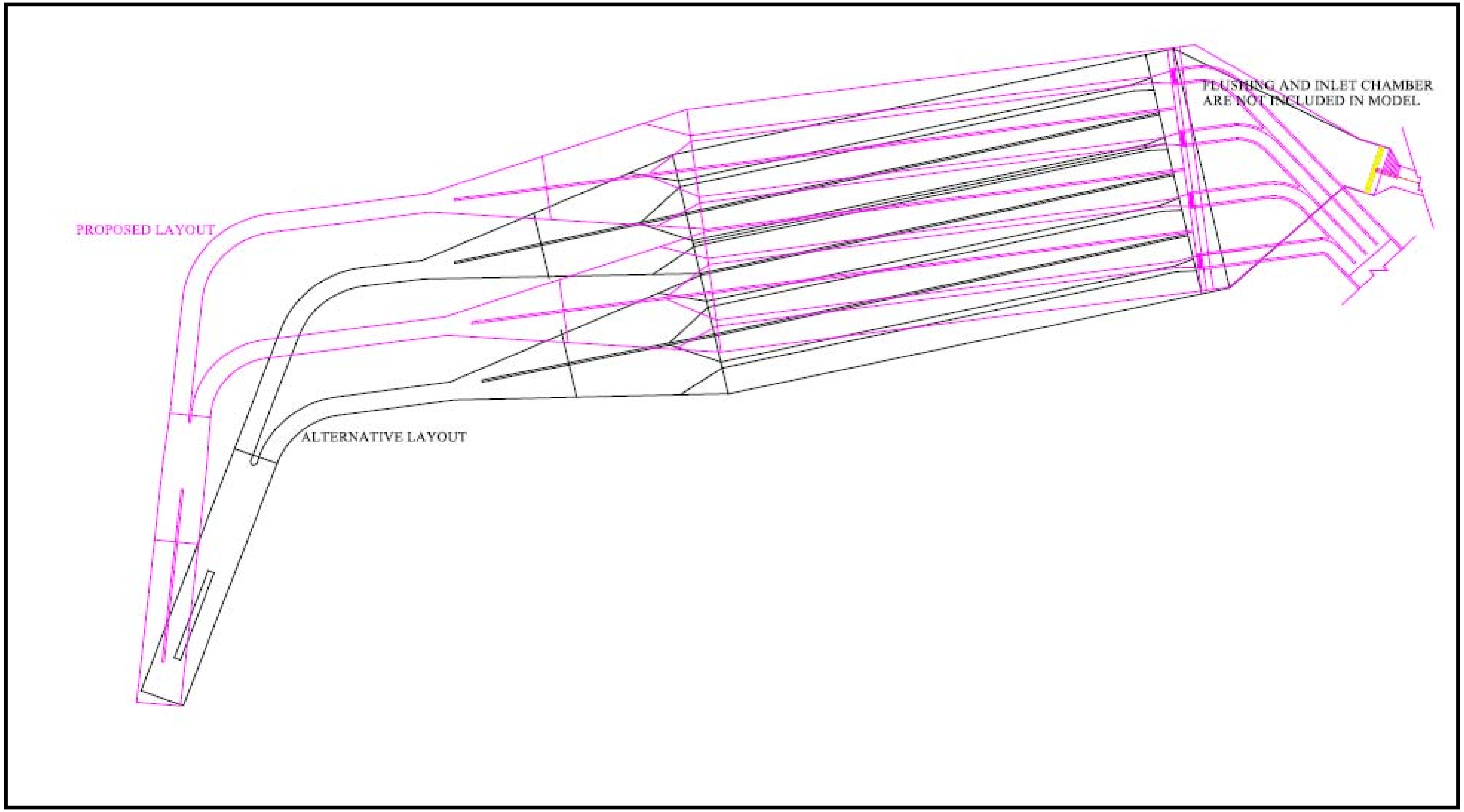


Figure 4.3 Plan view of proposed and alternative layout

5. WATER FLOW SIMULATION

In this thesis work, settling basin of Mai Khola Hydropower Project of Nepal was studied for 3D numerical investigation by SSIIM 1.0 model. To get optimum approach geometry of settling basin different layouts have made and 3D investigations have been done. After investigation optimum layout is recommended for implementation with respect to settling basin performance.

5.1 Grid generation

In the model simulation, inlet culvert, gravel trap, approach culvert and settling basin has simulated in same model. Grid is generated with the help of spread sheet (Microsoft Excel). First layout settling basin is transferred approximately parallel to x axis. With the help of orthogonal three axis co-ordinate system grid has generated in the system 'i', 'j' and 'k' represent stream-wise, cross stream and vertical elevations respectively. Figure 5.1 shows the grid mesh in three dimensions. The details of grid generation are listed in Annexure- B.

The expansion and aspect ratio of grid should not be too great. To reduce deviation with actual shape and dimension of the settling basin layout and to keep proper requirement of expansion and aspect ratio; fine grid is made with higher number of gridlines.

5.1.1 Detail of geometry

The grid geometry for proposed layout has 567X71X13 gridlines. 567 cross section and 71 profiles and 13 profiles in vertical direction have been introduced. By making blocks i.e using G 13 data sets approach culvert and settling chambers are separated. To make culver, water levels are written on koosurf file which act as culvert by keeping constant water level. Grid is generated with actual dimension of proposed layouts of settling basin plan. Details of simulated cross sections are listed in Annexure B. A sample of koordina file is listed in Appendix-A.

For performance comparisons, alternative layout has made. The alternative layout has less length and higher bend angle at approach culvert with same dimension of main settling chambers. It has 423X71X13 gridlines. 423 cross sections and 71 profiles and 13 profiles in vertical direction were introduced.

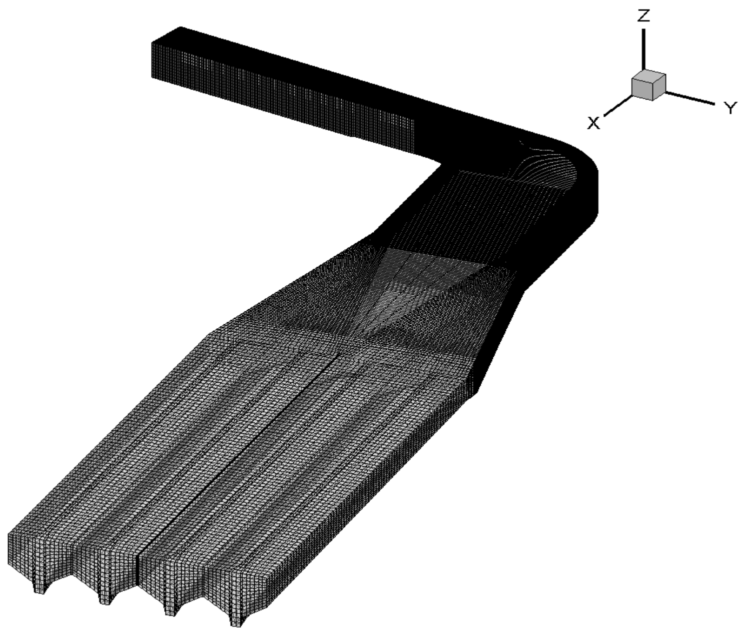


Figure 5.1 3D Grid view

To made comparison on settling basin performance, only one settling basin chamber is also investigated. It has 117X11X13 gridlines. Here settling chamber means there is no effect of approach geometry and it is an ideal layout. Also discharge is taken as dividing design discharge with number of chamber i.e. 5.8575 m3/s.

To check the performance improvement on proposed layout of settling basin, different modifications was made on approach of proposed layout. The modifications are discussed later.

5.1.2 Inlet and Outlet

Inlet for settling basin layout is taken at downstream from the intake of headworks. There is a slightly bed at intake to intake culvert. However, in this model, straight only straight portion is considered. Inlet has a dimension of 6.8m X 3 m.

The outlets, from the settling basin chamber to inlet chamber of headrace tunnel are made with G 7 data sets. It is assumed that flow is equally distributed at design discharge for all four chamber of settling basin. Outlets are rectangular type orifices. Rectangular orifices on SSIIM Model are shown in Figure 5.2 below with help of horizontal velocity vector.

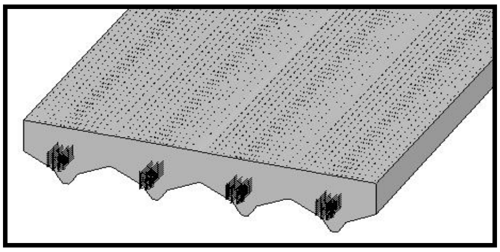


Figure 5.2 Outlet of settling chambers with horizontal velocity vectors

Simulation parameters

Different parameters are given for simulation by using control file. Examples of control files are listed in Appendix A. In control file, roughness, discharge and other control parameters are written for SSIIM Model for water and sediment flow computation.

5.2 Water flow Simulation Results

After preparing input for geometry i.e. koordina file and input for simulation i.e. control file, models of settling basin layout were simulated.

Residual Values

Water flow simulation was converged for all simulated model because residual values for all six partial differential equation that are solved are less than 10^{-3}. An example of residual values for simulated model is shown in Figure 5.3.

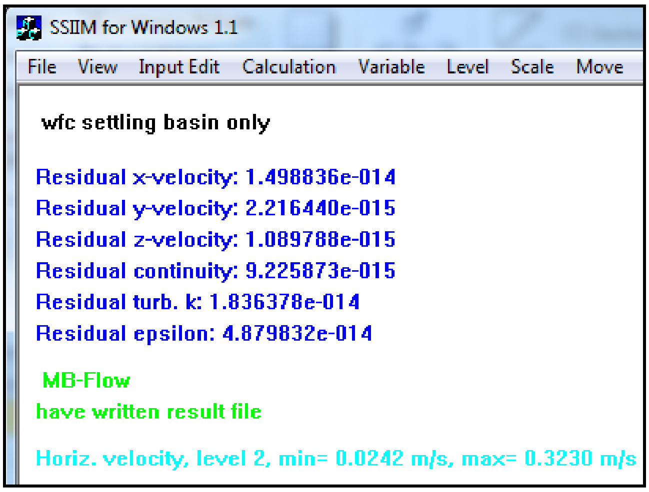


Figure 5.3 Residual Values for water flow simulation

Velocity Vector

Velocity vectors represent flow direction on the grid. It is very the correctness of geometry of grid with respect to actual layout. Velocity vectors for settling basin and proposed layout are shown in Figure 5.4 and Figure 5.5. Velocity vectors on plan and sectional views are listed in Annexure-C.

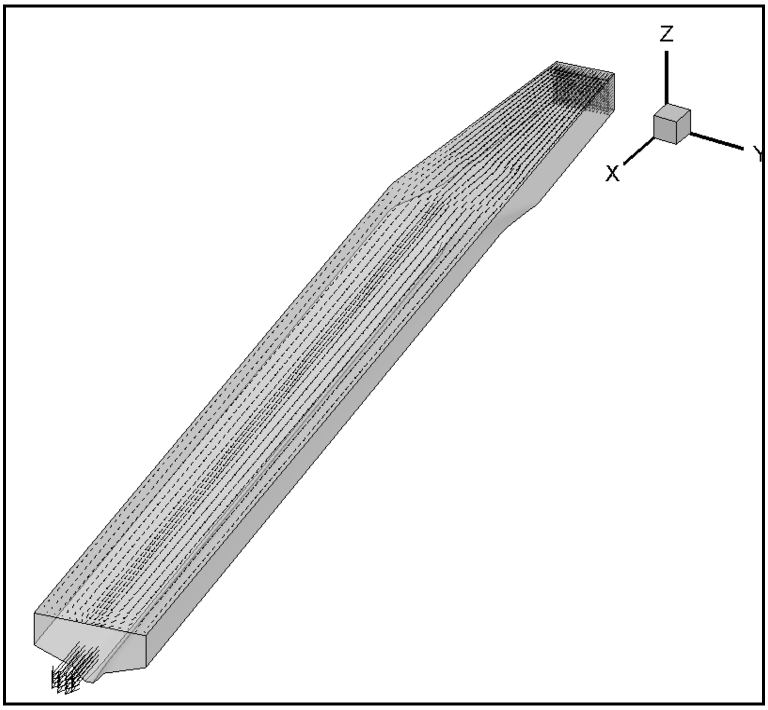


Figure 5.4 3D view of velocity vector

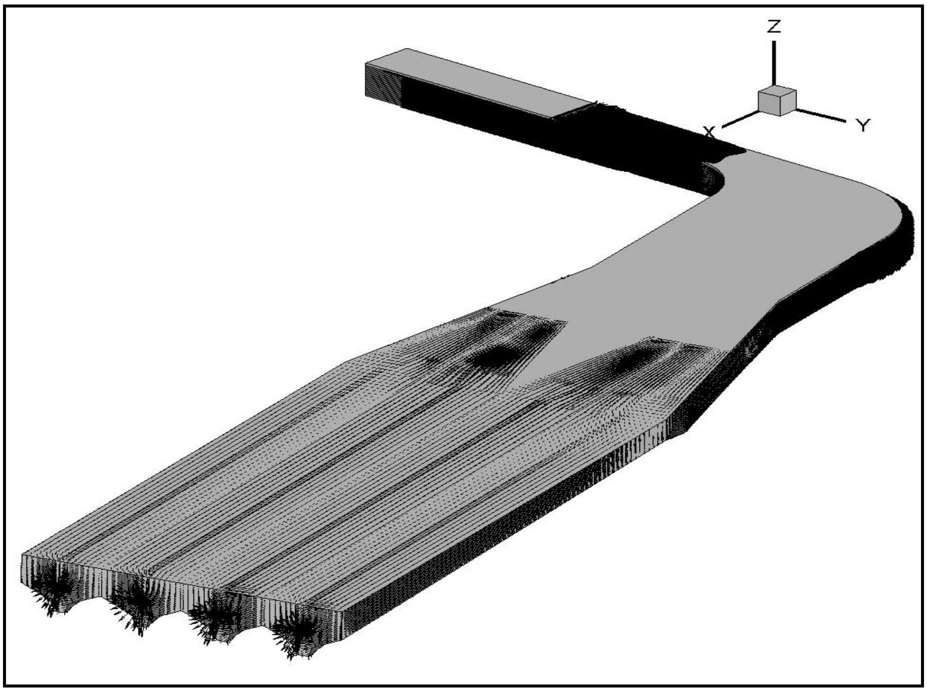


Figure 5.5 3D View of Velocity Vector of settling basin layput

5.2.1 Result of water flow computation on one settling chamber

Results of water flow computation are presented and discussed in this section.

Distribution of velocity at X, Y and Z direction

Distribution of velocity on X direction is similar to distribution of horizontal velocity because of settling basin layout is kept almost parallel with X- axis for model studies. The distribution of velocity on X, Y and Z direction seems uniform. Distribution of velocity on X direction is presented on Annexure-C. However, distribution of velocity on Y and Z directions are more uniform. From the distribution pattern of velocity it can be said that velocity is more on top layer than bottom.

Distribution of horizontal and vertical velocity

Figure 5.6 shows horizontal velocity distribution on settling chamber. It has uniform velocity distribution and most of velocities are between 0.1 to 0.3 m/s. This model does not have effect of approach geometry. Minimum horizontal velocity is 0.0504 m/s and maximum horizontal velocity is 0.3269 m/s. Maximum vertical velocity is 0.0002 m/s.

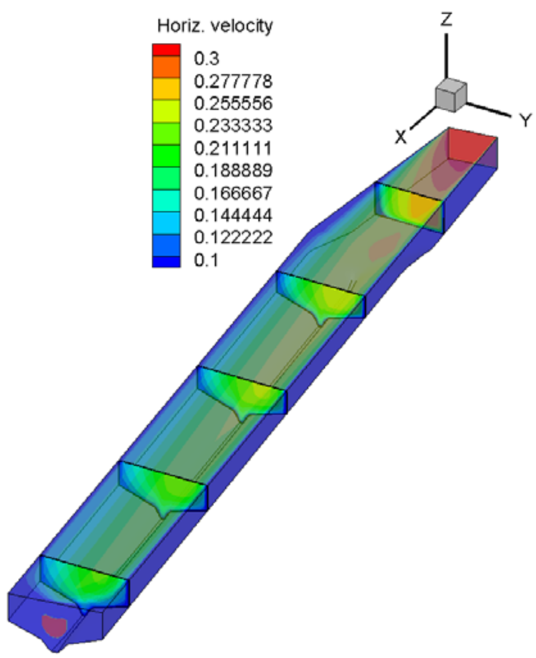


Figure 5.6 Horizontal velocity Distribution on settling chamber model

Distribution of turbulence kinetic energy

Turbulence kinetic energy is one of important parameter which influences the performance of settling basin. Distribution of turbulence kinetic energy is presented on Annexure-C. Minimun turbulence kinetic energy is $1.53x10^{-4}$ and maximum is $1.857x10^{-3}$.

5.2.2 Result of water flow computation on Proposed Layout

Approach geometry of proposed layout is shown in Figure 5.7.

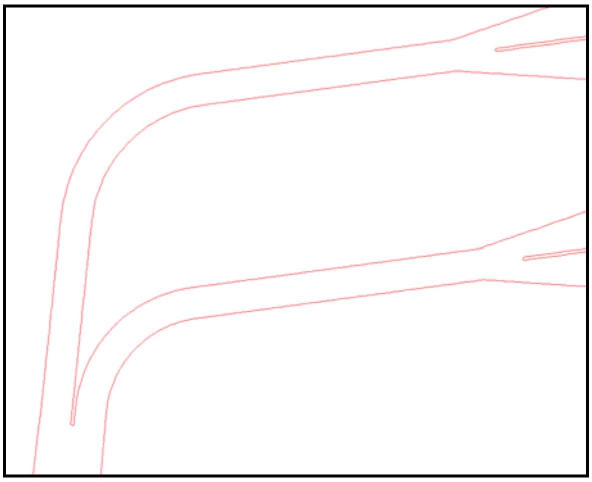


Figure 5.7 Geometry of Approach on Proposed Layout

Distribution of velocity at X, Y and Z direction

Distribution of velocity at X axis is similar to horizontal velocity distribution. Distribution of velocity on X axis is presented Annexure C. Velocity distribution on Y and Z axis is uniform.

Distribution of horizontal and vertical velocity

Figure 5.8 shows horizontal velocity distribution on proposed settling basin layout model the velocity between 0.1 m/s to 0.3 m/s. This model does not have effect of approach geometry. Minimum horizontal velocity is 0.0721 m/s and maximum horizontal velocity is 1.3536 m/s. Maximum vertical velocity is 0.2774 m/s.

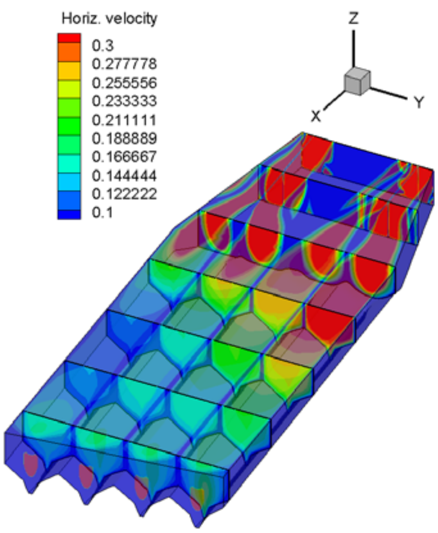


Figure 5.8 Distribution of horizontal velocity on proposed layout

Distribution of turbulence kinetic energy

Distribution if kinetic energy presented in Annexure –C. The maximum value of turbulence kinetic energy is $1.00x10^{-1}$ and minimum is $5.3x10^{-3}$.

5.2.3 Result of water flow computation on Alternative Layout

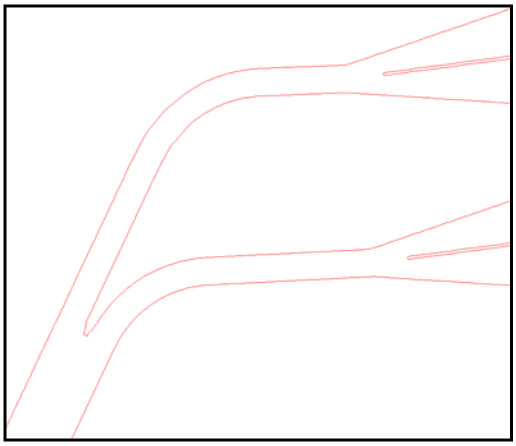


Figure 5.9 Geometry of Approach on Alternative Layout

Distribution of velocity at X, Y and Z direction

Distribution of velocity at X axis is similar to horizontal velocity distribution. Distribution of velocity on X axis is presented Annexure C. Velocity distribution on Y and Z axis is uniform.

Distribution of horizontal and vertical velocity

Figure 5.10 shows horizontal velocity distribution on alternative layout the velocity between 0.1 m/s to 0.3 m/s. This model does not have effect of approach geometry. Minimum horizontal velocity is 0.0722 m/s and maximum horizontal velocity is 1.3718 m/s. Maximum vertical velocity is 0.3 m/s.

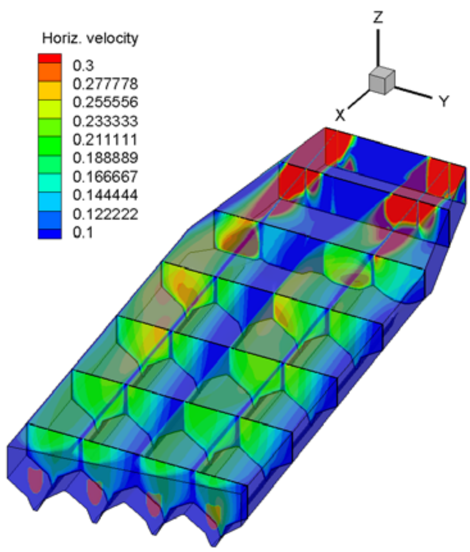


Figure 5.10 Distribution of horizontal velocity on alternative layout

Distribution of turbulence kinetic energy

Distribution if kinetic energy presented in Annexure –C. The maximum value of turbulence kinetic energy is $8.64x10^{-2}$ and minimum is $4.55x10^{-3}$.

5.2.4 Result of water flow computation on Modifications

The performance of settling basin chamber is greatly influence by approach geometry. Modifications are done by introducing divide wall at approach culvert on proposed layout. Width of divide walls is kept about 0.3 m so that flow width at approach culvert will be reduced. Due to the divide wall velocity at approach culvert will be increased and more turbulence will be passed to the settling basin so that to keep velocity as proposed layout width of approach culvert is increased by 0.3 m keeping flow width constant.

Modification 1

This modification is done by introducing divided wall at bend of approach culvert. Modification 1 is shown on Figure 5.11.

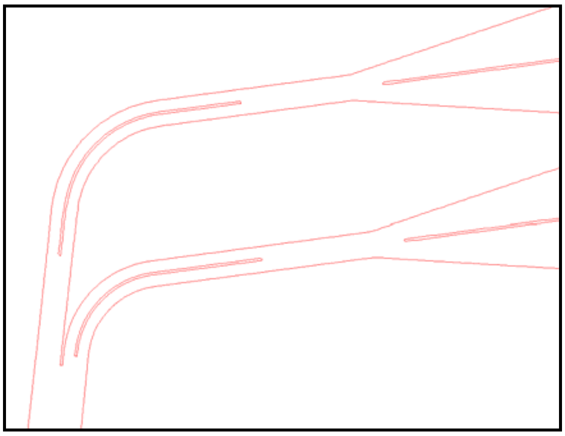


Figure 5.11 Modification 1

Distribution of velocity at X, Y and Z direction

Distribution of velocity at X axis is similar to horizontal velocity distribution. Velocity distribution on Y and Z axis is uniform.

Distribution of horizontal and vertical velocity

Figure 5.12 shows horizontal velocity distribution on modification 1 the velocity between 0.1 m/s to 0.3 m/s. This model does not have effect of approach geometry. Minimum horizontal velocity is 0.0582 m/s and maximum horizontal velocity is 1.29 m/s. Maximum vertical velocity is 0.29 m/s.

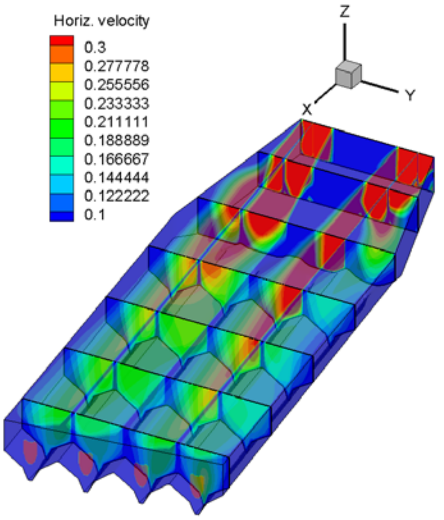


Figure 5.12 Distribution of horizontal velocity on modification 1.

Distribution of turbulence kinetic energy

The maximum value of turbulence kinetic energy is $2.51\text{x}10^{-2}$ and minimum is $1.33\text{x}10^{-3}$.

Modification 2

Modification 2 is done by extending divider of transition to approach culvert end. Modification 2 is shown on Figure 5.13.

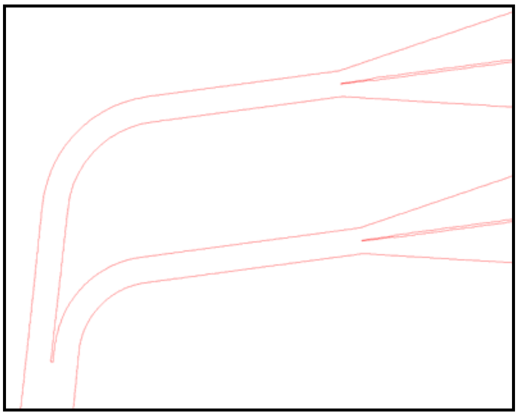


Figure 5.13 Modification 2

Distribution of velocity at X, Y and Z direction

Distribution of velocity at X axis is similar to horizontal velocity distribution. Velocity distribution on Y and Z axis is uniform.

Distribution of horizontal and vertical velocity

Figure 5.14 shows horizontal velocity distribution on proposed settling basin layout model the velocity between 0.1 m/s to 0.3 m/s. This model does not have effect of approach geometry. Minimum horizontal velocity is 0.0557 m/s and maximum horizontal velocity is 1.10 m/s. Maximum vertical velocity is 0.20 m/s.

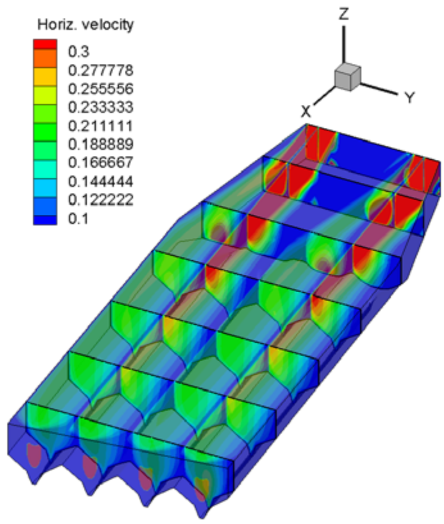


Figure 5.14 Distribution of horizontal velocity on modification 2.

Distribution of turbulence kinetic energy

The maximum value of turbulence kinetic energy is $2.38x10^{-2}$ and minimum is $1.267x10^{-3}$.

Modification 3

Modification 3 is done by introducing divide wall at curve part of approach culvert to transition part. Modification 3 is shown in Figure 5.15.

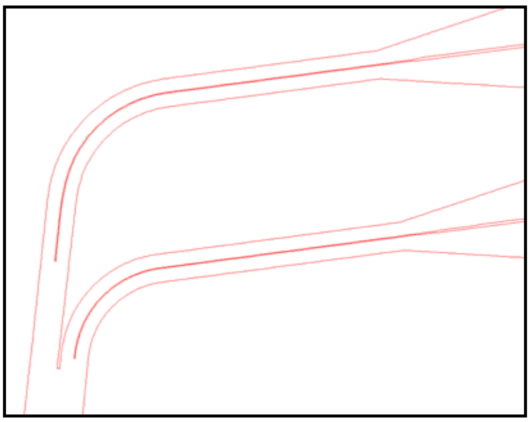


Figure 5.15Modification 3

Distribution of velocity at X, Y and Z direction

Distribution of velocity at X axis is similar to horizontal velocity distribution. Velocity distribution on Y and Z axis is uniform.

Distribution of horizontal velocity

Figure 5.16 shows horizontal velocity distribution on proposed settling basin layout model the velocity between 0.1 m/s to 0.3 m/s. This model does not have effect of approach geometry. Minimum horizontal velocity is 0.0545 m/s and maximum horizontal velocity is 1.03 m/s. Maximum vertical velocity is 0.15 m/s.

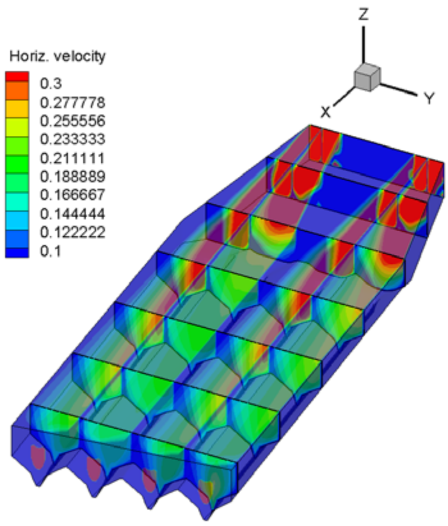


Figure 5.16 Distribution of horizontal velocity on modification 3

Distribution of turbulence kinetic energy

The maximum value of turbulence kinetic energy is 2.38×10^{-2} and minimum is 1.26×10^{-3}.

Modification 4

In modification 4 both modification 1 and modification 2 have made but length of divide wall is shorter at bend than on modification 1. Modification 4 is shown in Figure 5.17.

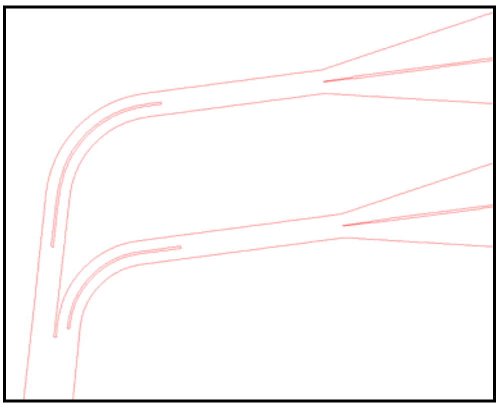


Figure 5.17 Modification 4

Distribution of velocity at X, Y and Z direction

Distribution of velocity at X axis is similar to horizontal velocity distribution. Velocity distribution on Y and Z axis is uniform.

Distribution of horizontal velocity

Figure 5.18 shows horizontal velocity distribution on proposed settling basin layout model the velocity between 0.1 m/s to 0.3 m/s. This model does not have effect of approach geometry. Minimum horizontal velocity is 0.0578 m/s and maximum horizontal velocity is 1.09 m/s. Maximum vertical velocity is 0.15m/s.

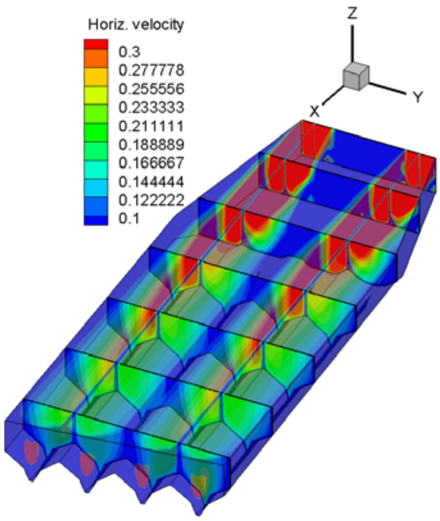


Figure 5.18 Distribution of horizontal velocity on modification 4

Distribution of turbulence kinetic energy

The maximum value of turbulence kinetic energy is 2.47×10^{-2} and minimum is 1.31×10^{-3}.

5.2.5 Discussion and comparison of velocity at X, Y and Z direction

Distribution of velocity on X, Y and Z direction is more uniform on settling chamber model because it has no effect of approach geometry. However, distribution of velocities on proposed, alternative layout and modification not seen much difference. By eye inspection it can be said that distribution is improved on modifications.

5.2.6 Discussion and comparison on Horizontal velocity

From horizontal distribution figure distribution is more uniform on settling chamber model. However, velocity distribution also is more uniform on modification than the proposed layout.

5.2.7 Discussion and Comparison on turbulence kinetic energy

Turbulence kinetic energy distribution does not show significant difference for all model. However, it is very low on one settling basin model due to no effect of approach.

5.2.8 Closing of chambers

This study is done because for maintenance proposed some chamber might be closed and other on operation. Here a case of one chamber is closed and other remaining chambers are on full operation with design discharge of power plant; has studied for proposed layout.

Closing of first chambers

During closing of first chamber; it seems that operation of remaining chamber will be subjected to more velocities, which will decrease performance of settling basin. Horizontal velocity distribution is shown in Figure 5.19 during closing of first chamber.

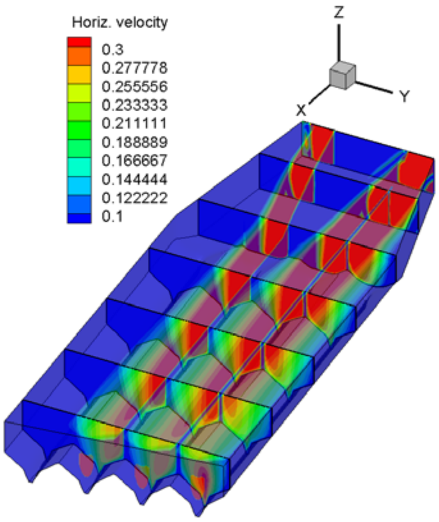


Figure 5.19 Horizontal velocity distribution on closing of first chamber

Closing of second chambers

During closing of second chamber; it seems that operation remaining chambers will be subjected to equally turbulence and higher velocities. Horizontal velocity distribution is shown in Figure 5.20 during closing of second chamber.

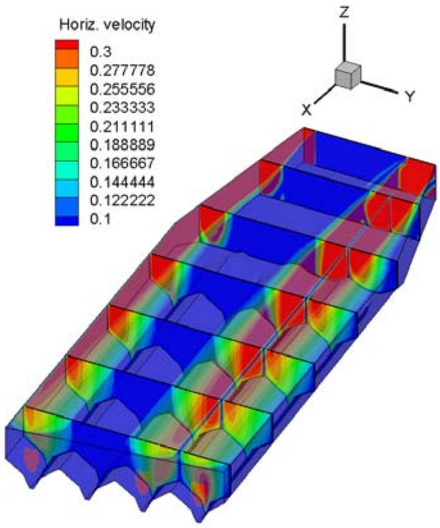


Figure 5.20 Horizontal velocity distribution on closing of second chamber

Closing of third chamber

During closing of third chamber; effect seems first and fourth chamber will be subjected to more velocities. Horizontal velocity distribution is shown in Figure 5.21 during closing of third chamber.

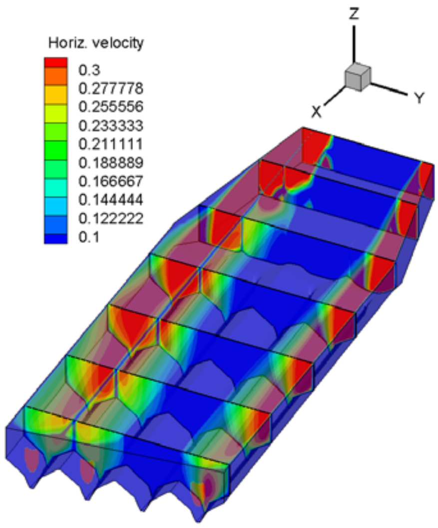


Figure 5.21Horizontal velocity distribution on closing of third chamber

Closing of fourth chamber

During closing of fourth chamber first and second will be subjected more velocities. Horizontal velocity distribution is shown in Figure 5.22 during closing of fourth chamber.

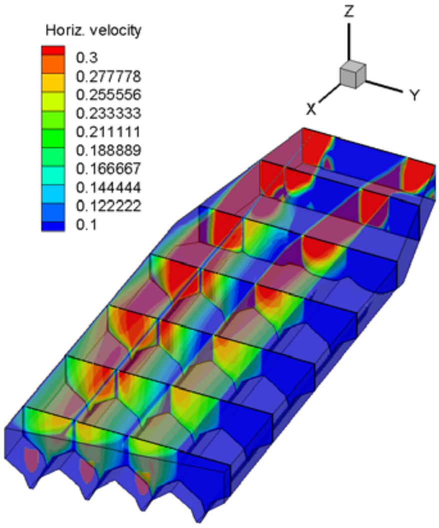


Figure 5.22 Horizontal velocity distribution on closing of fourth chamber

Comparing with operation of three chambers with closing of one chamber, it seems that closing of one chamber will have poor performance for design discharge. It may not have required trapping efficiency.

6. SEDIMENT FLOW SIMULATION

6.1 General

Sediment flow simulation was done to find trap efficiency and sediment flow pattern studies. Sediment transport can be divided in two parts; one bed load and suspended load. In SSIIM model it is assumed that most of sediment flow as suspension.

The main aim of sediment computation is; to find effect of approach geometry on sediment concentration distribution over four chambers, the trapping efficiency for different size of sediment particles and sediment concentration distribution over the settling basin with respect to time of computation. The results for sediment computation are presented in this chapter.

First flow patterns were determined from water flow computation. Results of water flow computation were used for sediment computation. During the sediment simulation F 68 2 parameter is used. This means the transient sediment computation will not re-compute water flow filed after an update of bed so a quasi-steady was modeled. F 37 1 data set was used as the transient sediment computation (TSC) algorithms and POW scheme is used for the convection diffusion equation for sediment flow.

Sediment computation is done for particle sizes 0.06mm, 0.1mm, 0.15 mm, 0.2 mm and 0.3 mm. It is assumed that 100 % of the particle size of 0.4 mm and 0.5mm will be settled. These particles sizes are excluded because increasing the number of set of particles on SSIIM model it will take longer time for simulation so higher particle size sediment are excluded. The particle size, its fall velocity and particle size distribution are presented on Table 6.1.

Due to lack of particle distribution diagram for suspended sediment of Mai Khola River, PSD of suspended sediment is adapted as Khimti river of Nepal.
Also, it is assumed that specific gravity of sediment is 2.65 and Critical shield coefficient is taken as 0.047 and roughness value is taken as 0.021 and a sensitivity analysis has made taking roughness value from 0.014 to 0.021 for one settling chamber model only.

Table 6.1 Sediment size, fall velocity and PSD

Number	Particle size mm	Fall velocity cm/s	% finner (PSD adopted)
1	0.5	6.8	100
2	0.4	5.4	85
3	0.3	3.8	80
4	0.2	2.3	66
5	0.15	1.25	50
6	0.1	0.65	46
7	0.06	0.30	38

6.2 Inputs files

For sediment computation, different input files are needed. The main input files are presented below.

Control file (Sediment flow computation parameters)

It is the main input file, which contain parameters for sediment computation. Detail of control file is presented in Appendix A.

timei files

This files used for input of sediment flow. Figure 6.1 shows actual measurement of sediment at Mai Khola Rive and Figure 6.2 shows input of sediment concentration with the help of the timei files. Detail of timei file is presented in Appendix A.

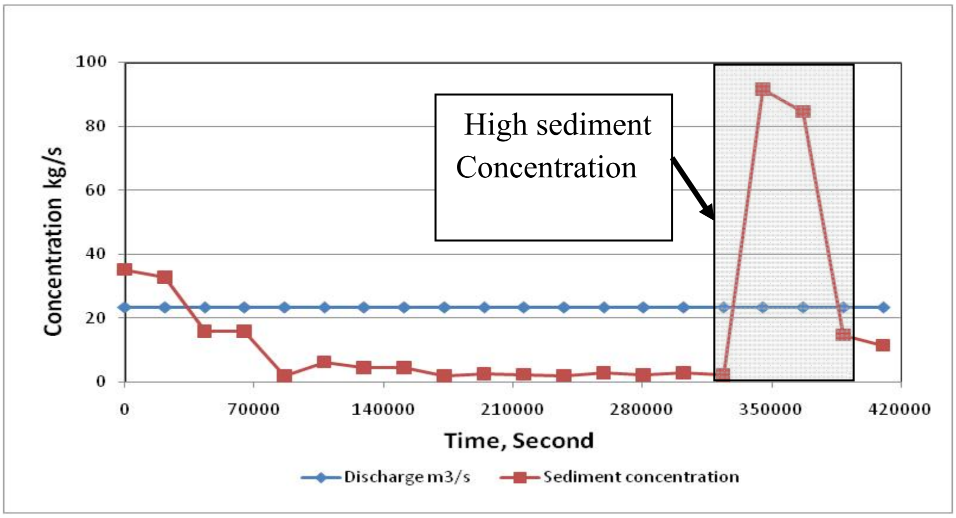


Figure 6.1 High low and high sediment inflow

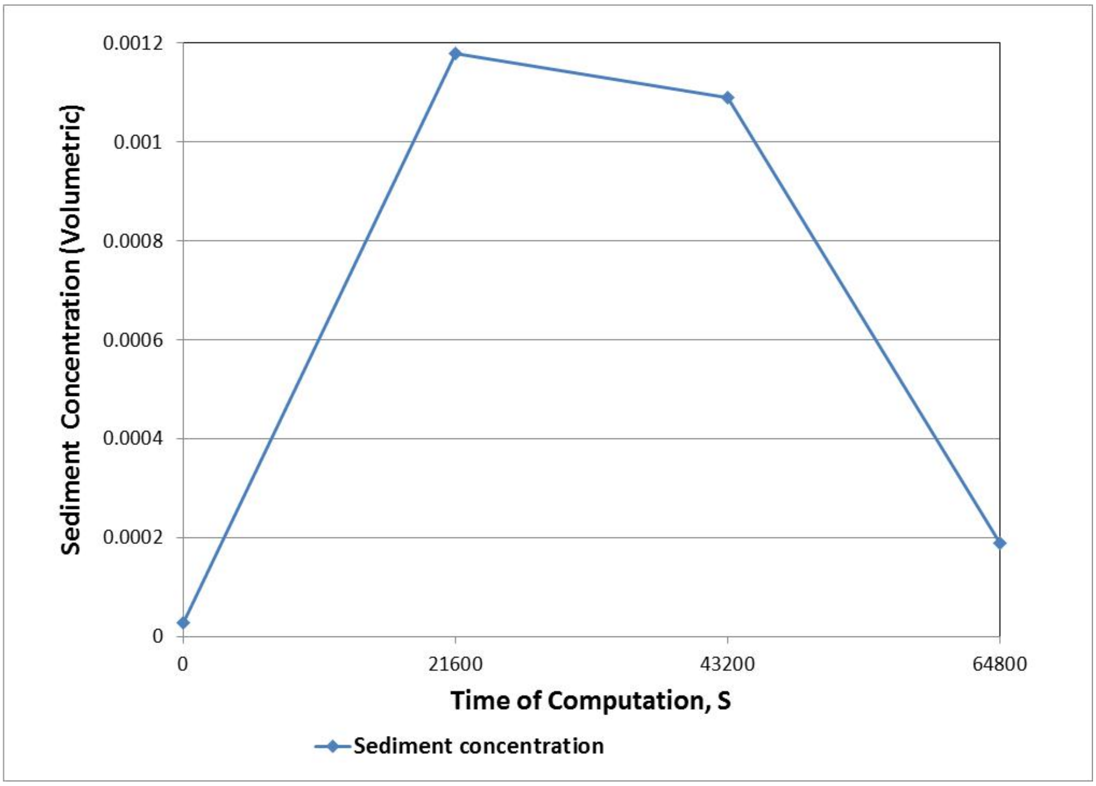


Figure 6.2 Sediment Volumetric concentration input SSIIM Model

6.3 Sediment flow simulation Result

When the models were run for 30000 seconds with time step of 50 seconds following result were obtained. After the sediment simulation, result file are read on Tecplot program. Sediment distribution and concentration is plotted. With the help of distribution and concentration pictures, a visual inspection has made for discussion and comparison of sediment simulation results. Distribution of sediment concentration of plan and cross section view are listed in Annexure-C.

6.3.1 Sediment distribution on one settling basin

This model does not have any effect of approach geometry. So concentration is distributed uniformly. Concentration level is higher at entrance and bottom level. Concentration level goes down on downstream and upper level. Figure 6.3 show the sediment concentration distribution on one settling chamber model.

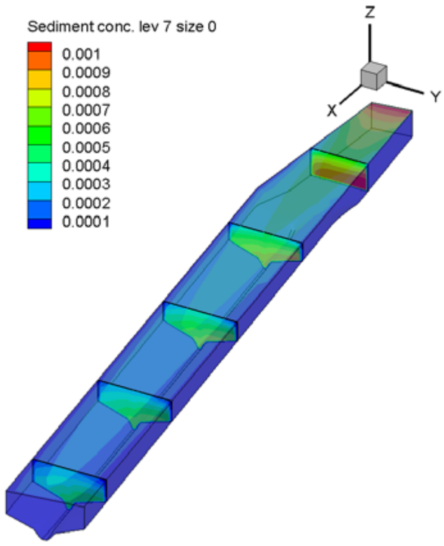


Figure 6.3 Sediment concentration distribution on one settling chamber

6.3.2 Sediment distribution on proposed layout settling basin

Sediment concentration is not equally distributed over four chamber of settling chamber. Effect of approach geometry is clearly seen on distribution of sediment concentration. More sediment is concentrated on inner chamber than outer chamber of two approach bends. Figure 6.4 shows sediment concentration distribution on proposed layout.

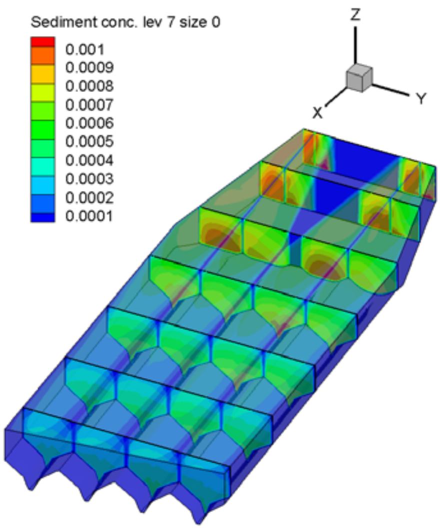


Figure 6.4 Sediment concentration distribution on proposed layout

6.3.3 Sediment distribution on alternative layout settling basin

Sediment concentration is not equally distributed over four chamber of settling chamber. Effect of approach geometry is clearly seen on distribution of sediment concentration. More sediment is concentrated on inner chamber than outer chamber of two approach bends. As comparing with proposed layout concentration is even more on inner chambers. Figure 6.5 shows sediment concentration distribution on alternative layout.

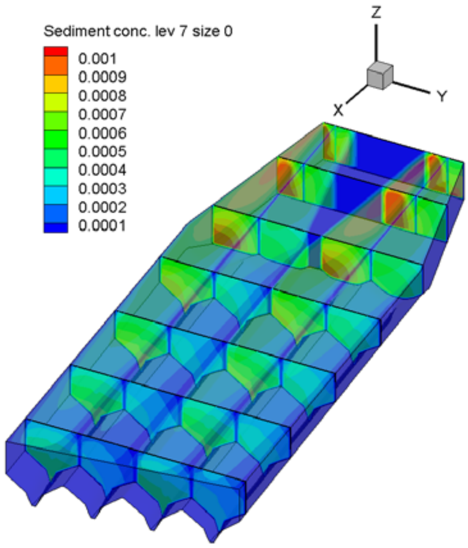


Figure 6.5Sediment concentration distribution on alternative layout

6.3.4 Sediment distribution on modification layouts

Results show modifications on approach geometry, improve in uniformity of distribution of sediment concentration.

Modification 1

Modification 1 show more uniform distribution of sediment concentration over four chambers. With visual inspection chamber four has little less sediment concentration than other chamber however, it seems more uniform than propose layout. Figure 6.6 shows sediment distribution over settling chamber due to modification 1.

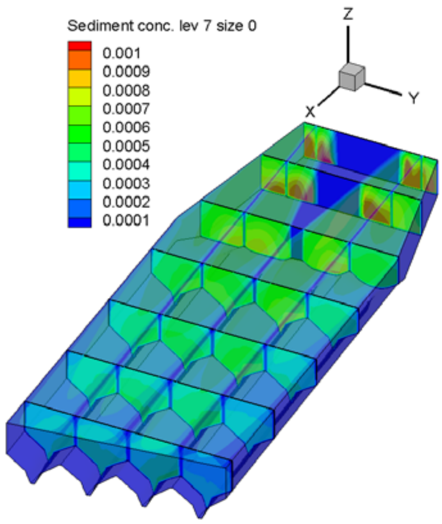


Figure 6.6 Sediment concentration distribution on modification 1

Modification 2

Sediment concentration distribution is more similar with proposed layout however, distribution can be said quite more uniform than proposed layout. Figure 6.7 shows distribution of sediment concentration due to modification 2.

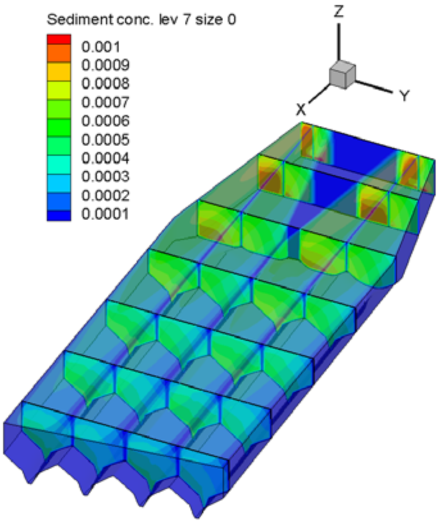


Figure 6.7Sediment concentration distribution on modification 2

Modification 3

Sediment concentration distribution is uniformly distributed on all four chambers due to modification 3. Figure 6.8 shows distribution of sediment concentration due to modification 3.

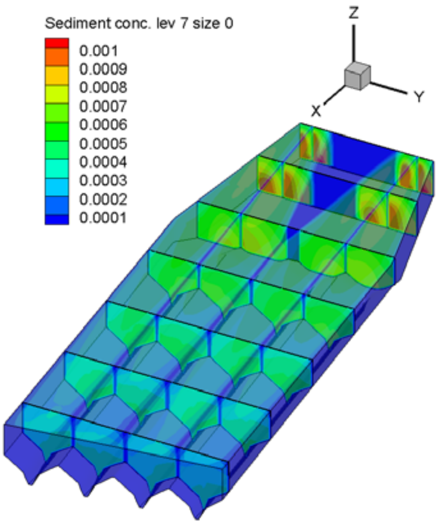


Figure 6.8Sediment concentration distribution on modification 3

Modification 4

Sediment concentration distribution is uniformly distributed on all four chambers due to modification 4. Figure 6.9 shows distribution of sediment concentration due to modification 4.

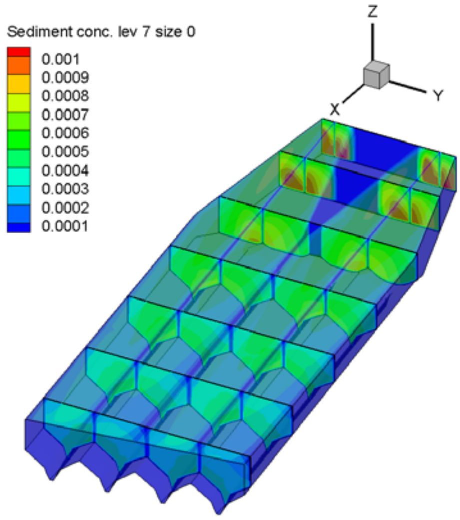


Figure 6.9 Sediment concentration distribution on modification 4

As comparing result of sediment distribution due to modifications on approach geometry, distribution is more uniform and Modification 3 and 4 give more uniformly distribution of sediment concentration.

6.3.5 Sediment distribution on closing of chambers

During closing of one chamber for full operation of plant, sediment concentration also not uniform on remaining chambers. Also sediment concentration is more at downstream of settling chamber than operation of four chambers. Figure 6.10 to Figure 6.13 shows the concentration of sediment distribution on closing of first to fourth.

Closing of first chambers

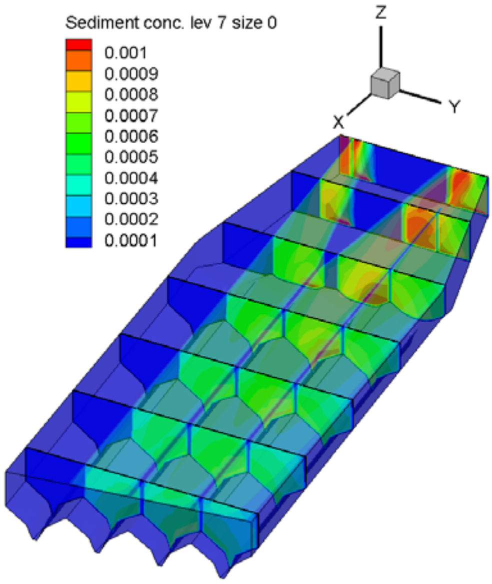


Figure 6.10Sediment concentration distribution on closing of first chamber

Closing of second chambers

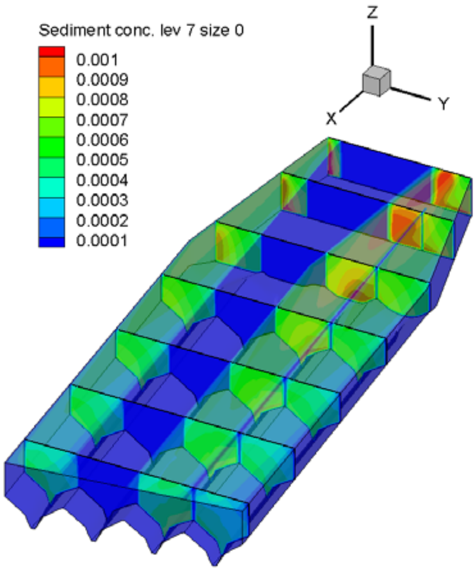


Figure 6.11Sediment concentration distribution on closing of second chamber

Closing of third chamber

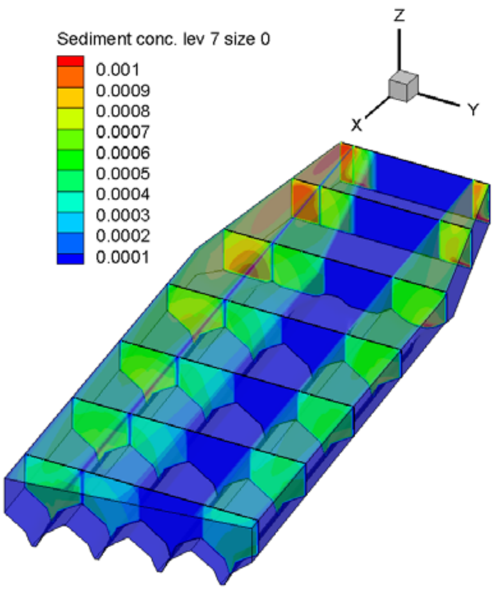


Figure 6.12Sediment concentration distribution on closing of third chamber

Closing of fourth chamber

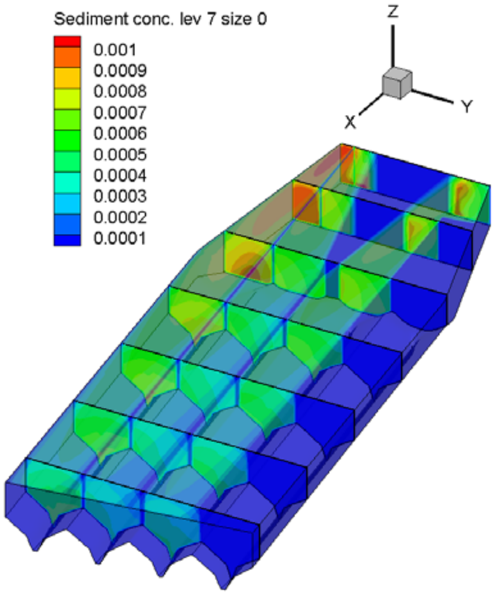


Figure 6.13 Sediment concentration distribution on closing of fourth chamber

6.4 Trap efficiency

6.4.1 Trap efficiency evaluation by Analytical Method

For one settling chamber trap efficiency is evaluated by Vetter's Method and Camp's Method. Trapping efficiency for different size of sediment is presented on Figure 6.14.
Camp's method seems more conservative because trapping efficiency for particle size greater than 0.15mm is 100% while from Vetter's method trapping efficiency 100% for particle size greater than 0.3mm.

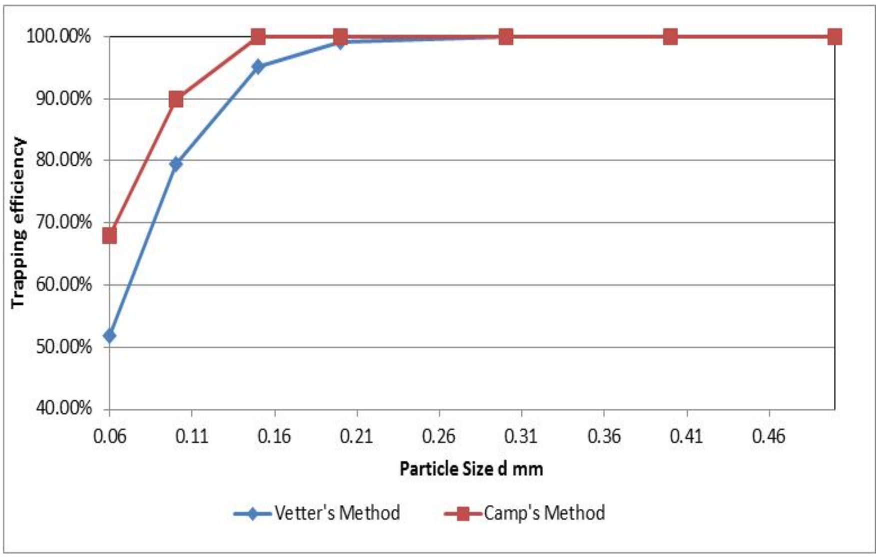


Figure 6.14 Trapping Efficiency by Analytical Method

6.4.2 Trap efficiency evaluation by SSIIM model

Trapping efficiency is evaluated for during high sediment band of inflow shown in Figure 6.1 and Figure 6.2 above and SSIIM was run only for five finest particle sizes. In SSIIM model trapping efficiency is calculated by sediment inflow flux and outflow flux, written in boogie file during the simulation.

One settling chamber was modeled with high sediment band and inflow and outflow of sediment concentration flux is evaluated with respect to time. Trap percentage for respected time is evaluated with inflow and out flow flux. Trap percentage is considered as trapping efficiency. When the model was run for 66000 second with time step of 20 second following results were obtained which is shown in Figure 6.15

Figure 6.15 shows trap percentage with respect to time of computation and sediment concentration inflow shown in Figure 6.2. It shows percentage of trap goes down with time of computation it may be due to high flow of sediment concentration with respect to time. When sediment flow to settling basin most of coarse particle settle down at entrance of basin and deposition may reduce the flow depth. Due to reduced flow depth fine particle may not settle down because of higher velocities. Settle fine particle may be become suspension and flow toward the outlet.

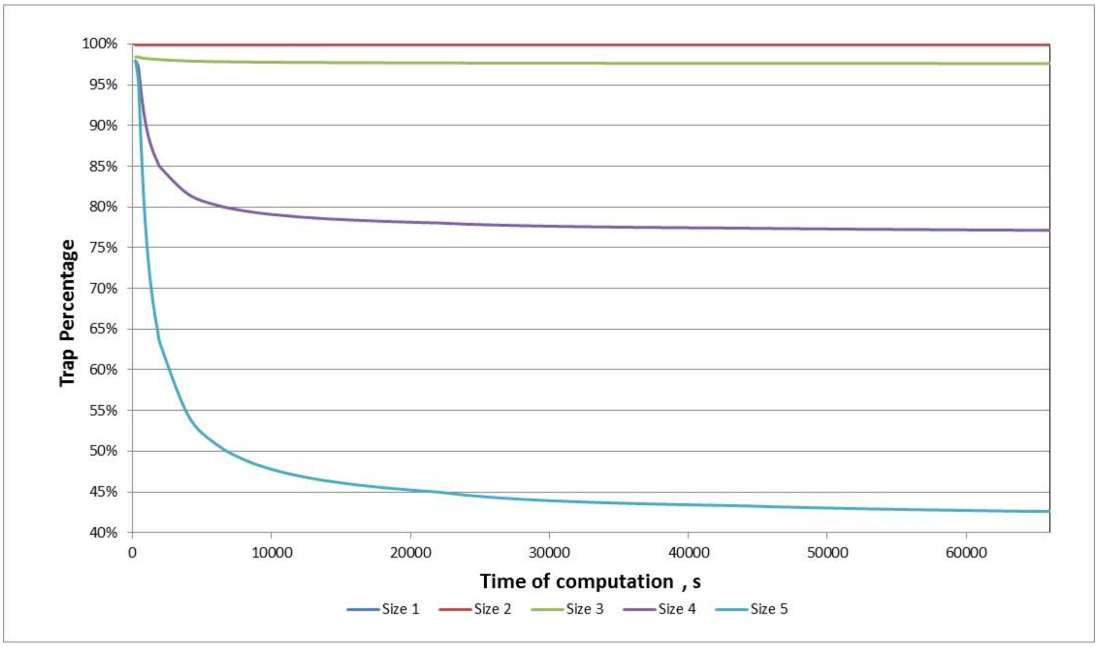


Figure 6.15 Trap percentage with time of computation

Comparison with analytical method

In Figure 6.16, trapping efficiency of SSIIM model is compared with trapping efficiency by analytical method. For fine particle SSIIM model gives lower trap value while for larger sediment particle SSIIM model gives higher trap value.

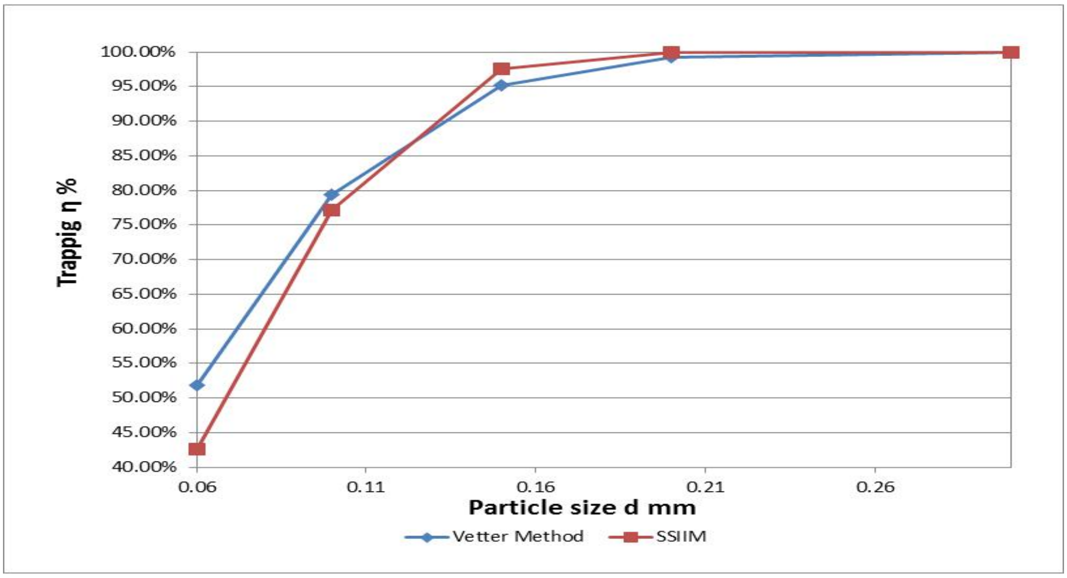


Figure 6.16 Comparison of trapping efficiency by SSIIM and Vetter Method

Trap percentage for proposed, alternative and modifications

SSIIM model were run for 65050 seconds with time step of 50 seconds Trap percentage are found as Table 6.2. It was assumed that there is no bed erosion.

Table 6.2 Trap percentage by SSIIM Model

Layouts Size,mm	**SC**	**PL**	**AL**	**M1**	**M2**	**M3**	**M4**
0.3	100.00	100.00	100.00	100.00	100.00	100.00	100.00
0.2	99.95	99.37	97.56	99.65	99.66	99.60	99.53
0.15	97.61	94.02	87.57	95.60	95.30	95.12	94.69
0.1	77.14	72.32	66.09	75.85	74.20	74.36	73.55
0.06	42.61	41.57	40.29	44.58	43.03	43.08	42.60
Average Trap %	**83.46**	**81.45**	**78.19**	**83.14**	**82.44**	**82.43**	**82.07**

SC- Settling chamber PL- Proposed layout AL- Alternative layout
M1- Modification 1 M2- Modification 2 M3- Modification 3
M4- Modification 4

From the Table 6.2 trap efficiency is more for settling basin chamber model it may be due to no effect of approach geometry and for other models trap percentage near to equal and modifications also increase trap percentage.

<u>Trap percentage during closing of one chamber</u>

Table 6.3 Trap percentage by SSIIM Model

Layouts				
Size,mm	**C1**	**C2**	**C3**	**C4**
0.3	99.96	99.95	99.94	99.91
0.2	96.60	96.59	96.86	97.70
0.15	84.53	84.86	86.17	88.19
0.1	57.95	58.72	61.84	63.86
0.06	31.56	32.13	35.40	36.11
Average Trap %	**74.12**	**74.45**	**76.04**	**77.15**

C1- Closing of first chamber
C2- Closing of second chamber
C3- Closing of Third chamber
C4- Closing of Fourth chamber

From Table 6.2 and 6.3 it is clearly seen that trap percentage reduces with closing one chamber and operation of remaining chambers with full design discharge.

All the calculation tables are presented on Appendix –C.

6.4.3 Sensitivity of control file parameters

6.4.3.1 Effect of Sediment pick-up rate, F 37 2

SSIIM model was run with F 37 2 data set and trap percentage is find out as on Table 6.4. Comparing trap percentage of F 37 2 data set with F 37 1 data set on Table 6.4 trap percentage is also most similar for coarse particle. However, for fine particle, F 37 2 data set has higher trap percentage. It may be due to F 37 1 data set is used for re-suspension of sediment at a constant rate and while F 37 2 data set is used re-suspension become function of flux. In both cases all other parameter are same.

Table 6.4 Trap efficiency variation due to F 37 data set

F 37 data set		
Size,mm	**F 37 1**	**F 37 2**
0.3	100.00%	100.00%
0.2	99.95%	99.95%
0.15	97.61%	97.70%
0.1	77.14%	78.15%
0.06	42.61%	45.03%
Average Trap %	**83.46%**	**84.17%**

6.4.3.2 Effect of change of F 16 data set

When model was run varying F 16 data set following result were obtained. It has very minor effect on trap percentage. The result is presented on Table 6.5.

Table 6.5 Trap percentage with variation of F 16 data set

Size mm	**F 16 data set values**			
	0.021	0.019	0.017	0.014
0.3	100.00%	100.00%	100.00%	100.00%
0.2	99.95%	99.95%	99.95%	99.95%
0.15	97.61%	97.61%	97.61%	97.62%
0.1	77.14%	77.15%	77.16%	77.19%
0.06	42.61%	42.60%	42.61%	42.61%

6.4.3.3 Effect of shield's coefficient F 11 data set

When model was run with shield's coefficient 0.04 following result was obtained. With comparing with result on Table 6.6 the result all most same so effect of Shield's coefficient is very minor. Defect percentage also reduces with shield coefficient 0.04. Trap percentage with F 11 2.65 0.04 is shown in Table 6.6.

Table 6.6Trap percentage with changing F 11 data set

F 11 data set Size,mm	**0.047**	**0.040**
0.3	100.00%	100.00%
0.2	99.95%	99.95%
0.15	97.61%	97.60%
0.1	77.14%	77.05%
0.06	42.61%	42.40%
Average Trap %	**83.46%**	**83.40%**

6.4.3.4 Effect of thickness of the upper active sediment layer

To achieve a reduced defect SSIIM model was run providing F 106 data set. It overrides the original value which is equal to maximum particle diameter. It reduced defect percentage. The figure has very low difference. Trap percentage with F 106 data set is presented on Table 6.7.

Table 6.7 Trap percentage with changing F 106 data set

F 106 data set **Size,mm**	**Without F 106**	**With F 106**
0.3	100.00%	100.00%
0.2	99.95%	99.94%
0.15	97.61%	97.61%
0.1	77.14%	77.13%
0.06	42.61%	42.59%
Average Trap %	**83.46%**	**83.45%**

6.5 Flushing Interval

Flushing interval is calculated for only proposed layout by using trap average trap percentage by SSIIM Model. Average trap percentage for proposed layout is taken as 81.45%. Flush interval is calculated by using spread sheet program. Capacity settling chamber is taken as dead storage of chamber; equal to 2532 m^3. Using measured sediment data dry volume of sediment trap is calculated assuming specific gravity of sediment is 2.65. It is assumed that wet volume of sediment is 1.5 times the dry volume and when deposited sediment volume reach to capacity of settling basin there will be flushing. The flushing pattern with respect to measure sediment data is presented on Figure 6.17. From the calculation, it is found that if there is 80% of average trap percentage maximum interval of flushing is 210 hours, i.e. 9 days and minimum interval of flushing is 12 hours .i.e. half day. However, flushing interval will be varied with PSD of suspension sediment inflow to the settling basin. Also flushing interval is short for high sediment concentration inflow to the settling basin. It is recommended that flush should be done according to deposition level of sediment in the settling basin and sediment inflow concentration because of the settling basin is conventional.

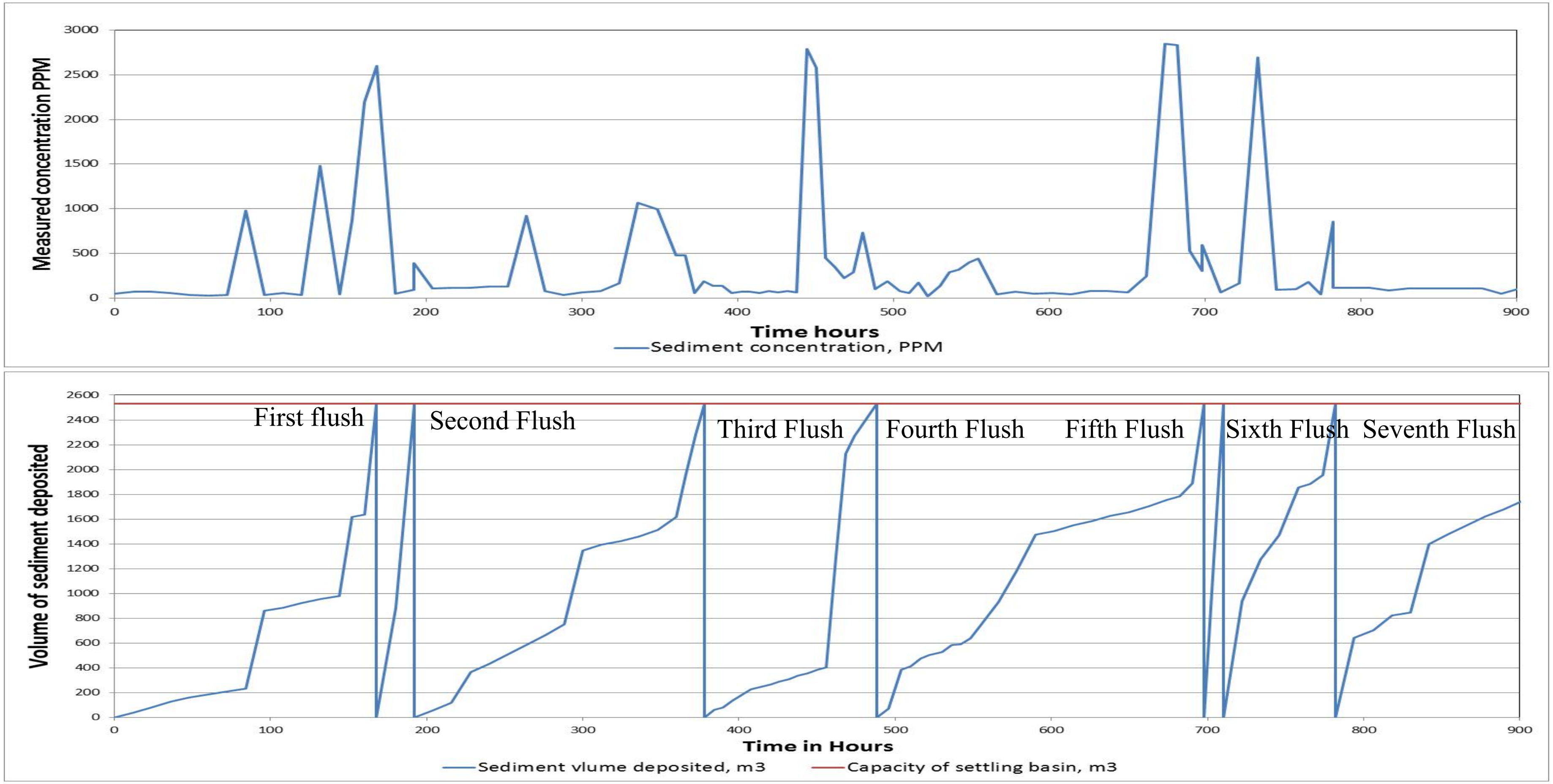


Figure 6.17 Flushing of sediment with respect to measured sediment data

Minimum and Maximum flushing interval = 12 hours and 210 hours

7. CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The study of hydraulics and sediment transport is very complex. CFD modeling of hydraulic and sediment transport is in research stage. SSIIM is freely available CFD modeling software to evaluate many problem associate with fluid dynamics. Following conclusion has made.

7.1.1 SSIIM Scope

The study result shows that SSIIM can be used for 3D numerical investigation of different hydraulic structures like headworks, settling basin, water way, headrace tunnel, river sediment transport problems. It can be used to evaluate effect of geometry on hydraulic performance and distribution of sediment concentration over multiple settling basin chambers. Also it can be used to evaluate trap efficiency of settling basin layouts.

It can be an ideal solution for small hydropower projects of sediment Problem River, like Nepalese Rivers. For small project lack of sufficient fund and time; physical modeling may not possible so for planning of hydraulic structures in hydropower project SSIIM can be a powerful tool.

For analysis of hydraulic performance, sediment transport, trap efficiency, bed deposition and sediment distribution pattern; SSIIM can be used at all stages of project. Also it can be used for comparing result of physical model.

7.1.2 Case Study on settling basin Layouts

In this study a case study of settling basin layouts of Mai Khola Hydropower Project, Nepal was carried out. Study of hydraulics and sediment transport performance of proposed layout was studied. To save cost an alternative layout with shorter length has studied but due to short approach from bend to settling chamber alternative layout gives poor hydraulics than proposed layout.

Further investigation on proposed layout was carried out with modification on approach geometry. From the investigation result, proposed layout may not distribute the sediment flow equally to all four chamber of settling basin. It might be problem on operation and flushing of sediment because some chamber might be filled up faster and reduced the trap performance. While modification was done on approach geometry, there will be more uniform distribution of sediment over four chambers and results shows better performance of sediment trap. Also case study of closing of chambers separately has done for full design discharge of power plant. Result shows that closing of chambers also greatly influenced on distribution and settlement of sediment.

Trapping efficiency for settling basin layouts are evaluated and it is fairly good for time dependent flow of sediment concentration. Trap performance is also better if there is divide wall at bend of approach culvert. It is concluded that to improve the settling performance there should be divide watt at approach bend.

7.2 Recommendation

It's strongly recommended for further study. Some recommendation has listed.

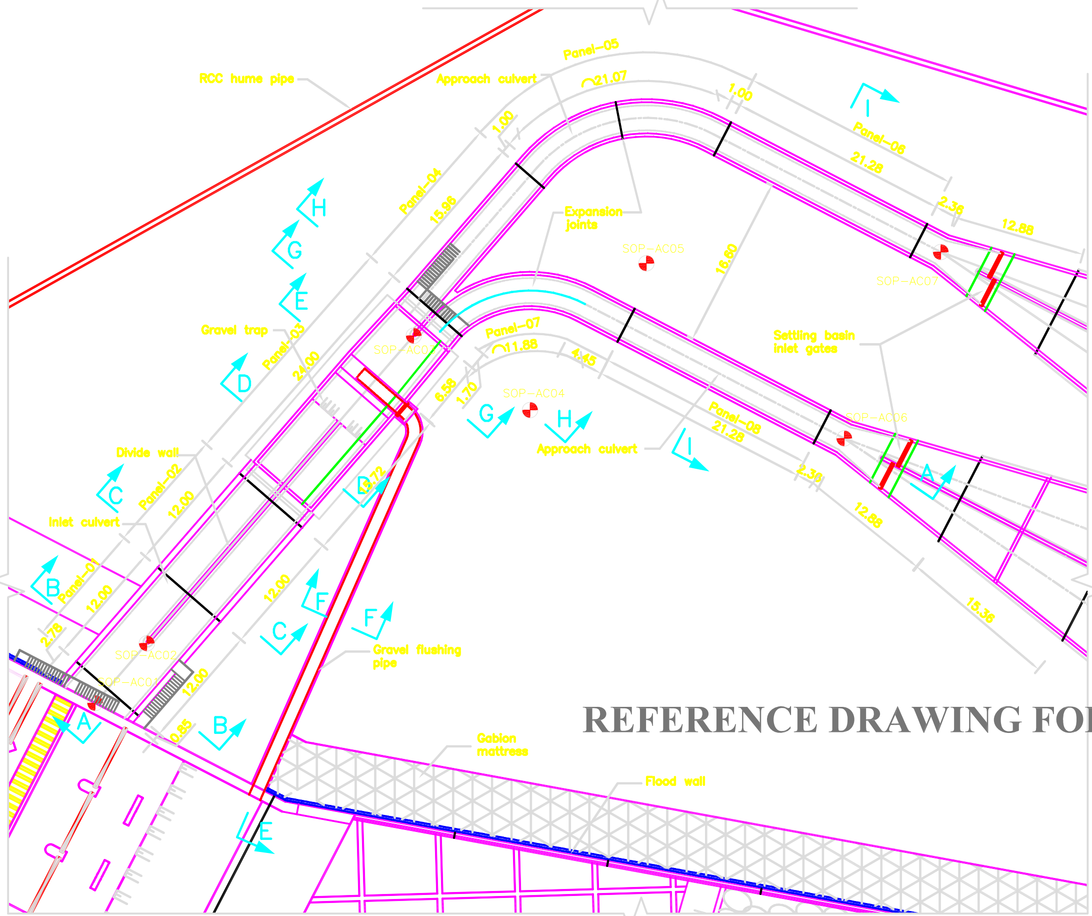
- Due to lack of user friendliness like commercial software it recommended that there should be more examples with detail procedure in user manual.
- While using the SSIIM, it need to great care while preparing grid and control file. Convergence depends on proper planning of grid and choosing of appropriate parameter. Trial should be done as much as possible to get converged solution.
- It will be great if there is help tools on window version of SSIIM for new user of SSIIM.
- It is found that SSIIM user manual is not updated and some data sets do not work as considered. It is recommended that user manual and data sets should be updated.

8. REFERENCES

1. Dagfinn lysne, Brian Glover, Hakon Stole, Einar Tesaker " Hydraulic Design , Volume 8 Hydropower development series "
2. Hakan Stole " Headworks and Sedimentation Engineering" Hand-out Literature for the course TVM5160"
3. Nils Reidar B. Olsen " Numerical Modeling and Hydraulics, 3rd edition, 2011"
4. Nils Reider B. Olsen" A three dimensional numerical model for simulation of sediment movements in water intakes with multiblock options (SSIIM) Version 1 and 2, User's Manual 2011"
5. Hydro Lab (P) Ltd. "Hydraulic Model Study of Headworks of Mai Khola Hydropower Project"
6. Aravind Kumar Agrawal "Numerical Modeling of Sediment Flow in Tala Desilting Chamber|"
7. Maskwy, Diwash lal " CFD modeling of hydraulic and sediment at the intake of Nyadi Hydropower Project, Nepal"

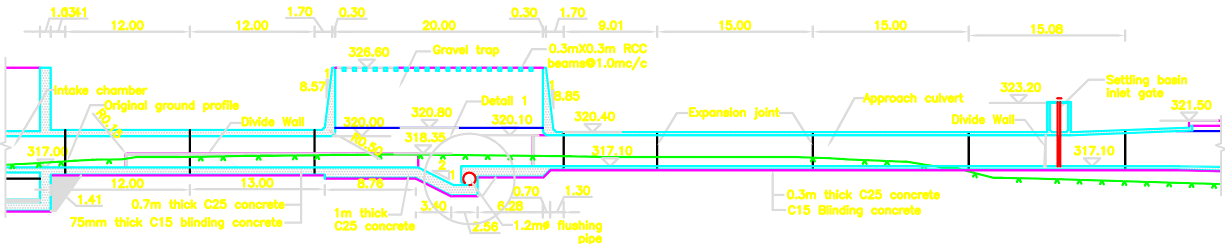
Annexure- A

DRAWINGS

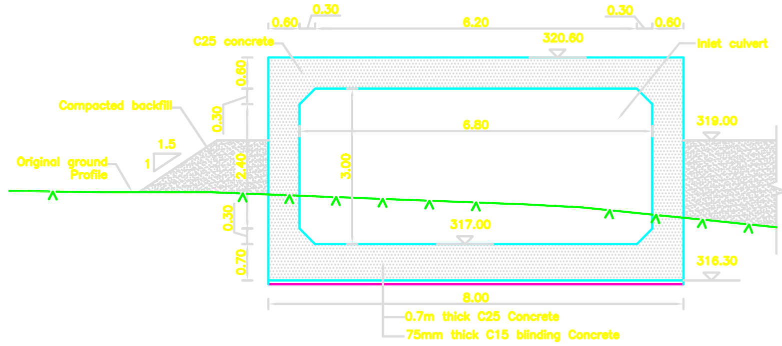


PLAN
Scale A

REFERENCE DRAWING FOR 3D MODEL



SECTION A–A
Scale A



SECTION B–B
Scale B

SETTING OUT POINTS

SOP	DESCRIPTION	EASTING	NORTHING
SOP-AC01	Start point of inlet culvert(Center line)	588981.390	2967698.240
SOP-AC02	Start point of inlet culvert divide wall (Center line)	588987.130	2967693.260
SOP-AC03	Start point of approach culvert divide wall (Center line)	589016.750	2967667.550
SOP-AC04	Center point of right side approach culvert bend(Center line)	589009.590	2967656.340
SOP-AC05	Center point of left side approach culvert bend(Center line)	589023.720	2967645.130
SOP-AC06	End point of right side approach culvert end(Center line)	589006.860	2967626.080
SOP-AC07	End point of left side approach culvert end(Center line)	589024.800	2967616.790

NOTES:

1. All dimensions are in meter & levels are in meter above sea level unless otherwise mentioned.
2. This drawing is to be read in conjunction with :
   MHP-10-G01 Headworks, General arrangement, Plan
   MHP-10-G02 Headworks, General arrangement, Profile
   MHP-15-C02 to C03 Headworks, Gravel trap and Approach culvert, Section
3. Blinding concrete shall be of C15 and 75mm thick unless mentioned.
4. Structural concrete shall be C25 unless mentioned.
5. Expansion joint shall be provided at 15m c/c unless otherwise mentioned.
6. Expansion joint shall be of J1 type in floor slab and J3 type in wall or suspended slab unless mentioned.
7. All exposed outer corner shall be provided with 25mmX25mm chamfer.
8. Silica concrete(5%) should be used at the base slab and lower half portion of side wall from inlet culvert to gravel trap.

metres 5 0 5 10 15 20 25 metres
Scale A

metres 1 0 1 2 3 4 5 metres
Scale B

Rev.	Amendment

SANIMA MAI HYDROPOWER (P.) LTD.

MAI HYDROPOWER PROJECT

HEADWORKS
INLET CULVERT,
GRAVEL TRAP & APPROACH CULVERT
PLAN AND SECTION
SHEET 1 OF 3

Particular:	Name	Initial	Date
Designed:	NRJ		
Drawn:	SjS		
Checked:	NRJ		
Recommended:	NKC		
Approved:	AK		

CONSTRUCTION DRAWINGS

Drawing No. : MHP-15-C01

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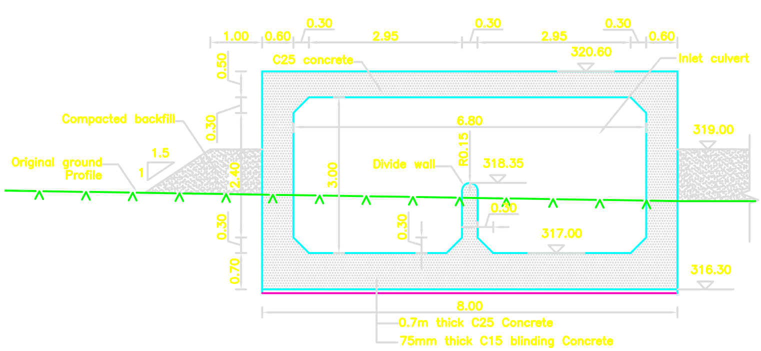
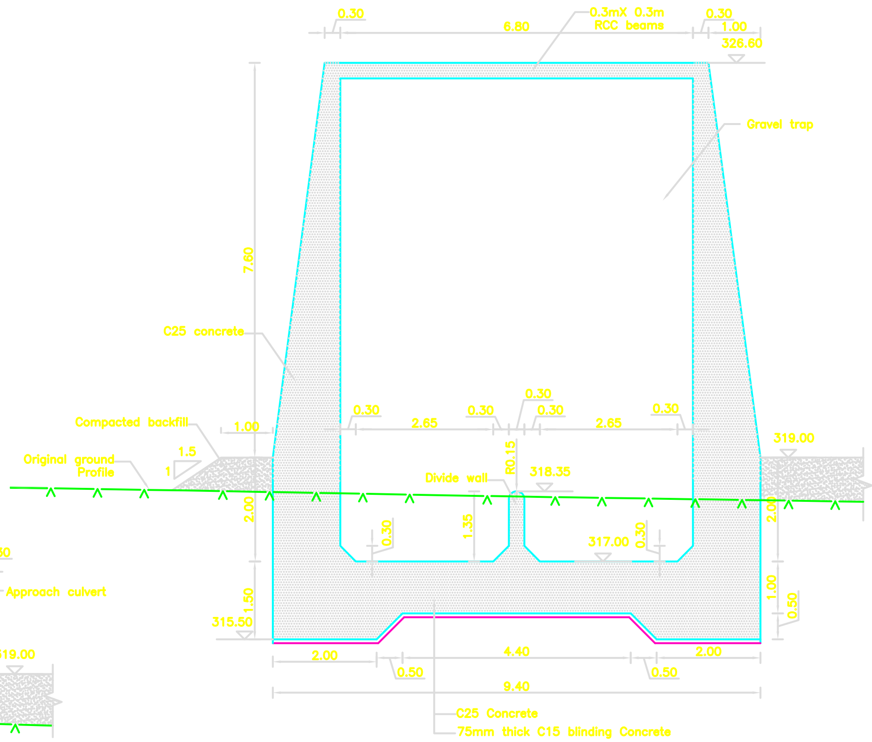
Web: www.sanimahydro.com.np

PLOT DATE:27-May-12
ISSUED DATE:25-Dec-11

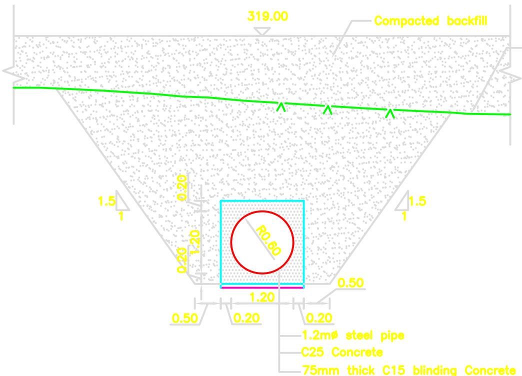
REFERENCE DRAWING FOR 3D MODEL



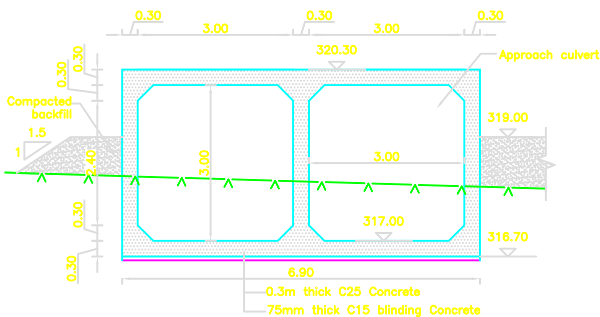
SECTION C–C
Scale B



SECTION D–D
Scale B



SECTION F–F
Scale B



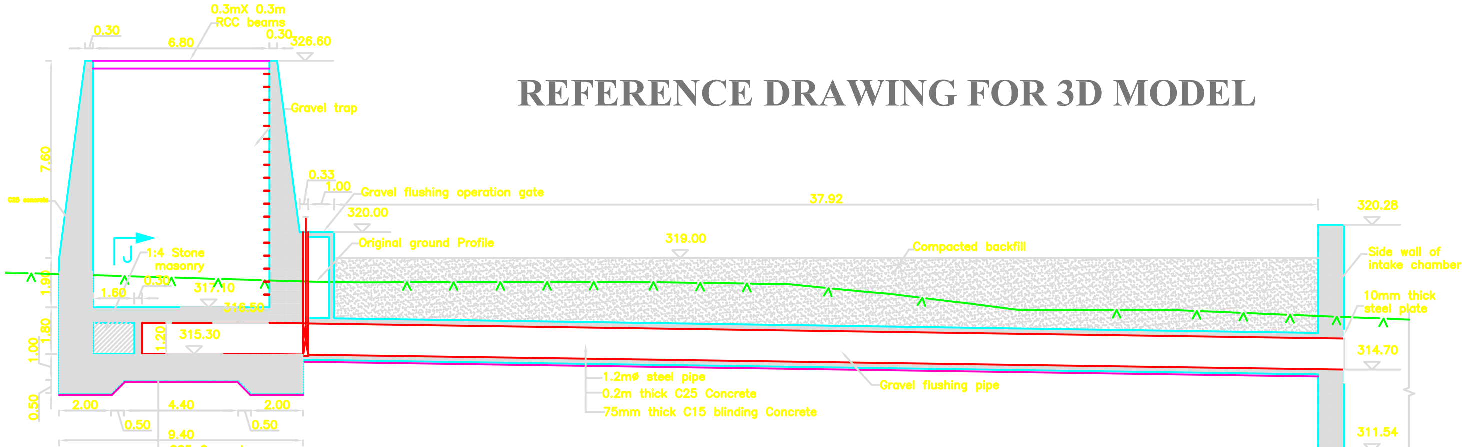
SECTION H–H

NOTES:

1. All dimensions are in meter & levels are in meter above sea level unless otherwise mentioned.
2. This drawing is to be read in conjunction with :
   MHP–10–G01 Headworks, General arrangement, Plan
   MHP–10–G02 Headworks, General arrangement, Profile
   MHP–15–C02 to C03 Headworks, Gravel trap and Approach culvert, Section
3. Blinding concrete shall be of C15 and 75mm thick unless mentioned.
4. Structural concrete shall be C25 unless mentioned.
5. Expansion joint shall be provided at 15m c/c unless otherwise mentioned.
6. Expansion joint shall be of J1 type in floor slab and J3 type in wall or suspended slab unless mentioned.
7. All exposed outer corner shall be provided with 25mmX25mm chamfer.

metres 2 0 2 4 6 8 10 metres
Scale A

metres 1 0 1 2 3 4 5 metres
Scale B



SECTION E–E
Scale A

Rev.	Amendment			
SANIMA MAI HYDROPOWER (P.) LTD.				
MAI HYDROPOWER PROJECT				
HEADWORKS INLET CULVERT, GRAVEL TRAP & APPROACH CULVERT PLAN AND SECTION SHEET 2 OF 3	Particular:	Name	Initial	Date
	Designed:	NRJ		
	Drawn:	SjS		
	Checked:	NRJ		
	Recommended:	NKC		
	Approved:	AK		
CONSTRUCTION DRAWINGS	Drawing No. :	MHP–15–C02		

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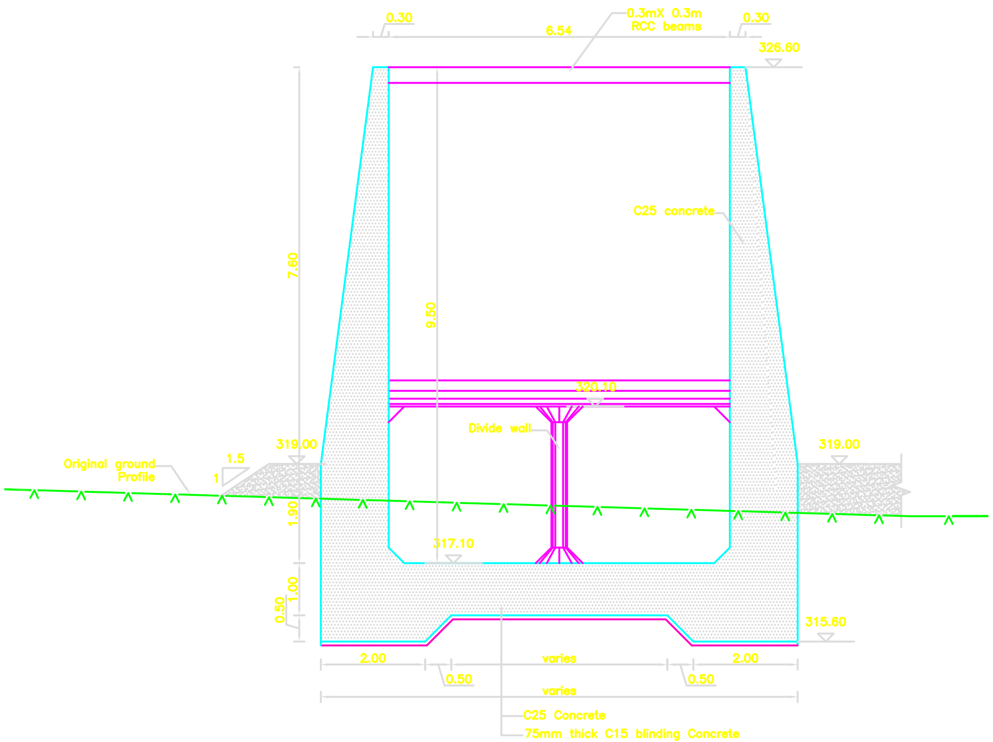
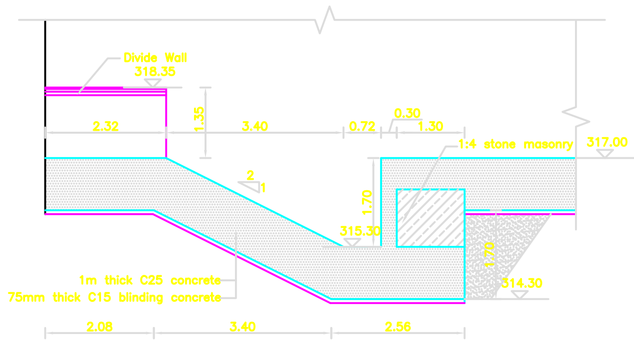
Web: www.sanimahydro.com.np

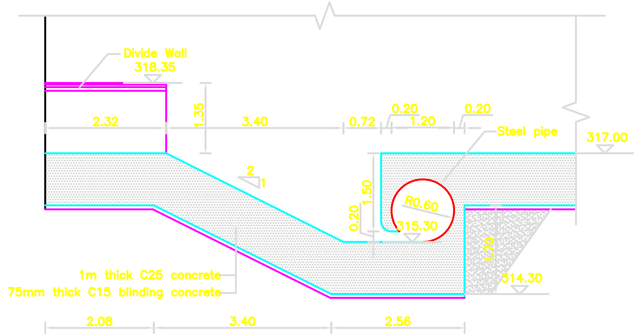
PLOT DATE:27–May–12
ISSUED DATE:25–Dec–11



SECTION G–G



SECTION J–J

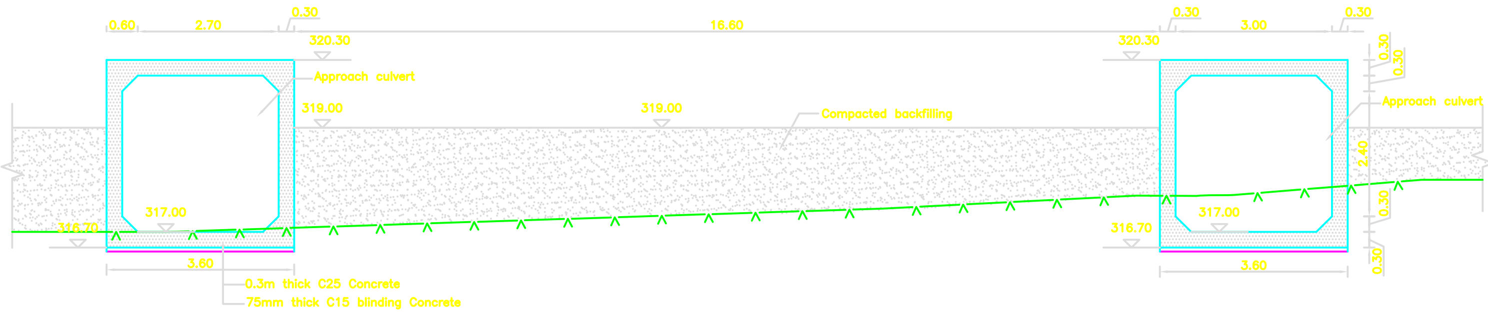


DETAIL 1

NOTES:

1. All dimensions are in meter & levels are in meter above sea level unless otherwise mentioned.
2. This drawing is to be read in conjunction with :
   MHP–10–G01 Headworks, General arrangement, Plan
   MHP–10–G02 Headworks, General arrangement, Profile
   MHP–15–C02 to C03 Headworks, Gravel trap and Approach culvert, Section
3. Blinding concrete shall be of C15 and 75mm thick unless mentioned.
4. Structural concrete shall be C25 unless mentioned.
5. Expansion joint shall be provided at 15m c/c unless otherwise mentioned.
6. Expansion joint shall be of J1 type in floor slab and J3 type in wall or suspended slab unless mentioned.
7. All exposed outer corner shall be provided with 25mmX25mm chamfer.

REFERENCE DRAWING FOR 3D MODEL



SECTION I–I

metres 1 0 1 2 3 4 5 metres

Scale

Rev.	Amendment

SANIMA MAI HYDROPOWER (P.) LTD.

MAI HYDROPOWER PROJECT

HEADWORKS
INLET CULVERT,
GRAVEL TRAP & APPROACH CULVERT
PLAN AND SECTION
SHEET 3 OF 3

Particular:	Name	Initial	Date
Designed:	NRJ		
Drawn:	SjS		
Checked:	NRJ		
Recommended:	NKC		
Approved:	AK		

CONSTRUCTION DRAWINGS

Drawing No. : MHP–15–C03

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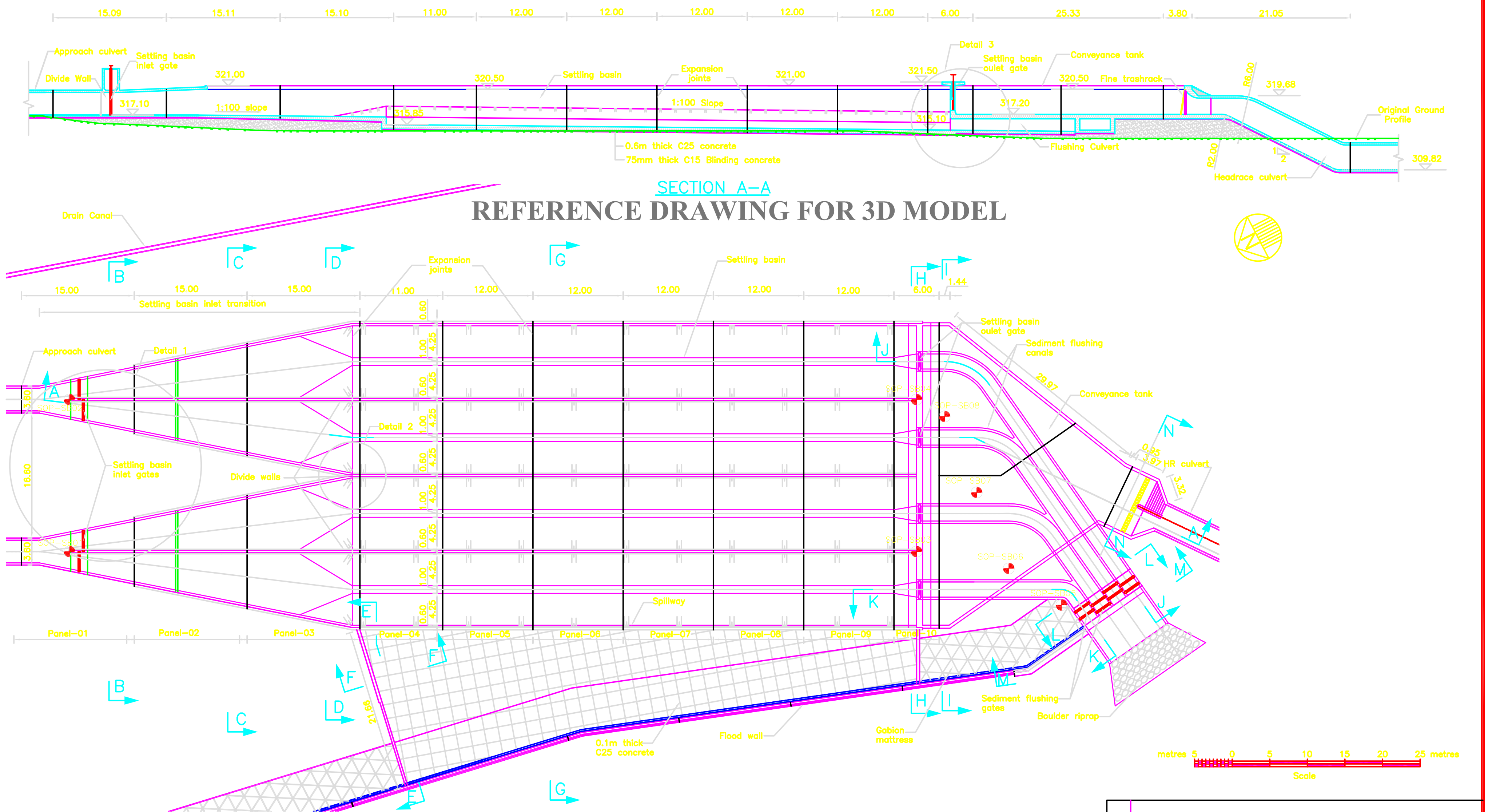
E-mail: sanima@sanimahydro.com.np
Web: www.sanimahydro.com.np

PLOT DATE:27–May–12
ISSUED DATE:25–Dec–11



SETTING OUT POINTS

SOP	DESCRIPTION	EASTING	NORTHING
SOP–SB01	Start point of left side divide wall (Center line)	589005.020	2967622.520
SOP–SB02	Start point of right side divide wall (Center line)	589022.960	2967613.230
SOP–SB03	End point of left side divide wall (Center line)	588953.220	2967522.550
SOP–SB04	End point of right side divide wall (Center line)	588971.160	2967513.250
SOP–SB05	Center point of first flushing canal bend (Center line)	588938.050	2967508.710
SOP–SB06	Center point of second flushing canal bend (Center line)	588945.590	2967512.690
SOP–SB07	Center point of third flushing canal bend (Center line)	588956.520	2967511.830
SOP–SB08	Center point of fourth flushing canal bend (Center line)	588967.450	2967510.970

NOTES:

1. All dimensions are in meter, levels are in meter above amsl unless otherwise mentioned.
2. This drawing is to be read in conjunction with:
   MHP–10–G01 Headworks, General arrangement, Plan
   MHP–10–C02 Headworks, General arrangement, Profile
   MHP–16–C01 to C07 Headworks, Settling basin, Plan, section & detail
3. Blinding concrete shall be C15.
4. Structural concrete shall be C25 unless mentioned.
5. Expansion joint shall be provided at 15m c/c unless mentioned.
6. Expansion joint shall be of J1 type in floor slab and J3 type in wall or suspended slab unless mentioned.
7. All exposed outer corner shall be provide with 25mmX25mm chamfer.

Rev.	Amendment

SANIMA MAI HYDROPOWER (P.) LTD.

MAI HYDROPOWER PROJECT

HEADWORKS
SETTLING BASIN
PLAN AND SECTION

SHEET 1 OF 7

Particular:	Name	Initial	Date
Designed:	NRJ		
Drawn:	SJS		
Checked:	NRJ		
Recommended:	NKC		
Approved:	AK		

CONSTRUCTION DRAWINGS — Drawing No. : MHP–16–C01

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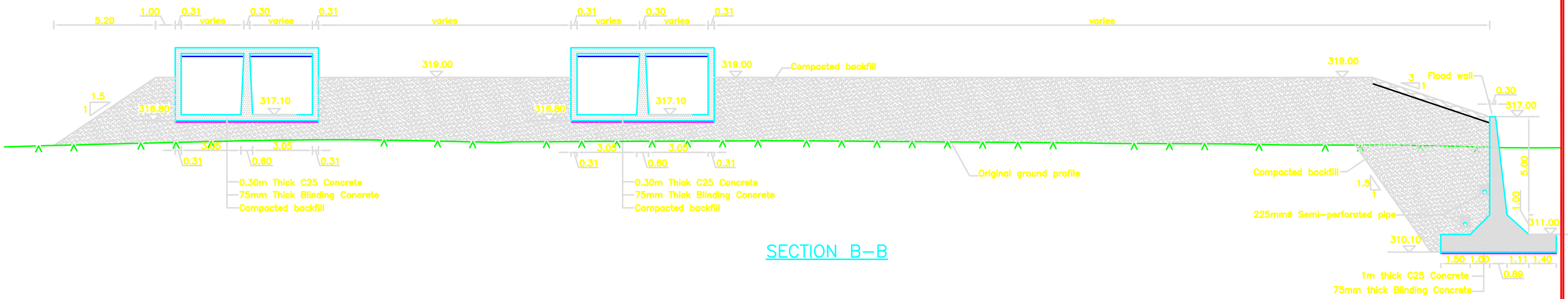
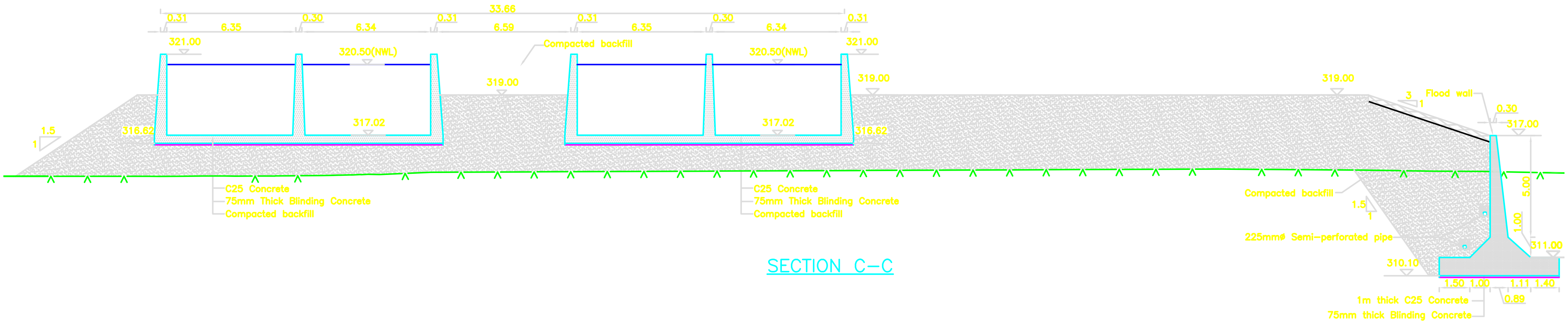
PLOT DATE: 27–May–12
ISSUED DATE: 25–Dec–11



SECTION B–B



SECTION C–C

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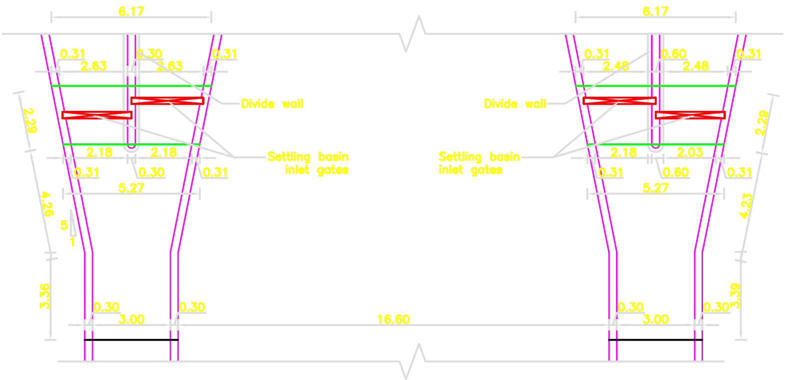

DETAIL 1

NOTES:

1. All dimensions are in meter, levels are in meter above amsl unless otherwise mentioned.
2. This drawing is to be read in conjunction with:
   MHP–10–G01 Headworks, General arrangement, Plan
   MHP–10–C02 Headworks, General arrangement, Profile
   MHP–16–C01 to C07 Headworks, Settling basin, Plan, section & detail
3. Blinding concrete shall be C15.
4. Structural concrete shall be C25 unless mentioned.
5. Expansion joint shall be provided at 15m c/c unless mentioned.
6. Expansion joint shall be of J1 type in floor slab and J3 type in wall or suspended slab unless mentioned.
7. All exposed outer corner shall be provide with 25mmX25mm chamfer.

metres 2 0 2 4 6 8 10 metres

Scale

Rev.	Amendment

SANIMA MAI HYDROPOWER (P.) LTD.

MAI HYDROPOWER PROJECT

HEADWORKS
SETTLING BASIN
SECTION AND DETAIL

SHEET 2 OF 7

Particular:	Name	Initial	Date
Designed:	NRJ		
Drawn:	SjS		
Checked:	NRJ		
Recommended:	NKC		
Approved:	AK		

CONSTRUCTION DRAWINGS

Drawing No. : MHP–16–C02

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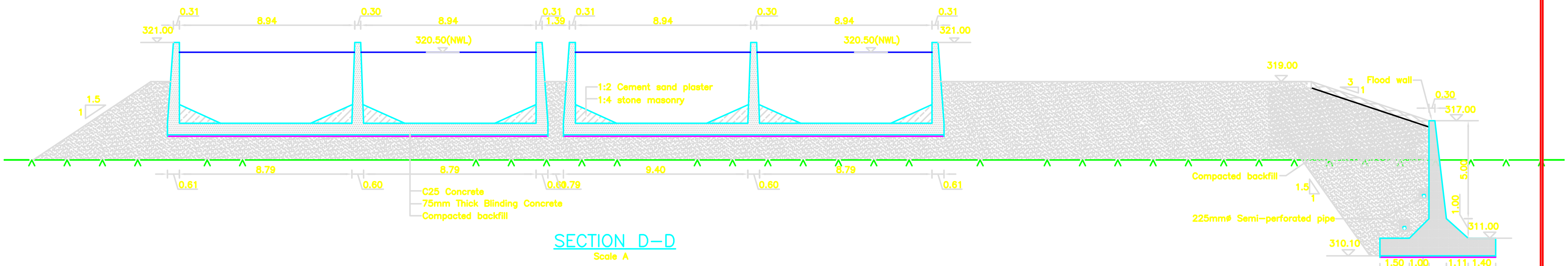
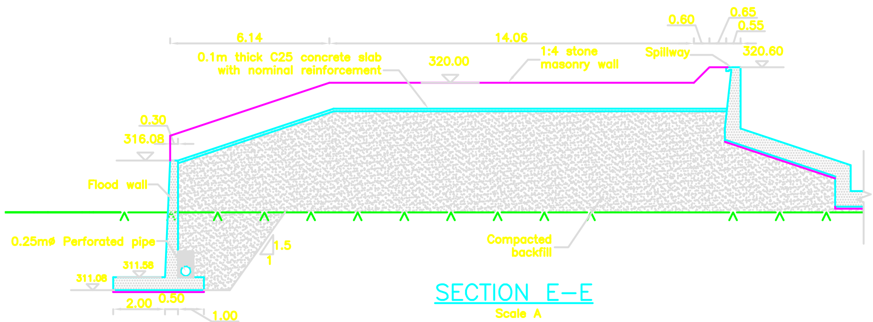
Web: www.sanimahydro.com.np

PLOT DATE:27–May–12
ISSUED DATE:25–Dec–11

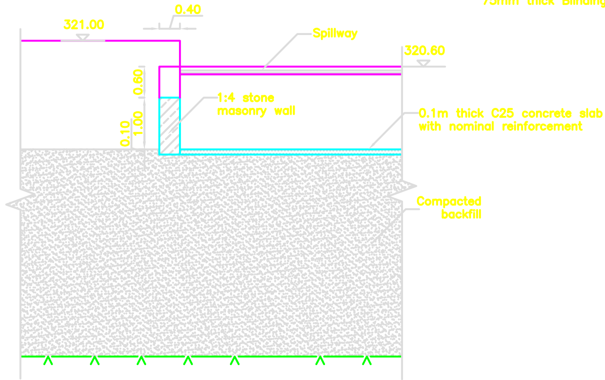
REFERENCE DRAWING FOR 3D MODEL



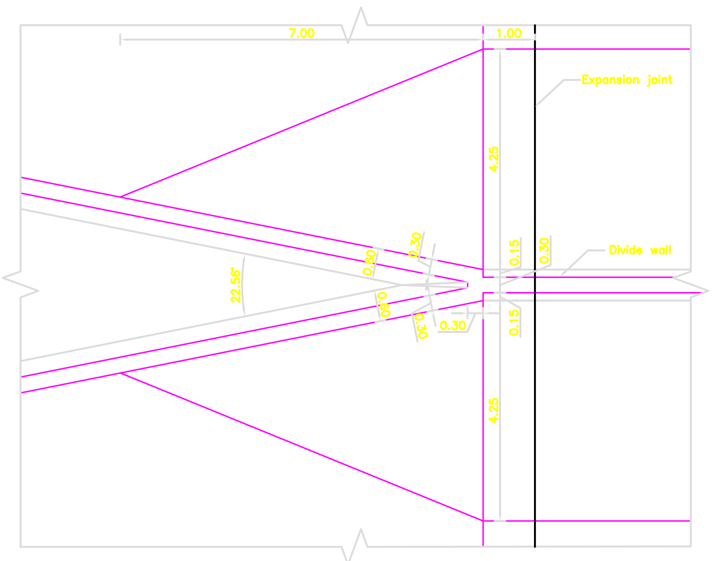
SECTION D–D
Scale A



SECTION E–E
Scale A



SECTION F–F
Scale B



DETAIL 2
Scale B

NOTES:

1. All dimensions are in meter, levels are in meter above amsl unless otherwise mentioned.
2. This drawing is to be read in conjunction with:
   MHP–10–G01 Headworks, General arrangement, Plan
   MHP–10–C02 Headworks, General arrangement, Profile
   MHP–16–C01 to C07 Headworks, Settling basin, Plan, section & detail
3. Blinding concrete shall be C15.
4. Structural concrete shall be C25 unless mentioned.
5. Expansion joint shall be provided at 15m c/c unless mentioned.
6. Expansion joint shall be of J1 type in floor slab and J3 type in wall or suspended slab unless mentioned.
7. All exposed outer corner shall be provide with 25mmX25mm chamfer.

metres 2 0 2 4 6 8 10 metres
Scale A

metres 1 0 1 2 3 4 5 metres
Scale B

Rev.	Amendment

SANIMA MAI HYDROPOWER (P.) LTD.

MAI HYDROPOWER PROJECT

HEADWORKS
SETTLING BASIN
SECTION AND DETAIL

SHEET 3 OF 7

Particular:	Name	Initial	Date
Designed:	NRJ		
Drawn:	SJS		
Checked:	NRJ		
Recommended:	NKC		
Approved:	AK		

CONSTRUCTION DRAWINGS

Drawing No. : MHP–16–C03

SANIMA HYDRO AND ENGINEERING (P.) LTD.
Narayan Chour, Naxal; P.O.Box 19737 Kathmandu, Nepal.
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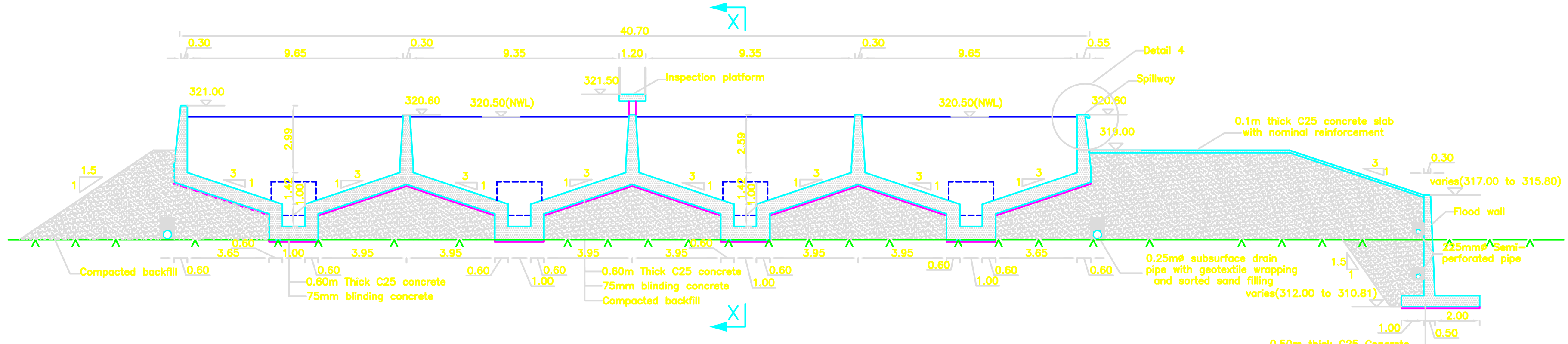
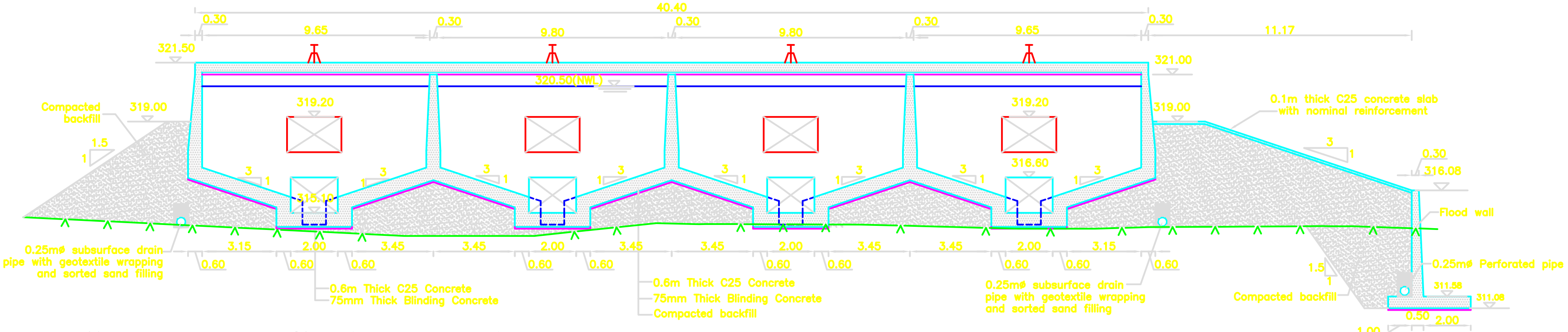
E-mail: sanima@sanimahydro.com.np
Web: www.sanimahydro.com.np

PLOT DATE:27–May–12
ISSUED DATE:25–Dec–11

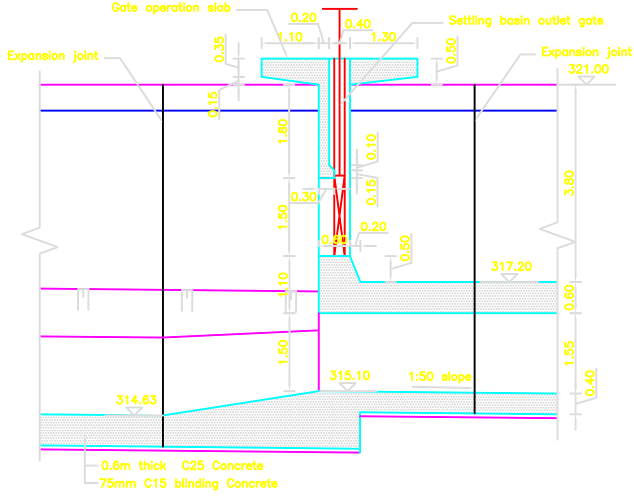


SECTION G–G
Scale A

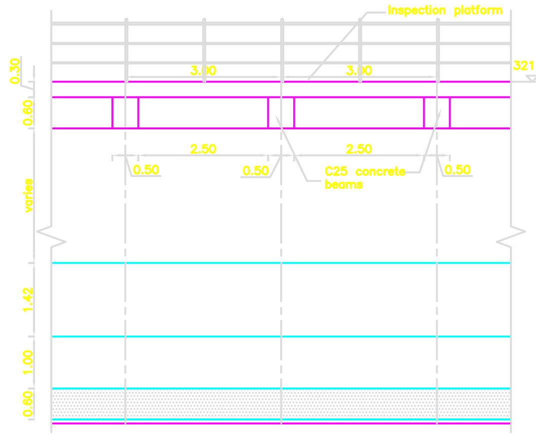


SECTION H–H
Scale A

REFERENCE DRAWING FOR 3D MODEL



DETAIL 3
Scale B



SECTION X–X
Scale B

NOTES:

1. All dimensions are in meter, levels are in meter above amsl unless otherwise mentioned.
2. This drawing is to be read in conjunction with:
   MHP–10–G01 Headworks, General arrangement, Plan
   MHP–10–C02 Headworks, General arrangement, Profile
   MHP–16–C01 to C07 Headworks, Settling basin, Plan, section & detail
3. Blinding concrete shall be C15.
4. Structural concrete shall be C25 unless mentioned.
5. Expansion joint shall be provided at 15m c/c unless mentioned.
6. Expansion joint shall be of J1 type in floor slab and J3 type in wall or suspended slab unless mentioned.
7. All exposed outer corner shall be provide with 25mmX25mm chamfer.

metres 2 0 2 4 6 8 10 metres
Scale A

metres 1 0 1 2 3 4 5 metres
Scale B

Rev.	Amendment			
SANIMA MAI HYDROPOWER (P.) LTD.				
MAI HYDROPOWER PROJECT				
HEADWORKS SETTLING BASIN SECTION AND DETAIL	Particular:	Name	Initial	Date
	Designed:	NRJ		
	Drawn:	SJS		
	Checked:	NRJ		
	Recommended:	NKC		
SHEET 4 OF 7	Approved:	AK		
CONSTRUCTION DRAWINGS	Drawing No. :	MHP–16–C04		

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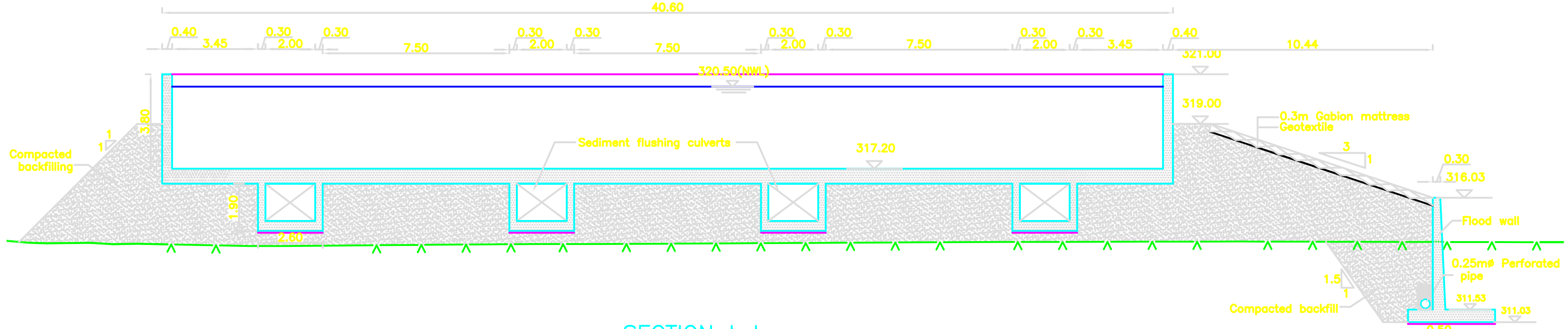
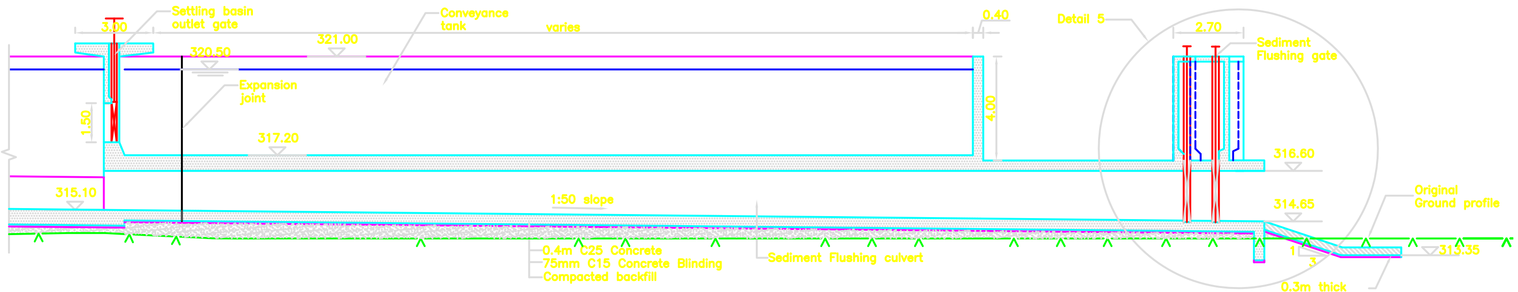
E–mail: sanima@sanimahydro.com.np
Web: www.sanimahydro.com.np

PLOT DATE:27–May–12
ISSUED DATE:25–Dec–11



SECTION I–I

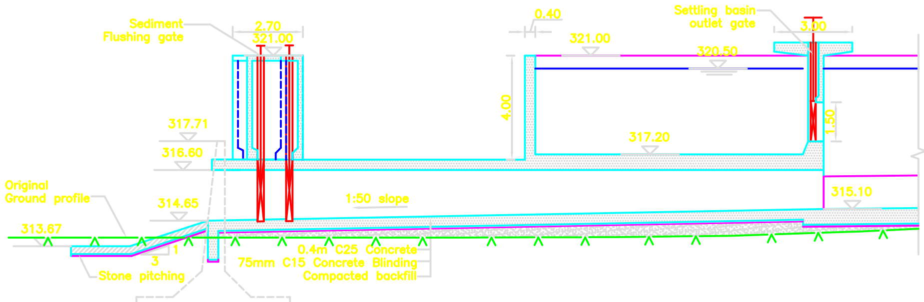
Scale A



SECTION J–J

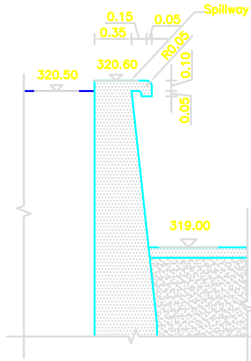
Scale A

REFERENCE DRAWING FOR 3D MODEL



SECTION K–K

Scale A



DETAIL 4

Scale B

NOTES:

1. All dimensions are in meter, levels are in meter above amsl unless otherwise mentioned.
2. This drawing is to be read in conjunction with:
   MHP–10–G01 Headworks, General arrangement, Plan
   MHP–10–C02 Headworks, General arrangement, Profile
   MHP–16–C01 to C07 Headworks, Settling basin, Plan, section & detail
3. Blinding concrete shall be C15.
4. Structural concrete shall be C25 unless mentioned.
5. Expansion joint shall be provided at 15m c/c unless mentioned.
6. Expansion joint shall be of J1 type in floor slab and J3 type in wall or suspended slab unless mentioned.
7. All exposed outer corner shall be provide with 25mmX25mm chamfer.

metres 2 0 2 4 6 8 10 metres

Scale

metres 0.5 0 0.5 1 1.5 2 2.5 metres

Scale

Rev.	Amendment

SANIMA MAI HYDROPOWER (P.) LTD.

MAI HYDROPOWER PROJECT

HEADWORKS
SETTLING BASIN
SECTION AND DETAIL

SHEET 5 OF 7

Particular:	Name	Initial	Date
Designed:	NRJ		
Drawn:	SjS		
Checked:	NRJ		
Recommended:	NKC		
Approved:	AK		

CONSTRUCTION DRAWINGS

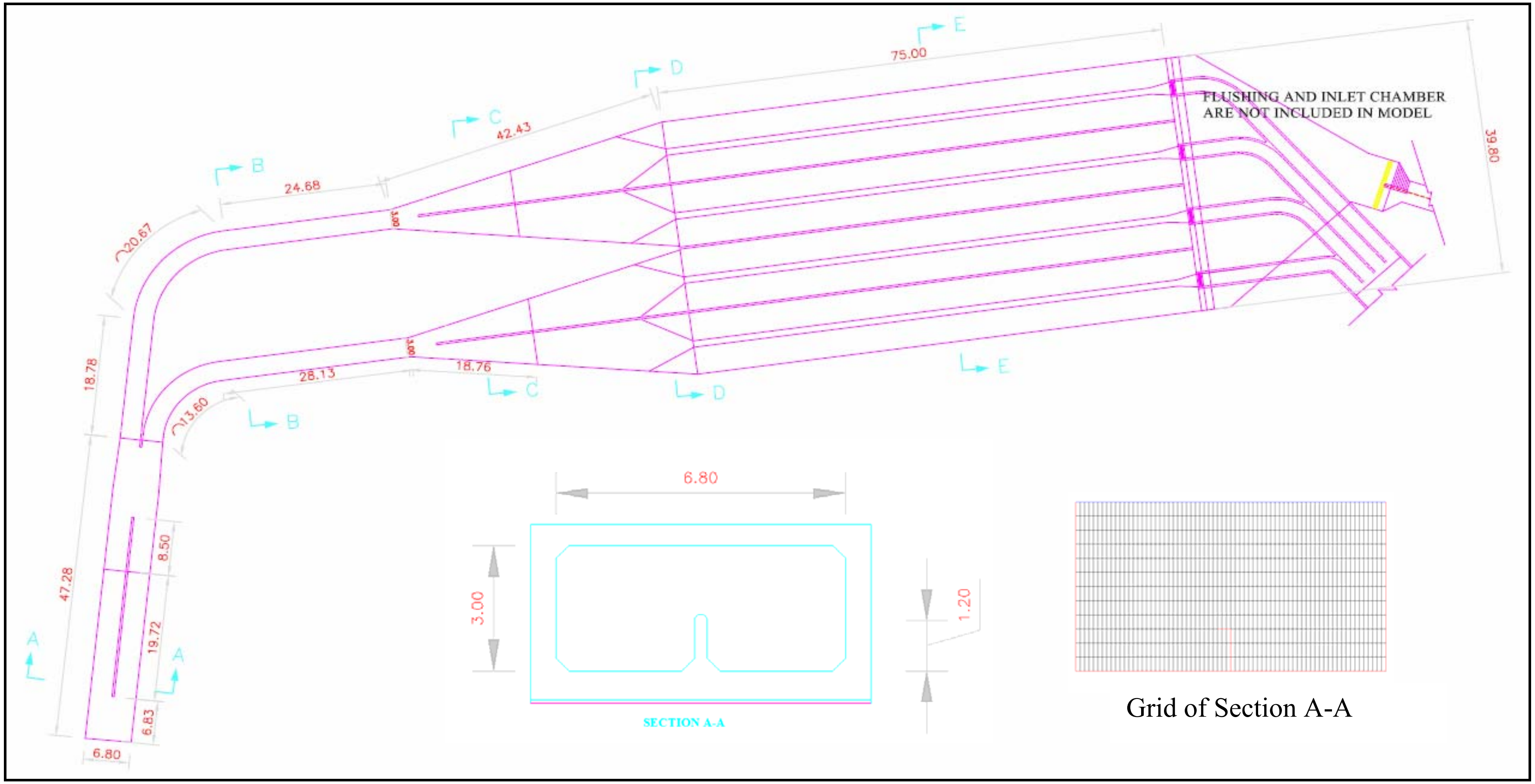
Drawing No. : MHP–16–C05

SANIMA HYDRO AND ENGINEERING (P.) LTD.
Narayan Chour, Naxal; P.O.Box 19737 Kathmandu, Nepal.
Tel: (977–1) 4446442, Fax: (977–1) 4441277
E-mail: sanima@sanimahydro.com.np
Web: www.sanimahydro.com.np

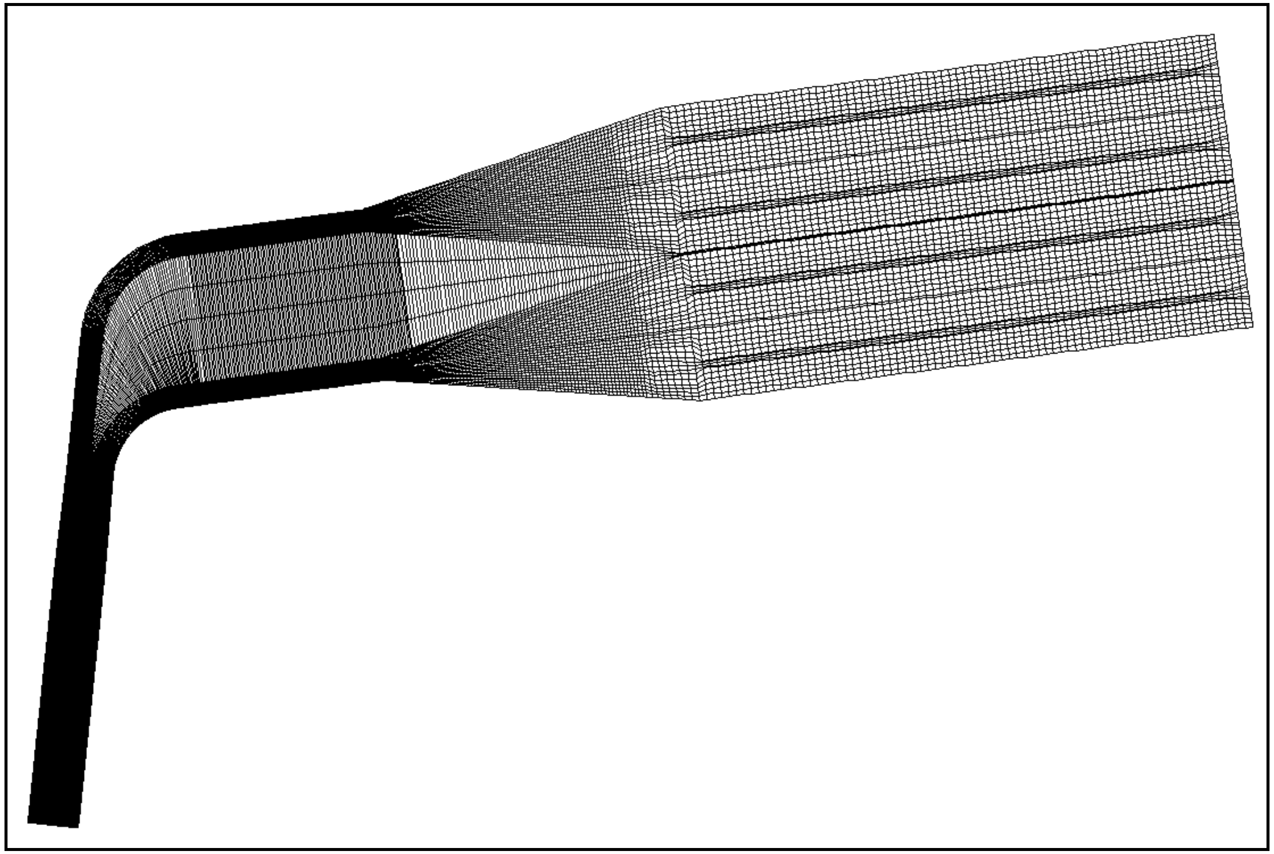
PLOT DATE:27–May–12
ISSUED DATE:25–Dec–11

Annexure-B

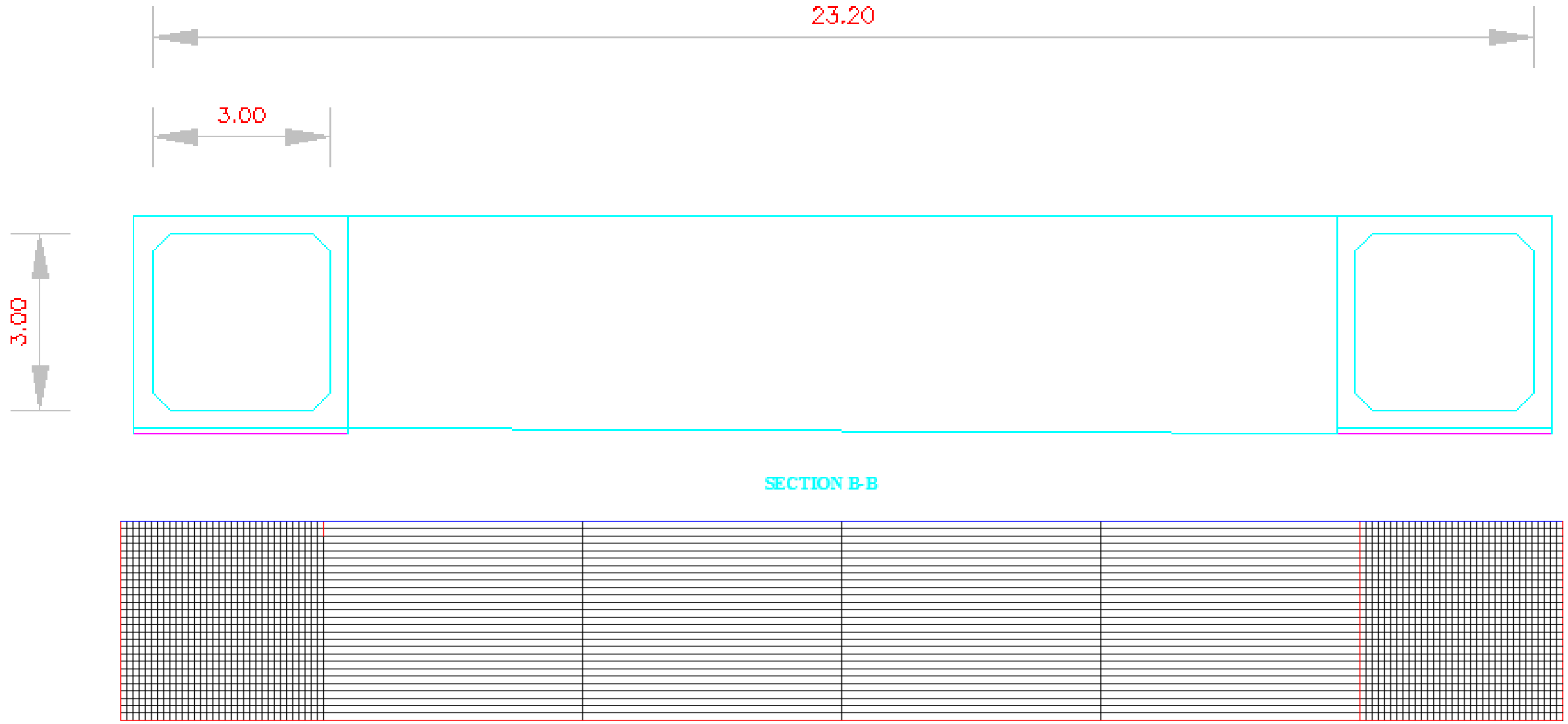
GRID GENERATION



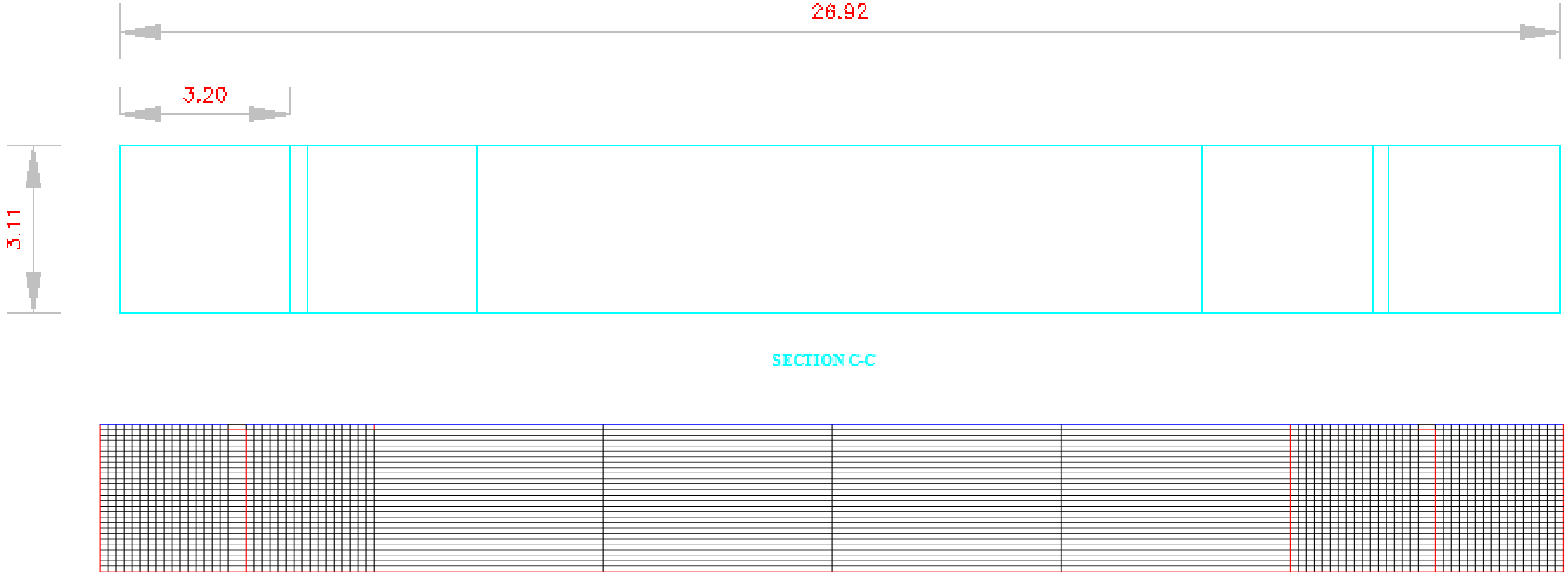
Layout Plan of Proposed Settling Basin



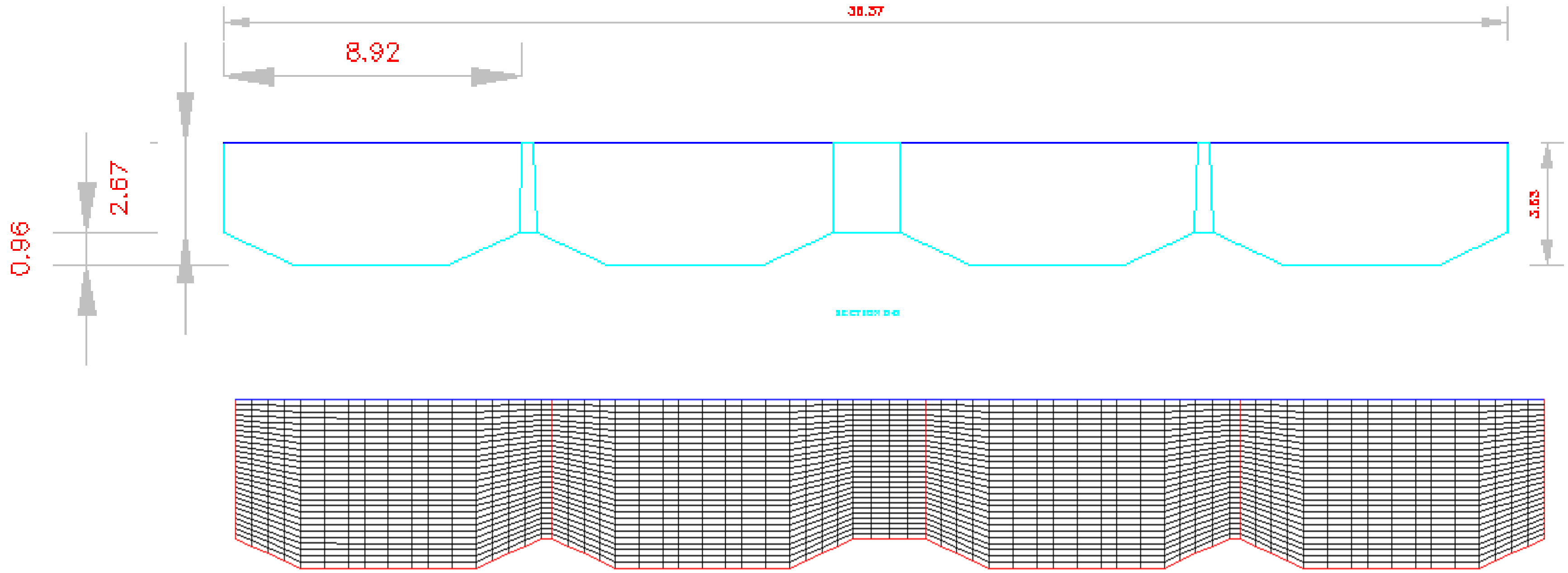
Grid Plan View of Proposed Layout of Settling Basin



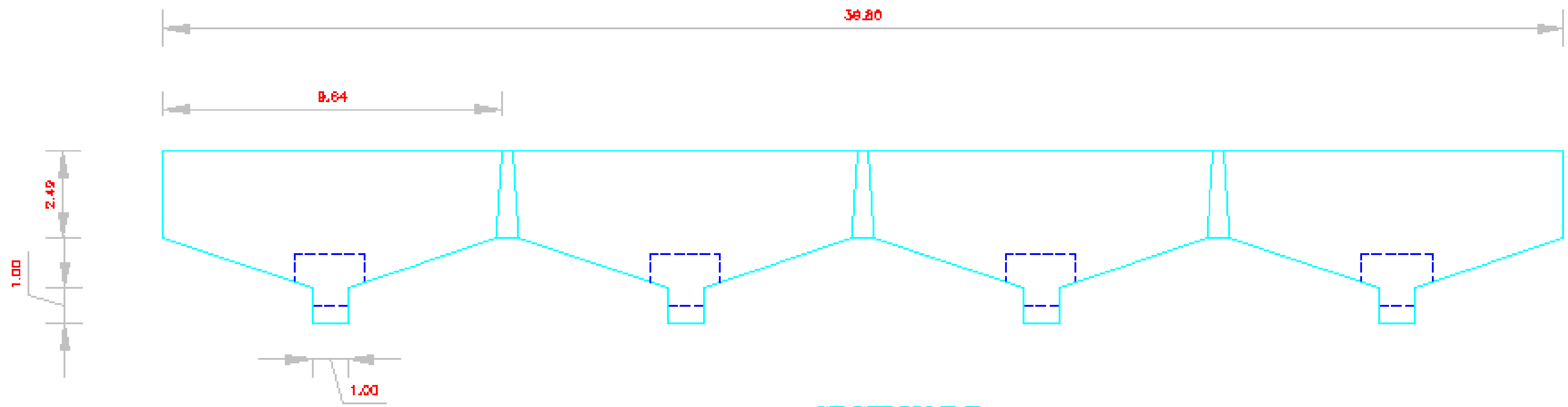
Grid of Section B-B

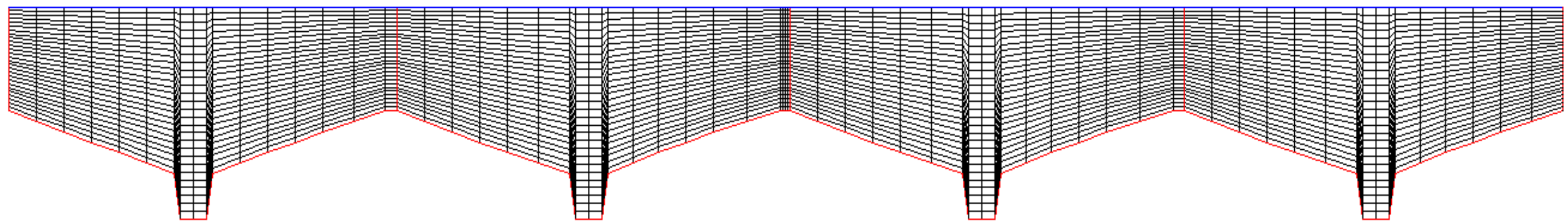


Grid of Section C-C

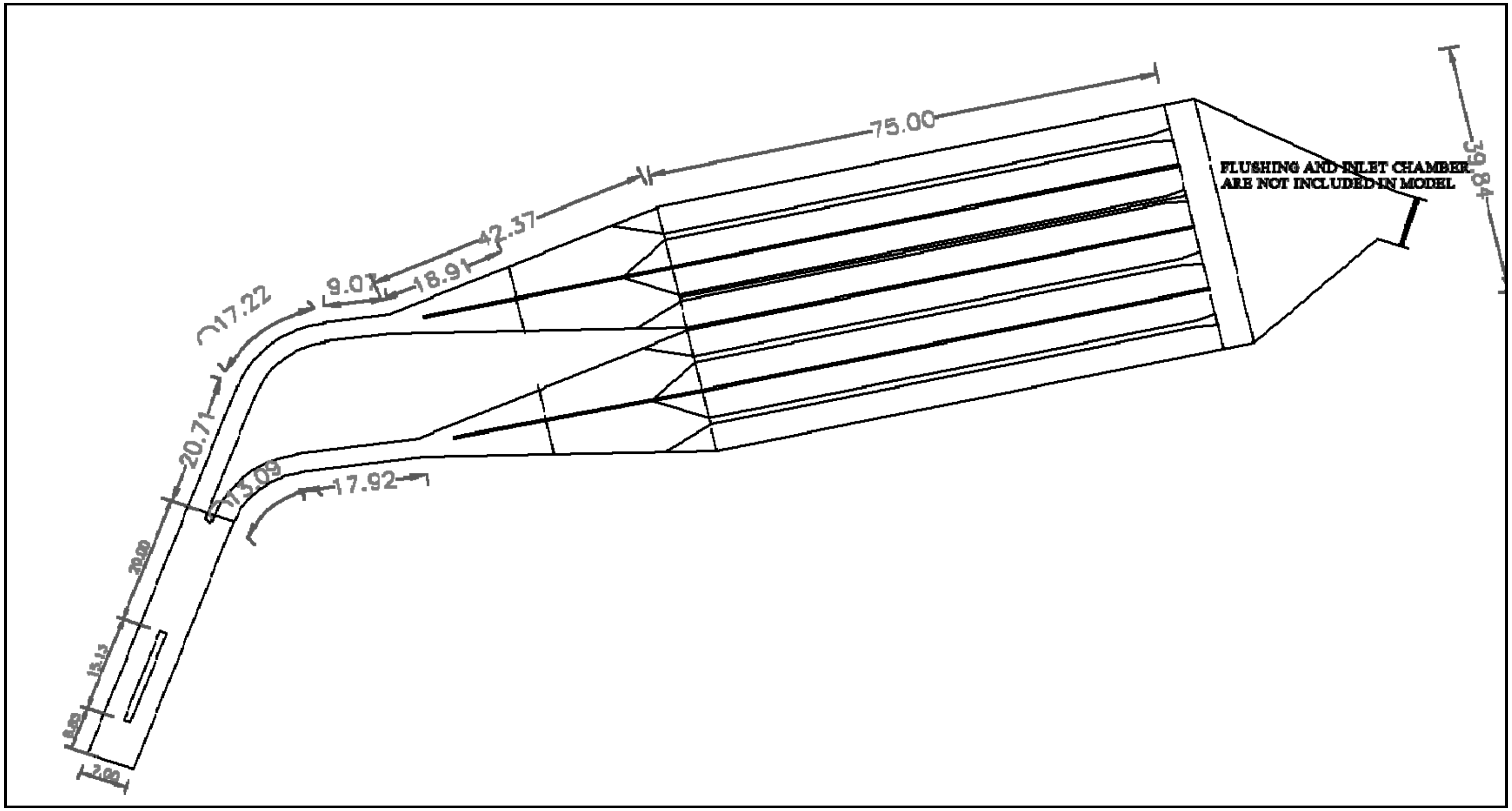


Grid of Section D-D

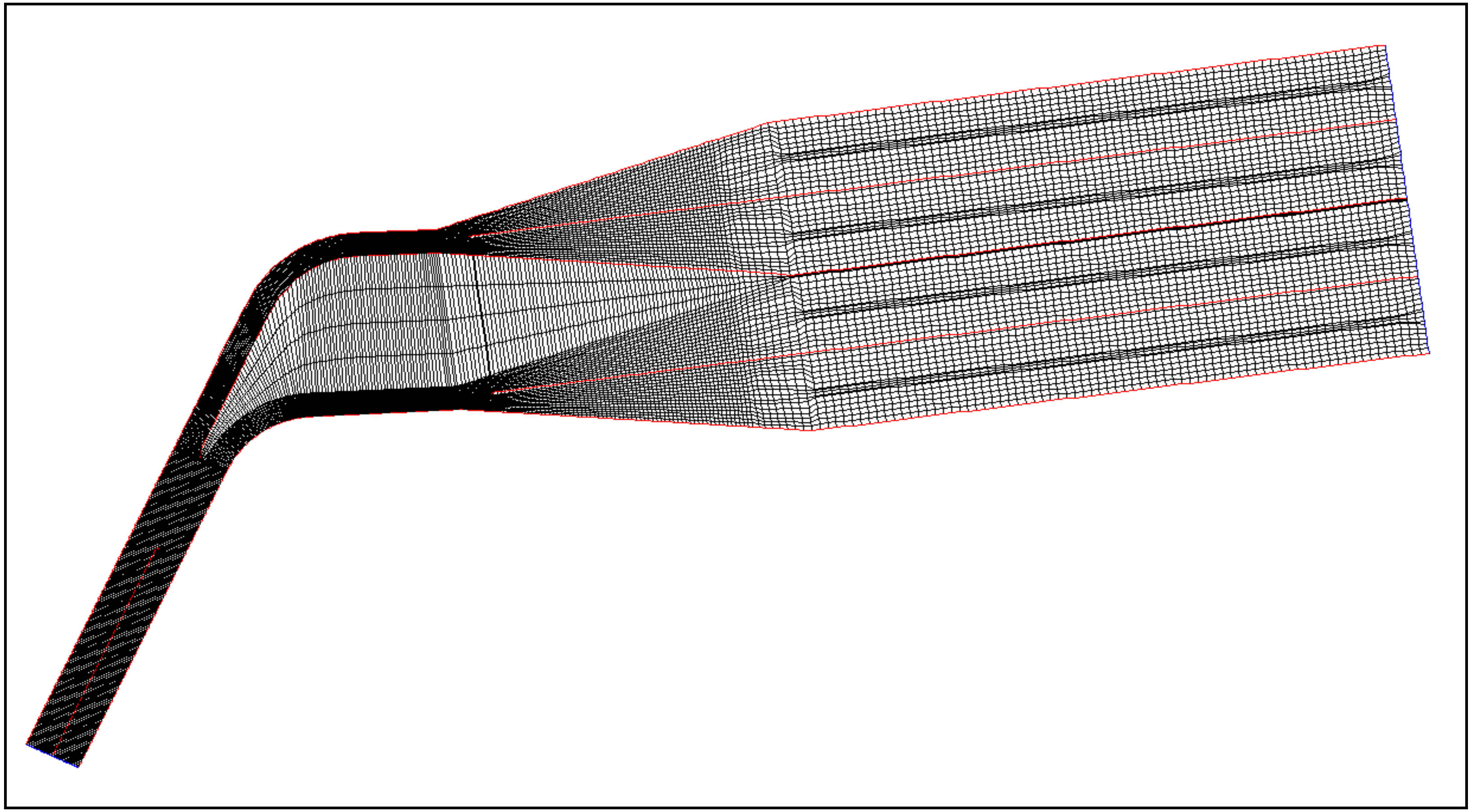




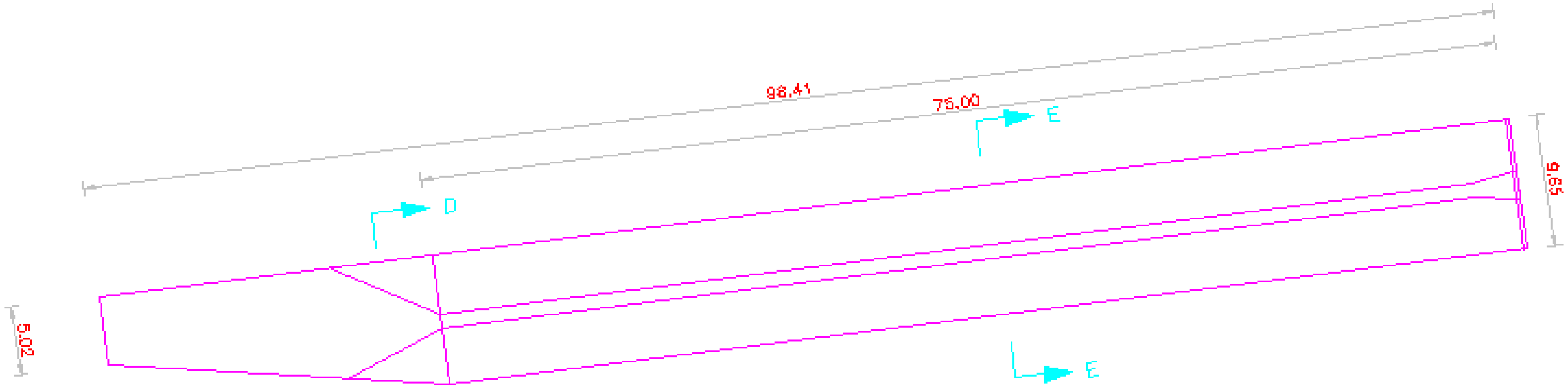
Grid of Section E-E

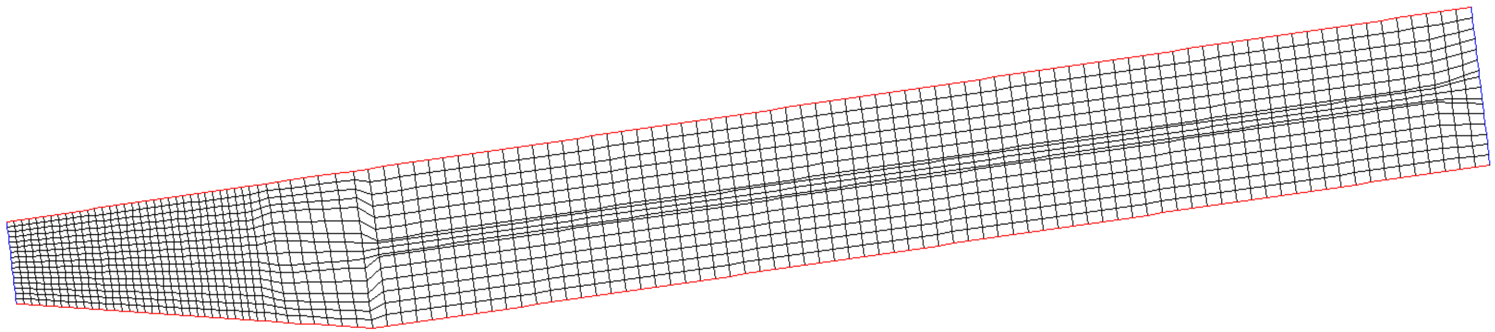


Plan of Alternative Layout Settling Basin

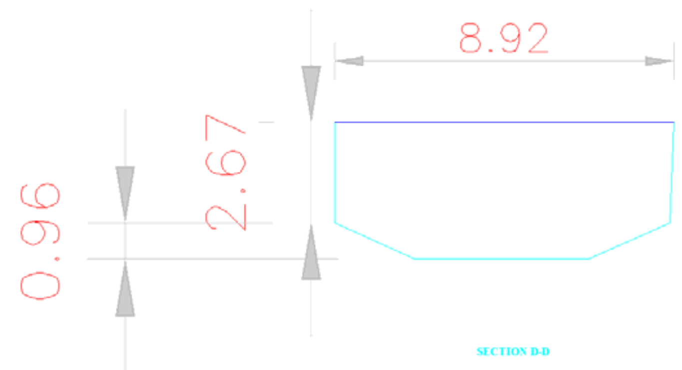


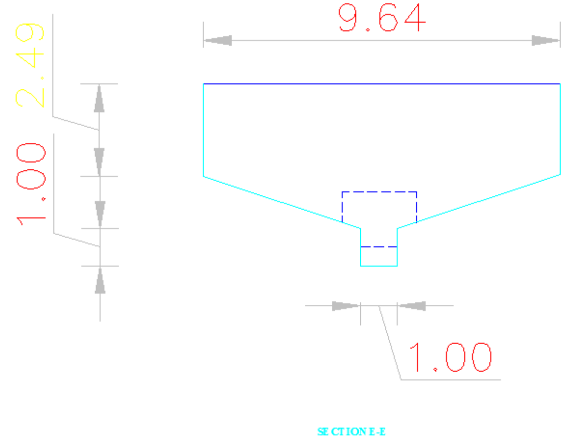
Grid Plan View of Alternative Layout of Settling Basin

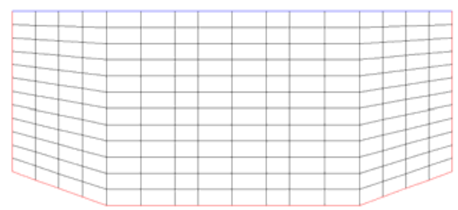




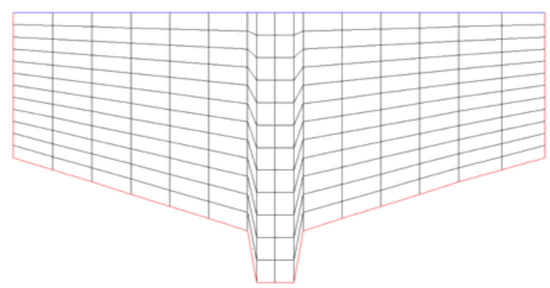
Grid Plan View of One Settling Chamber







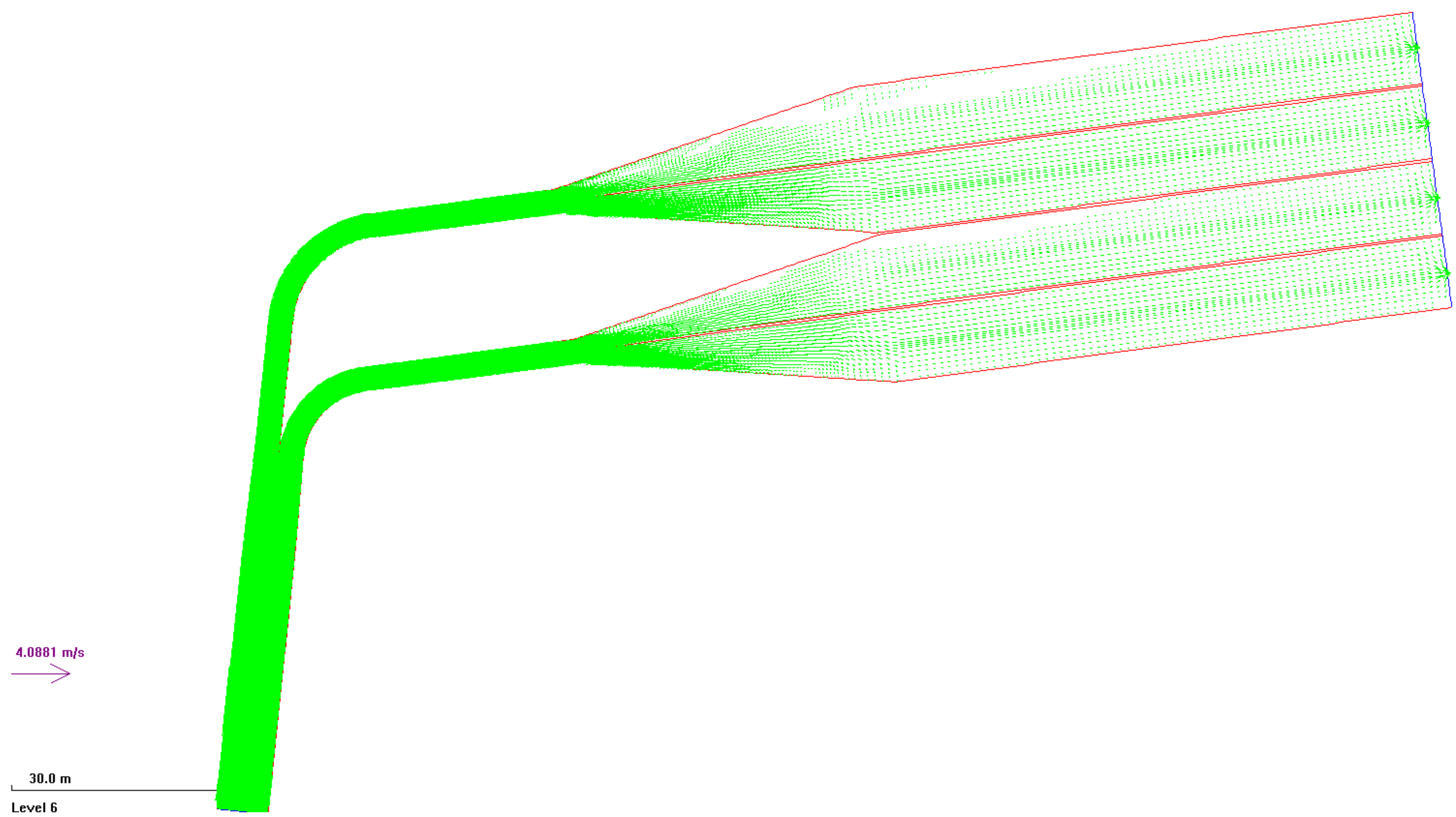
Grid of Section D-D



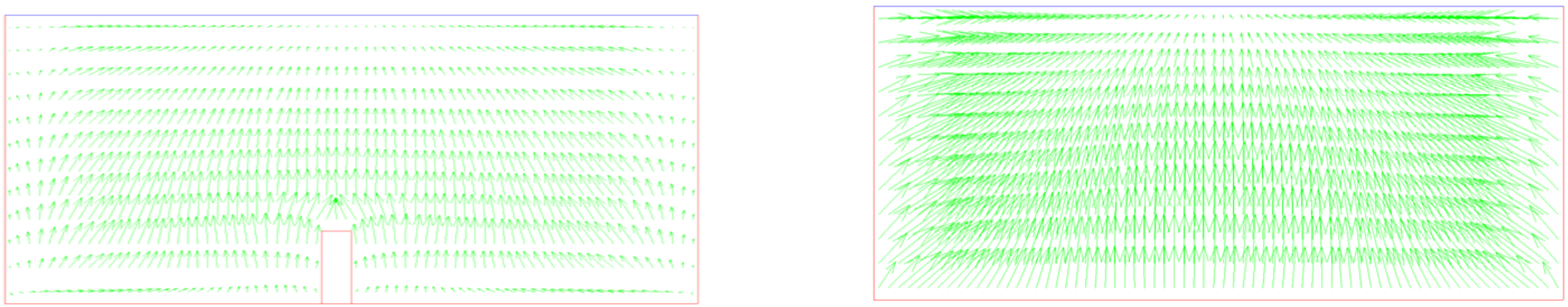
Grid of Section E-E

Annexure-C

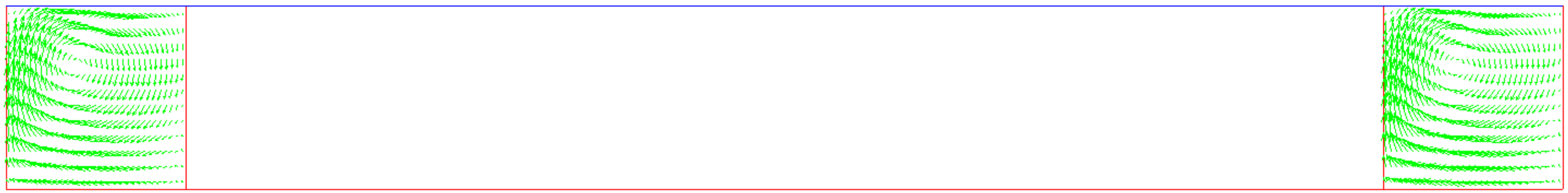
Results



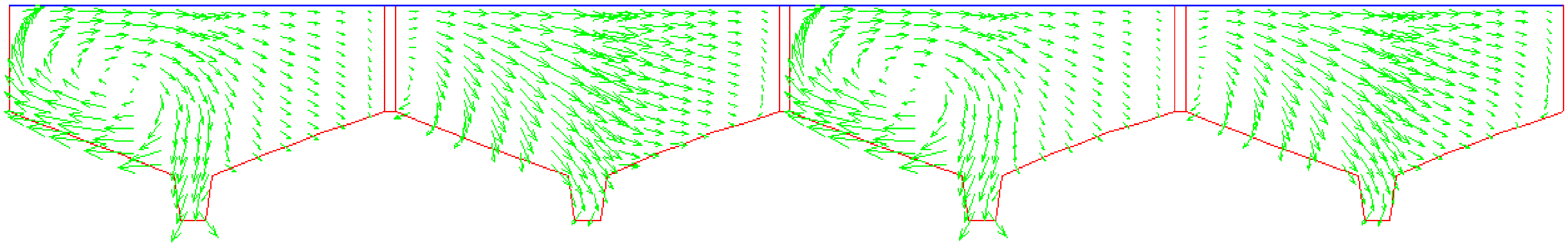
Examples of Velocity Vector On Proposed Layout



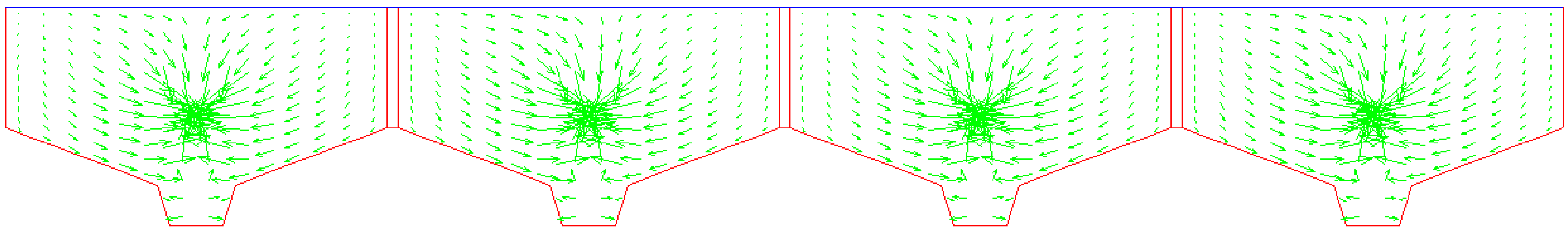
Velocity Vector at intake culvert of Proposed Layout



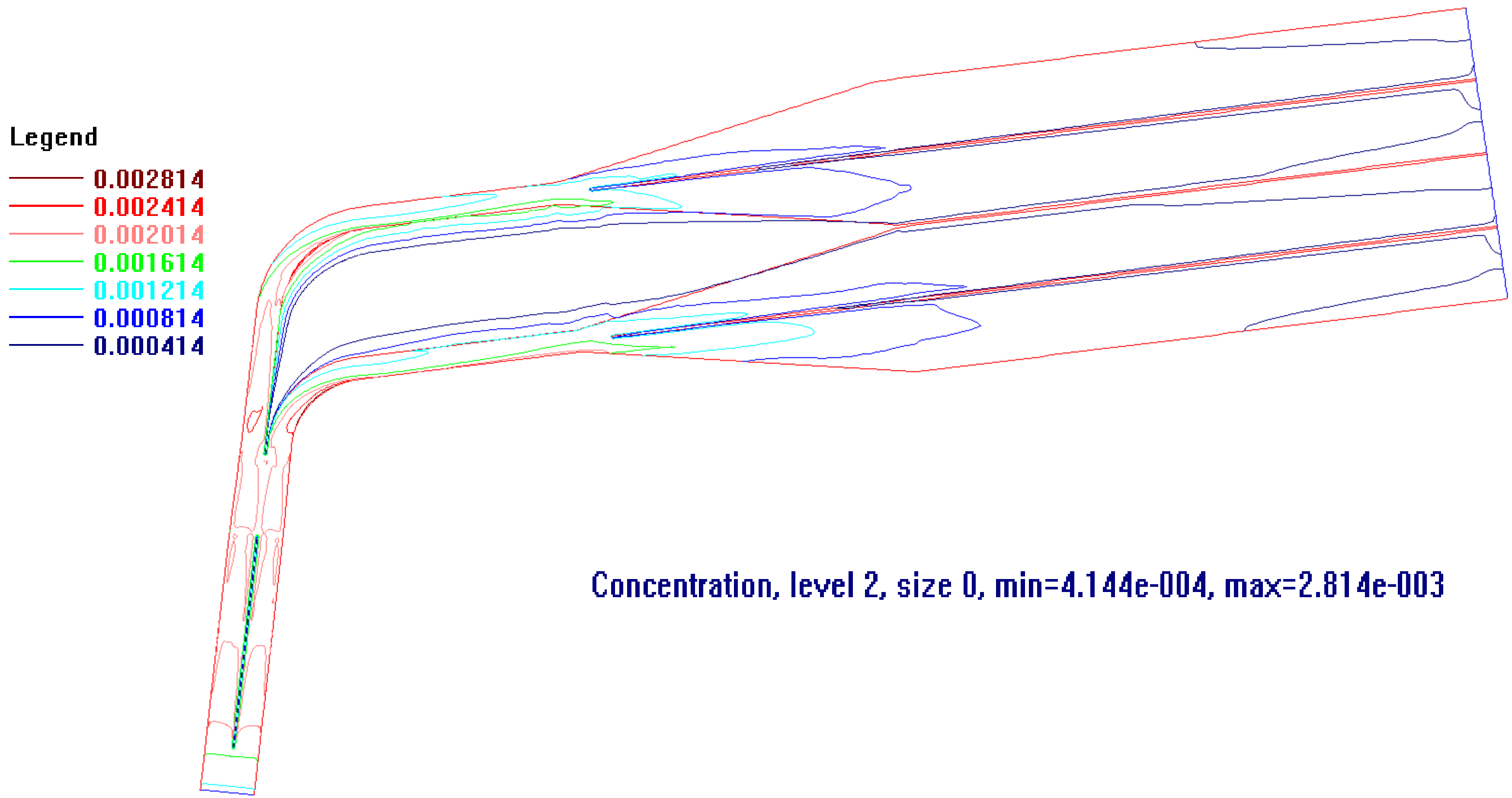
Velocity Vector at approach bend of Proposed Layout



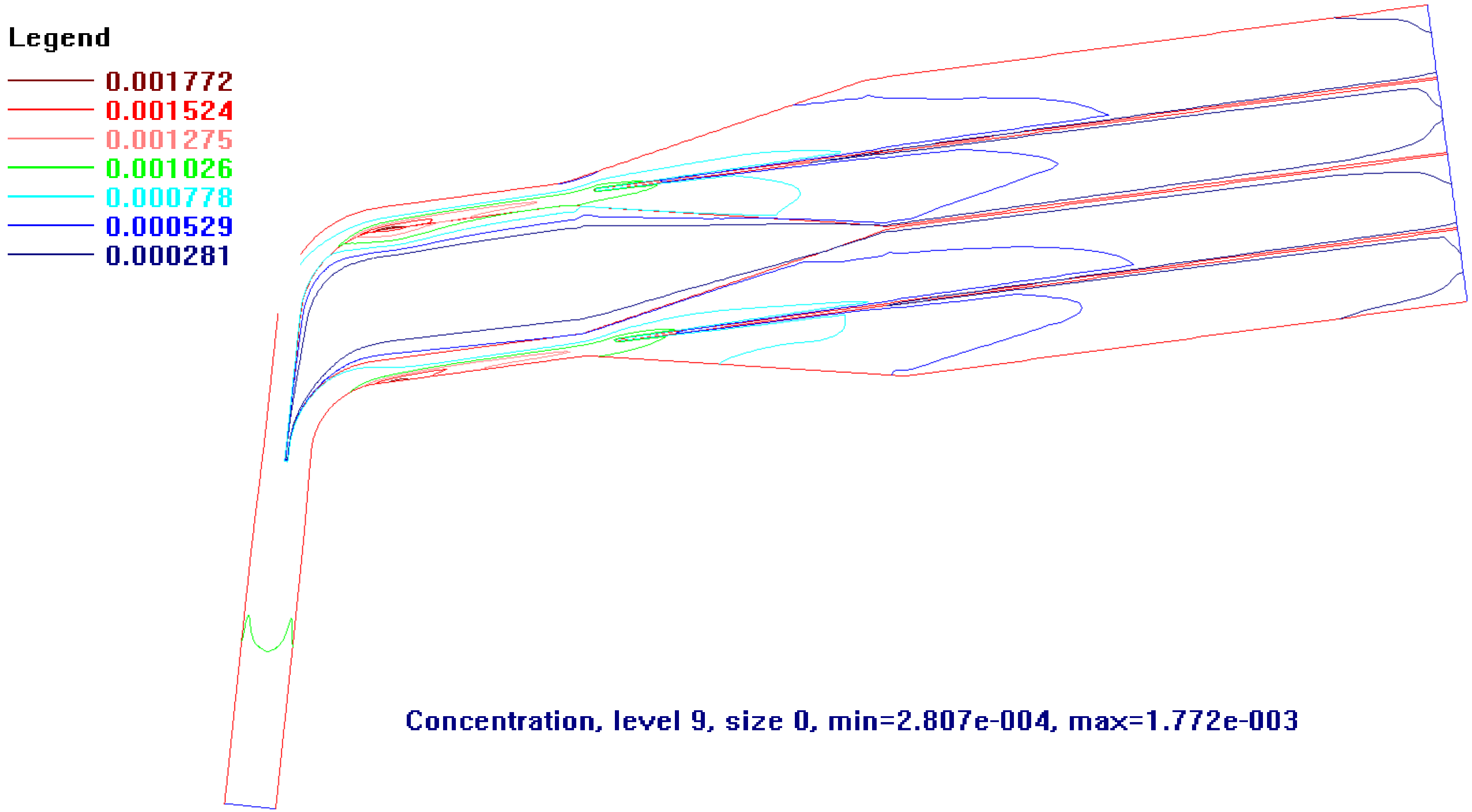
Velocity Vector at settling chambers of Proposed Layout



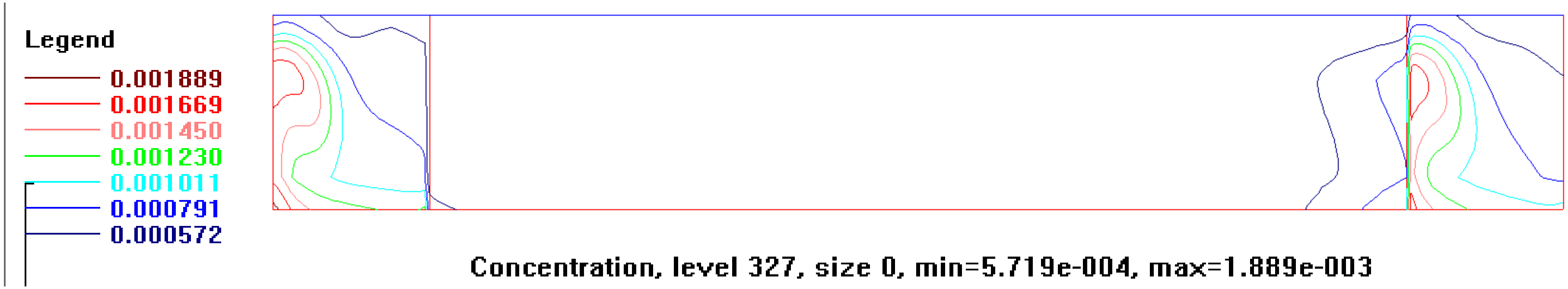
Velocity Vector at last cross section of Proposed Layout



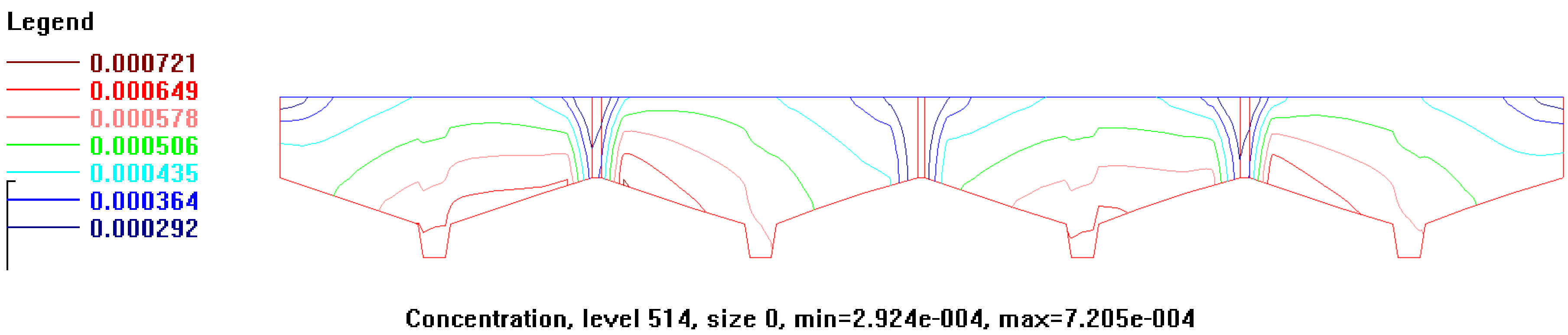
Sediment Concentration on Proposed layout at 32000 of time of computation at level 2



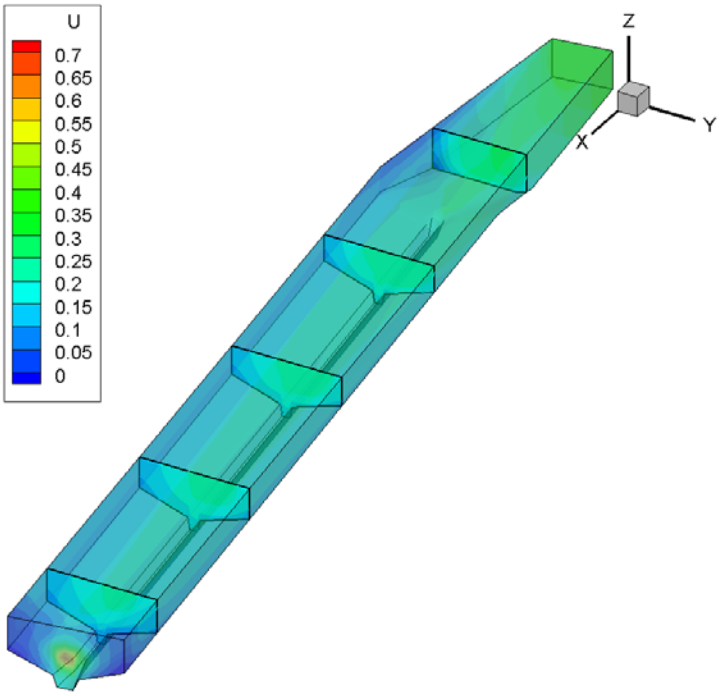
Sediment Concentration on Proposed layout at 32000 of time of computation at level 9



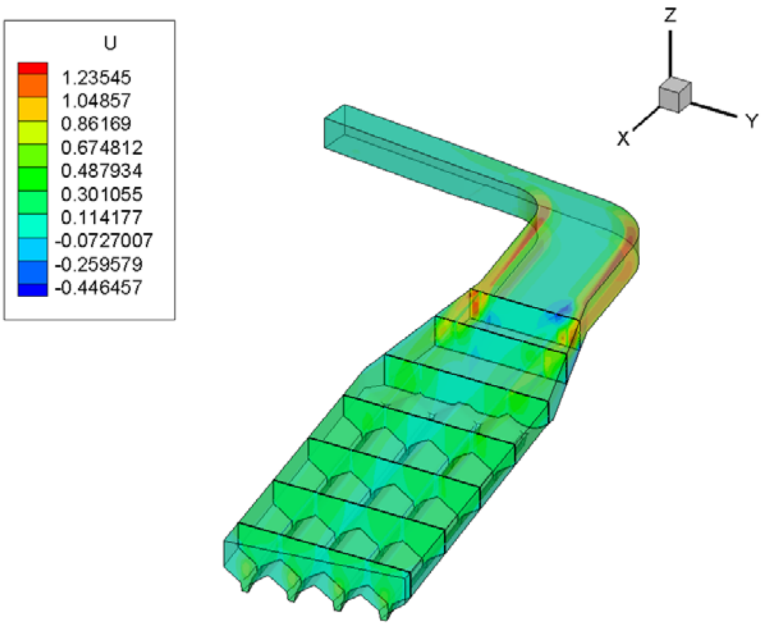
Sediment Concentration at approach bends on proposed layout at 32000 of time of computation



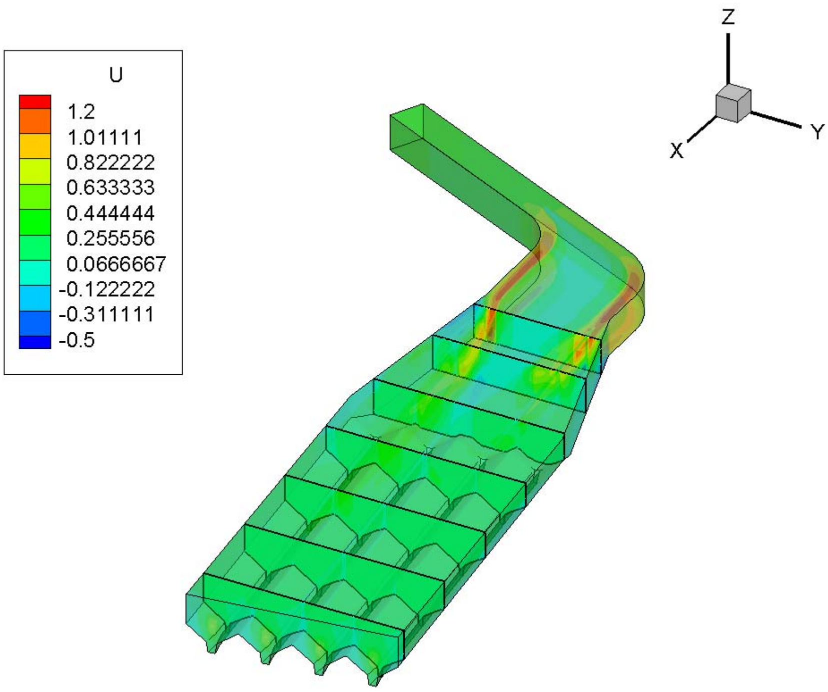
Sediment Concentration at settling chambers on proposed layout at 32000 of time of computation



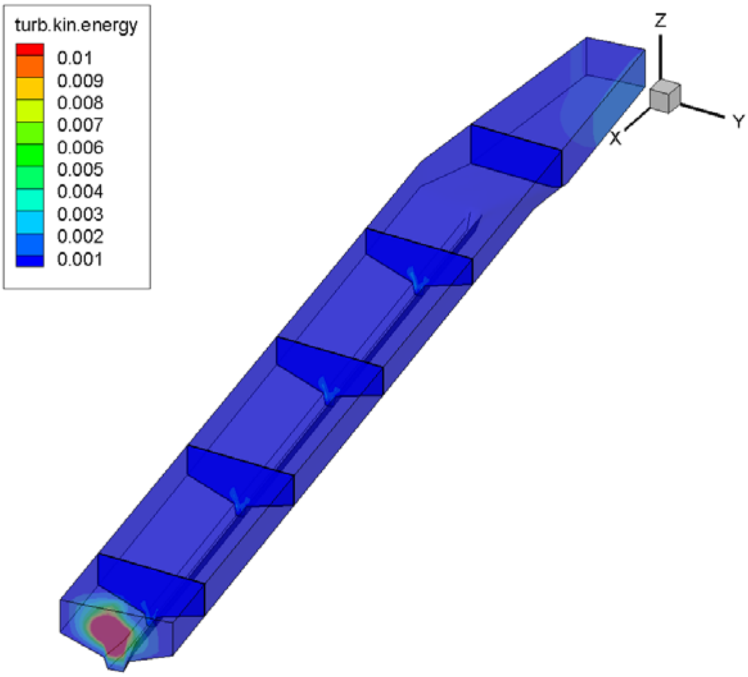
Velocity distribution on X direction on settling chamber Model



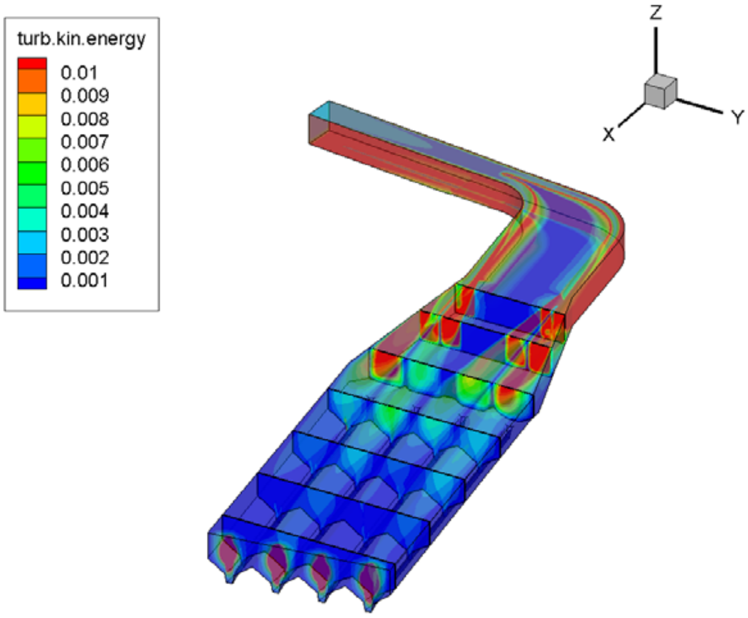
Velocity distribution on X direction on Proposed layout



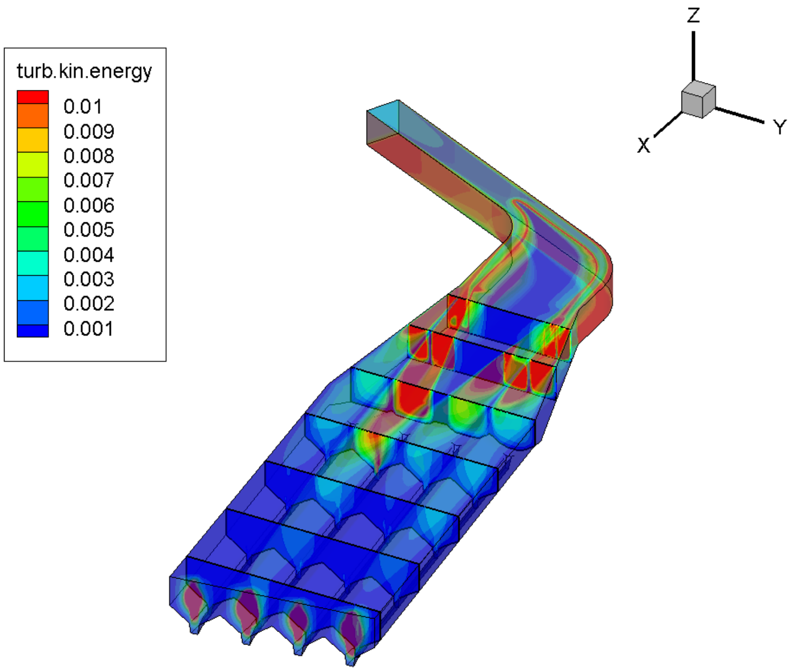
Velocity distribution on X direction on Alternative Layout



Turb.Kinetic Energy distribution on settling chamber model



Turb.Kinetic Energy distribution on Proposed Layout



Turb.Kinetic Energy distribution on Alternative Layout

Appendix-A

Input files for SSIIM Model

Example of Control Files

Control file for water flow computation

```
T wfc settling basin only
F 1 D more extensive printout to the boogie file
F 2 W water flow computation
F 15 1 wall law at cornes
F 16 0.021
F 33 1 5 transient flow parameter
F 211 0.001

G 1 117 17 13 1     grid and array sizes
G 3 0   8.33    16.66   24.99   33.32   41.65   49.98   58.31   66.64   74.97   83.3
        91.63   100     vertical grid distribution
G 7 0 1 2 17 2 13 0 0 5.8575 1.0 0.0 0.0 inflow
G 7 1 -1 8 11 6 9 0 0 5.8575 1.0 0.0 0.0 outflow

G 206 8  number of cpu

W 1 60 5.8575 320.500000
W 2 14 1    10    19    28    37    46    55    64    73    82
        91    100   109   117

K 1 40000 60000
K 2 0 1
K 3 0.8 0.8 0.8 0.1 0.5 0.5 relax factors
K 5 0 0 0 0 0 0    block correction
K 6 1 1 1 0 0 0   second order
T sc settling basin only
F 2 RIS water flow computation
F 4 0.5 100 0.001       relaxation, iteration and convergence criteria
F 11 2.65 -0.047
F 15 1 wall law at cornes
```

Example control file sediment flow computation

```
F 33 20 100 transient flow parameter
F 37 2 sediment transport
F 48 8 tecplot
F 68 2 calculation without any bed change

G 1 117 17 13 5         grid and array sizes
G 3 0   8.33    16.66   24.99   33.32   41.65   49.98   58.31   66.64   74.97   83.3
        91.63   100     vertical grid distribution
```

G 7 0 1 2 17 2 13 0 0 5.8575 1.0 0.0 0.0 inflow
G 7 1 -1 8 11 6 9 0 0 5.8575 1.0 0.0 0.0 outflow

G 24 9 u 1 0 w 1 0 p 2 0 c 5 0 c 5 1 c 5 2 c 5 3 c 5 4 c 5 5

G 206 8 number of cpu

S 1 0.0003 0.03 sediment size and fall velocity
S 2 0.0002 0.02 sediment size and fall velocity
S 3 0.00015 0.0125 sediment size and fall velocity
S 4 0.0001 0.0065 sediment size and fall velocity
S 5 0.00006 0.003 sediment size and fall velocity

N 0 1 0.175
N 0 2 0.2
N 0 3 0.05
N 0 4 0.1
N 0 5 0.475

B 0 0 0 0 0 where n is placed

P 10 40

W 1 80 5.8575 320.500000
W 2 14 1 10 19 28 37 46 55 64 73 82
91 100 109 117

K 1 3300 60000
K 2 0 1
K 3 0.8 0.8 0.8 0.1 0.5 0.5 relax factors
K 5 1 1 1 1 1 1 block correction
K 6 1 1 1 0 0 0 second order

Example control file water flow flow

T wfc peoposed layout

F 2 W water flow computation
F 15 1 wall law at cornes
F 16 0.021

F 33 5 100 transient flow parameter

F 211 0.001 convergent criteria

G 1 567 71 13 1 grid and array sizes
G 3 0 8.33 16.66 24.99 33.32 41.65 49.98 58.31 66.64 74.97 83.3 91.63 100 vertical grid distribution

G 7 0 1 2 71 2 13 0 0 23.43 1.0 0.0 0.0 inflow
G 7 1 -1 8 11 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 25 28 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 45 48 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 62 65 6 9 0 0 5.8575 1.0 0.0 0.0 outflow

G 13 3 27 141 34 36 2 4
G 13 2 187 567 35 38 2 13
G 13 2 422 567 18 18 2 13
G 13 2 422 567 55 55 2 13

G 206 8 number of cpu

W 1 80.000000 23.43 320.500000
W 2 64 1 10 19 28 37 46 55 64 73 82
91 100 109 118 127 136 145 154 163 172
181 190 199 208 217 226 235 244 253 262
271 280 289 298 307 316 325 334 343 352
361 370 379 388 397 406 415 424 433 442
451 460 469 478 487 496 505 514 523 532
541 550 559 567

K 1 40000 60000
K 2 0 1
K 3 0.8 0.8 0.8 0.1 0.5 0.5 relax factors
K 5 0 0 0 0 0 0 block correction
K 6 1 1 1 0 0 0 second order

Example control file sediment flow

T Sediment computation
F 2 RIS water flow computation
F 4 0.5 100 0.001 relaxation, iteration and convergence criteria
F 11 2.65 -0.047
F 15 1 wall law at cornes
F 16 0.021

F 33 20 100 transient flow parameter
F 37 1 sediment transport
F 48 8 tecplot
F 68 2 calculation without any bed change

G 1 567 71 13 1 grid and array sizes
G 3 0 8.33 16.66 24.99 33.32 41.65 49.98 58.31 66.64 74.97 83.3
91.63 100 vertical grid distribution

G 7 0 1 2 71 2 13 0 0 23.43 1.0 0.0 0.0 inflow
G 7 1 -1 8 11 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 25 28 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 45 48 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 62 65 6 9 0 0 5.8575 1.0 0.0 0.0 outflow

G 13 3 27 141 34 36 2 4
G 13 2 187 567 35 38 2 13
G 13 2 422 567 18 18 2 13
G 13 2 422 567 55 55 2 13

G 24 14 u 1 0 w 1 0 p 2 0 c 10 0 c 10 1 c 10 2 c 10 3 c 10 4 c 10 5 k 1 0 D 0 0 b 0 0 v 0 0 L 0 0

G 206 8 number of cpu

S 1 0.0003 0.051 sediment size and fall velocity
S 2 0.0002 0.02 sediment size and fall velocity
S 3 0.00015 0.0125 sediment size and fall velocity
S 4 0.0001 0.0065 sediment size and fall velocity
S 5 0.00006 0.003 sediment size and fall velocity

B 0 0 0 0 0 where n is placed

P 10 40

W 1 80.000000 23.43 320.500000
W 2 64 1 10 19 28 37 46 55 64 73 82
91 100 109 118 127 136 145 154 163 172
181 190 199 208 217 226 235 244 253 262
271 280 289 298 307 316 325 334 343 352
361 370 379 388 397 406 415 424 433 442
451 460 469 478 487 496 505 514 523 532
541 550 559 567

K 1 40000 60000
K 2 0 1
K 3 0.8 0.8 0.8 0.1 0.5 0.5 relax factors
K 5 1 1 1 1 1 1 block correction
K 6 1 1 1 0 0 0 second order

Example control file water flow flow

T wfc modi 2 m5

F 2 W water flow computation
F 15 1 wall law at cornes
F 16 0.021
F 33 1 5 transient flow parameter

F 211 0.001 convergent criteria

G 1 567 71 13 1 grid and array sizes
G 3 0 8.33 16.66 24.99 33.32 41.65 49.98 58.31 66.64 74.97 83.3 91.63 100 vertical grid distribution

G 7 0 1 2 71 2 13 0 0 23.43 1.0 0.0 0.0 inflow
G 7 1 -1 8 11 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 25 28 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 45 48 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 62 65 6 9 0 0 5.8575 1.0 0.0 0.0 outflow

G 13 3 27 141 34 36 2 4
G 13 2 187 567 35 38 2 13
G 13 2 406 567 18 18 2 13
G 13 2 406 567 55 55 2 13

G 206 8 number of cpu

I 1 0.238 inflowing sediments in kg/s

S 1 0.0002 0.05 sediment fraction nr, size, fallvelo

N 0 1 1.0 sediment sample

B 0 0 0 0 0 bed koordinates, composed of sediment

```
W 1 80.000000 23.43 320.500000
W 2 64 1   10   19   28   37   46   55   64   73   82
       91  100  109  118  127  136  145  154  163  172
      181  190  199  208  217  226  235  244  253  262
      271  280  289  298  307  316  325  334  343  352
      361  370  379  388  397  406  415  424  433  442
      451  460  469  478  487  496  505  514  523  532
      541  550  559  567

K 1 40000 60000
K 2 0 1
K 3 0.8 0.8 0.8 0.1 0.5 0.5 relax factors
K 5 0 0 0 0 0 0   block correction
K 6 1 1 1 0 0 0   second order
```

<u>Example control file sediment flow</u>

```
T wfc modi 2 m5

F 2 RIS water flow computation
F 4 0.5 500 0.001     relaxation, iteration and convergence criteria
F 11 2.65 -0.047
F 15 1 wall law at cornes
F 16 0.021
F 33 50 1 transient flow parameter
F 37 1 sediment transport
F 48 8 tecplot
F 68 2 calculation without any bed change


G 1 567 71 13 6    grid and array sizes
G 3 0  8.33   16.66  24.99  33.32  41.65  49.98  58.31  66.64  74.97  83.3
       91.63  100    vertical grid distribution

G 7 0 1 2 71 2 13 0 0 23.43 1.0 0.0 0.0 inflow
G 7 1 -1 8 11 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 25 28 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 45 48 6 9 0 0 5.8575 1.0 0.0 0.0 outflow
G 7 1 -1 62 65 6 9 0 0 5.8575 1.0 0.0 0.0 outflow

G 13 3 27 141 34 36 2 4
```

G 13 2 187 567 35 38 2 13
G 13 2 406 567 18 18 2 13
G 13 2 406 567 55 55 2 13

G 24 5 u 1 0 w 1 0 p 2 0 c 7 0 v 0 0

G 206 8 number of cpu

S	1	0.001	0.5	bed martial
S	2	0.0003	0.051	sediment size and fall velocity
S	3	0.0002	0.02	sediment size and fall velocity
S	4	0.00015	0.0125	sediment size and fall velocity
S	5	0.0001	0.0065	sediment size and fall velocity
S	6	0.00006	0.003	sediment size and fall velocity

N 0 1 1
N 0 2 0
N 0 3 0
N 0 4 0
N 0 5 0
N 0 6 0

B 0 0 0 0 0 bed koordinates, composed of sediment

P 10 40

W 1 80.000000 23.43 320.500000

W 2 64	1	10	19	28	37	46	55	64	73	82
	91	100	109	118	127	136	145	154	163	172
	181	190	199	208	217	226	235	244	253	262
	271	280	289	298	307	316	325	334	343	352
	361	370	379	388	397	406	415	424	433	442
	451	460	469	478	487	496	505	514	523	532
	541	550	559	567						

K 1 1500 60000
K 2 0 1
K 3 0.8 0.8 0.8 0.1 0.5 0.5 relax factors
K 5 0 0 0 0 0 0 block correction
K 6 1 1 1 0 0 0 second order

Coordinate for Grid for settling chamber

1	1	69.89	69.11	317.09	3	12	70.42	72.59	317.08
1	2	69.85	69.42	317.09	3	13	70.38	72.92	317.08
1	3	69.81	69.73	317.09	3	14	70.34	73.24	317.08
1	4	69.77	70.04	317.09	3	15	70.29	73.56	317.08
1	5	69.73	70.35	317.09	3	16	70.25	73.88	317.08
1	6	69.69	70.66	317.09	3	17	70.21	74.21	317.08
1	7	69.64	70.97	317.09	4	1	71.40	69.01	317.07
1	8	69.60	71.28	317.09	4	2	71.35	69.34	317.07
1	9	69.56	71.59	317.09	4	3	71.31	69.67	317.07
1	10	69.52	71.90	317.09	4	4	71.27	70.00	317.07
1	11	69.48	72.21	317.09	4	5	71.22	70.33	317.07
1	12	69.44	72.52	317.09	4	6	71.18	70.66	317.07
1	13	69.40	72.83	317.09	4	7	71.13	70.98	317.07
1	14	69.35	73.14	317.09	4	8	71.09	71.31	317.07
1	15	69.31	73.45	317.09	4	9	71.05	71.64	317.07
1	16	69.27	73.77	317.09	4	10	71.00	71.97	317.07
1	17	69.23	74.08	317.09	4	11	70.96	72.30	317.07
2	1	70.39	69.08	317.08	4	12	70.92	72.63	317.07
2	2	70.35	69.39	317.08	4	13	70.87	72.96	317.07
2	3	70.31	69.71	317.08	4	14	70.83	73.29	317.07
2	4	70.27	70.03	317.08	4	15	70.78	73.61	317.07
2	5	70.23	70.34	317.08	4	16	70.74	73.94	317.07
2	6	70.18	70.66	317.08	4	17	70.70	74.27	317.07
2	7	70.14	70.98	317.08	5	1	71.90	68.98	317.07
2	8	70.10	71.29	317.08	5	2	71.85	69.32	317.07
2	9	70.06	71.61	317.08	5	3	71.81	69.65	317.07
2	10	70.01	71.93	317.08	5	4	71.77	69.98	317.07
2	11	69.97	72.24	317.08	5	5	71.72	70.32	317.07
2	12	69.93	72.56	317.08	5	6	71.68	70.65	317.07
2	13	69.89	72.87	317.08	5	7	71.63	70.99	317.07
2	14	69.84	73.19	317.08	5	8	71.59	71.32	317.07
2	15	69.80	73.51	317.08	5	9	71.54	71.66	317.07
2	16	69.76	73.82	317.08	5	10	71.50	71.99	317.07
2	17	69.72	74.14	317.08	5	11	71.45	72.33	317.07
3	1	70.90	69.04	317.08	5	12	71.41	72.66	317.07
3	2	70.85	69.37	317.08	5	13	71.36	73.00	317.07
3	3	70.81	69.69	317.08	5	14	71.32	73.33	317.07
3	4	70.77	70.01	317.08	5	15	71.27	73.67	317.07
3	5	70.72	70.33	317.08	5	16	71.23	74.00	317.07
3	6	70.68	70.66	317.08	5	17	71.18	74.34	317.07
3	7	70.64	70.98	317.08	6	1	72.40	68.95	317.06
3	8	70.59	71.30	317.08	6	2	72.36	69.29	317.06
3	9	70.55	71.63	317.08	6	3	72.31	69.63	317.06
3	10	70.51	71.95	317.08	6	4	72.26	69.97	317.06
3	11	70.47	72.27	317.08	6	5	72.22	70.31	317.06

6	6	72.17	70.65	317.06
6	7	72.13	70.99	317.06
6	8	72.08	71.33	317.06
6	9	72.04	71.68	317.06
6	10	71.99	72.02	317.06
6	11	71.95	72.36	317.06
6	12	71.90	72.70	317.06
6	13	71.86	73.04	317.06
6	14	71.81	73.38	317.06
6	15	71.76	73.72	317.06
6	16	71.72	74.06	317.06
6	17	71.67	74.40	317.06
7	1	72.90	68.92	317.06
7	2	72.86	69.26	317.06
7	3	72.81	69.61	317.06
7	4	72.76	69.96	317.06
7	5	72.72	70.30	317.06
7	6	72.67	70.65	317.06
7	7	72.63	71.00	317.06
7	8	72.58	71.34	317.06
7	9	72.53	71.69	317.06
7	10	72.49	72.04	317.06
7	11	72.44	72.39	317.06
7	12	72.39	72.73	317.06
7	13	72.35	73.08	317.06
7	14	72.30	73.43	317.06
7	15	72.25	73.77	317.06
7	16	72.21	74.12	317.06
7	17	72.16	74.47	317.06
8	1	73.40	68.88	317.05
8	2	73.36	69.24	317.05
8	3	73.31	69.59	317.05
8	4	73.26	69.94	317.05
8	5	73.22	70.30	317.05
8	6	73.17	70.65	317.05
8	7	73.12	71.00	317.05
8	8	73.07	71.36	317.05
8	9	73.03	71.71	317.05
8	10	72.98	72.06	317.05
8	11	72.93	72.41	317.05
8	12	72.89	72.77	317.05
8	13	72.84	73.12	317.05
8	14	72.79	73.47	317.05
8	15	72.75	73.83	317.05
8	16	72.70	74.18	317.05
8	17	72.65	74.53	317.05
9	1	73.91	68.85	317.05
9	2	73.86	69.21	317.05
9	3	73.81	69.57	317.05
9	4	73.76	69.93	317.05
9	5	73.71	70.29	317.05
9	6	73.67	70.65	317.05
9	7	73.62	71.01	317.05
9	8	73.57	71.37	317.05
9	9	73.52	71.73	317.05
9	10	73.48	72.08	317.05
9	11	73.43	72.44	317.05
9	12	73.38	72.80	317.05
9	13	73.33	73.16	317.05
9	14	73.28	73.52	317.05
9	15	73.24	73.88	317.05
9	16	73.19	74.24	317.05
9	17	73.14	74.60	317.05
10	1	74.41	68.82	317.04
10	2	74.36	69.19	317.04
10	3	74.31	69.55	317.04
10	4	74.26	69.92	317.04
10	5	74.21	70.28	317.04
10	6	74.16	70.65	317.04
10	7	74.12	71.01	317.04
10	8	74.07	71.38	317.04
10	9	74.02	71.74	317.04
10	10	73.97	72.11	317.04
10	11	73.92	72.47	317.04
10	12	73.87	72.84	317.04
10	13	73.82	73.20	317.04
10	14	73.77	73.57	317.04
10	15	73.73	73.93	317.04
10	16	73.68	74.30	317.04
10	17	73.63	74.66	317.04
11	1	74.91	68.79	317.04
11	2	74.86	69.16	317.04
11	3	74.81	69.53	317.04
11	4	74.76	69.90	317.04
11	5	74.71	70.27	317.04
11	6	74.66	70.64	317.04
11	7	74.61	71.02	317.04
11	8	74.56	71.39	317.04
11	9	74.51	71.76	317.04
11	10	74.46	72.13	317.04
11	11	74.41	72.50	317.04
11	12	74.37	72.87	317.04

11	13	74.32	73.24	317.04
11	14	74.27	73.61	317.04
11	15	74.22	73.99	317.04
11	16	74.17	74.36	317.04
11	17	74.12	74.73	317.04
12	1	75.41	68.76	317.03
12	2	75.36	69.13	317.03
12	3	75.31	69.51	317.03
12	4	75.26	69.89	317.03
12	5	75.21	70.27	317.03
12	6	75.16	70.64	317.03
12	7	75.11	71.02	317.03
12	8	75.06	71.40	317.03
12	9	75.01	71.77	317.03
12	10	74.96	72.15	317.03
12	11	74.91	72.53	317.03
12	12	74.86	72.91	317.03
12	13	74.81	73.28	317.03
12	14	74.76	73.66	317.03
12	15	74.71	74.04	317.03
12	16	74.66	74.42	317.03
12	17	74.61	74.79	317.03
13	1	75.91	68.72	317.03
13	2	75.86	69.11	317.03
13	3	75.81	69.49	317.03
13	4	75.76	69.87	317.03
13	5	75.71	70.26	317.03
13	6	75.66	70.64	317.03
13	7	75.61	71.02	317.03
13	8	75.56	71.41	317.03
13	9	75.50	71.79	317.03
13	10	75.45	72.18	317.03
13	11	75.40	72.56	317.03
13	12	75.35	72.94	317.03
13	13	75.30	73.33	317.03
13	14	75.25	73.71	317.03
13	15	75.20	74.09	317.03
13	16	75.15	74.48	317.03
13	17	75.10	74.86	317.03
14	1	76.42	68.69	317.02
14	2	76.36	69.08	317.02
14	3	76.31	69.47	317.02
14	4	76.26	69.86	317.02
14	5	76.21	70.25	317.02
14	6	76.16	70.64	317.02
14	7	76.10	71.03	317.02
14	8	76.05	71.42	317.02
14	9	76.00	71.81	317.02
14	10	75.95	72.20	317.02
14	11	75.90	72.59	317.02
14	12	75.84	72.98	317.02
14	13	75.79	73.37	317.02
14	14	75.74	73.76	317.02
14	15	75.69	74.15	317.02
14	16	75.64	74.54	317.02
14	17	75.58	74.92	317.02
15	1	76.92	68.66	317.02
15	2	76.86	69.06	317.02
15	3	76.81	69.45	317.02
15	4	76.76	69.85	317.02
15	5	76.71	70.24	317.02
15	6	76.65	70.64	317.02
15	7	76.60	71.03	317.02
15	8	76.55	71.43	317.02
15	9	76.49	71.82	317.02
15	10	76.44	72.22	317.02
15	11	76.39	72.62	317.02
15	12	76.34	73.01	317.02
15	13	76.28	73.41	317.02
15	14	76.23	73.80	317.02
15	15	76.18	74.20	317.02
15	16	76.13	74.59	317.02
15	17	76.07	74.99	317.02
16	1	77.42	68.63	317.01
16	2	77.37	69.03	317.01
16	3	77.31	69.43	317.01
16	4	77.26	69.83	317.01
16	5	77.20	70.23	317.01
16	6	77.15	70.64	317.01
16	7	77.10	71.04	317.01
16	8	77.04	71.44	317.01
16	9	76.99	71.84	317.01
16	10	76.94	72.24	317.01
16	11	76.88	72.64	317.01
16	12	76.83	73.05	317.01
16	13	76.78	73.45	317.01
16	14	76.72	73.85	317.01
16	15	76.67	74.25	317.01
16	16	76.62	74.65	317.01
16	17	76.56	75.06	317.01
17	1	77.92	68.60	317.01
17	2	77.87	69.00	317.01

17	3	77.81	69.41	317.01
17	4	77.76	69.82	317.01
17	5	77.70	70.23	317.01
17	6	77.65	70.63	317.01
17	7	77.59	71.04	317.01
17	8	77.54	71.45	317.01
17	9	77.49	71.86	317.01
17	10	77.43	72.27	317.01
17	11	77.38	72.67	317.01
17	12	77.32	73.08	317.01
17	13	77.27	73.49	317.01
17	14	77.21	73.90	317.01
17	15	77.16	74.30	317.01
17	16	77.10	74.71	317.01
17	17	77.05	75.12	317.01
18	1	78.42	68.56	317.00
18	2	78.37	68.98	317.00
18	3	78.31	69.39	317.00
18	4	78.26	69.81	317.00
18	5	78.20	70.22	317.00
18	6	78.15	70.63	317.00
18	7	78.09	71.05	317.00
18	8	78.04	71.46	317.00
18	9	77.98	71.87	317.00
18	10	77.93	72.29	317.00
18	11	77.87	72.70	317.00
18	12	77.82	73.12	317.00
18	13	77.76	73.53	317.00
18	14	77.70	73.94	317.00
18	15	77.65	74.36	317.00
18	16	77.59	74.77	317.00
18	17	77.54	75.19	317.00
19	1	78.92	68.53	317.00
19	2	78.87	68.95	317.00
19	3	78.81	69.37	317.00
19	4	78.76	69.79	317.00
19	5	78.70	70.21	317.00
19	6	78.64	70.63	317.00
19	7	78.59	71.05	317.00
19	8	78.53	71.47	317.00
19	9	78.48	71.89	317.00
19	10	78.42	72.31	317.00
19	11	78.36	72.73	317.00
19	12	78.31	73.15	317.00
19	13	78.25	73.57	317.00
19	14	78.20	73.99	317.00
19	15	78.14	74.41	317.00
19	16	78.08	74.83	317.00
19	17	78.03	75.25	317.00
20	1	79.43	68.50	316.99
20	2	79.37	68.93	316.99
20	3	79.31	69.35	316.99
20	4	79.26	69.78	316.99
20	5	79.20	70.20	316.99
20	6	79.14	70.63	316.99
20	7	79.08	71.06	316.99
20	8	79.03	71.48	316.99
20	9	78.97	71.91	316.99
20	10	78.91	72.33	316.99
20	11	78.86	72.76	316.99
20	12	78.80	73.19	316.99
20	13	78.74	73.61	316.99
20	14	78.69	74.04	316.99
20	15	78.63	74.46	316.99
20	16	78.57	74.89	316.99
20	17	78.52	75.32	316.99
21	1	79.93	68.47	316.99
21	2	79.87	68.90	316.99
21	3	79.81	69.33	316.99
21	4	79.75	69.76	316.99
21	5	79.70	70.20	316.99
21	6	79.64	70.63	316.99
21	7	79.58	71.06	316.99
21	8	79.52	71.49	316.99
21	9	79.47	71.92	316.99
21	10	79.41	72.36	316.99
21	11	79.35	72.79	316.99
21	12	79.29	73.22	316.99
21	13	79.24	73.65	316.99
21	14	79.18	74.09	316.99
21	15	79.12	74.52	316.99
21	16	79.06	74.95	316.99
21	17	79.01	75.38	316.99
22	1	80.43	68.44	316.98
22	2	80.37	68.87	316.98
22	3	80.31	69.31	316.98
22	4	80.25	69.75	316.98
22	5	80.20	70.19	316.98
22	6	80.14	70.63	316.98
22	7	80.08	71.06	316.98
22	8	80.02	71.50	316.98
22	9	79.96	71.94	316.98

22	10	79.90	72.38	316.98
22	11	79.85	72.82	316.98
22	12	79.79	73.26	316.98
22	13	79.73	73.69	316.98
22	14	79.67	74.13	316.98
22	15	79.61	74.57	316.98
22	16	79.55	75.01	316.98
22	17	79.49	75.45	316.98
23	1	80.93	68.40	316.98
23	2	80.87	68.85	316.98
23	3	80.81	69.29	316.98
23	4	80.75	69.74	316.98
23	5	80.69	70.18	316.98
23	6	80.63	70.62	316.98
23	7	80.58	71.07	316.98
23	8	80.52	71.51	316.98
23	9	80.46	71.96	316.98
23	10	80.40	72.40	316.98
23	11	80.34	72.85	316.98
23	12	80.28	73.29	316.98
23	13	80.22	73.73	316.98
23	14	80.16	74.18	316.98
23	15	80.10	74.62	316.98
23	16	80.04	75.07	316.98
23	17	79.98	75.51	316.98
24	1	81.43	68.37	316.97
24	2	81.37	68.82	316.97
24	3	81.31	69.27	316.97
24	4	81.25	69.72	316.97
24	5	81.19	70.17	316.97
24	6	81.13	70.62	316.97
24	7	81.07	71.07	316.97
24	8	81.01	71.52	316.97
24	9	80.95	71.97	316.97
24	10	80.89	72.42	316.97
24	11	80.83	72.88	316.97
24	12	80.77	73.33	316.97
24	13	80.71	73.78	316.97
24	14	80.65	74.23	316.97
24	15	80.59	74.68	316.97
24	16	80.53	75.13	316.97
24	17	80.47	75.58	316.97
25	1	81.93	68.34	316.97
25	2	81.87	68.80	316.97
25	3	81.81	69.25	316.97
25	4	81.75	69.71	316.97

25	5	81.69	70.16	316.97
25	6	81.63	70.62	316.97
25	7	81.57	71.08	316.97
25	8	81.51	71.53	316.97
25	9	81.45	71.99	316.97
25	10	81.39	72.45	316.97
25	11	81.33	72.90	316.97
25	12	81.27	73.36	316.97
25	13	81.20	73.82	316.97
25	14	81.14	74.27	316.97
25	15	81.08	74.73	316.97
25	16	81.02	75.19	316.97
25	17	80.96	75.64	316.97
26	1	82.44	68.31	316.96
26	2	82.37	68.77	316.96
26	3	82.31	69.23	316.96
26	4	82.25	69.69	316.96
26	5	82.19	70.16	316.96
26	6	82.13	70.62	316.96
26	7	82.07	71.08	316.96
26	8	82.00	71.54	316.96
26	9	81.94	72.01	316.96
26	10	81.88	72.47	316.96
26	11	81.82	72.93	316.96
26	12	81.76	73.40	316.96
26	13	81.70	73.86	316.96
26	14	81.63	74.32	316.96
26	15	81.57	74.78	316.96
26	16	81.51	75.25	316.96
26	17	81.45	75.71	316.96
27	1	82.94	68.27	316.96
27	2	82.88	68.74	316.96
27	3	82.81	69.21	316.96
27	4	82.75	69.68	316.96
27	5	82.69	70.15	316.96
27	6	82.63	70.62	316.96
27	7	82.56	71.09	316.96
27	8	82.50	71.56	316.96
27	9	82.44	72.02	316.96
27	10	82.38	72.49	316.96
27	11	82.31	72.96	316.96
27	12	82.25	73.43	316.96
27	13	82.19	73.90	316.96
27	14	82.13	74.37	316.96
27	15	82.06	74.84	316.96
27	16	82.00	75.30	316.96

27	17	81.94	75.77	316.96	30	12	83.73	73.53	316.94
28	1	83.44	68.24	316.95	30	13	83.66	74.02	316.94
28	2	83.38	68.72	316.95	30	14	83.60	74.51	316.94
28	3	83.31	69.19	316.95	30	15	83.53	75.00	316.94
28	4	83.25	69.67	316.95	30	16	83.47	75.48	316.94
28	5	83.19	70.14	316.95	30	17	83.41	75.97	316.94
28	6	83.12	70.62	316.95	31	1	84.95	68.15	316.94
28	7	83.06	71.09	316.95	31	2	84.88	68.64	316.94
28	8	83.00	71.57	316.95	31	3	84.81	69.13	316.94
28	9	82.93	72.04	316.95	31	4	84.75	69.63	316.94
28	10	82.87	72.52	316.95	31	5	84.68	70.12	316.94
28	11	82.81	72.99	316.95	31	6	84.62	70.61	316.94
28	12	82.74	73.47	316.95	31	7	84.55	71.10	316.94
28	13	82.68	73.94	316.95	31	8	84.49	71.60	316.94
28	14	82.62	74.41	316.95	31	9	84.42	72.09	316.94
28	15	82.55	74.89	316.95	31	10	84.35	72.58	316.94
28	16	82.49	75.36	316.95	31	11	84.29	73.08	316.94
28	17	82.43	75.84	316.95	31	12	84.22	73.57	316.94
29	1	83.94	68.21	316.95	31	13	84.16	74.06	316.94
29	2	83.88	68.69	316.95	31	14	84.09	74.56	316.94
29	3	83.81	69.17	316.95	31	15	84.03	75.05	316.94
29	4	83.75	69.65	316.95	31	16	83.96	75.54	316.94
29	5	83.69	70.13	316.95	31	17	83.89	76.03	316.94
29	6	83.62	70.61	316.95	32	1	85.45	68.11	316.93
29	7	83.56	71.10	316.95	32	2	85.38	68.61	316.93
29	8	83.49	71.58	316.95	32	3	85.31	69.11	316.93
29	9	83.43	72.06	316.95	32	4	85.25	69.61	316.93
29	10	83.36	72.54	316.95	32	5	85.18	70.11	316.93
29	11	83.30	73.02	316.95	32	6	85.11	70.61	316.93
29	12	83.24	73.50	316.95	32	7	85.05	71.11	316.93
29	13	83.17	73.98	316.95	32	8	84.98	71.61	316.93
29	14	83.11	74.46	316.95	32	9	84.91	72.11	316.93
29	15	83.04	74.94	316.95	32	10	84.85	72.61	316.93
29	16	82.98	75.42	316.95	32	11	84.78	73.11	316.93
29	17	82.92	75.90	316.95	32	12	84.72	73.60	316.93
30	1	84.44	68.18	316.94	32	13	84.65	74.10	316.93
30	2	84.38	68.67	316.94	32	14	84.58	74.60	316.93
30	3	84.31	69.15	316.94	32	15	84.52	75.10	316.93
30	4	84.25	69.64	316.94	32	16	84.45	75.60	316.93
30	5	84.18	70.13	316.94	32	17	84.38	76.10	316.93
30	6	84.12	70.61	316.94	33	1	85.95	68.08	316.93
30	7	84.05	71.10	316.94	33	2	85.88	68.59	316.93
30	8	83.99	71.59	316.94	33	3	85.81	69.09	316.93
30	9	83.92	72.07	316.94	33	4	85.75	69.60	316.93
30	10	83.86	72.56	316.94	33	5	85.68	70.10	316.93
30	11	83.79	73.05	316.94	33	6	85.61	70.61	316.93

33	7	85.54	71.11	316.93	36	2	87.88	68.39	317.05
33	8	85.48	71.62	316.93	36	3	87.80	68.82	316.91
33	9	85.41	72.12	316.93	36	4	87.73	69.26	316.91
33	10	85.34	72.63	316.93	36	5	87.65	69.69	316.91
33	11	85.28	73.13	316.93	36	6	87.54	70.34	316.91
33	12	85.21	73.64	316.93	36	7	87.43	70.98	316.91
33	13	85.14	74.14	316.93	36	8	87.36	71.41	316.91
33	14	85.07	74.65	316.93	36	9	87.23	72.16	316.91
33	15	85.01	75.15	316.93	36	10	87.10	72.92	316.91
33	16	84.94	75.66	316.93	36	11	87.03	73.36	316.91
33	17	84.87	76.17	316.93	36	12	86.91	74.01	316.91
34	1	86.45	68.05	316.92	36	13	86.80	74.66	316.91
34	2	86.38	68.56	316.92	36	14	86.73	75.09	316.91
34	3	86.31	69.07	316.92	36	15	86.65	75.52	316.91
34	4	86.25	69.58	316.92	36	16	86.58	75.95	317.05
34	5	86.18	70.10	316.92	36	17	86.51	76.38	317.20
34	6	86.11	70.61	316.92	37	1	88.83	67.90	317.36
34	7	86.04	71.12	316.92	37	2	88.75	68.34	317.21
34	8	85.97	71.63	316.92	37	3	88.67	68.79	317.06
34	9	85.91	72.14	316.92	37	4	88.58	69.25	316.98
34	10	85.84	72.65	316.92	37	5	88.50	69.70	316.90
34	11	85.77	73.16	316.92	37	6	88.38	70.36	316.90
34	12	85.70	73.67	316.92	37	7	88.27	71.03	316.90
34	13	85.63	74.19	316.92	37	8	88.19	71.47	316.90
34	14	85.56	74.70	316.92	37	9	88.06	72.18	316.90
34	15	85.50	75.21	316.92	37	10	87.94	72.91	316.90
34	16	85.43	75.72	316.92	37	11	87.85	73.36	316.90
34	17	85.36	76.23	316.92	37	12	87.73	74.03	316.90
35	1	87.20	68.00	317.06	37	13	87.61	74.71	316.90
35	2	87.13	68.47	316.99	37	14	87.53	75.15	316.98
35	3	87.06	68.95	316.91	37	15	87.45	75.60	317.06
35	4	86.99	69.42	316.91	37	16	87.37	76.04	317.21
35	5	86.91	69.89	316.91	37	17	87.30	76.49	317.36
35	6	86.83	70.47	316.91	38	1	89.70	67.84	317.52
35	7	86.74	71.05	316.91	38	2	89.62	68.30	317.36
35	8	86.67	71.52	316.91	38	3	89.53	68.76	317.21
35	9	86.57	72.15	316.91	38	4	89.44	69.24	317.05
35	10	86.47	72.79	316.91	38	5	89.35	69.71	316.89
35	11	86.40	73.26	316.91	38	6	89.23	70.39	316.89
35	12	86.31	73.84	316.91	38	7	89.11	71.07	316.89
35	13	86.22	74.42	316.91	38	8	89.02	71.53	316.89
35	14	86.15	74.89	316.91	38	9	88.89	72.20	316.89
35	15	86.07	75.36	316.91	38	10	88.77	72.89	316.89
35	16	86.00	75.83	316.99	38	11	88.68	73.36	316.89
35	17	85.94	76.31	317.06	38	12	88.55	74.05	316.89
36	1	87.95	67.95	317.20	38	13	88.42	74.75	316.89

38	14	88.34	75.21	317.05
38	15	88.25	75.67	317.21
38	16	88.17	76.13	317.36
38	17	88.08	76.59	317.52
39	1	90.64	67.78	317.70
39	2	90.55	68.26	317.54
39	3	90.47	68.74	317.38
39	4	90.37	69.23	317.21
39	5	90.28	69.72	317.05
39	6	90.16	70.42	316.96
39	7	90.03	71.12	316.88
39	8	89.95	71.59	316.88
39	9	89.83	72.23	316.88
39	10	89.71	72.87	316.88
39	11	89.62	73.35	316.88
39	12	89.49	74.08	316.96
39	13	89.36	74.80	317.05
39	14	89.27	75.28	317.21
39	15	89.18	75.76	317.38
39	16	89.09	76.24	317.54
39	17	89.01	76.72	317.70
40	1	91.57	67.72	317.88
40	2	91.49	68.22	317.71
40	3	91.40	68.71	317.54
40	4	91.31	69.22	317.37
40	5	91.21	69.72	317.21
40	6	91.08	70.44	317.04
40	7	90.96	71.16	316.87
40	8	90.87	71.65	316.87
40	9	90.76	72.25	316.87
40	10	90.65	72.84	316.87
40	11	90.56	73.35	316.87
40	12	90.43	74.10	317.04
40	13	90.29	74.85	317.21
40	14	90.20	75.35	317.37
40	15	90.11	75.84	317.54
40	16	90.02	76.34	317.71
40	17	89.93	76.84	317.88
41	1	92.57	67.66	318.07
41	2	92.49	68.17	317.90
41	3	92.42	68.68	317.73
41	4	92.33	69.20	317.56
41	5	92.25	69.73	317.38
41	6	92.13	70.47	317.17
41	7	92.02	71.22	316.95
41	8	91.94	71.73	316.86
41	9	91.86	72.28	316.86
41	10	91.77	72.82	316.86
41	11	91.68	73.34	316.95
41	12	91.56	74.13	317.17
41	13	91.44	74.91	317.38
41	14	91.36	75.43	317.56
41	15	91.28	75.95	317.73
41	16	91.20	76.47	317.90
41	17	91.12	77.00	318.07
42	1	93.57	67.59	318.27
42	2	93.50	68.12	318.09
42	3	93.43	68.64	317.92
42	4	93.36	69.19	317.74
42	5	93.29	69.74	317.56
42	6	93.19	70.51	317.29
42	7	93.08	71.28	317.03
42	8	93.01	71.80	316.85
42	9	92.95	72.30	316.85
42	10	92.88	72.79	316.85
42	11	92.81	73.34	317.03
42	12	92.70	74.15	317.29
42	13	92.59	74.97	317.56
42	14	92.52	75.52	317.74
42	15	92.44	76.06	317.92
42	16	92.37	76.61	318.09
42	17	92.30	77.15	318.27
43	1	94.57	67.72	318.26
43	2	94.48	68.42	318.02
43	3	94.39	69.12	317.79
43	4	94.30	69.82	317.55
43	5	94.20	70.52	317.31
43	6	94.11	71.22	317.08
43	7	94.01	71.92	316.84
43	8	93.99	72.09	315.84
43	9	93.95	72.43	315.84
43	10	93.90	72.77	315.84
43	11	93.88	72.93	316.84
43	12	93.79	73.63	317.08
43	13	93.69	74.33	317.31
43	14	93.60	75.04	317.55
43	15	93.50	75.74	317.79
43	16	93.40	76.51	318.02
43	17	93.30	77.28	318.26
44	1	95.56	67.85	318.25
44	2	95.47	68.55	318.01
44	3	95.38	69.26	317.78

44	4	95.29	69.96	317.54
44	5	95.19	70.66	317.30
44	6	95.10	71.36	317.07
44	7	95.00	72.06	316.83
44	8	94.98	72.22	315.83
44	9	94.94	72.56	315.83
44	10	94.90	72.90	315.83
44	11	94.87	73.07	316.83
44	12	94.78	73.77	317.07
44	13	94.68	74.47	317.30
44	14	94.59	75.17	317.54
44	15	94.49	75.87	317.78
44	16	94.39	76.64	318.01
44	17	94.29	77.42	318.25
45	1	96.55	67.99	318.24
45	2	96.46	68.69	318.00
45	3	96.37	69.39	317.77
45	4	96.28	70.09	317.53
45	5	96.18	70.79	317.29
45	6	96.09	71.49	317.06
45	7	95.99	72.19	316.82
45	8	95.97	72.36	315.82
45	9	95.93	72.70	315.82
45	10	95.89	73.03	315.82
45	11	95.86	73.20	316.82
45	12	95.77	73.90	317.06
45	13	95.67	74.60	317.29
45	14	95.58	75.30	317.53
45	15	95.48	76.01	317.77
45	16	95.38	76.78	318.00
45	17	95.28	77.55	318.24
46	1	97.54	68.12	318.23
46	2	97.45	68.82	317.99
46	3	97.36	69.52	317.76
46	4	97.27	70.22	317.52
46	5	97.17	70.92	317.28
46	6	97.08	71.62	317.05
46	7	96.98	72.32	316.81
46	8	96.96	72.49	315.81
46	9	96.92	72.83	315.81
46	10	96.88	73.16	315.81
46	11	96.85	73.33	316.81
46	12	96.76	74.03	317.05
46	13	96.66	74.73	317.28
46	14	96.57	75.43	317.52
46	15	96.47	76.14	317.76
46	16	96.37	76.91	317.99
46	17	96.27	77.68	318.23
47	1	98.54	68.25	318.22
47	2	98.45	68.95	317.98
47	3	98.35	69.65	317.75
47	4	98.26	70.35	317.51
47	5	98.17	71.05	317.27
47	6	98.07	71.75	317.04
47	7	97.98	72.45	316.80
47	8	97.96	72.62	315.80
47	9	97.91	72.96	315.80
47	10	97.87	73.30	315.80
47	11	97.84	73.46	316.80
47	12	97.75	74.16	317.04
47	13	97.66	74.86	317.27
47	14	97.56	75.57	317.51
47	15	97.47	76.27	317.75
47	16	97.37	77.04	317.98
47	17	97.26	77.81	318.22
48	1	99.53	68.38	318.21
48	2	99.44	69.08	317.97
48	3	99.35	69.79	317.74
48	4	99.25	70.49	317.50
48	5	99.16	71.19	317.26
48	6	99.06	71.89	317.03
48	7	98.97	72.59	316.79
48	8	98.95	72.75	315.79
48	9	98.91	73.09	315.79
48	10	98.86	73.43	315.79
48	11	98.84	73.60	316.79
48	12	98.74	74.30	317.03
48	13	98.65	75.00	317.26
48	14	98.55	75.70	317.50
48	15	98.46	76.40	317.74
48	16	98.36	77.17	317.97
48	17	98.26	77.95	318.21
49	1	100.52	68.52	318.20
49	2	100.43	69.22	317.96
49	3	100.34	69.92	317.73
49	4	100.24	70.62	317.49
49	5	100.15	71.32	317.25
49	6	100.05	72.02	317.02
49	7	99.96	72.72	316.78
49	8	99.94	72.89	315.78
49	9	99.90	73.23	315.78
49	10	99.85	73.56	315.78

49	11	99.83	73.73	316.78
49	12	99.73	74.43	317.02
49	13	99.64	75.13	317.25
49	14	99.54	75.83	317.49
49	15	99.45	76.54	317.73
49	16	99.35	77.31	317.96
49	17	99.25	78.08	318.20
50	1	101.51	68.65	318.19
50	2	101.42	69.35	317.95
50	3	101.33	70.05	317.72
50	4	101.23	70.75	317.48
50	5	101.14	71.45	317.24
50	6	101.04	72.15	317.01
50	7	100.95	72.85	316.77
50	8	100.93	73.02	315.77
50	9	100.89	73.36	315.77
50	10	100.84	73.69	315.77
50	11	100.82	73.86	316.77
50	12	100.72	74.56	317.01
50	13	100.63	75.26	317.24
50	14	100.53	75.96	317.48
50	15	100.44	76.67	317.72
50	16	100.34	77.44	317.95
50	17	100.24	78.21	318.19
51	1	102.50	68.78	318.18
51	2	102.41	69.48	317.94
51	3	102.32	70.18	317.71
51	4	102.22	70.88	317.47
51	5	102.13	71.58	317.23
51	6	102.04	72.28	317.00
51	7	101.94	72.98	316.76
51	8	101.92	73.15	315.76
51	9	101.88	73.49	315.76
51	10	101.83	73.83	315.76
51	11	101.81	73.99	316.76
51	12	101.71	74.69	317.00
51	13	101.62	75.39	317.23
51	14	101.53	76.10	317.47
51	15	101.43	76.80	317.71
51	16	101.33	77.57	317.94
51	17	101.23	78.34	318.18
52	1	103.49	68.91	318.17
52	2	103.40	69.61	317.93
52	3	103.31	70.32	317.70
52	4	103.22	71.02	317.46
52	5	103.12	71.72	317.22
52	6	103.03	72.42	316.99
52	7	102.93	73.12	316.75
52	8	102.91	73.28	315.75
52	9	102.87	73.62	315.75
52	10	102.82	73.96	315.75
52	11	102.80	74.13	316.75
52	12	102.71	74.83	316.99
52	13	102.61	75.53	317.22
52	14	102.52	76.23	317.46
52	15	102.42	76.93	317.70
52	16	102.32	77.70	317.93
52	17	102.22	78.48	318.17
53	1	104.48	69.05	318.16
53	2	104.39	69.75	317.92
53	3	104.30	70.45	317.69
53	4	104.21	71.15	317.45
53	5	104.11	71.85	317.21
53	6	104.02	72.55	316.98
53	7	103.92	73.25	316.74
53	8	103.90	73.42	315.74
53	9	103.86	73.76	315.74
53	10	103.81	74.09	315.74
53	11	103.79	74.26	316.74
53	12	103.70	74.96	316.98
53	13	103.60	75.66	317.21
53	14	103.51	76.36	317.45
53	15	103.41	77.07	317.69
53	16	103.31	77.84	317.92
53	17	103.21	78.61	318.16
54	1	105.47	69.18	318.15
54	2	105.38	69.88	317.91
54	3	105.29	70.58	317.68
54	4	105.20	71.28	317.44
54	5	105.10	71.98	317.20
54	6	105.01	72.68	316.97
54	7	104.91	73.38	316.73
54	8	104.89	73.55	315.73
54	9	104.85	73.89	315.73
54	10	104.81	74.22	315.73
54	11	104.78	74.39	316.73
54	12	104.69	75.09	316.97
54	13	104.59	75.79	317.20
54	14	104.50	76.49	317.44
54	15	104.40	77.20	317.68
54	16	104.30	77.97	317.91
54	17	104.20	78.74	318.15

55	1	106.46	69.31	318.14
55	2	106.37	70.01	317.90
55	3	106.28	70.71	317.67
55	4	106.19	71.41	317.43
55	5	106.09	72.11	317.19
55	6	106.00	72.81	316.96
55	7	105.90	73.51	316.72
55	8	105.88	73.68	315.72
55	9	105.84	74.02	315.72
55	10	105.80	74.36	315.72
55	11	105.77	74.52	316.72
55	12	105.68	75.22	316.96
55	13	105.58	75.92	317.19
55	14	105.49	76.63	317.43
55	15	105.39	77.33	317.67
55	16	105.29	78.10	317.90
55	17	105.19	78.87	318.14
56	1	107.46	69.44	318.13
56	2	107.36	70.14	317.89
56	3	107.27	70.85	317.66
56	4	107.18	71.55	317.42
56	5	107.09	72.25	317.18
56	6	106.99	72.95	316.95
56	7	106.90	73.65	316.71
56	8	106.87	73.81	315.71
56	9	106.83	74.15	315.71
56	10	106.79	74.49	315.71
56	11	106.76	74.66	316.71
56	12	106.67	75.36	316.95
56	13	106.58	76.06	317.18
56	14	106.48	76.76	317.42
56	15	106.39	77.46	317.66
56	16	106.28	78.23	317.89
56	17	106.18	79.01	318.13
57	1	108.45	69.58	318.12
57	2	108.36	70.28	317.88
57	3	108.26	70.98	317.65
57	4	108.17	71.68	317.41
57	5	108.08	72.38	317.17
57	6	107.98	73.08	316.94
57	7	107.89	73.78	316.70
57	8	107.87	73.95	315.70
57	9	107.82	74.29	315.70
57	10	107.78	74.62	315.70
57	11	107.75	74.79	316.70
57	12	107.66	75.49	316.94
57	13	107.57	76.19	317.17
57	14	107.47	76.89	317.41
57	15	107.38	77.60	317.65
57	16	107.28	78.37	317.88
57	17	107.17	79.14	318.12
58	1	109.44	69.71	318.11
58	2	109.35	70.41	317.87
58	3	109.26	71.11	317.64
58	4	109.16	71.81	317.40
58	5	109.07	72.51	317.16
58	6	108.97	73.21	316.93
58	7	108.88	73.91	316.69
58	8	108.86	74.08	315.69
58	9	108.82	74.42	315.69
58	10	108.77	74.75	315.69
58	11	108.75	74.92	316.69
58	12	108.65	75.62	316.93
58	13	108.56	76.32	317.16
58	14	108.46	77.02	317.40
58	15	108.37	77.73	317.64
58	16	108.27	78.50	317.87
58	17	108.17	79.27	318.11
59	1	110.43	69.84	318.10
59	2	110.34	70.54	317.86
59	3	110.25	71.24	317.63
59	4	110.15	71.94	317.39
59	5	110.06	72.64	317.15
59	6	109.96	73.34	316.92
59	7	109.87	74.04	316.68
59	8	109.85	74.21	315.68
59	9	109.81	74.55	315.68
59	10	109.76	74.89	315.68
59	11	109.74	75.05	316.68
59	12	109.64	75.75	316.92
59	13	109.55	76.45	317.15
59	14	109.45	77.16	317.39
59	15	109.36	77.86	317.63
59	16	109.26	78.63	317.86
59	17	109.16	79.40	318.10
60	1	111.42	69.97	318.09
60	2	111.33	70.67	317.85
60	3	111.24	71.38	317.62
60	4	111.14	72.08	317.38
60	5	111.05	72.78	317.14
60	6	110.96	73.48	316.91
60	7	110.86	74.18	316.67

60	8	110.84	74.34	315.67	63	3	114.21	71.77	317.59
60	9	110.80	74.68	315.67	63	4	114.12	72.47	317.35
60	10	110.75	75.02	315.67	63	5	114.02	73.17	317.11
60	11	110.73	75.19	316.67	63	6	113.93	73.87	316.88
60	12	110.63	75.89	316.91	63	7	113.83	74.57	316.64
60	13	110.54	76.59	317.14	63	8	113.81	74.74	315.64
60	14	110.45	77.29	317.38	63	9	113.77	75.08	315.64
60	15	110.35	77.99	317.62	63	10	113.72	75.41	315.64
60	16	110.25	78.76	317.85	63	11	113.70	75.58	316.64
60	17	110.15	79.54	318.09	63	12	113.61	76.28	316.88
61	1	112.41	70.10	318.08	63	13	113.51	76.98	317.11
61	2	112.32	70.81	317.84	63	14	113.42	77.69	317.35
61	3	112.23	71.51	317.61	63	15	113.32	78.39	317.59
61	4	112.13	72.21	317.37	63	16	113.22	79.16	317.82
61	5	112.04	72.91	317.13	63	17	113.12	79.93	318.06
61	6	111.95	73.61	316.90	64	1	115.38	70.50	318.05
61	7	111.85	74.31	316.66	64	2	115.29	71.20	317.81
61	8	111.83	74.48	315.66	64	3	115.20	71.91	317.58
61	9	111.79	74.81	315.66	64	4	115.11	72.61	317.34
61	10	111.74	75.15	315.66	64	5	115.01	73.31	317.10
61	11	111.72	75.32	316.66	64	6	114.92	74.01	316.87
61	12	111.62	76.02	316.90	64	7	114.82	74.71	316.63
61	13	111.53	76.72	317.13	64	8	114.80	74.87	315.63
61	14	111.44	77.42	317.37	64	9	114.76	75.21	315.63
61	15	111.34	78.12	317.61	64	10	114.71	75.55	315.63
61	16	111.24	78.90	317.84	64	11	114.69	75.72	316.63
61	17	111.14	79.67	318.08	64	12	114.60	76.42	316.87
62	1	113.40	70.24	318.07	64	13	114.50	77.12	317.10
62	2	113.31	70.94	317.83	64	14	114.41	77.82	317.34
62	3	113.22	71.64	317.60	64	15	114.31	78.52	317.58
62	4	113.13	72.34	317.36	64	16	114.21	79.29	317.81
62	5	113.03	73.04	317.12	64	17	114.11	80.07	318.05
62	6	112.94	73.74	316.89	65	1	116.38	70.63	318.04
62	7	112.84	74.44	316.65	65	2	116.28	71.34	317.80
62	8	112.82	74.61	315.65	65	3	116.19	72.04	317.57
62	9	112.78	74.95	315.65	65	4	116.10	72.74	317.33
62	10	112.73	75.28	315.65	65	5	116.01	73.44	317.09
62	11	112.71	75.45	316.65	65	6	115.91	74.14	316.86
62	12	112.62	76.15	316.89	65	7	115.82	74.84	316.62
62	13	112.52	76.85	317.12	65	8	115.79	75.01	315.62
62	14	112.43	77.55	317.36	65	9	115.75	75.34	315.62
62	15	112.33	78.26	317.60	65	10	115.71	75.68	315.62
62	16	112.23	79.03	317.83	65	11	115.68	75.85	316.62
62	17	112.13	79.80	318.07	65	12	115.59	76.55	316.86
63	1	114.39	70.37	318.06	65	13	115.50	77.25	317.09
63	2	114.30	71.07	317.82	65	14	115.40	77.95	317.33

65	15	115.31	78.65	317.57
65	16	115.20	79.43	317.80
65	17	115.10	80.20	318.04
66	1	117.37	70.77	318.03
66	2	117.28	71.47	317.79
66	3	117.18	72.17	317.56
66	4	117.09	72.87	317.32
66	5	117.00	73.57	317.08
66	6	116.90	74.27	316.85
66	7	116.81	74.97	316.61
66	8	116.79	75.14	315.61
66	9	116.74	75.48	315.61
66	10	116.70	75.81	315.61
66	11	116.67	75.98	316.61
66	12	116.58	76.68	316.85
66	13	116.49	77.38	317.08
66	14	116.39	78.08	317.32
66	15	116.30	78.79	317.56
66	16	116.20	79.56	317.79
66	17	116.09	80.33	318.03
67	1	118.36	70.90	318.02
67	2	118.27	71.60	317.78
67	3	118.17	72.30	317.55
67	4	118.08	73.00	317.31
67	5	117.99	73.70	317.07
67	6	117.89	74.40	316.84
67	7	117.80	75.10	316.60
67	8	117.78	75.27	315.60
67	9	117.73	75.61	315.60
67	10	117.69	75.94	315.60
67	11	117.66	76.11	316.60
67	12	117.57	76.81	316.84
67	13	117.48	77.51	317.07
67	14	117.38	78.22	317.31
67	15	117.29	78.92	317.55
67	16	117.19	79.69	317.78
67	17	117.08	80.46	318.02
68	1	119.35	71.03	318.01
68	2	119.26	71.73	317.77
68	3	119.17	72.44	317.54
68	4	119.07	73.14	317.30
68	5	118.98	73.84	317.06
68	6	118.88	74.54	316.83
68	7	118.79	75.24	316.59
68	8	118.77	75.40	315.59
68	9	118.73	75.74	315.59
68	10	118.68	76.08	315.59
68	11	118.66	76.25	316.59
68	12	118.56	76.95	316.83
68	13	118.47	77.65	317.06
68	14	118.37	78.35	317.30
68	15	118.28	79.05	317.54
68	16	118.18	79.82	317.77
68	17	118.08	80.60	318.01
69	1	120.34	71.16	318.00
69	2	120.25	71.87	317.76
69	3	120.16	72.57	317.53
69	4	120.06	73.27	317.29
69	5	119.97	73.97	317.05
69	6	119.88	74.67	316.82
69	7	119.78	75.37	316.58
69	8	119.76	75.54	315.58
69	9	119.72	75.87	315.58
69	10	119.67	76.21	315.58
69	11	119.65	76.38	316.58
69	12	119.55	77.08	316.82
69	13	119.46	77.78	317.05
69	14	119.37	78.48	317.29
69	15	119.27	79.18	317.53
69	16	119.17	79.96	317.76
69	17	119.07	80.73	318.00
70	1	121.33	71.30	317.99
70	2	121.24	72.00	317.75
70	3	121.15	72.70	317.52
70	4	121.05	73.40	317.28
70	5	120.96	74.10	317.04
70	6	120.87	74.80	316.81
70	7	120.77	75.50	316.57
70	8	120.75	75.67	315.57
70	9	120.71	76.01	315.57
70	10	120.66	76.34	315.57
70	11	120.64	76.51	316.57
70	12	120.54	77.21	316.81
70	13	120.45	77.91	317.04
70	14	120.36	78.61	317.28
70	15	120.26	79.32	317.52
70	16	120.16	80.09	317.75
70	17	120.06	80.86	317.99
71	1	122.32	71.43	317.98
71	2	122.23	72.13	317.74
71	3	122.14	72.83	317.51
71	4	122.05	73.53	317.27

71	5	121.95	74.23	317.03	73	17	123.03	81.26	317.96
71	6	121.86	74.93	316.80	74	1	125.30	71.83	317.95
71	7	121.76	75.63	316.56	74	2	125.20	72.53	317.71
71	8	121.74	75.80	315.56	74	3	125.11	73.23	317.48
71	9	121.70	76.14	315.56	74	4	125.02	73.93	317.24
71	10	121.65	76.47	315.56	74	5	124.93	74.63	317.00
71	11	121.63	76.64	316.56	74	6	124.83	75.33	316.77
71	12	121.54	77.34	316.80	74	7	124.74	76.03	316.53
71	13	121.44	78.04	317.03	74	8	124.71	76.20	315.53
71	14	121.35	78.75	317.27	74	9	124.67	76.54	315.53
71	15	121.25	79.45	317.51	74	10	124.62	76.87	315.53
71	16	121.15	80.22	317.74	74	11	124.60	77.04	316.53
71	17	121.05	80.99	317.98	74	12	124.51	77.74	316.77
72	1	123.31	71.56	317.97	74	13	124.42	78.44	317.00
72	2	123.22	72.26	317.73	74	14	124.32	79.14	317.24
72	3	123.13	72.97	317.50	74	15	124.23	79.85	317.48
72	4	123.04	73.67	317.26	74	16	124.12	80.62	317.71
72	5	122.94	74.37	317.02	74	17	124.02	81.39	317.95
72	6	122.85	75.07	316.79	75	1	126.29	71.96	317.94
72	7	122.75	75.77	316.55	75	2	126.19	72.66	317.70
72	8	122.73	75.93	315.55	75	3	126.10	73.36	317.47
72	9	122.69	76.27	315.55	75	4	126.01	74.06	317.23
72	10	122.64	76.61	315.55	75	5	125.92	74.76	316.99
72	11	122.62	76.78	316.55	75	6	125.82	75.46	316.76
72	12	122.53	77.48	316.79	75	7	125.73	76.16	316.52
72	13	122.43	78.18	317.02	75	8	125.71	76.33	315.52
72	14	122.34	78.88	317.26	75	9	125.66	76.67	315.52
72	15	122.24	79.58	317.50	75	10	125.62	77.00	315.52
72	16	122.14	80.35	317.73	75	11	125.59	77.17	316.52
72	17	122.04	81.13	317.97	75	12	125.50	77.87	316.76
73	1	124.30	71.69	317.96	75	13	125.41	78.57	316.99
73	2	124.21	72.40	317.72	75	14	125.31	79.28	317.23
73	3	124.12	73.10	317.49	75	15	125.22	79.98	317.47
73	4	124.03	73.80	317.25	75	16	125.11	80.75	317.70
73	5	123.93	74.50	317.01	75	17	125.01	81.52	317.94
73	6	123.84	75.20	316.78	76	1	127.28	72.09	317.93
73	7	123.74	75.90	316.54	76	2	127.19	72.79	317.69
73	8	123.72	76.07	315.54	76	3	127.09	73.50	317.46
73	9	123.68	76.40	315.54	76	4	127.00	74.20	317.22
73	10	123.63	76.74	315.54	76	5	126.91	74.90	316.98
73	11	123.61	76.91	316.54	76	6	126.81	75.60	316.75
73	12	123.52	77.61	316.78	76	7	126.72	76.30	316.51
73	13	123.42	78.31	317.01	76	8	126.70	76.46	315.51
73	14	123.33	79.01	317.25	76	9	126.65	76.80	315.51
73	15	123.23	79.71	317.49	76	10	126.61	77.14	315.51
73	16	123.13	80.49	317.72	76	11	126.58	77.31	316.51

76	12	126.49	78.01	316.75
76	13	126.40	78.71	316.98
76	14	126.30	79.41	317.22
76	15	126.21	80.11	317.46
76	16	126.11	80.88	317.69
76	17	126.00	81.66	317.93
77	1	128.27	72.22	317.92
77	2	128.18	72.93	317.68
77	3	128.08	73.63	317.45
77	4	127.99	74.33	317.21
77	5	127.90	75.03	316.97
77	6	127.80	75.73	316.74
77	7	127.71	76.43	316.50
77	8	127.69	76.60	315.50
77	9	127.64	76.93	315.50
77	10	127.60	77.27	315.50
77	11	127.57	77.44	316.50
77	12	127.48	78.14	316.74
77	13	127.39	78.84	316.97
77	14	127.29	79.54	317.21
77	15	127.20	80.24	317.45
77	16	127.10	81.02	317.68
77	17	126.99	81.79	317.92
78	1	129.26	72.36	317.91
78	2	129.17	73.06	317.67
78	3	129.08	73.76	317.44
78	4	128.98	74.46	317.20
78	5	128.89	75.16	316.96
78	6	128.80	75.86	316.73
78	7	128.70	76.56	316.49
78	8	128.68	76.73	315.49
78	9	128.64	77.07	315.49
78	10	128.59	77.40	315.49
78	11	128.57	77.57	316.49
78	12	128.47	78.27	316.73
78	13	128.38	78.97	316.96
78	14	128.29	79.67	317.20
78	15	128.19	80.38	317.44
78	16	128.09	81.15	317.67
78	17	127.99	81.92	317.91
79	1	130.25	72.49	317.90
79	2	130.16	73.19	317.66
79	3	130.07	73.89	317.43
79	4	129.97	74.59	317.19
79	5	129.88	75.29	316.95
79	6	129.79	75.99	316.72
79	7	129.69	76.69	316.48
79	8	129.67	76.86	315.48
79	9	129.63	77.20	315.48
79	10	129.58	77.53	315.48
79	11	129.56	77.70	316.48
79	12	129.46	78.40	316.72
79	13	129.37	79.10	316.95
79	14	129.28	79.80	317.19
79	15	129.18	80.51	317.43
79	16	129.08	81.28	317.66
79	17	128.98	82.05	317.90
80	1	131.24	72.62	317.89
80	2	131.15	73.32	317.65
80	3	131.06	74.03	317.42
80	4	130.96	74.73	317.18
80	5	130.87	75.43	316.94
80	6	130.78	76.13	316.71
80	7	130.68	76.83	316.47
80	8	130.66	76.99	315.47
80	9	130.62	77.33	315.47
80	10	130.57	77.67	315.47
80	11	130.55	77.84	316.47
80	12	130.45	78.54	316.71
80	13	130.36	79.24	316.94
80	14	130.27	79.94	317.18
80	15	130.17	80.64	317.42
80	16	130.07	81.41	317.65
80	17	129.97	82.19	317.89
81	1	132.23	72.75	317.88
81	2	132.14	73.45	317.64
81	3	132.05	74.16	317.41
81	4	131.96	74.86	317.17
81	5	131.86	75.56	316.93
81	6	131.77	76.26	316.70
81	7	131.67	76.96	316.46
81	8	131.65	77.13	315.46
81	9	131.61	77.46	315.46
81	10	131.56	77.80	315.46
81	11	131.54	77.97	316.46
81	12	131.45	78.67	316.70
81	13	131.35	79.37	316.93
81	14	131.26	80.07	317.17
81	15	131.16	80.77	317.41
81	16	131.06	81.54	317.64
81	17	130.96	82.32	317.88
82	1	133.22	72.88	317.87

82	2	133.13	73.59	317.63
82	3	133.04	74.29	317.40
82	4	132.95	74.99	317.16
82	5	132.85	75.69	316.92
82	6	132.76	76.39	316.69
82	7	132.66	77.09	316.45
82	8	132.64	77.26	315.45
82	9	132.60	77.59	315.45
82	10	132.55	77.93	315.45
82	11	132.53	78.10	316.45
82	12	132.44	78.80	316.69
82	13	132.34	79.50	316.92
82	14	132.25	80.20	317.16
82	15	132.15	80.90	317.40
82	16	132.05	81.68	317.63
82	17	131.95	82.45	317.87
83	1	134.22	73.02	317.86
83	2	134.12	73.72	317.62
83	3	134.03	74.42	317.39
83	4	133.94	75.12	317.15
83	5	133.85	75.82	316.91
83	6	133.75	76.52	316.68
83	7	133.66	77.22	316.44
83	8	133.63	77.39	315.44
83	9	133.59	77.73	315.44
83	10	133.54	78.06	315.44
83	11	133.52	78.23	316.44
83	12	133.43	78.93	316.68
83	13	133.34	79.63	316.91
83	14	133.24	80.33	317.15
83	15	133.15	81.04	317.39
83	16	133.04	81.81	317.62
83	17	132.94	82.58	317.86
84	1	135.21	73.15	317.85
84	2	135.11	73.85	317.61
84	3	135.02	74.56	317.38
84	4	134.93	75.26	317.14
84	5	134.84	75.96	316.90
84	6	134.74	76.66	316.67
84	7	134.65	77.36	316.43
84	8	134.62	77.52	315.43
84	9	134.58	77.86	315.43
84	10	134.53	78.20	315.43
84	11	134.51	78.37	316.43
84	12	134.42	79.07	316.67
84	13	134.33	79.77	316.90
84	14	134.23	80.47	317.14
84	15	134.14	81.17	317.38
84	16	134.03	81.94	317.61
84	17	133.93	82.72	317.85
85	1	136.20	73.28	317.84
85	2	136.10	73.98	317.60
85	3	136.01	74.69	317.37
85	4	135.92	75.39	317.13
85	5	135.83	76.09	316.89
85	6	135.73	76.79	316.66
85	7	135.64	77.49	316.42
85	8	135.62	77.66	315.42
85	9	135.57	77.99	315.42
85	10	135.53	78.33	315.42
85	11	135.50	78.50	316.42
85	12	135.41	79.20	316.66
85	13	135.32	79.90	316.89
85	14	135.22	80.60	317.13
85	15	135.13	81.30	317.37
85	16	135.02	82.07	317.60
85	17	134.92	82.85	317.84
86	1	137.19	73.41	317.83
86	2	137.10	74.12	317.59
86	3	137.00	74.82	317.36
86	4	136.91	75.52	317.12
86	5	136.82	76.22	316.88
86	6	136.72	76.92	316.65
86	7	136.63	77.62	316.41
86	8	136.61	77.79	315.41
86	9	136.56	78.12	315.41
86	10	136.52	78.46	315.41
86	11	136.49	78.63	316.41
86	12	136.40	79.33	316.65
86	13	136.31	80.03	316.88
86	14	136.21	80.73	317.12
86	15	136.12	81.43	317.36
86	16	136.02	82.21	317.59
86	17	135.91	82.98	317.83
87	1	138.18	73.55	317.82
87	2	138.09	74.25	317.58
87	3	137.99	74.95	317.35
87	4	137.90	75.65	317.11
87	5	137.81	76.35	316.87
87	6	137.72	77.05	316.64
87	7	137.62	77.75	316.40
87	8	137.60	77.92	315.40

87	9	137.55	78.26	315.40	90	4	140.88	76.05	317.08
87	10	137.51	78.59	315.40	90	5	140.78	76.75	316.84
87	11	137.48	78.76	316.40	90	6	140.69	77.45	316.61
87	12	137.39	79.46	316.64	90	7	140.59	78.15	316.37
87	13	137.30	80.16	316.87	90	8	140.57	78.32	315.37
87	14	137.21	80.86	317.11	90	9	140.53	78.65	315.37
87	15	137.11	81.57	317.35	90	10	140.48	78.99	315.37
87	16	137.01	82.34	317.58	90	11	140.46	79.16	316.37
87	17	136.90	83.11	317.82	90	12	140.37	79.86	316.61
88	1	139.17	73.68	317.81	90	13	140.27	80.56	316.84
88	2	139.08	74.38	317.57	90	14	140.18	81.26	317.08
88	3	138.98	75.09	317.34	90	15	140.08	81.96	317.32
88	4	138.89	75.79	317.10	90	16	139.98	82.74	317.55
88	5	138.80	76.49	316.86	90	17	139.88	83.51	317.79
88	6	138.71	77.19	316.63	91	1	142.14	74.08	317.78
88	7	138.61	77.89	316.39	91	2	142.05	74.78	317.54
88	8	138.59	78.05	315.39	91	3	141.96	75.48	317.31
88	9	138.54	78.39	315.39	91	4	141.87	76.18	317.07
88	10	138.50	78.73	315.39	91	5	141.77	76.88	316.83
88	11	138.47	78.90	316.39	91	6	141.68	77.58	316.60
88	12	138.38	79.60	316.63	91	7	141.58	78.28	316.36
88	13	138.29	80.30	316.86	91	8	141.56	78.45	315.36
88	14	138.20	81.00	317.10	91	9	141.52	78.79	315.36
88	15	138.10	81.70	317.34	91	10	141.47	79.12	315.36
88	16	138.00	82.47	317.57	91	11	141.45	79.29	316.36
88	17	137.89	83.25	317.81	91	12	141.36	79.99	316.60
89	1	140.16	73.81	317.80	91	13	141.26	80.69	316.83
89	2	140.07	74.51	317.56	91	14	141.17	81.39	317.07
89	3	139.98	75.22	317.33	91	15	141.07	82.10	317.31
89	4	139.88	75.92	317.09	91	16	140.97	82.87	317.54
89	5	139.79	76.62	316.85	91	17	140.87	83.64	317.78
89	6	139.70	77.32	316.62	92	1	143.14	74.21	317.77
89	7	139.60	78.02	316.38	92	2	143.04	74.91	317.53
89	8	139.58	78.19	315.38	92	3	142.95	75.62	317.30
89	9	139.54	78.52	315.38	92	4	142.86	76.32	317.06
89	10	139.49	78.86	315.38	92	5	142.77	77.02	316.82
89	11	139.47	79.03	316.38	92	6	142.67	77.72	316.59
89	12	139.37	79.73	316.62	92	7	142.58	78.42	316.35
89	13	139.28	80.43	316.85	92	8	142.55	78.58	315.35
89	14	139.19	81.13	317.09	92	9	142.51	78.92	315.35
89	15	139.09	81.83	317.33	92	10	142.46	79.26	315.35
89	16	138.99	82.60	317.56	92	11	142.44	79.43	316.35
89	17	138.89	83.38	317.80	92	12	142.35	80.13	316.59
90	1	141.15	73.94	317.79	92	13	142.26	80.83	316.82
90	2	141.06	74.65	317.55	92	14	142.16	81.53	317.06
90	3	140.97	75.35	317.32	92	15	142.07	82.23	317.30

92	16	141.96	83.00	317.53	95	11	145.41	79.82	316.32
92	17	141.86	83.78	317.77	95	12	145.32	80.52	316.56
93	1	144.13	74.34	317.76	95	13	145.23	81.22	316.79
93	2	144.03	75.04	317.52	95	14	145.13	81.92	317.03
93	3	143.94	75.75	317.29	95	15	145.04	82.63	317.27
93	4	143.85	76.45	317.05	95	16	144.94	83.40	317.50
93	5	143.76	77.15	316.81	95	17	144.83	84.17	317.74
93	6	143.66	77.85	316.58	96	1	147.10	74.74	317.73
93	7	143.57	78.55	316.34	96	2	147.01	75.44	317.49
93	8	143.54	78.72	315.34	96	3	146.91	76.15	317.26
93	9	143.50	79.05	315.34	96	4	146.82	76.85	317.02
93	10	143.45	79.39	315.34	96	5	146.73	77.55	316.78
93	11	143.43	79.56	316.34	96	6	146.64	78.25	316.55
93	12	143.34	80.26	316.58	96	7	146.54	78.95	316.31
93	13	143.25	80.96	316.81	96	8	146.52	79.11	315.31
93	14	143.15	81.66	317.05	96	9	146.47	79.45	315.31
93	15	143.06	82.36	317.29	96	10	146.43	79.79	315.31
93	16	142.95	83.13	317.52	96	11	146.40	79.96	316.31
93	17	142.85	83.91	317.76	96	12	146.31	80.66	316.55
94	1	145.12	74.47	317.75	96	13	146.22	81.36	316.78
94	2	145.02	75.18	317.51	96	14	146.13	82.06	317.02
94	3	144.93	75.88	317.28	96	15	146.03	82.76	317.26
94	4	144.84	76.58	317.04	96	16	145.93	83.53	317.49
94	5	144.75	77.28	316.80	96	17	145.82	84.31	317.73
94	6	144.65	77.98	316.57	97	1	148.09	74.87	317.72
94	7	144.56	78.68	316.33	97	2	148.00	75.57	317.48
94	8	144.54	78.85	315.33	97	3	147.90	76.28	317.25
94	9	144.49	79.18	315.33	97	4	147.81	76.98	317.01
94	10	144.44	79.52	315.33	97	5	147.72	77.68	316.77
94	11	144.42	79.69	316.33	97	6	147.63	78.38	316.54
94	12	144.33	80.39	316.57	97	7	147.53	79.08	316.30
94	13	144.24	81.09	316.80	97	8	147.51	79.24	315.30
94	14	144.14	81.79	317.04	97	9	147.46	79.58	315.30
94	15	144.05	82.49	317.28	97	10	147.42	79.92	315.30
94	16	143.94	83.27	317.51	97	11	147.39	80.09	316.30
94	17	143.84	84.04	317.75	97	12	147.30	80.79	316.54
95	1	146.11	74.61	317.74	97	13	147.21	81.49	316.77
95	2	146.02	75.31	317.50	97	14	147.12	82.19	317.01
95	3	145.92	76.01	317.27	97	15	147.02	82.89	317.25
95	4	145.83	76.71	317.03	97	16	146.92	83.66	317.48
95	5	145.74	77.41	316.79	97	17	146.81	84.44	317.72
95	6	145.64	78.11	316.56	98	1	149.08	75.00	317.71
95	7	145.55	78.81	316.32	98	2	148.99	75.71	317.47
95	8	145.53	78.98	315.32	98	3	148.89	76.41	317.24
95	9	145.48	79.32	315.32	98	4	148.80	77.11	317.00
95	10	145.43	79.65	315.32	98	5	148.71	77.81	316.76

98	6	148.62	78.51	316.53
98	7	148.52	79.21	316.29
98	8	148.50	79.38	315.29
98	9	148.45	79.71	315.29
98	10	148.41	80.05	315.29
98	11	148.38	80.22	316.29
98	12	148.29	80.92	316.53
98	13	148.20	81.62	316.76
98	14	148.11	82.32	317.00
98	15	148.01	83.02	317.24
98	16	147.91	83.80	317.47
98	17	147.80	84.57	317.71
99	1	150.07	75.13	317.70
99	2	149.98	75.84	317.46
99	3	149.89	76.54	317.23
99	4	149.79	77.24	316.99
99	5	149.70	77.94	316.75
99	6	149.61	78.64	316.52
99	7	149.51	79.34	316.28
99	8	149.49	79.51	315.28
99	9	149.45	79.84	315.28
99	10	149.40	80.18	315.28
99	11	149.38	80.35	316.28
99	12	149.28	81.05	316.52
99	13	149.19	81.75	316.75
99	14	149.10	82.45	316.99
99	15	149.00	83.15	317.23
99	16	148.90	83.93	317.46
99	17	148.80	84.70	317.70
100	1	151.06	75.27	317.69
100	2	150.97	75.97	317.45
100	3	150.88	76.68	317.22
100	4	150.79	77.38	316.98
100	5	150.69	78.08	316.74
100	6	150.60	78.78	316.51
100	7	150.50	79.48	316.27
100	8	150.48	79.64	315.27
100	9	150.44	79.98	315.27
100	10	150.39	80.32	315.27
100	11	150.37	80.49	316.27
100	12	150.28	81.19	316.51
100	13	150.18	81.89	316.74
100	14	150.09	82.59	316.98
100	15	149.99	83.29	317.22
100	16	149.89	84.06	317.45
100	17	149.79	84.84	317.69
101	1	152.06	75.40	317.68
101	2	151.96	76.10	317.44
101	3	151.87	76.81	317.21
101	4	151.78	77.51	316.97
101	5	151.69	78.21	316.73
101	6	151.59	78.91	316.50
101	7	151.50	79.61	316.26
101	8	151.47	79.77	315.26
101	9	151.43	80.11	315.26
101	10	151.38	80.45	315.26
101	11	151.36	80.62	316.26
101	12	151.27	81.32	316.50
101	13	151.18	82.02	316.73
101	14	151.08	82.72	316.97
101	15	150.99	83.42	317.21
101	16	150.88	84.19	317.44
101	17	150.78	84.97	317.68
102	1	153.05	75.53	317.67
102	2	152.95	76.24	317.43
102	3	152.86	76.94	317.20
102	4	152.77	77.64	316.96
102	5	152.68	78.34	316.72
102	6	152.58	79.04	316.49
102	7	152.49	79.74	316.25
102	8	152.46	79.91	315.25
102	9	152.42	80.24	315.25
102	10	152.37	80.58	315.25
102	11	152.35	80.75	316.25
102	12	152.26	81.45	316.49
102	13	152.17	82.15	316.72
102	14	152.07	82.85	316.96
102	15	151.98	83.55	317.20
102	16	151.87	84.33	317.43
102	17	151.77	85.10	317.67
103	1	154.04	75.66	317.66
103	2	153.94	76.37	317.42
103	3	153.85	77.07	317.19
103	4	153.76	77.77	316.95
103	5	153.67	78.47	316.71
103	6	153.57	79.17	316.48
103	7	153.48	79.87	316.24
103	8	153.45	80.04	315.24
103	9	153.41	80.37	315.24
103	10	153.36	80.71	315.24
103	11	153.34	80.88	316.24
103	12	153.25	81.58	316.48

103	13	153.16	82.28	316.71
103	14	153.06	82.98	316.95
103	15	152.97	83.68	317.19
103	16	152.86	84.46	317.42
103	17	152.76	85.23	317.66
104	1	155.03	75.80	317.65
104	2	154.93	76.50	317.41
104	3	154.84	77.21	317.18
104	4	154.75	77.91	316.94
104	5	154.66	78.61	316.70
104	6	154.56	79.31	316.47
104	7	154.47	80.01	316.23
104	8	154.45	80.17	315.23
104	9	154.40	80.51	315.23
104	10	154.35	80.85	315.23
104	11	154.33	81.02	316.23
104	12	154.24	81.72	316.47
104	13	154.15	82.42	316.70
104	14	154.05	83.12	316.94
104	15	153.96	83.82	317.18
104	16	153.85	84.59	317.41
104	17	153.75	85.37	317.65
105	1	156.02	75.93	317.64
105	2	155.93	76.63	317.40
105	3	155.83	77.34	317.17
105	4	155.74	78.04	316.93
105	5	155.65	78.74	316.69
105	6	155.56	79.44	316.46
105	7	155.46	80.14	316.22
105	8	155.44	80.30	315.22
105	9	155.39	80.64	315.22
105	10	155.34	80.98	315.22
105	11	155.32	81.15	316.22
105	12	155.23	81.85	316.46
105	13	155.14	82.55	316.69
105	14	155.05	83.25	316.93
105	15	154.95	83.95	317.17
105	16	154.85	84.72	317.40
105	17	154.74	85.50	317.64
106	1	157.01	76.06	317.63
106	2	156.92	76.77	317.39
106	3	156.82	77.47	317.16
106	4	156.73	78.17	316.92
106	5	156.64	78.87	316.68
106	6	156.55	79.57	316.45
106	7	156.45	80.27	316.21
106	8	156.43	80.44	315.21
106	9	156.38	80.77	315.21
106	10	156.34	81.11	315.21
106	11	156.31	81.28	316.21
106	12	156.22	81.98	316.45
106	13	156.13	82.68	316.68
106	14	156.04	83.38	316.92
106	15	155.94	84.08	317.16
106	16	155.84	84.86	317.39
106	17	155.73	85.63	317.63
107	1	158.00	76.19	317.62
107	2	157.91	76.90	317.38
107	3	157.81	77.60	317.15
107	4	157.72	78.30	316.91
107	5	157.63	79.00	316.67
107	6	157.54	79.70	316.44
107	7	157.44	80.40	316.20
107	8	157.42	80.57	315.20
107	9	157.37	80.90	315.20
107	10	157.33	81.24	315.20
107	11	157.30	81.41	316.20
107	12	157.21	82.11	316.44
107	13	157.12	82.81	316.67
107	14	157.03	83.51	316.91
107	15	156.93	84.21	317.15
107	16	156.83	84.99	317.38
107	17	156.72	85.76	317.62
108	1	158.99	76.33	317.61
108	2	158.90	77.03	317.37
108	3	158.80	77.74	317.14
108	4	158.71	78.44	316.90
108	5	158.62	79.14	316.66
108	6	158.53	79.84	316.43
108	7	158.43	80.54	316.19
108	8	158.41	80.70	315.19
108	9	158.36	81.04	315.19
108	10	158.32	81.38	315.19
108	11	158.29	81.55	316.19
108	12	158.20	82.25	316.43
108	13	158.11	82.95	316.66
108	14	158.02	83.65	316.90
108	15	157.92	84.35	317.14
108	16	157.82	85.12	317.37
108	17	157.71	85.90	317.61
109	1	159.98	76.46	317.60
109	2	159.89	77.16	317.36

109	3	159.80	77.87	317.13	111	15	160.90	84.74	317.11
109	4	159.70	78.57	316.89	111	16	160.79	85.52	317.34
109	5	159.61	79.27	316.65	111	17	160.69	86.29	317.58
109	6	159.52	79.97	316.42	112	1	162.96	76.86	317.57
109	7	159.42	80.67	316.18	112	2	162.86	77.56	317.33
109	8	159.40	80.83	315.18	112	3	162.77	78.27	317.10
109	9	159.36	81.17	315.18	112	4	162.68	78.97	316.86
109	10	159.31	81.51	315.18	112	5	162.59	79.67	316.62
109	11	159.29	81.68	316.18	112	6	162.49	80.37	316.39
109	12	159.19	82.38	316.42	112	7	162.40	81.07	316.15
109	13	159.10	83.08	316.65	112	8	162.37	81.23	315.15
109	14	159.01	83.78	316.89	112	9	162.33	81.57	315.15
109	15	158.91	84.48	317.13	112	10	162.28	81.91	315.15
109	16	158.81	85.25	317.36	112	11	162.26	82.08	316.15
109	17	158.71	86.03	317.60	112	12	162.17	82.78	316.39
110	1	160.98	76.59	317.59	112	13	162.08	83.48	316.62
110	2	160.88	77.30	317.35	112	14	161.98	84.18	316.86
110	3	160.79	78.00	317.12	112	15	161.89	84.88	317.10
110	4	160.70	78.70	316.88	112	16	161.78	85.65	317.33
110	5	160.61	79.40	316.64	112	17	161.68	86.43	317.57
110	6	160.51	80.10	316.41	113	1	163.95	76.99	317.56
110	7	160.42	80.80	316.17	113	2	163.85	77.69	317.32
110	8	160.39	80.97	315.17	113	3	163.76	78.40	317.09
110	9	160.35	81.30	315.17	113	4	163.67	79.10	316.85
110	10	160.30	81.64	315.17	113	5	163.58	79.80	316.61
110	11	160.28	81.81	316.17	113	6	163.48	80.50	316.38
110	12	160.19	82.51	316.41	113	7	163.39	81.20	316.14
110	13	160.10	83.21	316.64	113	8	163.37	81.36	315.14
110	14	160.00	83.91	316.88	113	9	163.32	81.70	315.14
110	15	159.91	84.61	317.12	113	10	163.27	82.04	315.14
110	16	159.80	85.39	317.35	113	11	163.25	82.21	316.14
110	17	159.70	86.16	317.59	113	12	163.16	82.91	316.38
111	1	161.97	76.72	317.58	113	13	163.07	83.61	316.61
111	2	161.87	77.43	317.34	113	14	162.97	84.31	316.85
111	3	161.78	78.13	317.11	113	15	162.88	85.01	317.09
111	4	161.69	78.83	316.87	113	16	162.77	85.78	317.32
111	5	161.60	79.53	316.63	113	17	162.67	86.56	317.56
111	6	161.50	80.23	316.40	114	1	164.94	77.12	317.55
111	7	161.41	80.93	316.16	114	2	164.85	77.83	317.31
111	8	161.38	81.10	315.16	114	3	164.75	78.53	317.08
111	9	161.34	81.43	315.16	114	4	164.66	79.23	316.84
111	10	161.29	81.77	315.16	114	5	164.57	79.93	316.60
111	11	161.27	81.94	316.16	114	6	164.48	80.63	316.37
111	12	161.18	82.64	316.40	114	7	164.38	81.33	316.13
111	13	161.09	83.34	316.63	114	8	164.36	81.50	315.13
111	14	160.99	84.04	316.87	114	9	164.31	81.83	315.13

114	10	164.26	82.17	315.13
114	11	164.24	82.34	316.13
114	12	164.15	83.04	316.37
114	13	164.06	83.74	316.60
114	14	163.97	84.44	316.84
114	15	163.87	85.14	317.08
114	16	163.77	85.92	317.31
114	17	163.66	86.69	317.55
115	1	165.93	77.25	317.54
115	2	165.84	77.93	317.30
115	3	165.75	78.61	317.07
115	4	165.66	79.28	316.83
115	5	165.57	79.95	316.59
115	6	165.48	80.62	316.36
115	7	165.39	81.30	316.12
115	8	165.36	81.52	315.12
115	9	165.30	81.96	315.12
115	10	165.24	82.41	315.12
115	11	165.21	82.64	316.12
115	12	165.12	83.32	316.36
115	13	165.03	84.00	316.59
115	14	164.94	84.68	316.83
115	15	164.85	85.36	317.07
115	16	164.75	86.09	317.30
115	17	164.65	86.82	317.54
116	1	166.92	77.39	317.53
116	2	166.83	78.03	317.29
116	3	166.75	78.68	317.06
116	4	166.66	79.33	316.82
116	5	166.58	79.97	316.58
116	6	166.49	80.62	316.35
116	7	166.41	81.26	316.11
116	8	166.37	81.54	315.11
116	9	166.29	82.10	315.11
116	10	166.22	82.66	315.11
116	11	166.18	82.94	316.11
116	12	166.09	83.60	316.35
116	13	166.01	84.26	316.58
116	14	165.92	84.92	316.82
116	15	165.83	85.58	317.06
116	16	165.74	86.27	317.29
116	17	165.65	86.96	317.53
117	1	167.91	77.52	317.52
117	2	167.83	78.14	317.28
117	3	167.75	78.76	317.05
117	4	167.67	79.38	316.81
117	5	167.58	79.99	316.57
117	6	167.50	80.61	316.34
117	7	167.42	81.23	316.10
117	8	167.38	81.56	315.10
117	9	167.29	82.23	315.10
117	10	167.20	82.90	315.10
117	11	167.15	83.24	316.10
117	12	167.07	83.88	316.34
117	13	166.98	84.52	316.57
117	14	166.90	85.17	316.81
117	15	166.81	85.81	317.05
117	16	166.73	86.45	317.28
117	17	166.64	87.09	317.52

timei files

I 0 23.43 23.43 -320.5 320.5 0 0.00000485970
0.00000555394 0.00000138849 0.00000277697
0.00001319061

I 21600 23.43 23.43 -320.5 320.5 0 0.00020618563
0.00023564072 0.00005891018 0.00011782036
0.00055964670

I 43200 23.43 23.43 -320.5 320.5 0 0.00019065700
0.00021789372 0.00005447343 0.00010894686
0.00051749758

I 64800 23.43 23.43 -320.5 320.5 0 0.00003312181
0.00003785349 0.00000946337 0.00001892675
0.00008990205

Measured Sediment data

Date As B.S.	River Flow m3/s	Measured Suspended Sediment Concentration PPM	Measured Suspended Sediment Discharge kg/s	Unmeasured Measured Suspended Sediment Discharge 40% of measured kg/s	Total Suspended Sediment Discharge kg/s	Estimated Bed Load 25% of Total Suspended Sediment kg/s	Total Suspended Sediment to Settling basin kg/s
24.04.063	530	54.2	29	11.6	40.6	10.15	1.79
24.04.063	526	73.2	38	15.2	53.2	13.3	2.37
25.04.063	518	69.5	36	14.4	50.4	12.6	2.28
25.04.063	507	55.8	28	11.2	39.2	9.8	1.81
26.04.063	492	38.6	19	7.6	26.6	6.65	1.27
26.04.063	492	31.7	16	6.4	22.4	5.6	1.07
27.04.063	484	37	18	7.2	25.2	6.3	1.22
27.04.063	481	981.3	472	188.8	660.8	165.2	32.19
28.04.063	473	33.4	16	6.4	22.4	5.6	1.11
28.04.063	465	61.7	29	11.6	40.6	10.15	2.05
29.04.063	454	39.2	18	7.2	25.2	6.3	1.30
30.04.063	454	1483.7	674	269.6	943.6	235.9	48.70
30.04.063	738	43.2	32	12.8	44.8	11.2	1.42
30.04.063	446	869.2	388	155.2	543.2	135.8	28.54
31.04.063	435	2193.3	954	381.6	1335.6	333.9	71.94
31.04.063	431	2602.4	1122	448.8	1570.8	392.7	85.39
3.05.063	454	48.3	22	8.8	30.8	7.7	1.59
3.05.063	446	95.6	43	17.2	60.2	15.05	3.16
4.05.063	643	389.4	250	100	350	87.5	12.75
4.05.063	643	105.8	68	27.2	95.2	23.8	3.47
5.05.063	492	118.9	58	23.2	81.2	20.3	3.87
5.05.063	473	116.7	55	22	77	19.25	3.81
6.05.063	465	128.8	60	24	84	21	4.23
6.05.063	454	134.5	61	24.4	85.4	21.35	4.41
7.05.063	450	923.1	415	166	581	145.25	30.25
7.05.063	450	76.8	35	14	49	12.25	2.55
8.05.063	446	37.2	17	6.8	23.8	5.95	1.25
8.05.063	443	65	29	11.6	40.6	10.15	2.15
9.05.063	435	79.2	34	13.6	47.6	11.9	2.56
9.05.063	431	167.4	72	28.8	100.8	25.2	5.48
10.05.063	908	1071.1	973	389.2	1362.2	340.55	35.15
10.05.063	870	997.5	868	347.2	1215.2	303.8	32.73
10.05.063	681	480.1	327	130.8	457.8	114.45	15.75
10.05.063	681	479.9	327	130.8	457.8	114.45	15.75
11.05.063	549	58.5	32	12.8	44.8	11.2	1.91
11.05.063	549	187.4	103	41.2	144.2	36.05	6.15
11.05.063	530	135.3	72	28.8	100.8	25.2	4.46
11.05.063	530	134.8	71	28.4	99.4	24.85	4.39
12.05.063	515	58.8	30	12	42	10.5	1.91
12.05.063	515	71.5	37	14.8	51.8	12.95	2.36
12.05.063	511	70.1	36	14.4	50.4	12.6	2.31
12.05.063	511	58.9	30	12	42	10.5	1.93
13.05.063	643	82	53	21.2	74.2	18.55	2.70

13.05.063	643	65.7	42	16.8	58.8	14.7	2.14
13.05.063	624	81.7	51	20.4	71.4	17.85	2.68
13.05.063	624	66.4	41	16.4	57.4	14.35	2.16
14.05.063	1286	2787.4	3585	1434	5019	1254.75	91.44
14.05.063	1286	2578.1	3315	1326	4641	1160.25	84.56
14.05.063	757	448.1	339	135.6	474.6	118.65	14.69
14.05.063	757	349.2	264	105.6	369.6	92.4	11.44
15.05.063	700	224.9	157	62.8	219.8	54.95	7.36
15.05.063	681	287.7	196	78.4	274.4	68.6	9.44
15.05.063	738	733.2	541	216.4	757.4	189.35	24.05
16.05.063	590	99.8	59	23.6	82.6	20.65	3.28
16.05.063	590	192	113	45.2	158.2	39.55	6.28
16.05.063	568	79.3	45	18	63	15.75	2.60
16.05.063	568	59.1	34	13.6	47.6	11.9	1.96
17.05.063	549	176.3	97	38.8	135.8	33.95	5.80
17.05.063	549	22.8	12	4.8	16.8	4.2	0.72
17.05.063	541	136.4	74	29.6	103.6	25.9	4.49
17.05.063	624	290.3	181	72.4	253.4	63.35	9.51
8.05.063	549	318.6	175	70	245	61.25	10.46
18.05.063	545	401.8	219	87.6	306.6	76.65	13.18
19.05.063	530	440.6	234	93.6	327.6	81.9	14.48
19.05.063	530	40.7	22	8.8	30.8	7.7	1.36
20.05.063	511	75.6	39	15.6	54.6	13.65	2.50
20.05.063	507	54.6	28	11.2	39.2	9.8	1.81
21.05.063	499	61.6	31	12.4	43.4	10.85	2.04
21.05.063	496	43.8	22	8.8	30.8	7.7	1.45
22.05.063	488	77.7	38	15.2	53.2	13.3	2.55
22.05.063	484	78.1	38	15.2	53.2	13.3	2.58
23.05.063	477	65.5	31	12.4	43.4	10.85	2.13
23.05.063	477	243.7	116	46.4	162.4	40.6	7.98
23.05.063	477	2848.7	1359	543.6	1902.6	475.65	93.45
24.05.063	1059	2830.8	2998	1199.2	4197.2	1049.3	92.86
25.05.063	643	527	339	135.6	474.6	118.65	17.29
25.05.063	636	304.9	194	77.6	271.6	67.9	10.01
26.05.063	632	598	378	151.2	529.2	132.3	19.62
26.05.063	632	69.1	44	17.6	61.6	15.4	2.28
27.05.063	605	167	101	40.4	141.4	35.35	5.48
27.05.063	590	2697.2	1591	636.4	2227.4	556.85	88.45
28.05.063	568	92.7	53	21.2	74.2	18.55	3.06
28.05.063	556	102.2	57	22.8	79.8	19.95	3.36
29.05.063	541	179.5	97	38.8	135.8	33.95	5.88
29.05.063	530	43.2	23	9.2	32.2	8.05	1.42
30.05.063	643	860.6	553	221.2	774.2	193.55	28.21
30.05.063	613	119	73	29.2	102.2	25.55	3.91
31.05.063	605	113.6	69	27.6	96.6	24.15	3.74
31.05.063	598	114	68	27.2	95.2	23.8	3.73
1.06.063	568	84.6	48	19.2	67.2	16.8	2.77
1.06.063	568	110.7	63	25.2	88.2	22.05	3.64

Appendix- B

RESULTS

Trap Efficiency Calculation by SSIIM Model

Proposed	Layout							
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	4.43E-01	1.55E-01	-5.39E-02	3.44E-01	0.00E+00	2.22E-03	3.44E-01	
Sum:	2.41E+03	7.45E+02	3.49E+00	1.67E+03	9.15E-12	8.82E+00	1.67E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect	%defect	%trap
1	1.00E-04	0.00E+00	-1.94E+00	1.90E+00	4.00E-02	-1.46E-04	0.00%	100.00%
2	2.11E+02	3.05E-05	1.74E-01	2.12E+02	8.29E-02	-1.45E+00	-0.69%	100.00%
3	2.41E+02	1.52E+00	4.47E-01	2.44E+02	1.92E-01	-5.04E+00	-2.10%	99.37%
4	6.02E+01	3.60E+00	1.47E-01	5.79E+01	6.71E-02	-1.54E+00	-2.55%	94.02%
5	1.20E+02	3.33E+01	2.88E-01	9.07E+01	1.93E-01	-4.16E+00	-3.45%	72.32%
6	5.72E+02	3.34E+02	8.81E-01	2.61E+02	1.17E+00	-2.51E+01	-4.39%	41.57%

Alternative	Layout							
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	4.43E-01	1.43E-01	-1.89E-02	2.97E-01	0.00E+00	-2.20E-02	2.97E-01	
Sum:	2.41E+03	6.75E+02	3.25E+00	1.59E+03	9.15E-12	-1.36E+02	1.59E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect	% defect	Trap %
1	2.11E+02	1.40E-01	1.82E-01	2.28E+02	8.61E-02	-1.82E+01	-8.66%	99.46%
2	2.41E+02	8.72E-01	3.77E-01	2.47E+02	1.87E-01	-7.51E+00	-3.12%	97.56%
3	6.02E+01	2.48E+00	1.31E-01	5.65E+01	6.18E-02	1.05E+00	1.75%	87.57%
4	1.20E+02	4.08E+01	2.90E-01	8.78E+01	1.75E-01	4.24E+00	3.52%	66.09%
5	5.72E+02	3.41E+02	9.95E-01	2.54E+02	1.09E+00	9.48E+00	1.66%	40.29%
							Average	78.19%

Settling	basin	only						
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	1.11E-01	3.51E-02	-3.08E-03	7.89E-02	0.00E+00	7.88E-05	7.89E-02	
Sum:	6.02E+02	1.79E+02	5.83E-01	4.23E+02	2.21E-12	3.47E-01	4.23E+02	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect		
1	0.00E+00	0.00E+00	-4.46E-01	4.46E-01	0.00E+00	-3.72E-09	0.00%	100.00%
2	5.27E+01	2.43E-11	3.90E-02	5.26E+01	7.39E-03	-2.76E-03	-0.01%	100.00%
3	6.02E+01	3.17E-02	8.55E-02	6.00E+01	2.26E-02	2.69E-03	0.00%	99.95%
4	1.50E+01	3.59E-01	3.15E-02	1.46E+01	9.28E-03	-2.75E-03	-0.02%	97.61%
5	3.01E+01	6.88E+00	7.11E-02	2.32E+01	3.26E-02	-1.24E-01	-0.41%	77.14%
6	1.43E+02	8.20E+01	2.19E-01	6.18E+01	2.20E-01	-1.38E+00	-0.97%	42.61%

Modificatio	1							
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	4.43E-01	1.47E-01	-5.39E-02	3.43E-01	0.00E+00	-7.94E-03	3.43E-01	
Sum:	2.41E+03	6.99E+02	3.36E+00	1.66E+03	9.16E-12	-4.32E+01	1.66E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect		
1	0.00E+00	0.00E+00	-2.00E+00	1.97E+00	2.97E-02	-1.27E-04	0.00%	100.00%
2	2.11E+02	1.09E-05	1.48E-01	2.10E+02	7.23E-02	3.04E-01	0.14%	100.00%
3	2.41E+02	8.44E-01	4.02E-01	2.40E+02	1.73E-01	-1.09E+00	-0.45%	99.65%
4	6.02E+01	2.65E+00	1.46E-01	5.74E+01	6.21E-02	-9.23E-02	-0.15%	95.60%
5	1.20E+02	2.91E+01	3.11E-01	9.14E+01	1.84E-01	-6.29E-01	-0.52%	75.85%
6	5.72E+02	3.17E+02	9.98E-01	2.64E+02	1.16E+00	-1.17E+01	-2.05%	44.58%

Modificatio	2							
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	4.43E-01	1.51E-01	-5.22E-02	3.45E-01	0.00E+00	4.80E-04	3.45E-01	
Sum:	2.41E+03	7.21E+02	3.47E+00	1.68E+03	9.16E-12	1.67E+00	1.68E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect		
1	0.00E+00	0.00E+00	-1.96E+00	1.92E+00	3.87E-02	-8.24E-05	0.00%	100.00%
2	2.11E+02	2.69E-05	1.66E-01	2.11E+02	8.06E-02	-9.70E-01	-0.46%	100.00%
3	2.41E+02	8.09E-01	4.22E-01	2.43E+02	1.90E-01	-4.06E+00	-1.69%	99.66%
4	6.02E+01	2.83E+00	1.47E-01	5.83E+01	6.65E-02	-1.19E+00	-1.98%	95.30%
5	1.20E+02	3.11E+01	2.98E-01	9.16E+01	1.92E-01	-2.82E+00	-2.35%	74.20%
6	5.72E+02	3.26E+02	9.29E-01	2.60E+02	1.17E+00	-1.61E+01	-2.82%	43.03%

Modificatio	3							
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	4.43E-01	1.51E-01	-5.23E-02	3.45E-01	0.00E+00	7.51E-04	3.45E-01	
Sum:	2.41E+03	7.20E+02	3.46E+00	1.69E+03	9.16E-12	2.66E+00	1.69E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect		
1	0.00E+00	0.00E+00	-1.98E+00	1.95E+00	3.23E-02	-7.63E-05	0.00%	100.00%
2	2.11E+02	8.37E-06	1.58E-01	2.12E+02	7.65E-02	-1.80E+00	-0.86%	100.00%
3	2.41E+02	9.52E-01	4.37E-01	2.45E+02	1.87E-01	-5.52E+00	-2.29%	99.60%
4	6.02E+01	2.94E+00	1.51E-01	5.86E+01	6.63E-02	-1.55E+00	-2.58%	95.12%
5	1.20E+02	3.09E+01	3.04E-01	9.26E+01	1.92E-01	-3.56E+00	-2.96%	74.36%
6	5.72E+02	3.25E+02	9.34E-01	2.64E+02	1.18E+00	-1.99E+01	-3.49%	43.08%

Modificatio	4							
Time:	60050	seconds						
1200	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	9.12E-01	3.02E-01	-9.07E-02	7.02E-01	0.00E+00	6.93E-04	7.02E-01	
Sum:	2.34E+03	7.08E+02	6.67E+00	1.63E+03	9.16E-12	1.39E+00	1.63E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect		
1	0.00E+00	0.00E+00	-2.08E+00	2.05E+00	2.29E-02	-4.23E-05	0.00%	100.00%
2	2.05E+02	8.78E-06	1.46E-01	2.07E+02	1.13E-01	-2.27E+00	-1.11%	100.00%
3	2.34E+02	1.10E+00	4.52E-01	2.39E+02	3.36E-01	-7.12E+00	-3.04%	99.53%
4	5.85E+01	3.11E+00	1.59E-01	5.71E+01	1.25E-01	-1.98E+00	-3.38%	94.69%
5	1.17E+02	3.10E+01	3.21E-01	8.97E+01	3.78E-01	-4.35E+00	-3.72%	73.55%
6	5.56E+02	3.19E+02	9.98E-01	2.57E+02	2.36E+00	-2.35E+01	-4.23%	42.60%

Closing	**1**							
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	4.43E-01	1.92E-01	-3.06E-02	2.80E-01	0.00E+00	-1.87E-03	2.80E-01	
Sum:	2.41E+03	9.19E+02	3.22E+00	1.48E+03	6.86E-12	-2.55E+00	1.48E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect	% defect	Trap %
1	2.11E+02	8.67E-02	2.01E-01	2.38E+02	9.78E-02	-2.76E+01	-13.11%	99.96%
2	2.41E+02	8.19E+00	4.18E-01	2.61E+02	2.25E-01	-2.87E+01	-11.90%	96.60%
3	6.02E+01	9.31E+00	1.14E-01	5.59E+01	7.20E-02	-5.20E+00	-8.65%	84.53%
4	1.20E+02	5.06E+01	1.80E-01	7.65E+01	1.81E-01	-7.14E+00	-5.93%	57.95%
5	5.72E+02	3.91E+02	4.93E-01	2.07E+02	9.90E-01	-2.76E+01	-4.83%	31.56%
							Average	74.12%

Closing	**2**							
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	4.43E-01	1.91E-01	-2.71E-02	2.74E-01	0.00E+00	-6.26E-03	2.74E-01	
Sum:	2.41E+03	9.10E+02	3.19E+00	1.48E+03	6.87E-12	-1.65E+01	1.48E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect	% defect	Trap %
1	2.11E+02	1.04E-01	1.99E-01	2.37E+02	9.68E-02	-2.66E+01	-12.64%	99.95%
2	2.41E+02	8.21E+00	4.23E-01	2.58E+02	2.24E-01	-2.62E+01	-10.90%	96.59%
3	6.02E+01	9.11E+00	1.14E-01	5.51E+01	7.14E-02	-4.24E+00	-7.05%	84.86%
4	1.20E+02	4.97E+01	1.81E-01	7.62E+01	1.79E-01	-5.85E+00	-4.86%	58.72%
5	5.72E+02	3.88E+02	5.06E-01	2.06E+02	9.84E-01	-2.39E+01	-4.18%	32.13%
Closing	3						Average	74.45%
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	4.43E-01	1.82E-01	-1.63E-02	2.59E-01	0.00E+00	-1.84E-02	2.59E-01	
Sum:	2.41E+03	8.62E+02	3.09E+00	1.44E+03	6.86E-12	-9.90E+01	1.44E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect	% defect	Trap %
1	2.11E+02	1.26E-01	2.05E-01	2.35E+02	9.96E-02	-2.46E+01	-11.67%	99.94%
2	2.41E+02	7.55E+00	3.95E-01	2.45E+02	2.15E-01	-1.23E+01	-5.10%	96.86%
3	6.02E+01	8.33E+00	1.10E-01	5.24E+01	6.87E-02	-7.52E-01	-1.25%	86.17%
4	1.20E+02	4.59E+01	1.84E-01	7.32E+01	1.72E-01	8.41E-01	0.70%	61.84%
5	5.72E+02	3.69E+02	5.38E-01	2.03E+02	9.55E-01	-2.57E+00	-0.45%	35.40%
Closing	4						Average	76.04%
Time:	65050	seconds						
1300	Sedim.	continuity:	In,	Out,	Susp,	Bedch.,	Bedmove,	ContDef.,
Dt:	4.43E-01	1.77E-01	-1.40E-02	2.68E-01	0.00E+00	-1.23E-02	2.68E-01	
Sum:	2.41E+03	8.43E+02	3.09E+00	1.48E+03	6.97E-12	-7.75E+01	1.48E+03	
Grain	size	breakdown	(m3,	no	water)			
Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	Defect	% defect	Trap %
1	2.11E+02	1.91E-01	2.03E-01	2.36E+02	9.76E-02	-2.54E+01	-12.04%	99.91%
2	2.41E+02	5.54E+00	4.11E-01	2.49E+02	2.08E-01	-1.43E+01	-5.94%	97.70%
3	6.02E+01	7.10E+00	1.18E-01	5.42E+01	6.74E-02	-1.31E+00	-2.17%	88.19%
4	1.20E+02	4.35E+01	2.01E-01	7.67E+01	1.72E-01	-2.07E-01	-0.17%	63.86%
5	5.72E+02	3.65E+02	5.83E-01	2.13E+02	9.70E-01	-7.70E+00	-1.35%	36.11%
							Average	77.15%

Trap percentage with F 37 2

Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	%Defect	Trapp efficiency
1	1.38E+01	1.55E-05	-7.89E-03	1.38E+01	7.96E-02	-0.004%	100.00%
2	1.58E+01	8.31E-03	-2.73E-03	1.56E+01	1.39E-01	0.01%	99.95%
3	3.95E+00	9.08E-02	2.38E-03	3.80E+00	5.70E-02	0.05%	97.70%
4	7.90E+00	1.73E+00	7.51E-03	5.96E+00	1.98E-01	0.03%	78.15%
5	3.75E+01	2.06E+01	7.30E-04	1.56E+01	1.33E+00	-0.11%	45.03%

Trap percentage with changing F 11 data set

Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	%Defect	Trapp efficiency
1	5.28E+01	2.62E-04	-7.81E-03	5.28E+01	1.30E-02	-0.006%	100.00%
2	6.04E+01	3.25E-02	-2.76E-03	6.03E+01	2.28E-02	0.011%	99.95%
3	1.51E+01	3.62E-01	2.38E-03	1.47E+01	9.30E-03	0.057%	97.60%
4	3.02E+01	6.93E+00	7.53E-03	2.32E+01	3.23E-02	0.070%	77.05%
5	1.43E+02	8.26E+01	6.48E-04	6.07E+01	2.17E-01	-0.077%	42.40%

Trap percentage with F 106 data set

Size:	Inflow	Outflow	LayerActive	LayerInac.	Suspended	%Defect	Trapp efficiency
1	5.28E+01	2.17E-03	-1.90E+00	5.47E+01	1.31E-02	-0.007%	100.00%
2	6.04E+01	3.63E-02	-2.29E-01	6.06E+01	2.27E-02	0.010%	99.94%
3	1.51E+01	3.61E-01	8.20E-01	1.39E+01	9.27E-03	0.058%	97.61%
4	3.02E+01	6.91E+00	2.14E+00	2.11E+01	3.22E-02	0.079%	77.13%
5	1.43E+02	8.23E+01	-8.21E-01	6.18E+01	2.15E-01	-0.057%	42.59%

Appendix- C

Trap Efficiency Calculation by Analytical Method

Trapping Efficiency by Analytical Method

Design discharge	5.8575	m^3/s
Installed capacity	22	MW
Head	122.1	m
Flushing system	Coventional Type	
Estimated flushing flow	0.58575	m^3/s
Water temperature	10	Deg C

a) Review the adopted design with respect to trap efficiency

Width of settling basin	9.5	m
Depth of hopper	1	m
Width of flushing canal	1	m
Width of slope part of hopper	4.25	m
Depth of settling basin (Rectangular Portion)	2.49	m
Effective Length	75	m
Wetted Perimeter	14.71	m
Cross Area	28.905	m2
As	712.5	m2
Settling particle Size	0.1	mm
Settling Velocity of particle for given condition	0.65	cm/s
Hydraulic Radius, R	1.96	m
Manning' s Value M	80.00	
Energy slope , Se	0.0000007	
Efficiency of the basin by vetter method for given settling particle		0.1 mm
Vetter's Method	79%	
Camp's Method	90%	

Trapping efficiency for different particle

i) Vetter's Method ii) Camp's Method and compare the result

Particle Size	w, cm/s	wAs/Q	η (Vetter)	u*	w/u*	η (Camp)
0.06	0.3	0.729834	0.52	0.0035	0.8464	0.68
0.1	0.65	1.581306	0.79	0.0035	1.8338	0.90
0.15	1.25	3.040973	0.95	0.0035	3.5265	1.00
0.2	2	4.865557	0.99	0.0035	5.6423	1.00
0.3	5.1	12.40717	1.00	0.0035	14.3880	1.00
0.4	6.8	16.54289	1.00	0.0035	19.1839	1.00
0.5	8.5	20.67862	1.00	0.0035	23.9799	1.00