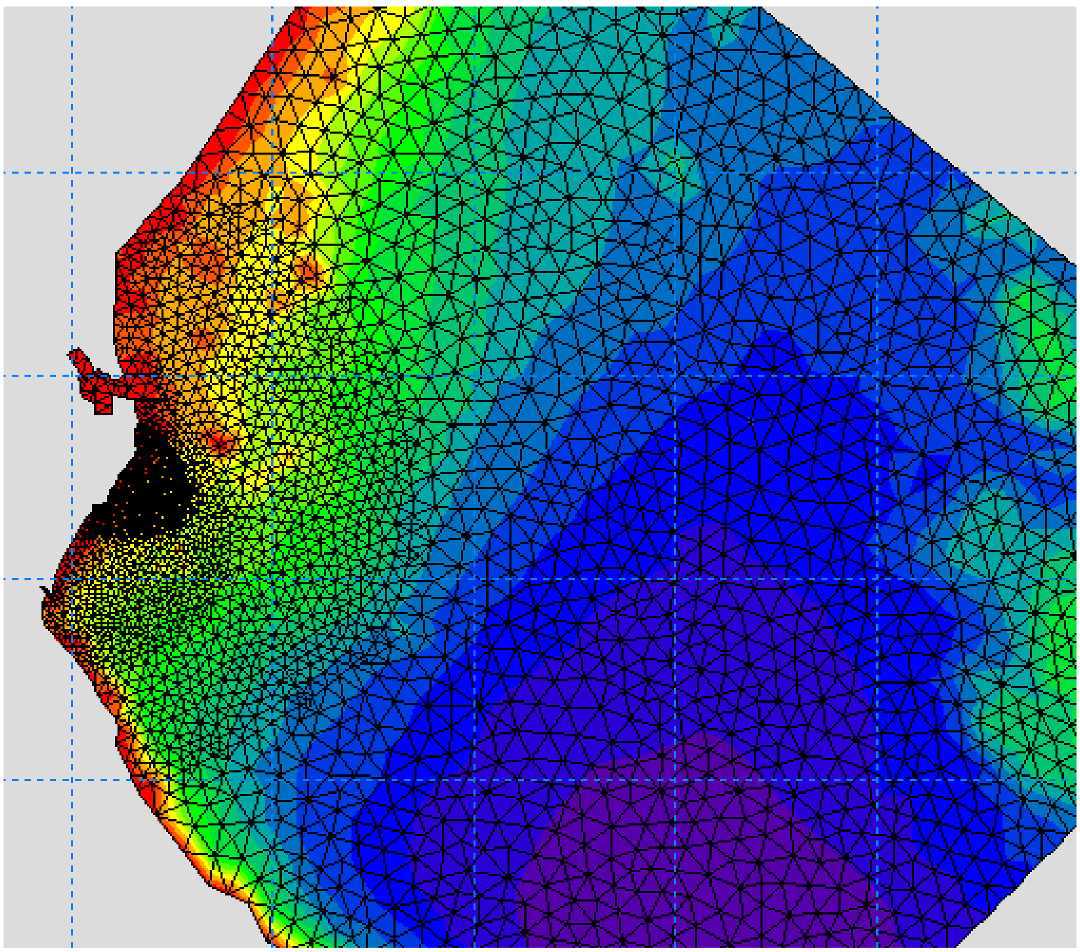
Tahrir Petrochemicals Complex, Economic Zone, Ain Sokhna, Egypt

Intake/Outfall Modelling



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13.01.2015

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Egypt

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PROJECT 455-EJ6195 - TAHRIR PETROCHEMICALS COMPLEX, ECONOMIC ZONE, AIN SOKHNA, EGYPT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
1	Issued for Client Use	MABS	FLOJ	IES	13.01.2015		

EXECUTIVE SUMMARY

WorleyParsons was requested by Tahrir Petrochemicals to conduct seawater intake/outfall modelling and pipeline route identification for the Tahrir Petrochemicals Complex project. The proposed Complex is located to the West of the Gulf of Suez, in the Economic Zone in Ain Sokhna, 33 km southwest of the city of Suez and is situated close to Suez-Hurghada Road from the East and Cairo-Sokhna Road from the South.

The proposed Complex will use seawater as source of water for different purposes including but to limited to cooling. Seawater will be collected via an intake with an inflow rate of 14,259 m3/hr. A marine outfall will be used to release the desalination brine/reject with a design flow rate of 8,984 m3/hr. The proposed desalination plant and the pump station are located at Sokhna 1 (McDermott) Port.

Tahrir Petrochemicals Complex intake/outfall site have the following characteristics (Figure EX-1-1):

- There is an existing and proposed intake/outfall for the power plant to the south of the proposed Complex intake/outfall location;
- DP World Sokhna Port in the south of the proposed Complex; and,
- Sokhna 1 (McDermott) Port to be utilised as part of the proposed Complex is to the north of DP World Sokhna Port

The main objectives of this study are to:

- Investigate feasible locations for the siting of the proposed Tahrir Petrochemicals intake/outfall in the vicinity of Sokhna 1 (McDermott) Port and selecting the preferred option from environmental, technical and economic perspective;
- Assess compliance of the selected Tahrir Petrochemicals outfall effluent discharge with environmental regulations;
- Identify the most feasible pipeline route from the pump station to the location of the Tahrir Petrochemicals intake/outfall; and
- Carry out the conceptual design of the preferred location of the intake/outfall.

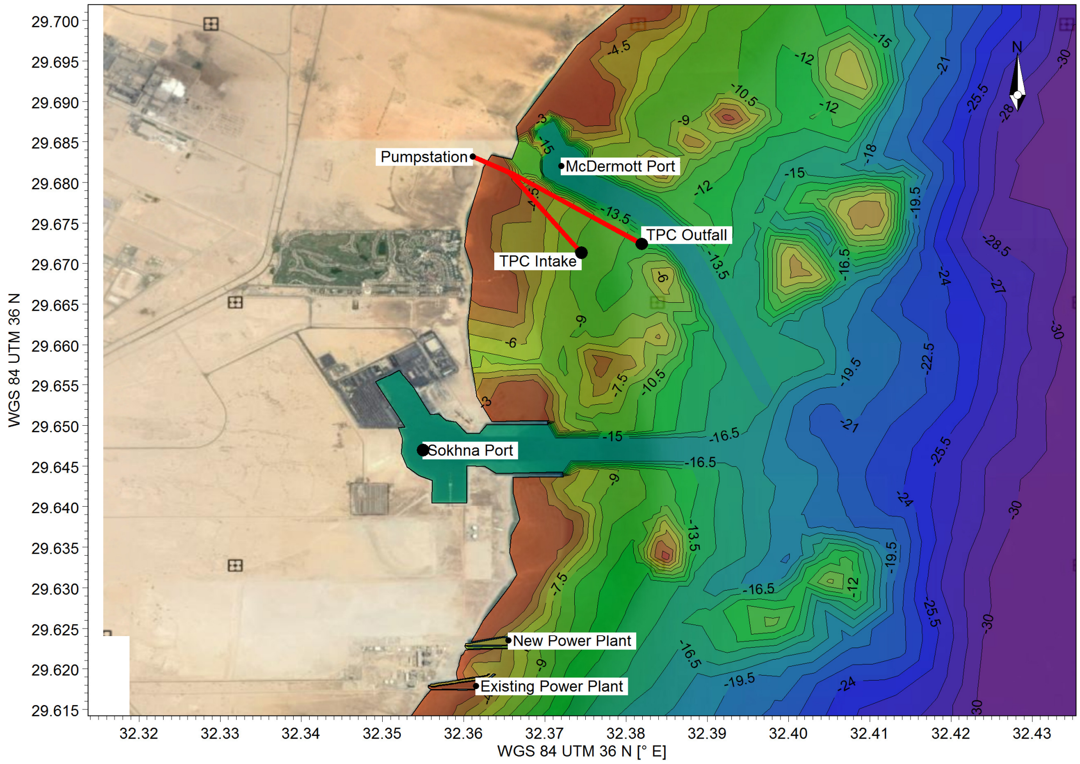

Figure EX-1-1: Proposed Tahrir Petrochemicals Intake/Outfall location

Key findings of this study are:

- Currents at the proposed project site are very mild, seldom reaching values higher than 0.2 m/s and are predominantly to the North, and North West;
- The construction of the new power plant intake/outfall structure prevents the advection of the thermal plume from the existing power plant intake/outfall northwards;
- It was found that the Option 1 was the preferred location for the Tahrir Petrochemicals intake/outfall and therefore, it was investigated further in this report. The results for Option 1 show the following:
    - It complies with the environmental criteria in terms of salinity and temperature;
    - It is more than 500 m away from the shoreline as per Egyptian regulations;
    - It presents no recirculation between the Tahrir Petrochemicals intake and outfall (even under the assumed worst case of southerly winds);
    - It presents no risks in terms of water recirculation between the existing and proposed new power plant intakes/outfalls, and the selected Tahrir Petrochemicals intake/outfall even under the assumed worst case of southerly winds;

  - It does not have any detrimental effect on the existing and proposed new power plant intakes/outfalls, DP World Sokhna Port or Sokhna 1 (McDermott) Port (including navigation channel to the final dredged depths);
  - It is outside the environmental noncompliance area resulting from the existing and proposed new power plant thermal plume.
- The selected Tahrir Petrochemicals intake/outfall has been found to cause minimal impact on surrounding environment and infrastructure, particularly if positioned at depths greater than 6 m and distances greater than 750 m.
- The onshore and offshore route for the pipeline was developed from the pump station to the intake/outfall; and
- The pipeline route may possibly consist of an inter-tidal zone of approximately 70 m, which has to be verified during later stages of the project based on future site specific survey data.

Additionally a number of recommendations during later stages of the project are proposed including but not limited to the following:

- Perform a topographic and bathymetric survey covering the selected pipelines route to assess any potential obstacles that could compromise the feasibility of the proposed route;
- Conduct geotechnical and geophysical surveys along the proposed pipeline routes to assess the feasibility of excavation for the pipeline installation and definition of best shore crossing methods; and
- Conduct a detailed metocean survey covering winds, waves, currents and water quality at the selected Tahrir Petrochemicals outfall location to improve confidence in the numerical model results.

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Appendix III - Concept Design Drawings

1. INTRODUCTION

WorleyParsons was requested by Tahrir Petrochemicals to conduct seawater intake/outfall modelling and pipeline route identification for the Tahrir Petrochemicals Complex. The proposed Complex is located to the West of the Gulf of Suez (Figure 1-1), in the Economic Zone in Sokhna, 33 km southwest of city of Suez and is situated close to Suez-Hurghada Road from the East and Cairo-Sokhna Road from the South.

Figure 1-1 Project Location

The proposed Complex is designed to produce approximately (in MT/hr) 180 of Ethylene, 171 Polyethylene, 105 Propylene, 28.6 Butadiene, 40 Benzene, 9.5 Hexene-1 and 20.5 PGO/PFO. The project is expected to start commercial production in Q3 2019.

The proposed Complex will use seawater as source of water for different purposes including but to limited to cooling. Seawater will be collected via an intake with an inflow rate of 14,259 m^3/hr[1]. (3.96 m^3/s). A marine outfall will be used to release the brine with a design flow rate of 8,984 m3/hr. (2.50 m^3/s). Based on the Pre-FEED information, the proposed desalination plant and the pump station are located at Sokhna 1 (McDermott) Port Area.

[1] The seawater normal inflow rate is 12,275 m^3/hr.; however the model has considered larger flow rate to accommodate any possible future increase in the intake flow rate.

1.1 Study Background

WorleyParsons has conducted various modelling and conceptual design studies [WP(2013) and WP(2014a,2014b)] for the feasibility of the Tahrir Petrochemicals intake/outfall pipeline and structures, at locations north and south of the existing and proposed new power plants.

For this study, a revised location for the intake/outfall (Figure 1-2), which is in the vicinity of the Sokhna 1 (McDermott) Port area was proposed as part of the Pre-FEED information. The revised location of the Tahrir Petrochemicals intake/outfall is approximately 4 km north of DP World Sokhna Port.

Tahrir Petrochemicals commissioned WorleyParsons to investigate the feasibility of implementing the intake/outfall at the revised location within the Sokhna 1 (McDermott) Port area as well as investigating other two alternative locations for the intake/outfall. The information provided and utilized in this report are based on the Pre-FEED information and takes into account the previous studies conducted for the proposed project as earlier mentioned in this section.

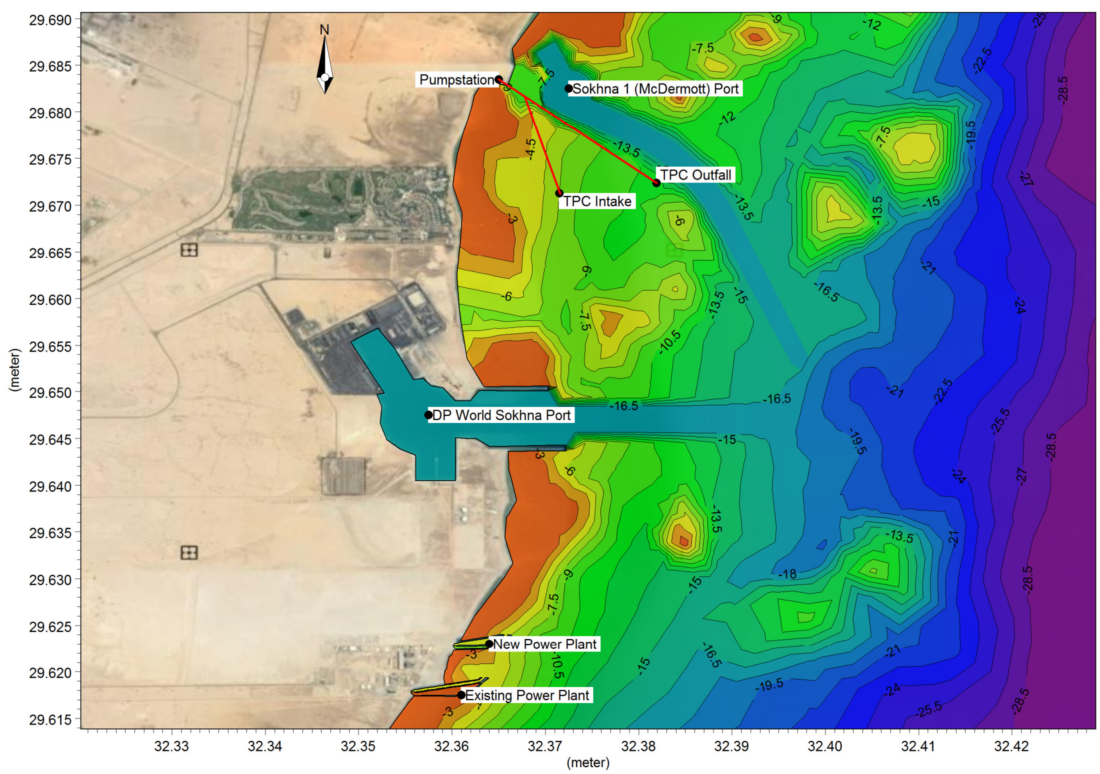

Figure 1-2: Proposed Tahrir Petrochemicals Intake/Outfall Locations

1.2 Study Objectives

The main objectives of this study are to:

- Investigate feasible locations for the siting of the proposed Tahrir Petrochemicals intake/outfall in the vicinity of Sokhna 1 (McDermott) Port and selecting the preferred option from environmental, technical and economic perspective;
- Assess compliance of the selected Tahrir Petrochemicals outfall effluent discharge with the applicable relevant environmental regulations;
- Identify the most feasible pipeline route from the pump station to the location of the selected Tahrir Petrochemicals intake/outfall; and
- Carry out the conceptual design of the preferred location of the selected intake/outfall.

1.3 Scope of Work

The scope of work of this study is limited to:

- Preparing a numerical model that incorporates the bathymetry of the site (including Sokhna 1 (McDermott) Port and DP World Sokhna Port access channels), and the existing and proposed new power plant intakes/outfalls;
- Performing hydrodynamic modelling for selected wind conditions to resolve the coastal circulation using available metocean information and WorleyParsons existing calibrated and validated model for the Red Sea;
- Incorporating the selected Tahrir Petrochemicals intake/ outfall into the hydrodynamic model and perform effluent dispersion modelling for selected wind and tidal conditions;
- Processing and analysing modelling results;
- Assessing the optimal route on land and sea that connects the desalination plant to the intake/outfall locations.

The scope of the present study does not include assessing the impact of the proposed intake/outfall operations on nearby infrastructure nor the seabed, if any.

1.4 Site selection for new Tahrir Petrochemicals intake and outfall

Three possible locations were investigated for the intake and outfall (Figure 1-3). These locations were selected based on WorleyParsons extensive experience in the area, previous assignments conducted in the vicinity of the proposed Complex location as well as the Pre-FEED information.

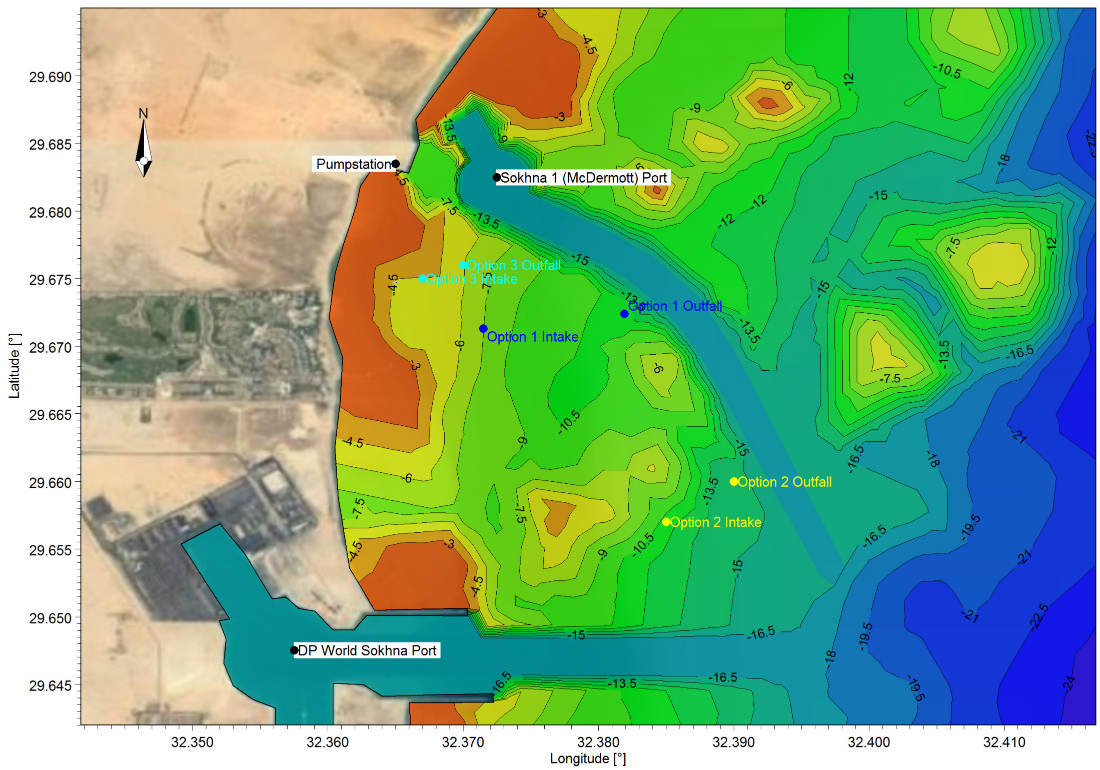

Figure 1-3: Location of possible intake and outfall in the Sokhna 1 (McDermott) port area

Table 1-1 shows the relevant information for the three locations. It is worth mentioning that the results of different previous effluent dispersion modelling conducted by WorleyParsons in the Gulf of Suez area indicated that in order to minimize the impact of intake and outfall on the surrounding environment and infrastructure, the intake/outfall should be located at depths greater than -6 m and at a distance greater than 750 m from the coastline.

Table 1-1: Alternative Intake/Outfall Locations

Description	Long (° E)	Lat (° N)	Distance from the Shoreline (approx. m)
Option 1 Intake	32.371500	29.671292	2,000
Option 1 Outfall	32.381919	29.672385	
Option 2 Intake	32.385000	29.657000	3,000
Option 2 Outfall	32.390000	29.660000	
Option 3 Intake	32.367000	29.675000	750
Option 3 Outfall	32.370000	29.676000	

From the identified three locations, Option 1 was selected as the preferred option. When compared to Option 1, it was found that:

- **Option 2**: A location offshore of the proposed location (located approximately 3 km from shoreline) – the impact of the TPC intake and outfall on the surrounding environment is not expected to be significantly reduced, based on the small impact estimated at the proposed location.
- **Option 3**: A location nearshore of the proposed location (located approximately 0.75 km from shoreline) – moving the intake to a location shallower than the proposed location will increase the impact to the surrounding environment and the risk of sediment intrusion.

Based on this analysis, Option 1 for intake and outfall location is considered technically adequate. Selecting locations at deeper locations or to the north of Sokhna 1 (McDermott) Port would increase the pipe lengths to the proposed Tahrir Petrochemicals Complex compared to the selected location for this project, which is in fact the optimal based on pipe length and depth requirements. As for the environmental feasibility and compliance, it will be discussed in details in Section 4 and Section 5.

1.5 Input Data

Pre-FEED Data provided by EPC Contractors has been used to the maximum extent in the definition of the model inputs. In the case of inputs for which no information was available, estimations have been made based on information available from previous similar assignments and international references. Complete list of references utilized in the present study are presented in Section 9.

The available data considered in this study includes:

- C-Map data for the project site; Figure 1-4 shows the available C-Map bathymetry plot and corresponding water point data;
- Wind records from Global Data Assimilation System (GDAS) model data covering the period January 2011 to December 2011;
- Meteorological and bathymetric data for SUMED area;

- Location and flows of existing and proposed new intakes/outfalls, and proposed flows of the new TPC intakes/outfall.

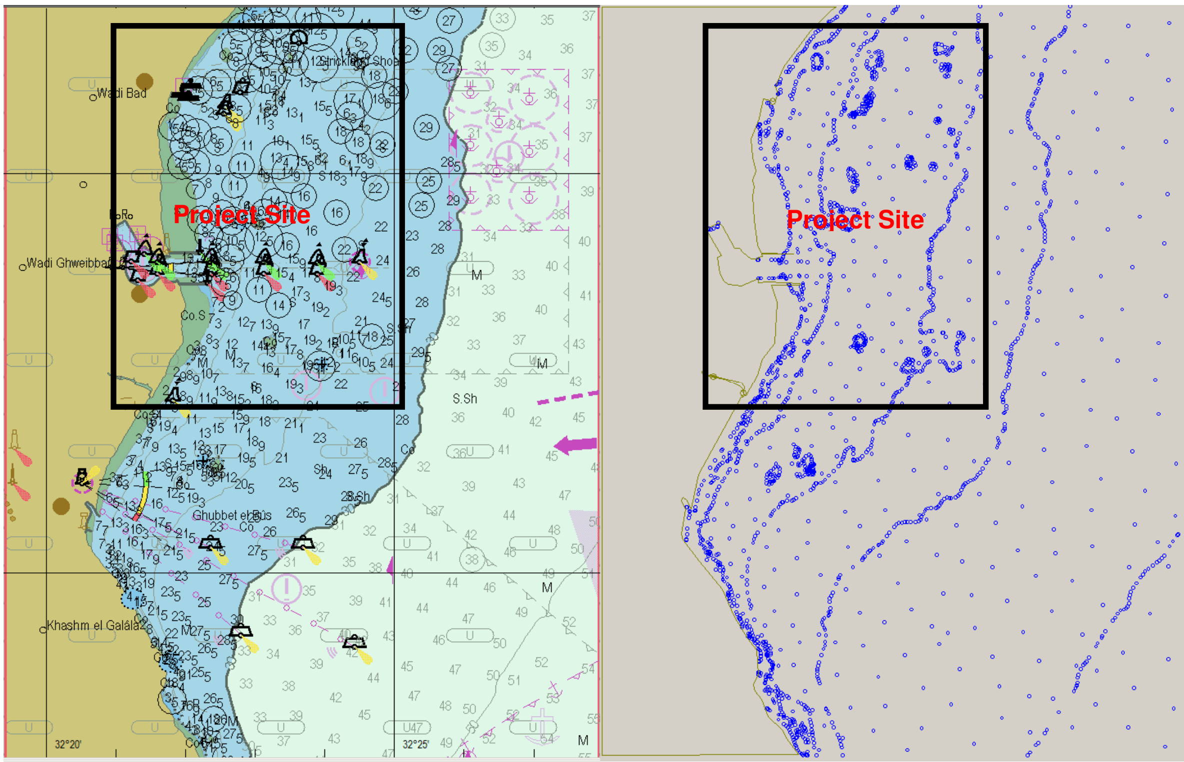

Figure 1-4: C-Map Bathymetry and Corresponding Water Point Data in the Domain

The coordinates of the existing and proposed intakes/outfalls are presented in Table 1-2. The existing power plant intake consists of a trapezoidal-shaped channel approximately 600 m long while its outfall is a shore open channel.

Details on the dimensions of the proposed power plant intake/outfall were not available during the execution of this study. For the purpose of this study these have been assumed to be the same as the existing power plant intakes/outfalls.

Table 1-3 presents the flow rates and water quality characteristics of existing and new proposed power plant intakes/outfalls, and and Tahrir Petrochemicals Complex intake/outfall.

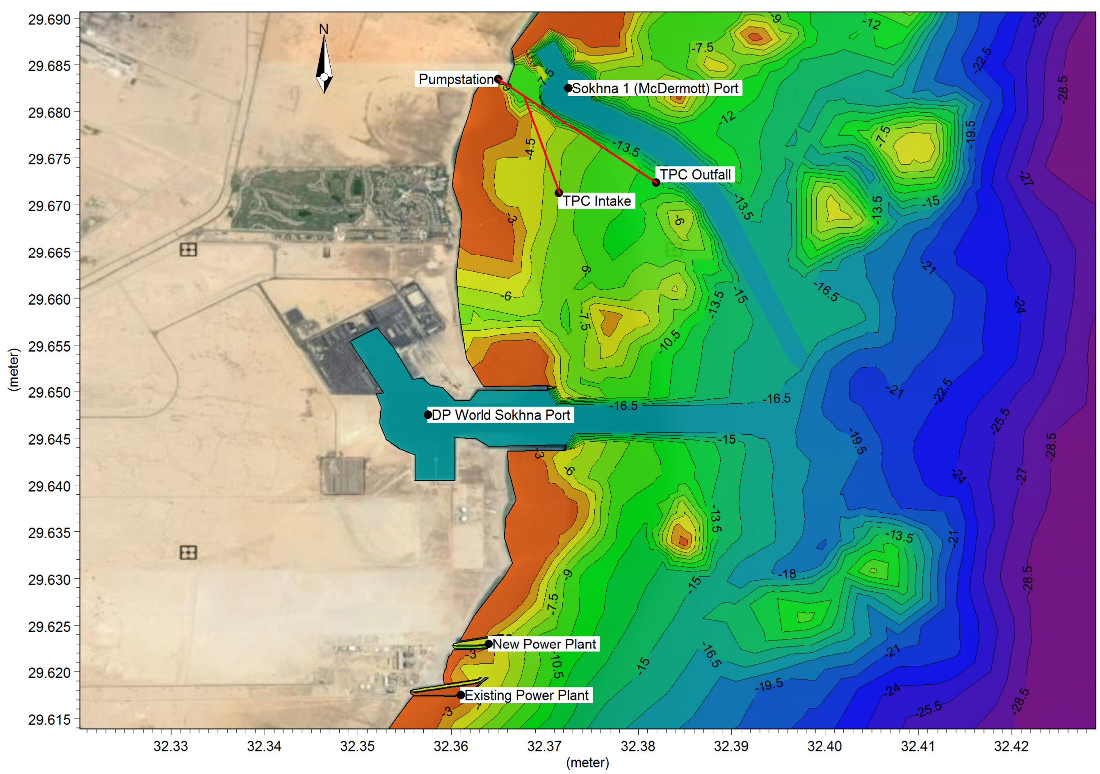

Figure 1-5: Proposed Pumpstation, and Existing and Proposed Power Plant Intake/Outfall Locations

Table 1-2: Coordinates of Existing and Proposed Power Plant Intakes/Outfalls

Description	Long (° E)	Lat (° N)
Existing Power Plant Intake	32.356008	29.617519
Existing Power Plant Outfall	32.356322	29.617981
New Power Plant Intake	32.360000	29.623000
New Power Plant Outfall	32.360000	29.622167

Table 1-3: Existing and Proposed Power Plant Intakes/Outfalls and TPC Intake/Outfall Characteristics

Description	Flow Rate (m^3/s)	Excess Temperature (°C)	Excess Salinity (PSU)	Water depth (m CD)
Existing Power Plant Intake[2]	26	-	-	Shore intake
Existing Power Plant Outfall[2]	26	8	-	Shore discharge
New Power Plant Intake[2]	41	-	-	Shore intake
New Power Plant Outfall[2]	41	10	-	Shore discharge
New TPC Intake[3]	3.96	-	-	-7.5
New TPC Outfall[3]	2.50	3	2	-10.8

1.6 Study Limitations

A calibrated regional numerical model for the Red Sea was used in this study. The regional model has however not been calibrated with site specific data but rather available predicted water levels and in-situ measurements, which are located elsewhere within the model domain – see Section 3.4.4 for details of the model calibration and validation. Additionally, available information for the study area has been utilized such as C-Map data (Section 1.5)..

1.7 Assumptions

The key assumptions of the study include:

- The seabed and l and areas of the project have properties that allow the excavation of trenches for the implementation of the intake and outfall pipelines (i.e. no rocky substrate material);
- The intake/outfall flow rates for the existing and proposed new power plant intakes/outfalls located to the south of the project site obtained from published sources are accurate;
- The on-land route does not have obstacles impeding the implementation of the pipeline; and
- The land proposed for the desalination plant and pump station is available.

[2] Data extracted from the presentation by Sayed A: Modeling of Thermal Effluents into Al-Ain Al-Sokhna Coastal Region by a Cooling System of New Power Plant, Suez Gulf, Egypt
[3] According to Pre-FEED information.

2. LEGISLATION AND REGULATORY FRAMEWORK

Relevant national (the Executive Regulation issued by Decree 1095 in the year 2011) and international standards (World Bank guidelines) are presented briefly in this section. As for the European Union relevant guidelines, Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 stablishes a framework for Community action in the field of water policy. The directive stablishes that Member States should aim to achieve the objective of at least good water status by defining and implementing the necessary measures within integrated programmes of measures, taking into account existing Community requirements. The directive does not give values which define good water status; hence there are no reference values on water quality set by European legislation to be presented in this section.

2.1 National Legislation

The Executive Regulation issued by Decree 1095 in the year 2011 set the conditions below for the discharge of cooling water to the marine environment.

- The cooling circuit shall be totally different from any other discharge process;
- The rise of temperature shall not exceed 10 °C above the temperature of entering water, with a ceiling of 38 °C;
- The cooling water is taken from same source into which it is discharged;
- Oil and grease concentrations in the discharge shall not exceed 15 ppm.

The legislation also states that in all cases it is not allowed to discharge to the marine environment except at a distance not less than 500 m from the shoreline.

It is noteworthy that, while the allowed temperature increase caused by the discharge of cooling water to the marine environment is 10 °C in the national regulation, as mentioned above, the limit for discharge of liquids in general is only 5 °C.

Drainage of liquid wastes is forbidden in bathing, fishing and natural protectorates' zones. Fishing and natural protectorates' zones are identified and monitored according to specific national laws. It is worth noting that the proposed study area is neither considered as bathing, fishing nor natural protectorates zones.

2.2 International Legislation

The World Bank (1998) has set guideline values for liquid effluents; those values are presented in Table 2-1 and compared to national limits for a selected number of parameters. The Complex should comply with the more stringent values of the World Bank guideline and the Egyptian regulation.

Table 2-1: National Limits, World Bank Guideline (1998) Values and Project Discharge Requirements

Parameter	Unit	National Limit	World Bank Guideline	Discharge Requirement
pH	-	6-9	6-9	6-9
Biological Oxygen Demand (BOD)	mg/l	60	-	≤60
Chromium	mg/l	0.01	0.5	≤0.01
Copper	mg/l	1	0.5	≤0.5
Iron	mg/l	1.5	1	≤1
Zinc	mg/l	1	1	≤1
Oil and Grease	mg/l	15	10	≤10
Total Suspended Solids (TSS)	mg/l	-	50	≤50
Residual Chlorine (Total)[4]	mg/l	-	0.2	≤0.2
Temperature Increase[5]	°C	≤5 at discharge point. Maximum ceiling of 38 ºC	≤3 at edge of mixing zone	Should not exceed 3 ºC above the prevailing temperature. Maximum ceiling of 38 ºC

2.3 National & International Legislation Assessment

The present study focuses mainly on seawater salinity and temperature. The corresponding National, World Bank (1998), and Project regulations that were considered in this chapter are presented in Table 2-2.

Table 2-2: National limits, World Bank guideline values and project discharge requirements

Parameter	Unit	National Limit	World Bank Guideline	Discharge Requirement
Residual Chlorine (Total)[4]	mg/l	-	0.2	≤0.2
Temperature Increase[5]	°C	≤5 at discharge point. Maximum ceiling of 38 ºC	≤3 at edge of mixing zone	Should not exceed 3 ºC above the prevailing temperature. Maximum ceiling of 38 ºC

[4] "Chlorine shocking" may be preferable in certain circumstances, which involves using high chlorine levels for a few seconds rather than a continuous low level release. The maximum value is 2 mg/l for up to 2 hours, which must not be more frequent than once in 24 hours (and the 24 hour average should be 0.2 mg/l).

[5] The effluent should result in a temperature increase of no more than 3 °C at the edge of the zone where initial mixing and dilution take place. Where this zone is not defined, use 100 m from the point of discharge when there are no sensitive aquatic ecosystems within this distance (World Bank).

The salinity and total residual chlorine are different parameters; however, they are closely related. Further reading on the relationship of PSU to chlorine and conductivity can be found in the standard reference i.e. UNESCO (1981). The typical amount of chlorine present in seawater at 35 PSU (35,000 mg/l) would range between 0.5 to 10 mg/l. For the present study, excess salinity (difference of the salinity due to the discharge to ambient water) of 2 PSU limit was introduced to limit chlorine disposal to less than 0.2 mg/l in the mixing zone.

Excess Temperature (difference of temperature due to the discharge to ambient water) of no more than 3℃ at the edge of mixing zone is permitted. A 100 m radius was assumed as mixing zone as per World Bank (1998) guidelines.

3. HYDRODYNAMIC MODELLING

Hydrodynamic modelling for selected wind conditions has been performed to simulate the coastal circulation at the project site. This section presents an assessment of the currents at the project site and a description of the hydrodynamic modelling carried out in this study.

3.1 Red Sea & Suez Gulf Characteristics

The Red Sea is a semi enclosed basin which separates Africa from Arabia. The Red Sea connects to the Indian Ocean via the Straits of Bab el Mandeb and the Gulf of Aden, and extends approximately 2000 km in the NW-SE direction. The Sinai Peninsula, the Gulf of Aqaba, and the Gulf of Suez (leading to the Suez Canal) are located to the north of the project site. The sea is underlain by the Red Sea Rift which is part of the Great Rift Valley.

Water level variations are governed by the astronomical tide, especially in the northern and southern Red Sea. Meteorological forcing is also believed to be a major contributing factor to the sea level variations in the central part of the Red Sea.

Tidal currents are noted as being predominantly weak in the Red Sea (UKHO, 2004). The predominant currents tend to set in the north-west or south-east direction, however with significant variation. Due to the weak tidal currents it is expected that wind and wave driven currents will govern current speeds in the shallow areas.

The annual surface water temperature in the Suez Gulf site area varies between 16℃ (recorded in February) to 30.4℃ (recorded in August). The highest monthly average surface water temperatures are 27.1℃ in July and 28.0℃ in August.

3.2 Description of MIKE 21/3 HD

MIKE 21/3 HD is a modelling system for 2D and 3D free-surface flows (DHI, 20011a) applicable to the simulation of hydraulic and environmental phenomena in lakes, estuaries, bays, coastal areas, and seas. MIKE21/3 HD FM is a version of the flow model based on a finite volume numerical solution of the shallow water equations; this version been applied in this study. In 2D mode, the model can be used to simulate a wide range of hydraulic and related items, including tidal exchange and currents, storm surges, heat transfer, wave induced currents, and sediment transport. In 3D mode, a wider range of phenomena can be simulated, including thermal and saline stratification and baroclinic flows.

The principal information provided by MIKE21 HD FM includes water levels, depth-averaged currents, and exchange coefficients. Whilst the use of the 2D model leads to significantly shorter simulation times than the 3D model, a drawback lies in the assumption of the constant vertical structure of the flow, which can lead to an inaccurate description of the effects related to the buoyancy of hot water, which is under consideration in this study. The constant vertical structure of the flow assumed in the regional model has minor implications to the overall results due to the following reasons:

- The model boundaries are sufficiently far from the site to have an influence on results;
- The water temperature and salinity are not expected to vary considerably along the water column away from the site;
- The outfall dispersion “footprint” extends within the domain of the local model only;
- Water depths at the site are shallow; therefore, water column stratification is expected to be negligible.

3.3 Methodology

The modeling methodology adopted in this study is discussed below.

3.3.1 Regional 2D Model

- A regional model covering the whole Red Sea was set up via MIKE 21 HD
- The model was forced with:
    - GDAS (Global Data Assimilation System) data set for wind and pressure. GDAS provides time varying wind and air pressure maps;
    - Predicted tidal levels at the Gulf of Aden (south entrance of the Red Sea) sourced from the global astronomical tide model FES’2004 (Le Provost, 1999);
- Boundary conditions of the local 3D model were extracted at the required boundary locations.

3.3.2 Local 3D Model

- A local 3D model was setup to carry out brine dispersion modelling
- The hydrodynamics for the local 3D model were forced with the boundary conditions from the regional model, and intake and outfall discharges. The worst case meteorological conditions for the advection and dispersion were also provided as input into the brine dispersion models used to quantify the potential water recirculation between existing and proposed new power plant intakes/outfalls and the proposed Tahrir Petrochemicals Complex intake/outfall;
- The local 3D model was used to identify the feasible locations for the Tahrir Petrochemicals Complex intake and outfall and to perform the detailed intake/outfall modelling assessment for the selected location.

3.4 Regional Model Setup

This section provides an overview of the regional model setup.

3.4.1 Model Description

The model domain was selected to cover the entire Red Sea and the Gulf of Aden (Figure 3-1) to allow for the best possible prediction of water levels and currents at the project site.

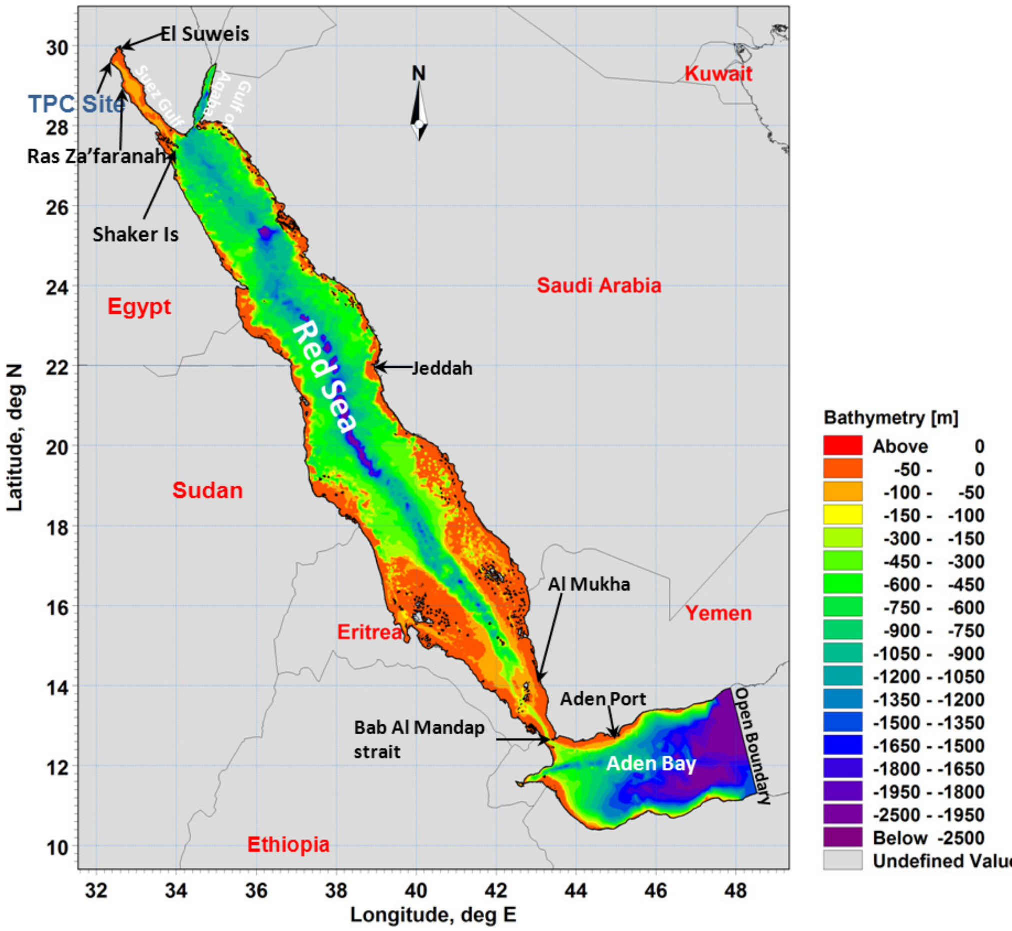

Figure 3-1: Extent and Bathymetry of the Red Sea Model

3.4.2 Bathymetry

The coverage and bathymetry of the Red Sea model is depicted in Figure 3-1. The model mesh comprised of approximately 36,000 triangular elements of varying size, ranging from as large as 30 km in the Gulf of Aden near the open boundary to as small as a few hundred of metres in the proximity to the project site. The gridded bathymetry was derived from digital admiralty charts C-Map (DHI, 2011b) by linear interpolation of soundings, supplemented by in-house digitized Admiralty Chart "Ports in the Gulf of Suez" (UK Hydrographic office, www.ukho.gov.uk, 2012) and high-resolution survey data of the area in the proximity to the TPC site.

3.4.3 Model Forcing

The two-dimensional Red Sea model was forced with the combined action of astronomical tide, prescribed at the open boundary, and meteorological forcing.

WIND FORCING

The GDAS data set was considered as meteorological forcing for the model for the calibration and validation stages. GDAS has a spatial resolution of 0.5°x0.5º and a temporal resolution of three hours, making it ideal for providing meteorological forcing to the hydrodynamic model of the Red Sea.

WATER LEVELS AT OPEN BOUNDARY

The model open boundary was located along the line crossing the Gulf of Aden from approximately (48°31'01.20"E, 11°19'04.80"N) to (47°51'03.60"E, 13°56'31.20"N), as indicated in Figure 3-1. Boundary conditions were derived from the global astronomical tide model FES'2004 (Le Provost, 1999).

3.4.4 Model Calibration and Validation

The Red Sea model was calibrated and validated as described below:

- The water level predictions assessed by the hydrodynamic model were initially compared to the C-Map tidal predictions (DHI, 2011b) at the tidal station of Aden to provide an initial confirmation of the boundary conditions sourced from the global astronomical tide model, FES 2004, at the open boundary of the model;
- The model coefficients were then tuned to obtain the best possible agreement in terms of tidal water level variations at several C-Map tidal stations including Shadwan Island (formerly known as Shaker Island) in the northern portion of the Red Sea, Jeddah in the central portion of the Red Sea and Al Mukha in the southern portion of the Red Sea;
- The model predictions using the coefficients derived in the previous calibration exercises were compared to the in situ measurements available to WorleyParsons for other projects.

Kindly refer to Appendix I for details of the model calibration and validation.

3.5 Local 3D Model Setup

This section provides an overview of the local 3D model setup.

3.5.1 Model Description

The extent and bathymetry of the local 3D model are shown in Figure 3-2, which also indicates the open model boundaries. The boundary conditions for the local 3D model were set as varying water levels, which were interpolated from the results of the regional model. The validation of the regional model is considered sufficient for the purpose of this study. A detailed view of the bathymetry in the vicinity of the project area is presented in Figure 3-3.

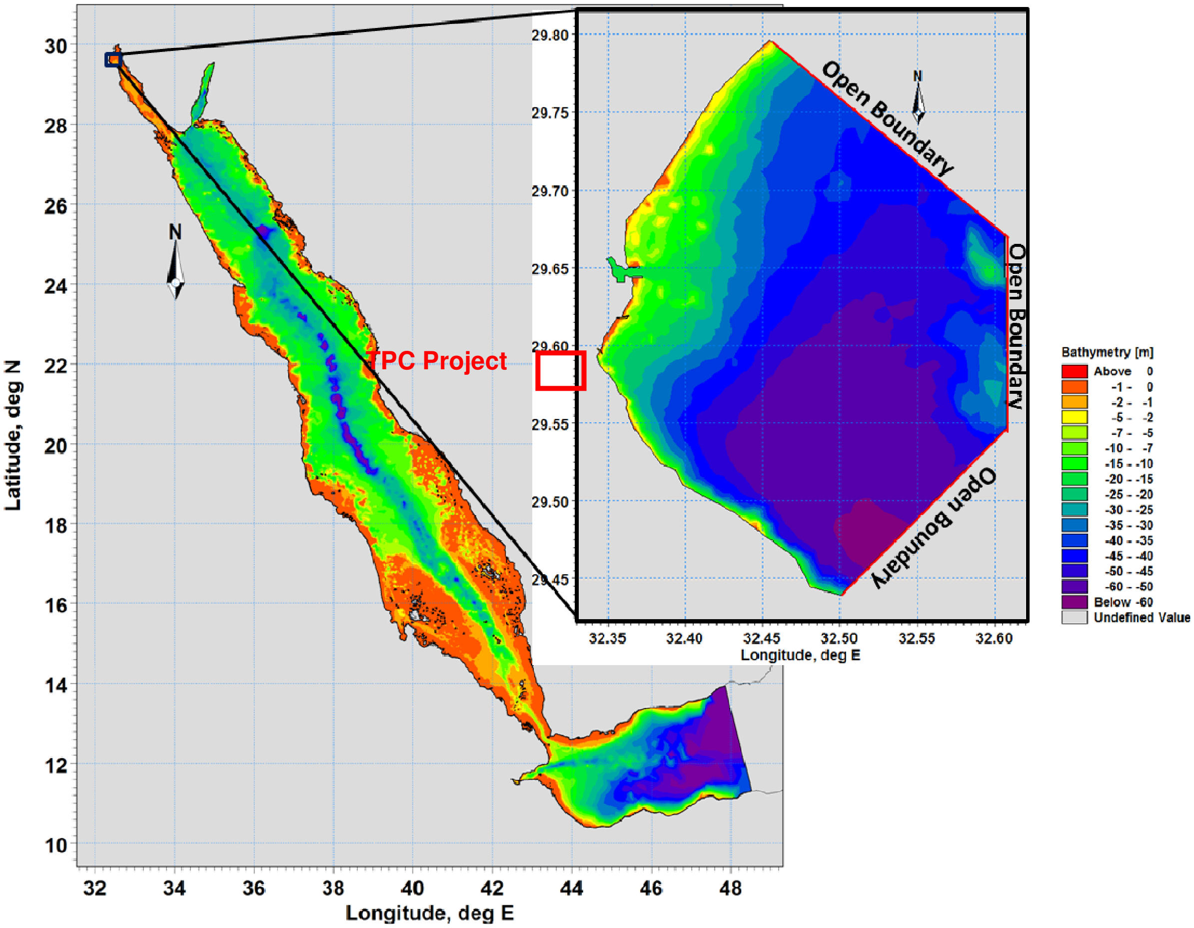

Figure 3-2: Extent and Bathymetry of the Local Model

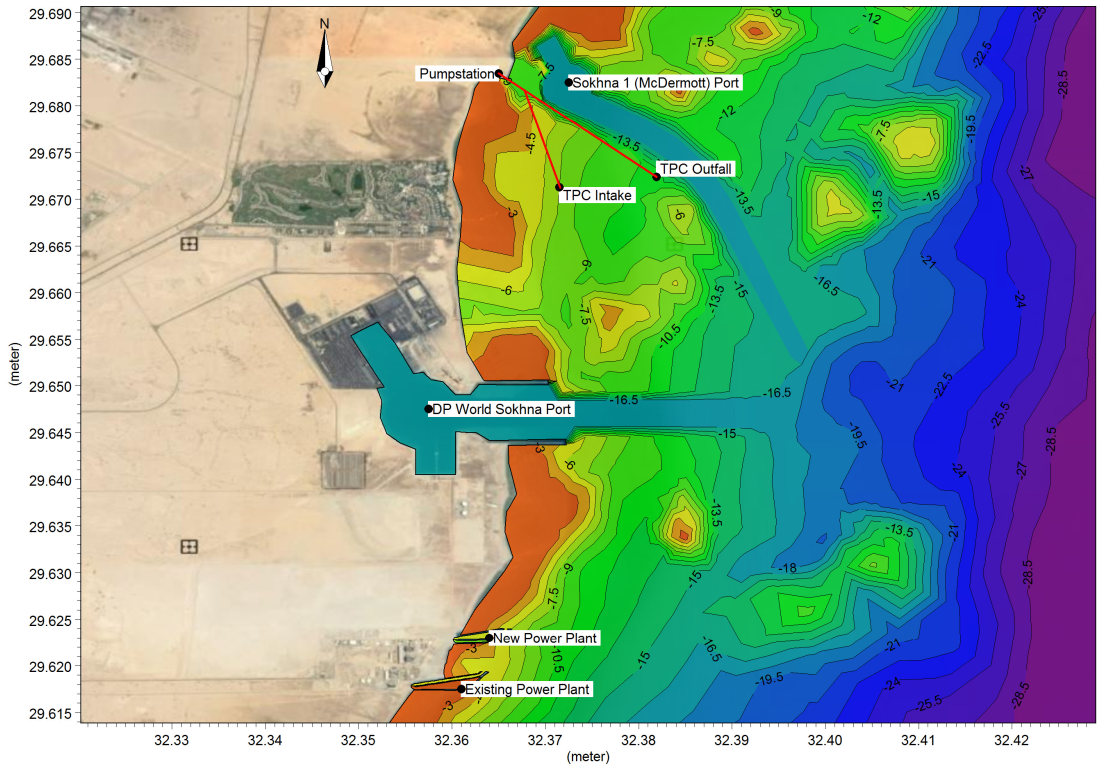

Figure 3-3: Detailed View of Bathymetry in the Vicinity of Project Area

The mesh of the local 3D model (Figure 3-4) has 5,822 triangular elements with grid resolution varying up to 50 m in the vicinity of the proposed intake/outfall to approximately 500 m in the deeper extents of the model domain. The regional model has a resolution of 200-300 m and, therefore, the boundary conditions for the local 3D model were linearly interpolated to obtain a boundary condition at each of the elements of the local 3D model. The local 3D model domain was resolved by ten (10) equidistant layers in the vertical direction.

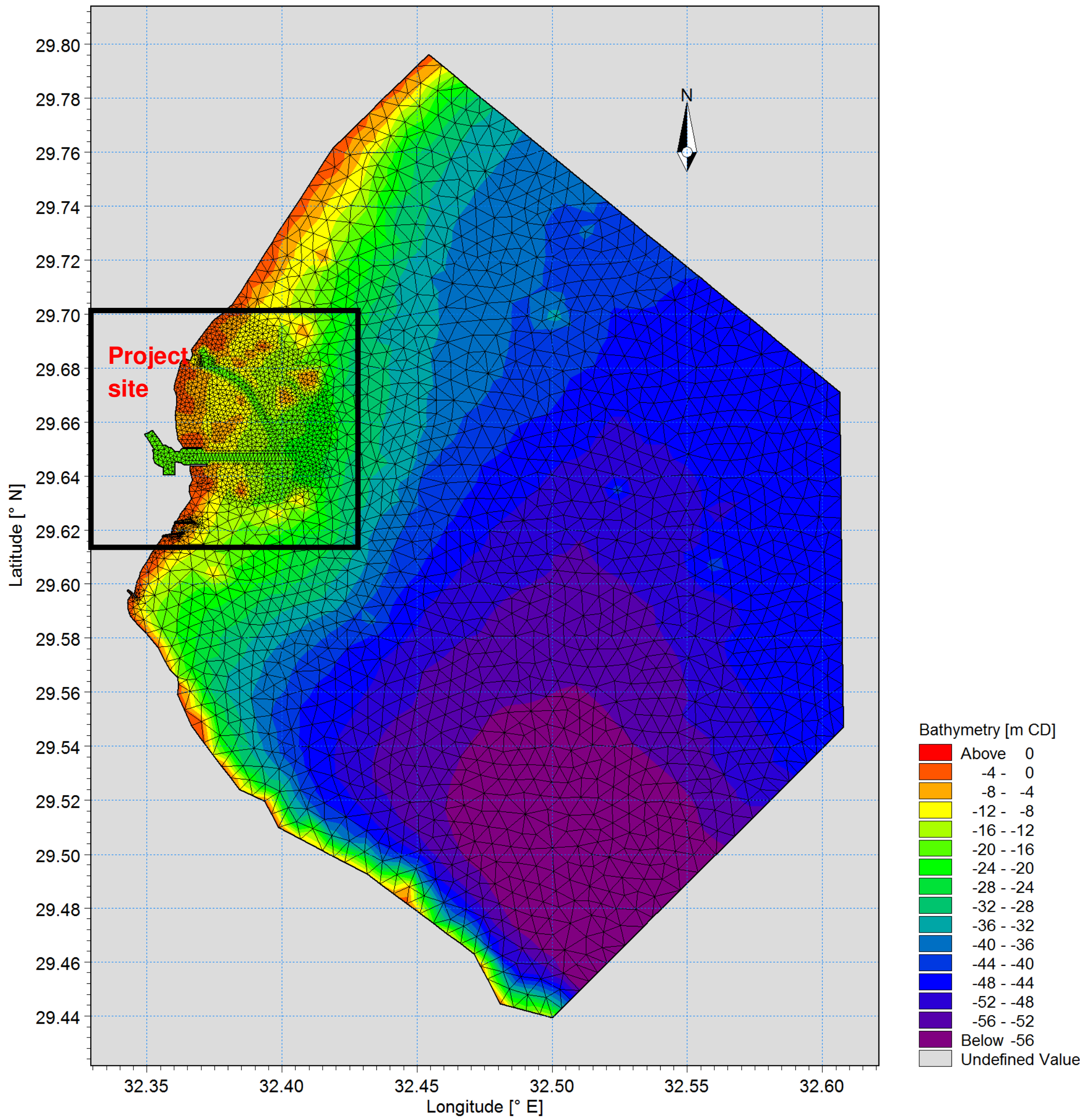

Figure 3-4: Bathymetry (with Mesh Elements) of the Local 3D Model

3.5.2 Setup Parameters and Model Limitations

The local 3D model considered the following setup formulations, parameters and limitations:

- Ten (10) vertical equidistant layers;
- 43,200 time steps were considered at time step interval of 60s (30-day period);
- Density assumed as a function of water temperature and salinity;
- k-ε (k-epsilon) turbulence model was used to describe mixing in vertical direction;
- Smagorinsky formulation with a coefficient of 0.2 m^{-1} was used to describe diffusion in horizontal directions;
- Wind shear stress was assumed to be a quadratic function of wind speed;
- Seawater temperature and salinity at the boundaries were considered constant. The 3D model represents stratification and it is considered as part of the dispersion; however, due to the lack of in-situ water temperature measurements, the temperature at the beginning of the simulations assumed constant seawater temperature through the water column;
- Ambient temperature and salinity were assumed to be constant at 26 °C and 40 PSU, respectively, which correspond to typical conditions. These values are based on mean annual climatology that could vary from 24-32°C for temperature and 38-44 PSU for salinity. Change in ambient salinity has negligible impacts on the results;
- The impact of waves was not taken into account. Wave action increases mixing and normally helps to minimize recirculation between intakes and outfalls. Therefore, it is assumed that worst-case scenarios for recirculation will occur when there is no wave action;
- Local 3D model simulations were run for a period of 30 days covering both neap and spring tides, which was assumed to be enough to reach a quasi-equilibrium state at the project site.

3.5.3 Wind Conditions

A typical/representative wind profile based on available hindcast wind data, GDAS, was selected for the north and winter winds. The Local 3D model was simulated for the following wind conditions:

- **Calm conditions (no wind):** This case is important as very little dispersion would be expected due to the relatively weak tidal currents. Any excess temperature and salinity from the discharged effluent (brine) could potentially "build-up" and accumulate around the site. The boundary conditions from the regional model without meteorological forcing were considered during this simulation.
- **Spatially constant, wind time series predominantly from the North**: This case is important as wind blowing from the North could push the discharged effluent (brine) from the proposed outfall towards the proposed intake, and towards the DP World Sokhna Port. This could potentially lead to recirculation of effluent (brine) and could also affect the environment and/or existing infrastructure (Figure 3-5).

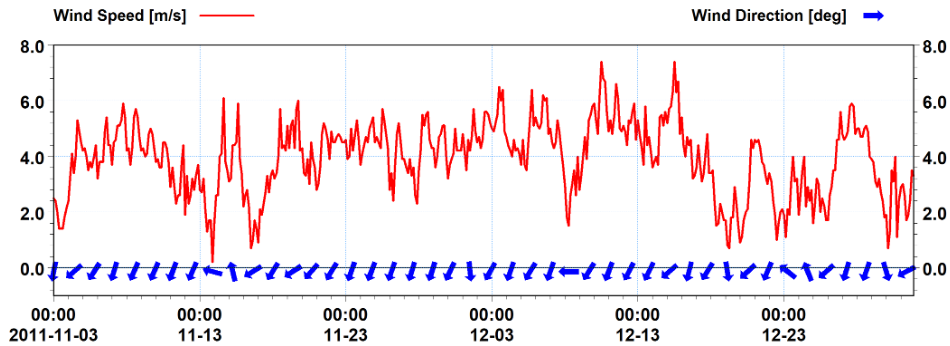

Figure 3-5: Wind Speed and Direction used in the North Wind Simulations

- **Spatially constant, wind time series predominantly from the South**: Wind time series data has been extracted from GDAS for the simulation period which is predominantly from South reaching a maximum speed of 7.5 m/s, as presented below (Figure 3-6). This case is important as wind blowing from the South could push the discharged effluent (brine) from the proposed outfall towards the planned Sokhna 1 (McDermott) Port. This could potentially lead to recirculation of effluent (brine) and could also affect the environment and/or existing infrastructure.

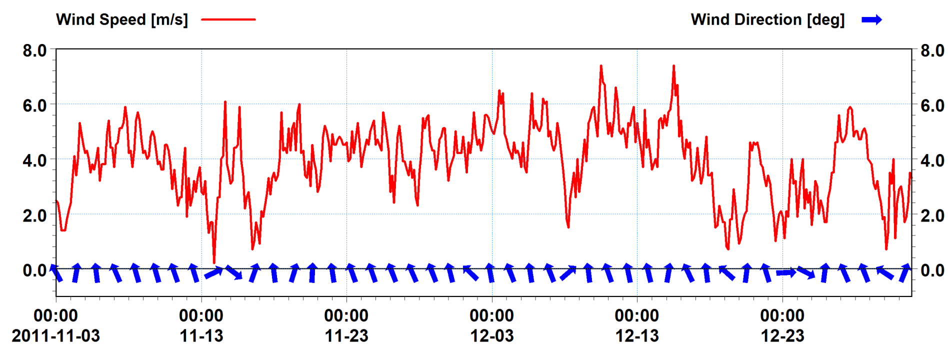

Figure 3-6: Wind Speed and Direction used in the South Wind Simulations

3.6 Results

Figure 3-7 shows the currents at the site during typical flood phase for the runs with tides alone. The results indicate that currents at the site are very mild.

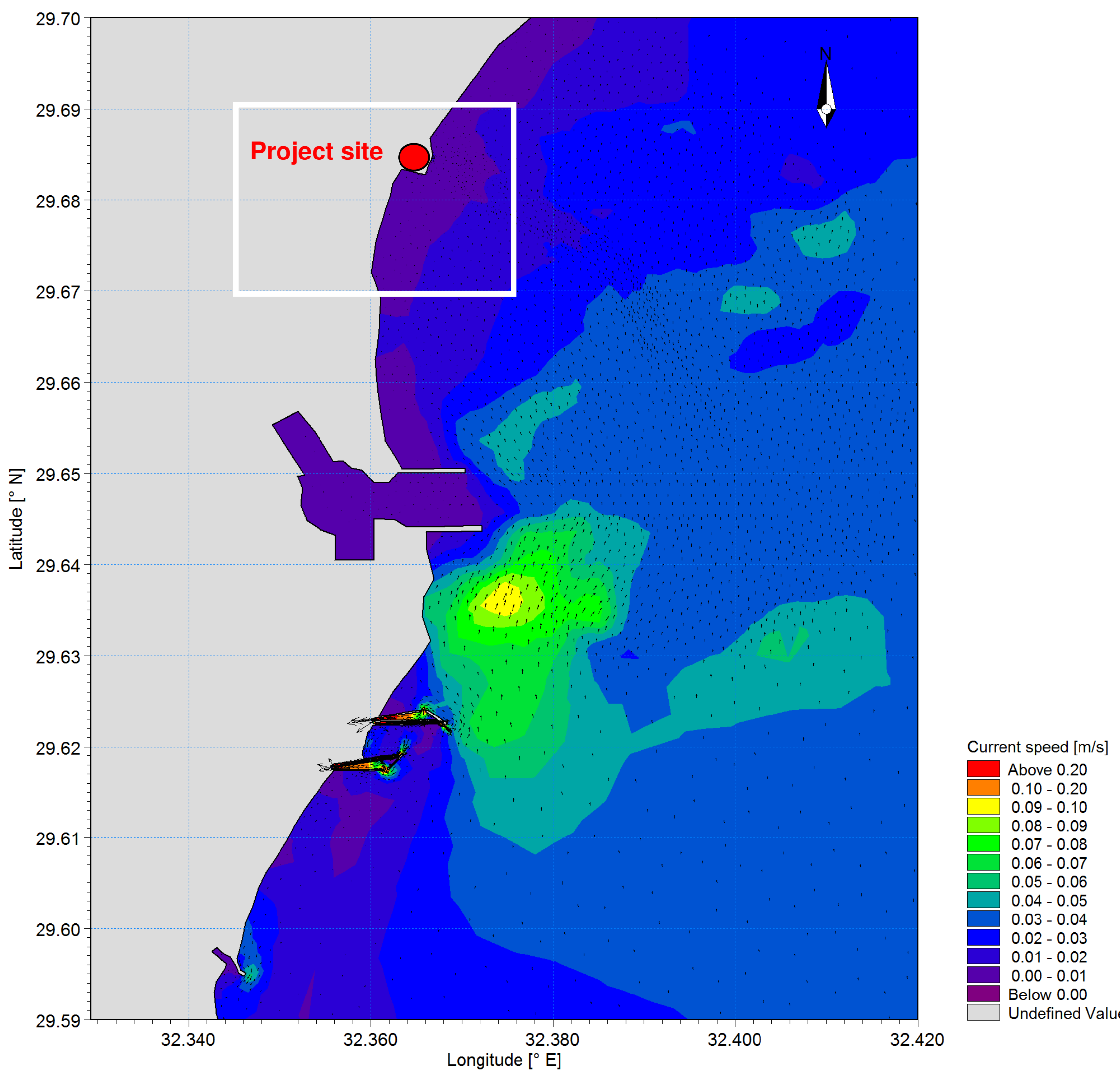

Figure 3-7: Current Patterns at the Project Site during typical Flood Phase for No Wind Conditions

Figure 3-8 and Figure 3-9 show the statistical mean and maximum current speeds near the site for the one month simulation period for the no wind condition. The mean and maximum current speeds at the proposed outfall locations are 0.02 m/s and 0.04 m/s, respectively.

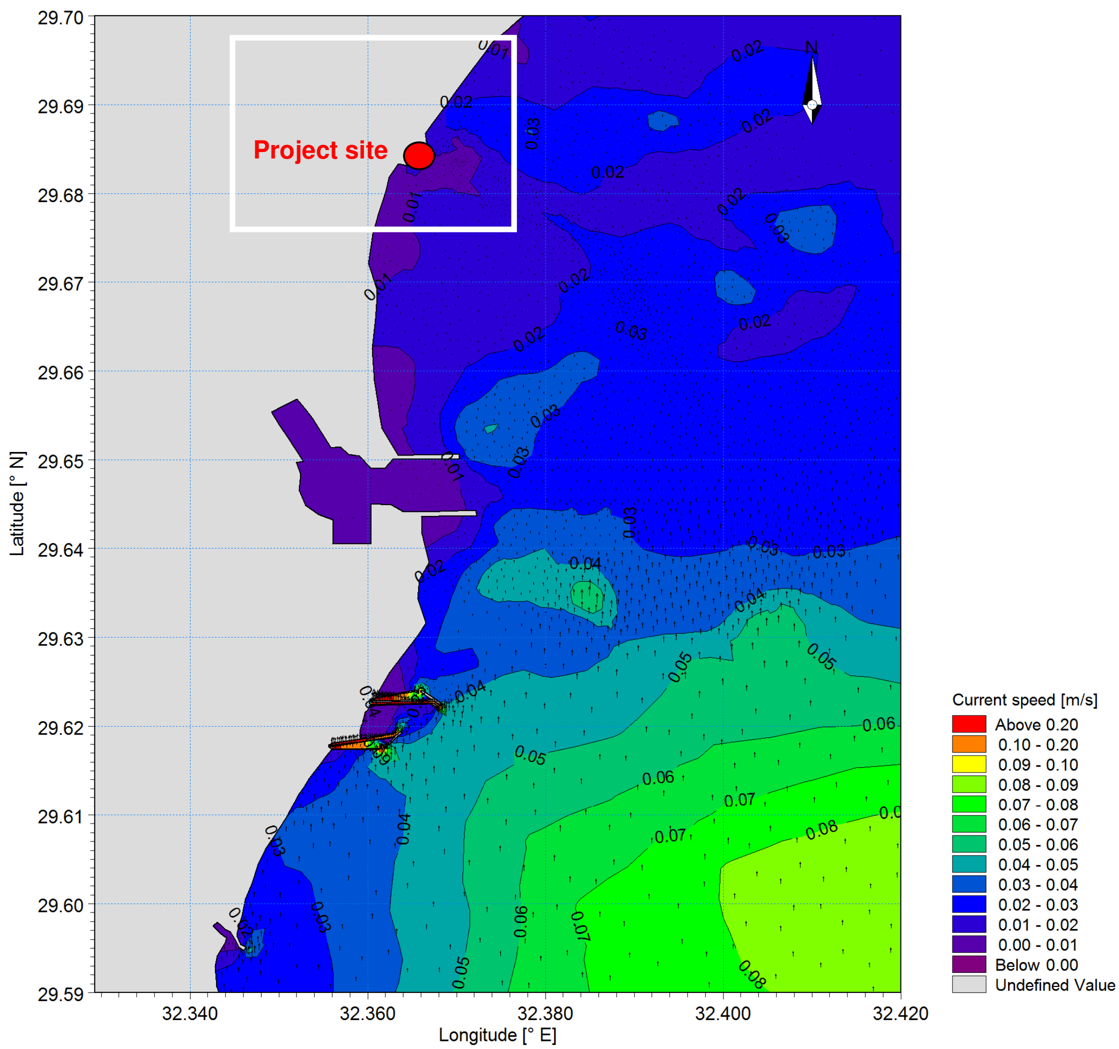

Figure 3-8: Statistical Mean Current Speeds near Project Site

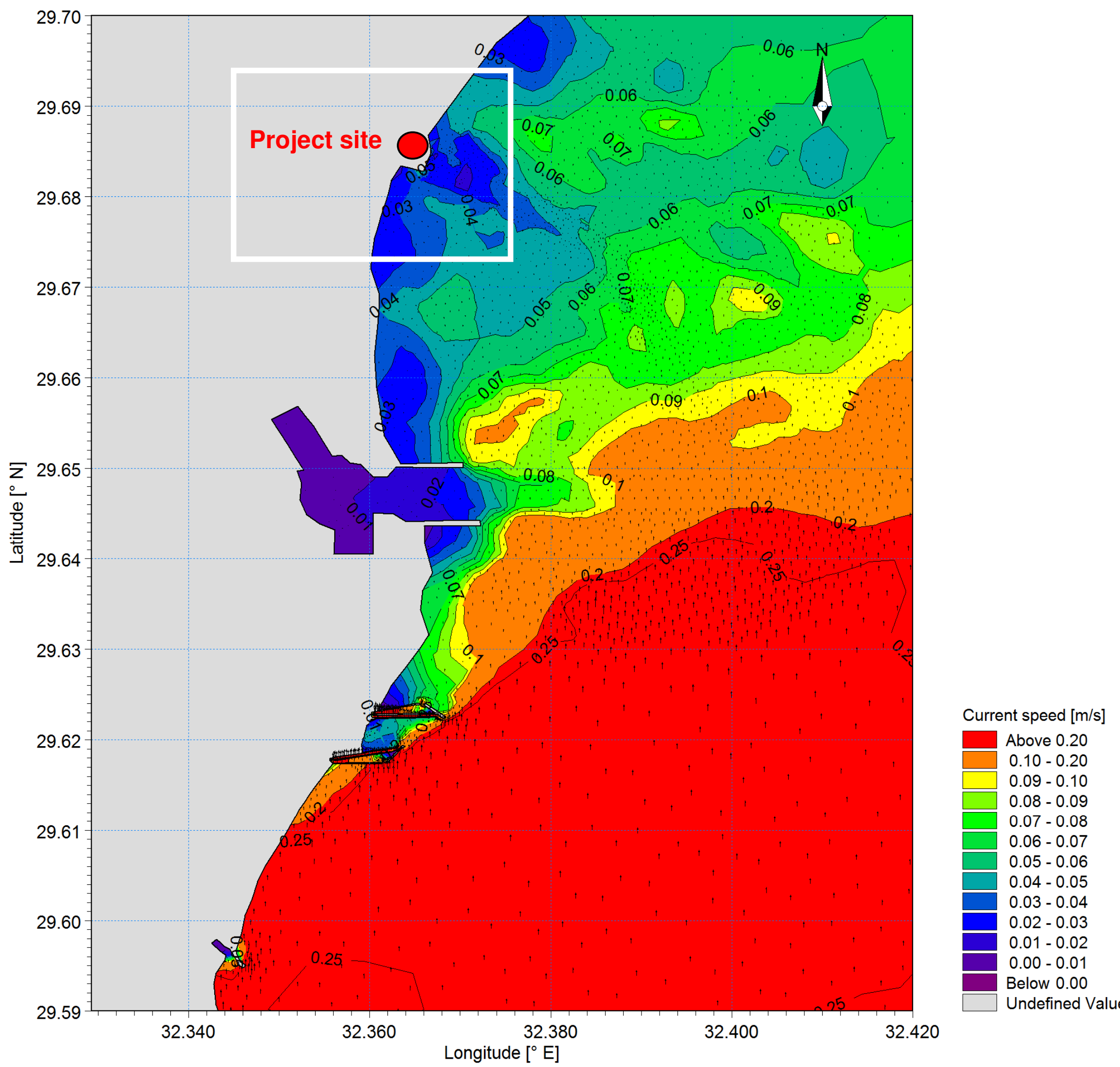

Figure 3-9: Statistical Maximum Current Speeds near Project Site

4. EFFLUENT DISPERSION MODELLING

Effluent dispersion modelling has been carried out to assess the proposed TPC intake/outfall location in terms of environmental compliance and recirculation.

4.1 Methodology

Intake/outfall characteristics as presented in Section 1.4 were incorporated into the local 3D hydrodynamic model. The following scenarios were investigated:

- **Scenario 1** (Baseline): Existing and proposed new power plant intakes and outfalls under tidal currents only;
- **Scenario 2** (Baseline): Existing and proposed new power plant intakes and outfalls under tidal currents and N wind conditions;
- **Scenario 3** (Baseline): Existing and proposed new power plant intakes and outfalls under tidal currents and S wind conditions;
- **Scenario 4**: Existing and proposed new power plant intakes and outfalls in addition to the selected intake and outfall under tidal currents only;
- **Scenario 5**: Existing and proposed new power plant intakes and outfalls in addition to the selected intake and outfall under tidal currents and N wind conditions;
- **Scenario 6**: Existing and proposed new power plant intakes and outfalls in addition to the selected intake and outfall under tidal currents and S wind conditions; and,
- **Scenario 7**: Existing and proposed new power plant intakes and outfalls in addition to the selected intake and outfall (as multiple diffuser) under tidal currents and S wind conditions;

The simulations were performed based on a single point diffuser to assess the worst case scenario with the exception of Scenario 7 which was selected as a multiport diffuser based on the worst case from Scenario 1 to 6. All simulations assumed discharge from the bottom for the selected outfall and surface discharge was considered for the existing and proposed new power plant outfalls..

4.2 Baseline Scenarios: Existing and proposed power plant intakes and outfalls only Scenario 1 (No Wind), Scenario 2 (N wind) and Scenario 3 (S Wind)

Figure **4-1** to Figure 4-6 present the temperature dispersion plots for Scenario 1, Scenario 2 and scenario 3 respectively.

The summary of the results are:

- The existing intake and outfall show a small sign of recirculation in terms of temperature;
- The size of the plume and the temperature increase indicate that the existing intake/outfall is not in accordance with environmental regulations. The increase in temperature from the effluent discharge from the existing power plant outfall is in excess of the 3℃, and there is recirculation of the effluent;
- A maximum temperature of 34-36°C (Figure **4-1**, Figure **4-3** and Figure 4-5) is noticed at the surface in the vicinity of existing outfall, while at the bottom it is in the range of 30-32°C (Figure 4-2, Figure 4-4 and Figure 4-6). The ambient temperature is 26°C;
- Results indicate that N and S winds influence a slightly larger area to the south indicating that the wind influences the spreading of the plume.

Salinity plots are not shown for the baseline scenarios as the existing intake/outfall consists only of heated effluent with no salinity increase compared to ambient water.

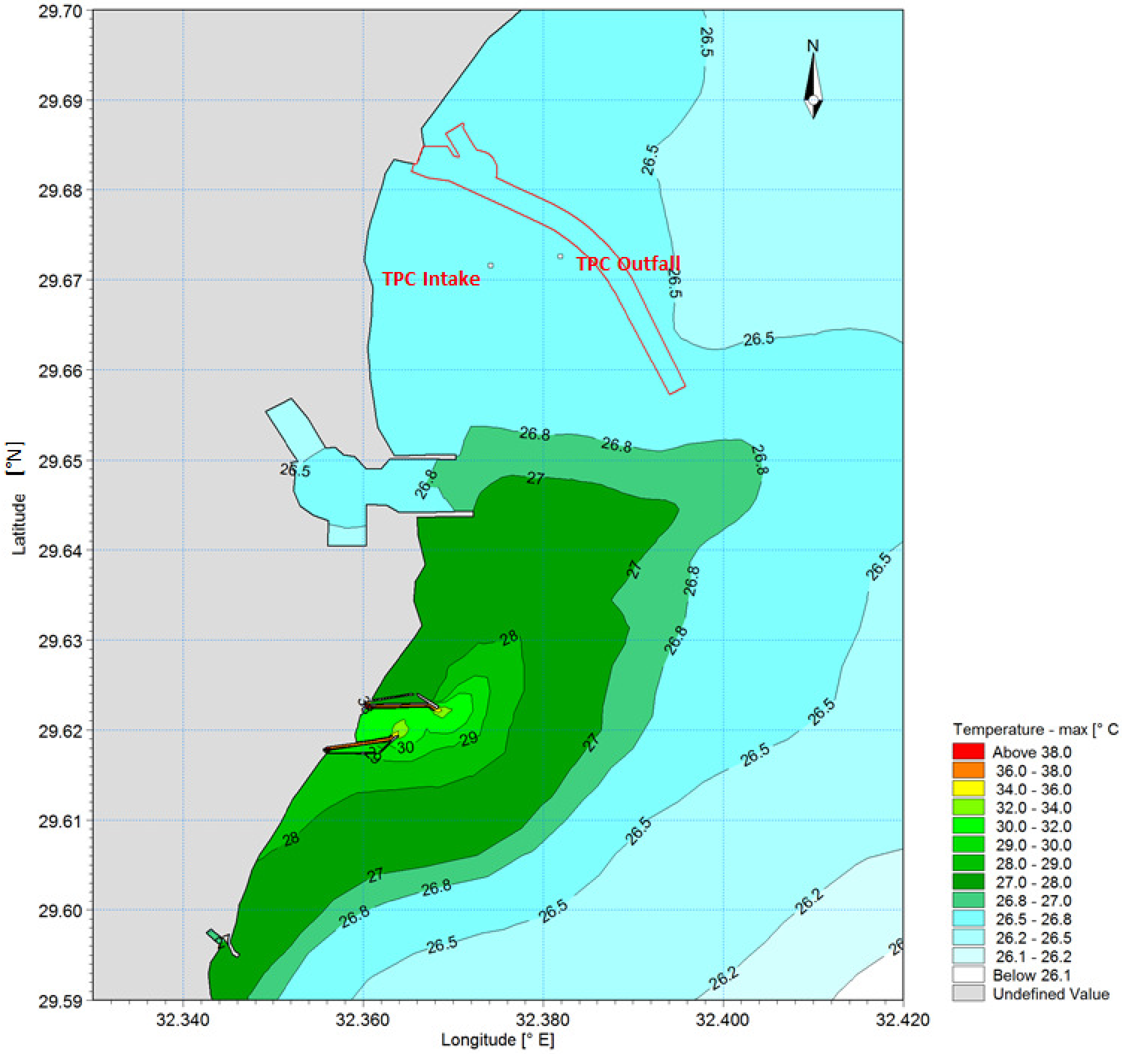

Figure 4-1: Maximum Temperature Plume at Surface for Scenario 1 (Tidal Currents Only)

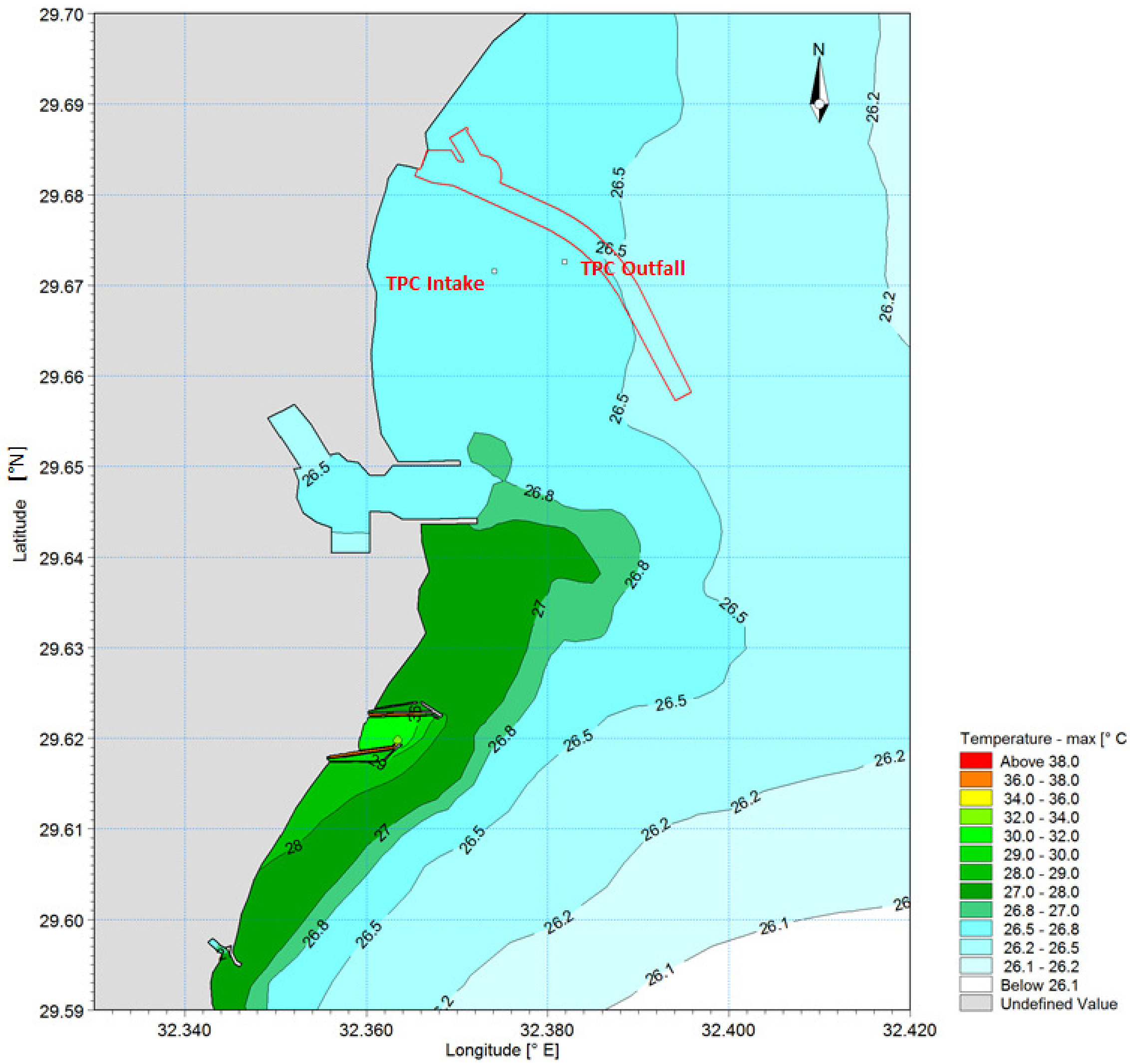

Figure 4-2: Maximum Temperature Plume at Sea bed for Scenario 1 (Tidal Currents Only)

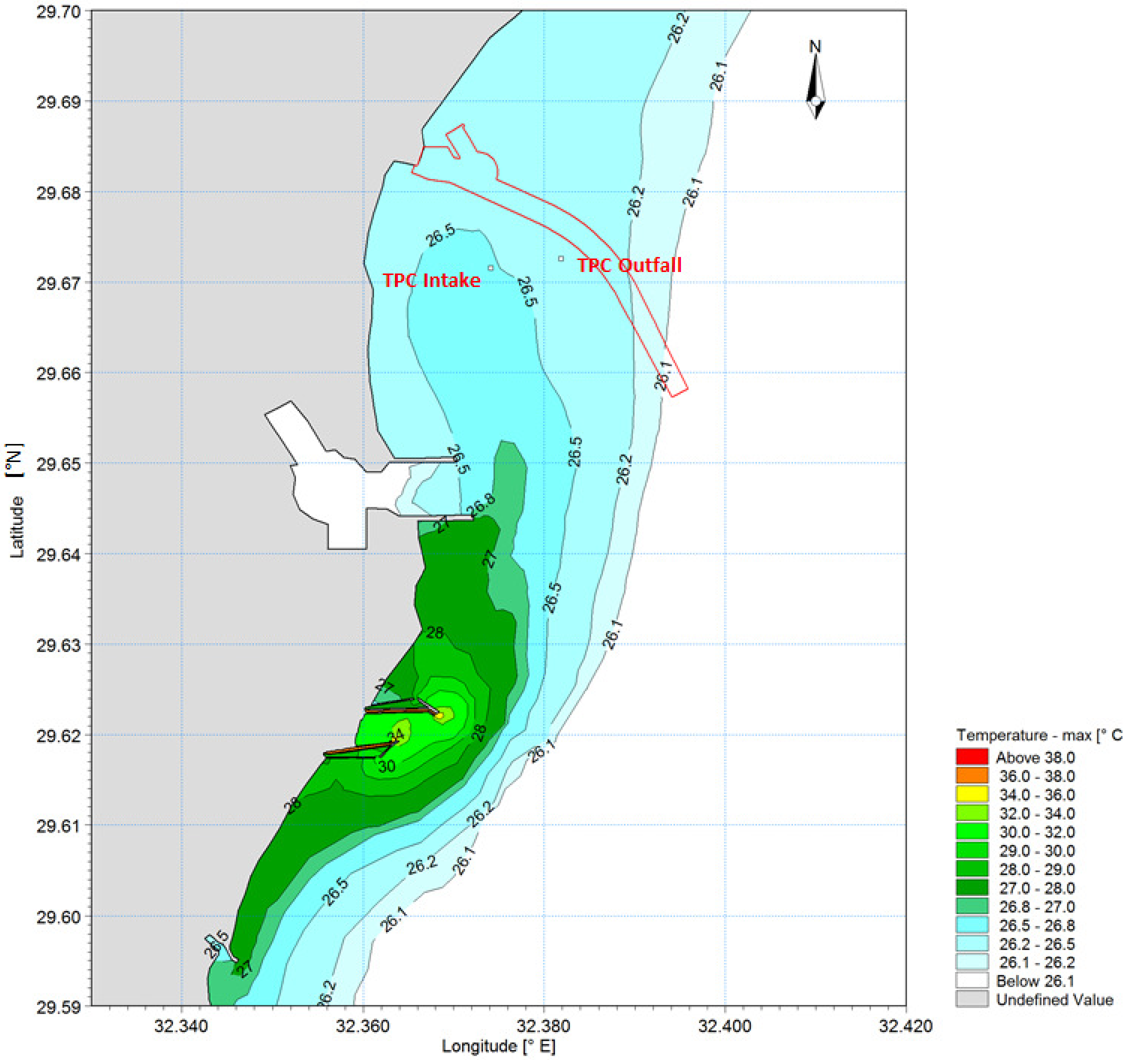

Figure 4-3: Maximum Temperature Plume at Surface for Scenario 2 (Tidal Currents Only)

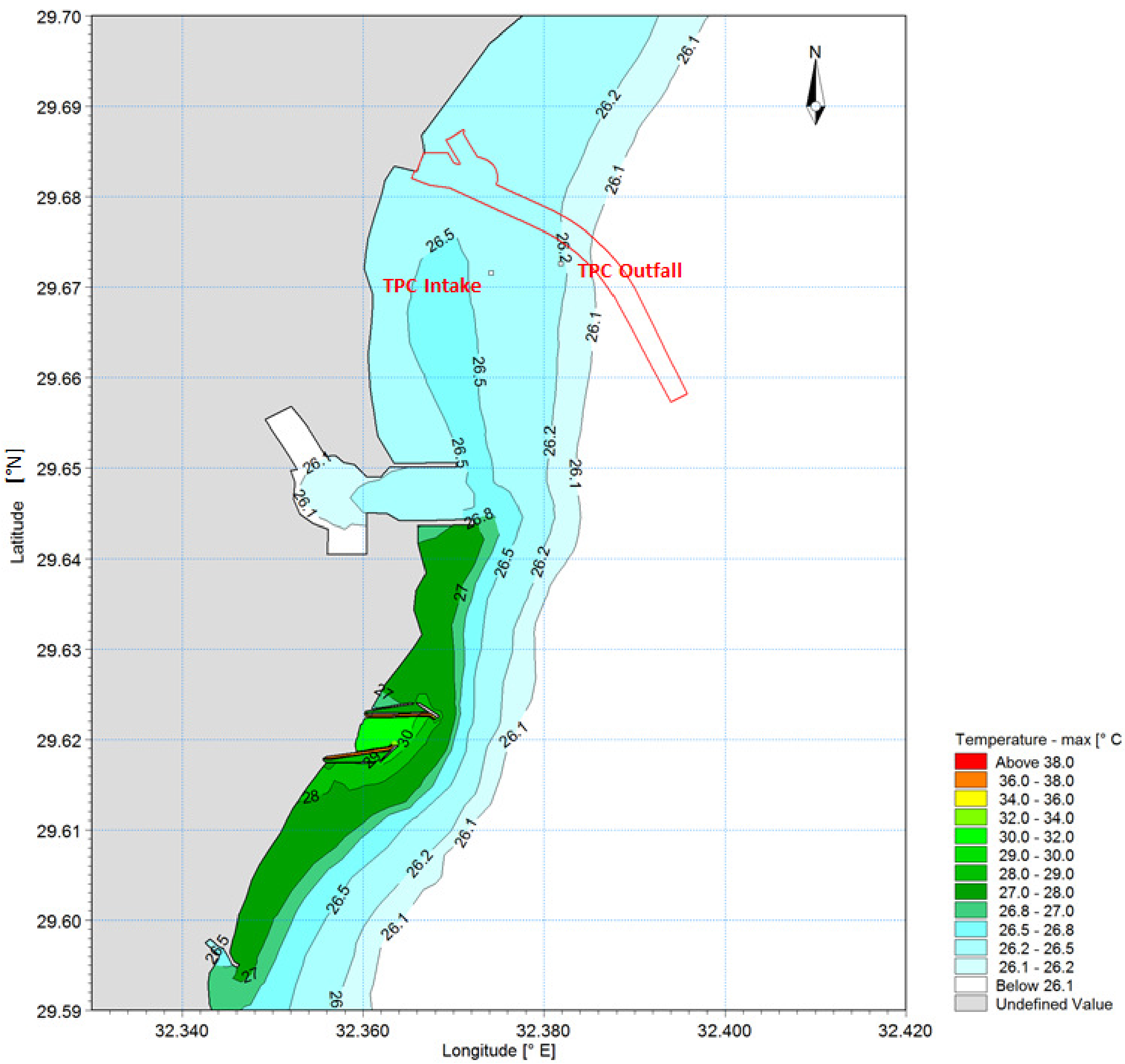

Figure 4-4: Maximum Temperature Plume at Sea bed for Scenario 2 (Tidal Currents Only)

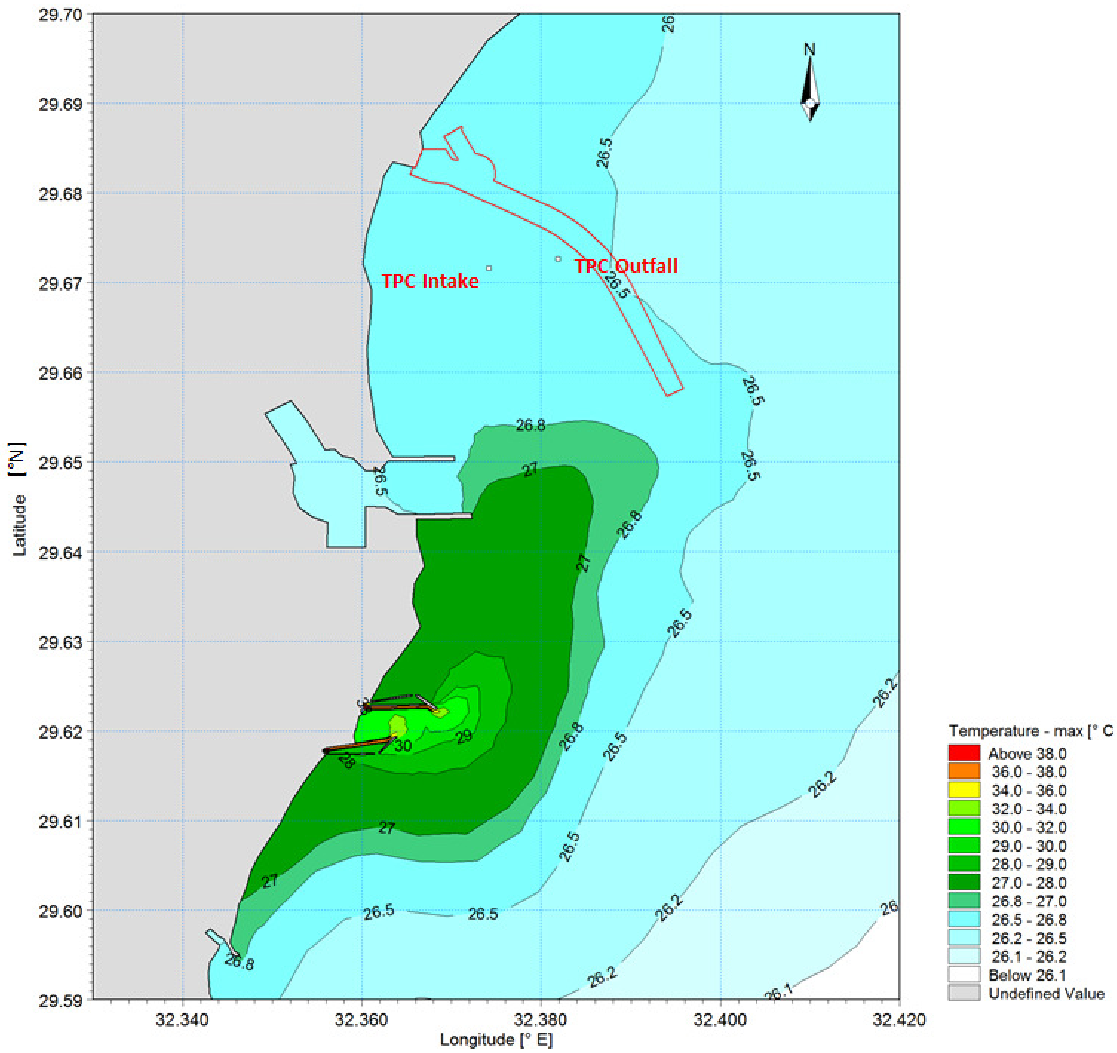

Figure 4-5: Maximum Temperature Plume at Seabed for Scenario 3 (Tidal Currents Only)

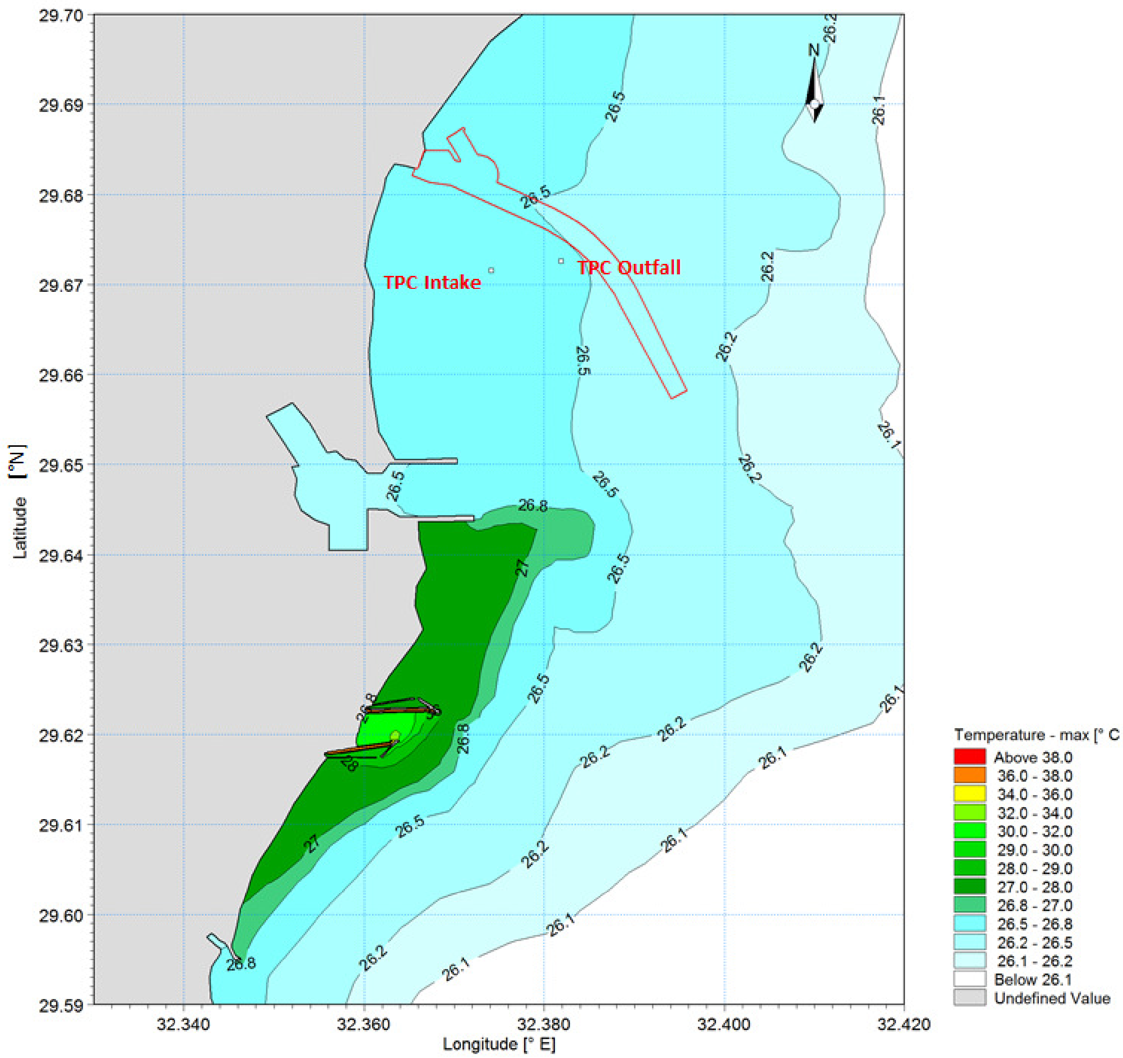

Figure 4-6: Maximum Temperature Plume at Surface for Scenario 3 (Tidal Currents Only)

4.3 Existing and proposed power plant intake and outfall plus new TPC intake and outfall Scenario 4 (No Wind), Scenario 5 (N wind) and Scenario 6 (S Wind)

Figure 4-7 to Figure 4-18 present the salinity and temperature dispersion plots including the selected intake/outfall.

Figure 4-19 to Figure 4-21 shows the time series for water temperature and salinity at the intake and outfall for Scenario 4, Scenario 5 and Scenario 6, respectively.

The summary of the results are:

- The maximum salinity plots (**Figure 4-7**, **Figure 4-11** and Figure **4-15**) show that salinity at the bottom is in the range of 40.1-41.0 PSU, while its extent is reduced and concentration lowered to 40.1 PSU at the surface indicating that the increase compared to ambient is less than 1 PSU at all depths;
- The maximum temperature plots (Figure4-9, Figure 4-13 and Figure 4-17) show that temperature at the bottom is in the range of 26-28°C, while the temperature at the surface is 27.5°C indicating that the increase compared to ambient is less than 2°C at all depths;
- The new TPC outfall at this location has negligible impacts on the existing and proposed new power plant intakes in terms of salinity and temperature for the conditions simulated;
- The selected outfall at this location has negligible impacts on the proposed site for the Sokhna 1 (McDermott) Port in terms of salinity and temperature for the conditions simulated;
- The plume from the selected intake/outfall does not reach the vicinity of the shoreline for any of the simulated conditions;
- There is minimal recirculation of brine between the selected intake and outfall (<0.1 PSU).

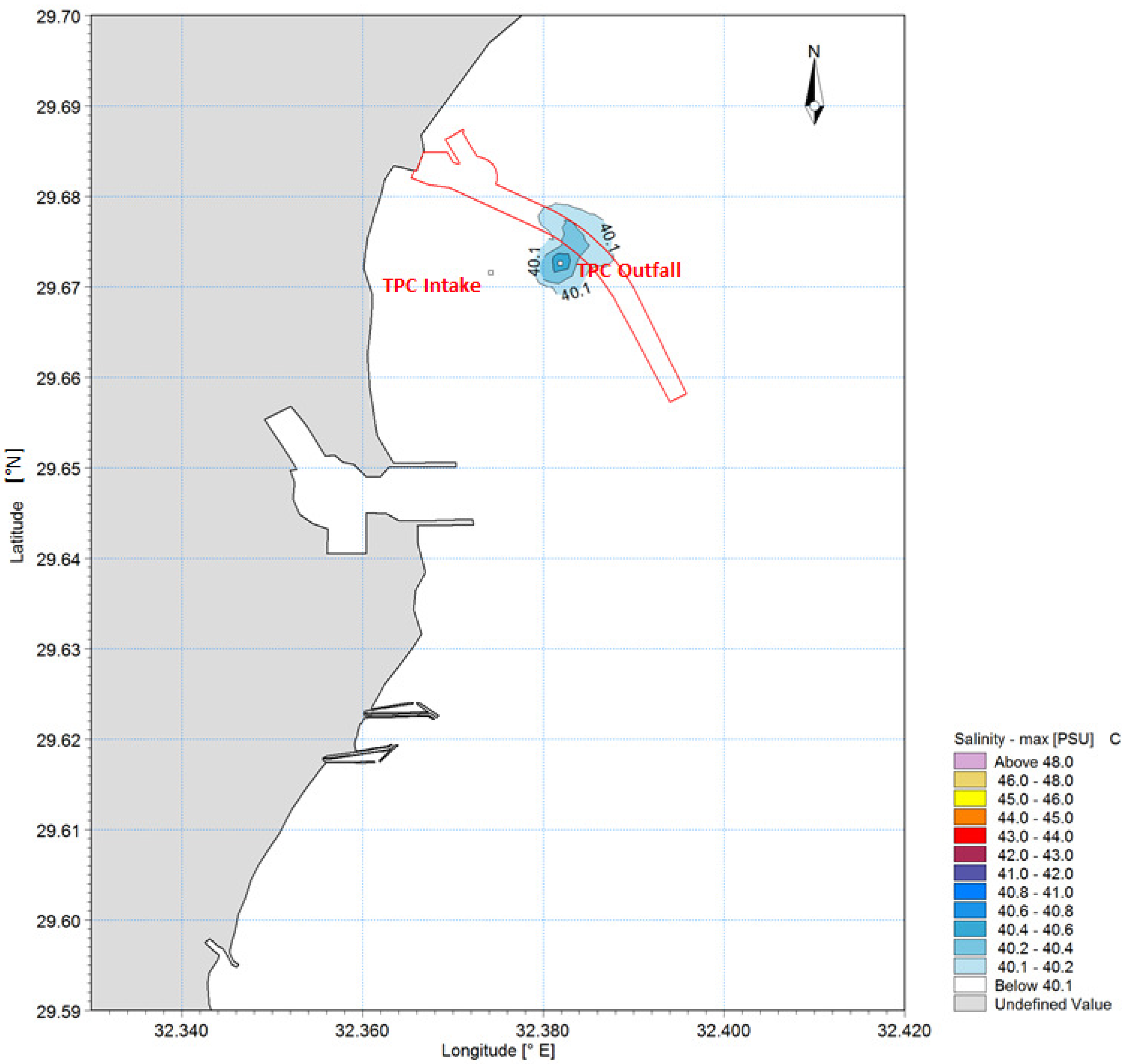

Figure 4-7: Maximum Salinity Plume at Seabed for Scenario 4 (Tidal Currents Only) for Single Port Diffuser

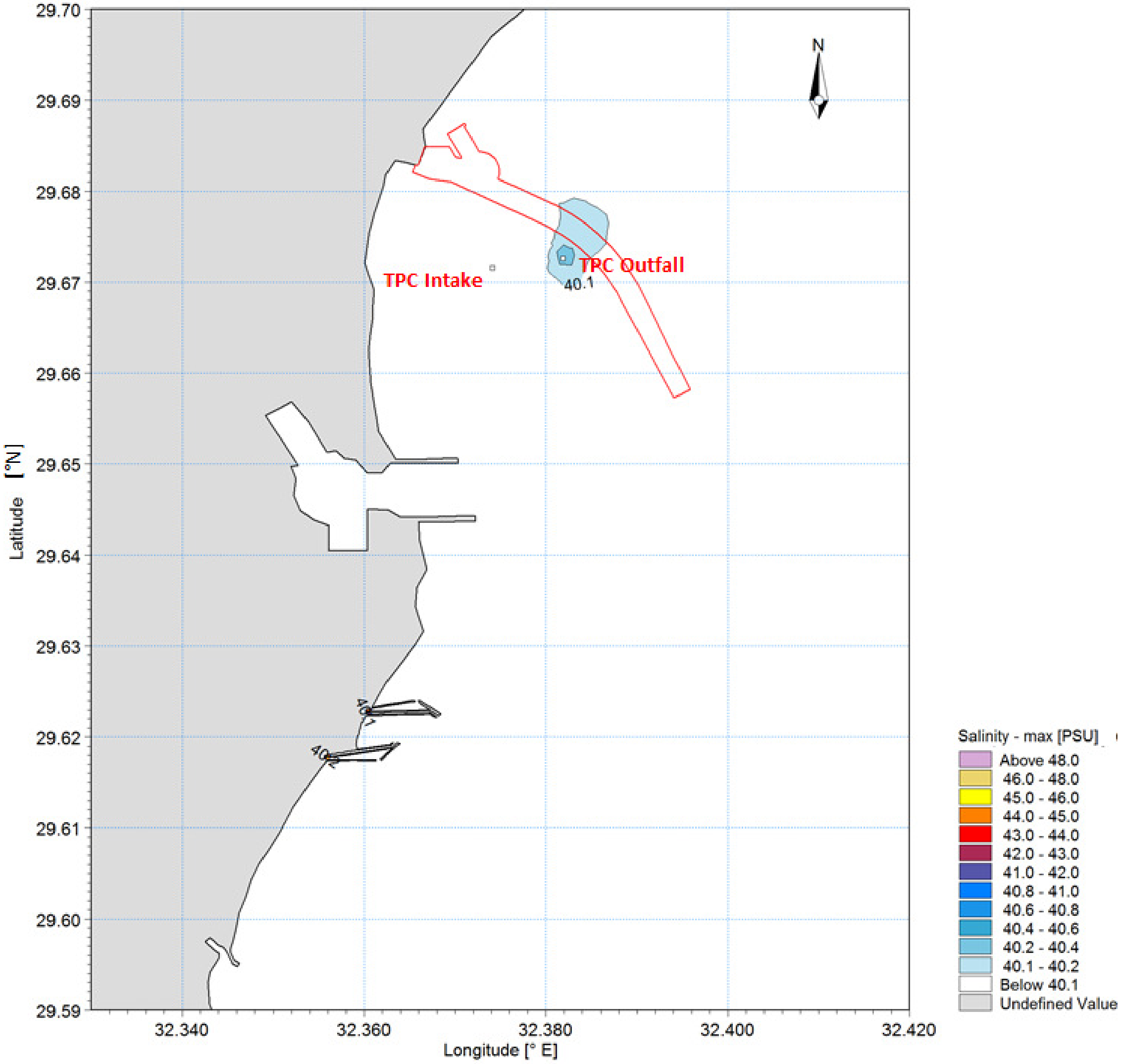

Figure 4-8: Maximum Salinity Plume at Surface for Scenario 4 (Tidal Currents Only) for Single Port Diffuser

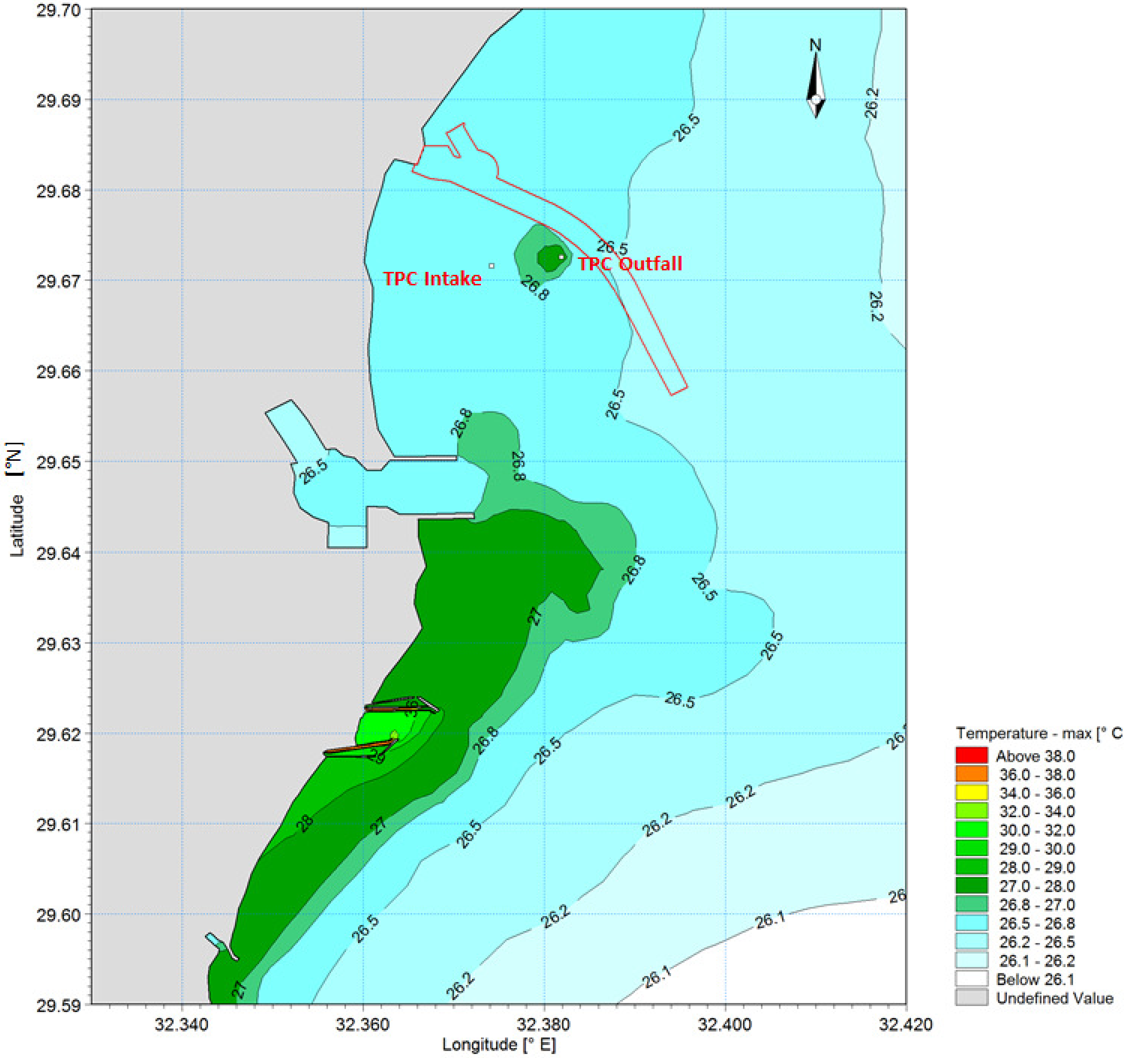

Figure 4-9: Maximum Temperature Plume at Seabed for Scenario 4 (Tidal Currents Only) for Single Port Diffuser

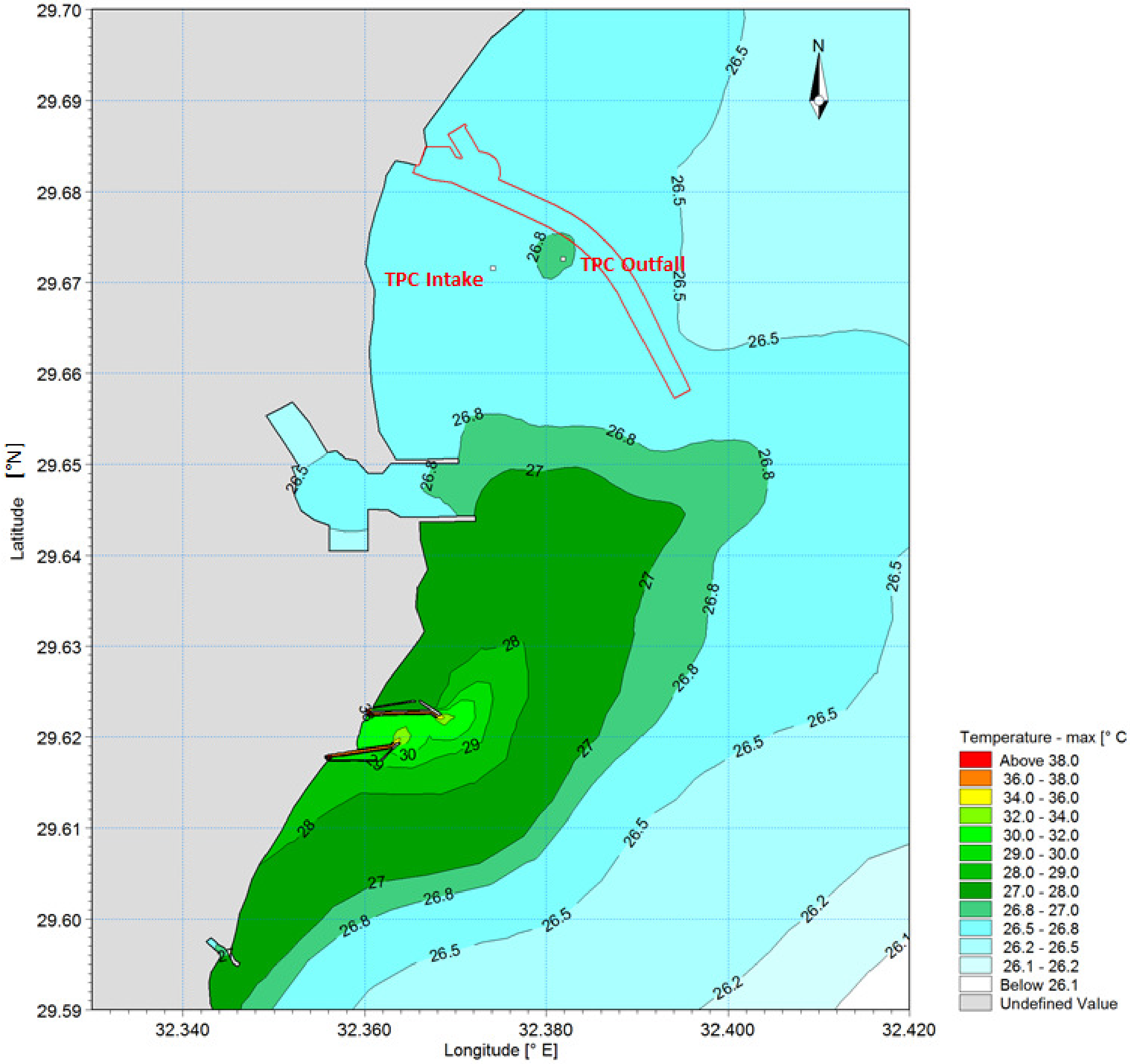

Figure 4-10: Maximum Temperature Plume at Surface for Scenario 4 (Tidal Currents Only) for Single Port Diffuser

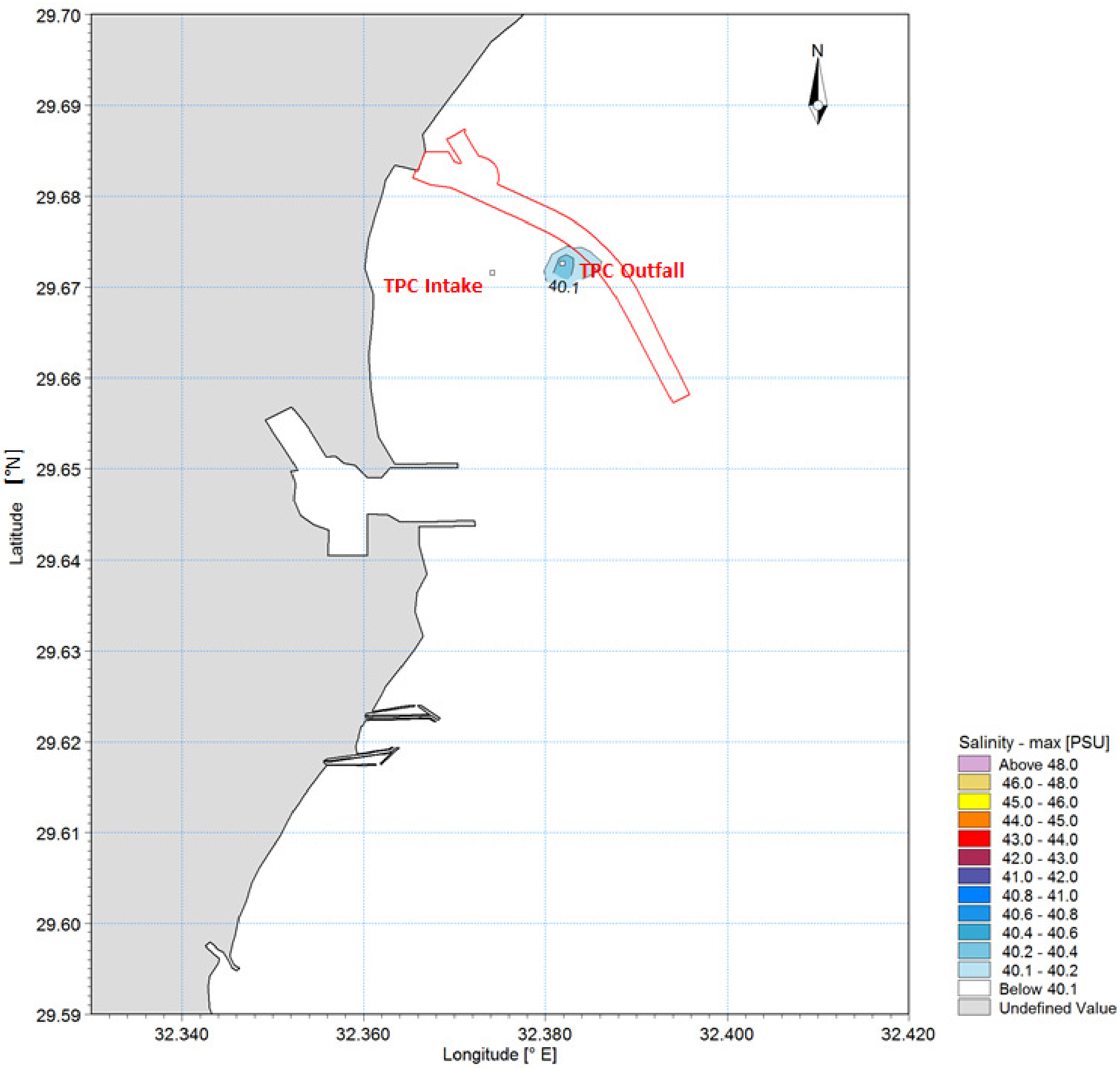

Figure 4-11: Maximum Salinity Plume at Seabed for Scenario 5 (Tidal Currents and N Wind) for Single Port Diffuser

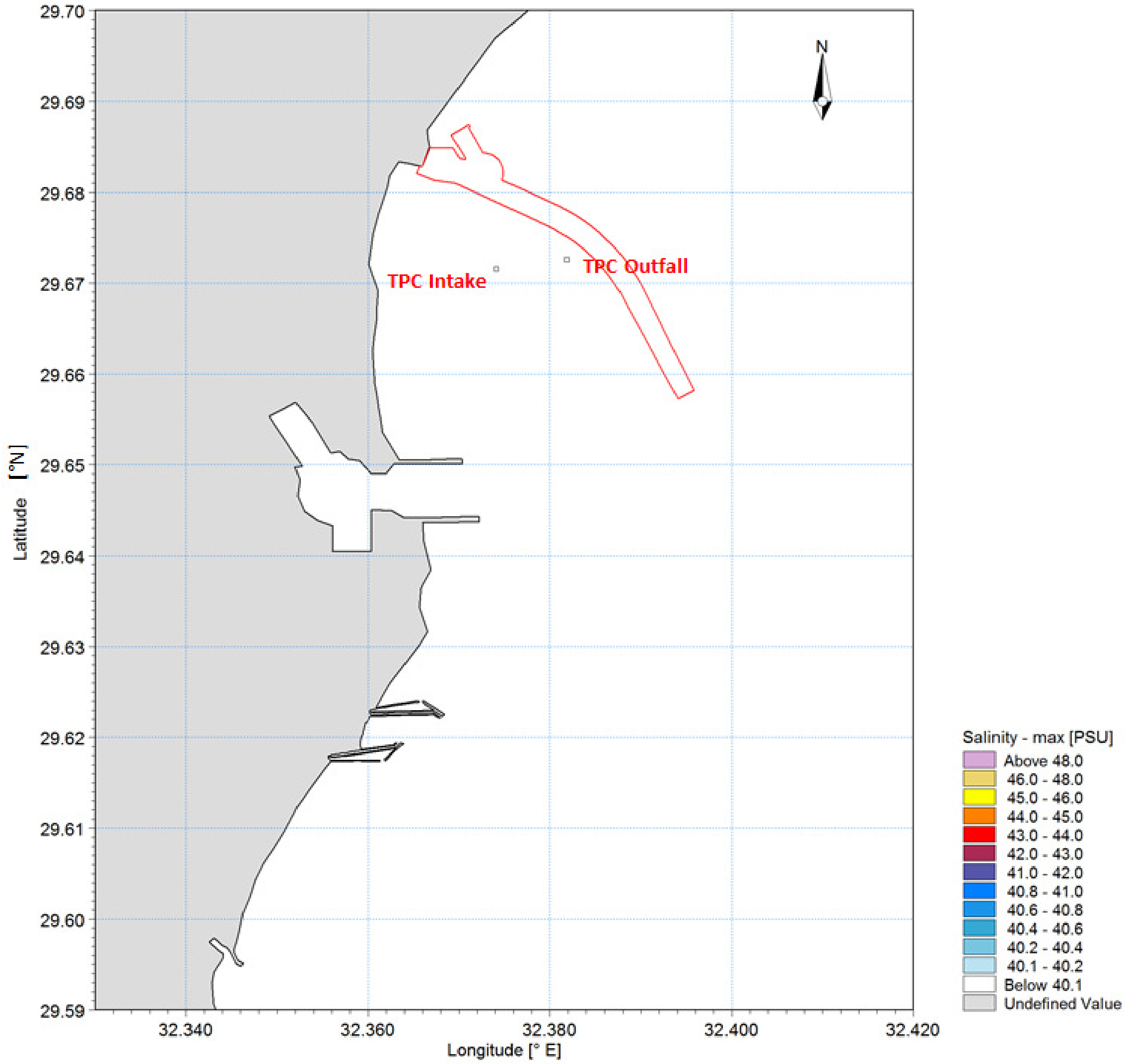

Figure 4-12: Maximum Salinity Plume at Surface for Scenario 5 (Tidal Currents and N Wind) for Single Port Diffuser

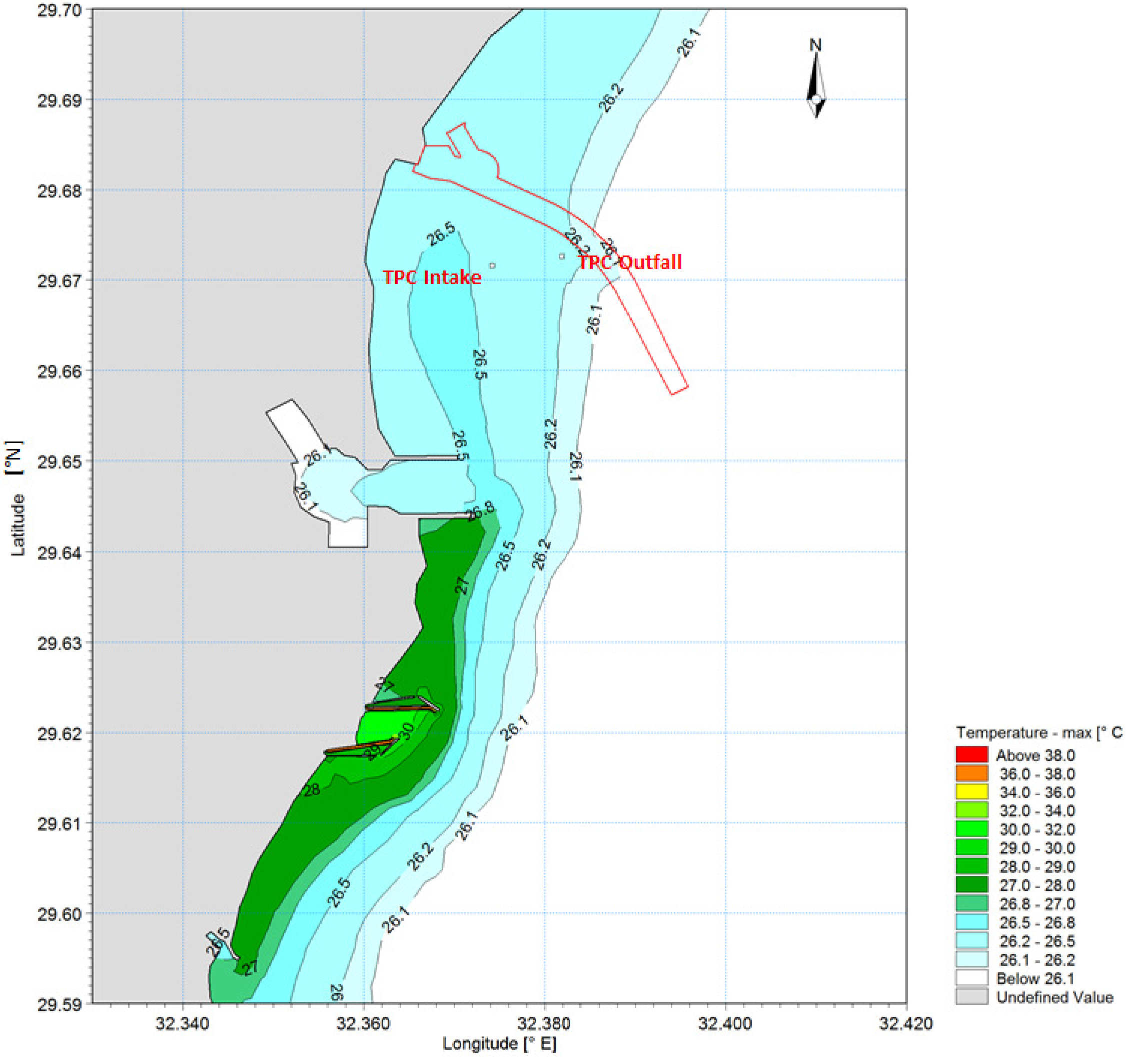

Figure 4-13: Maximum Temperature Plume at Seabed for Scenario 5 (Tidal Currents and N Wind) for Single Port Diffuser

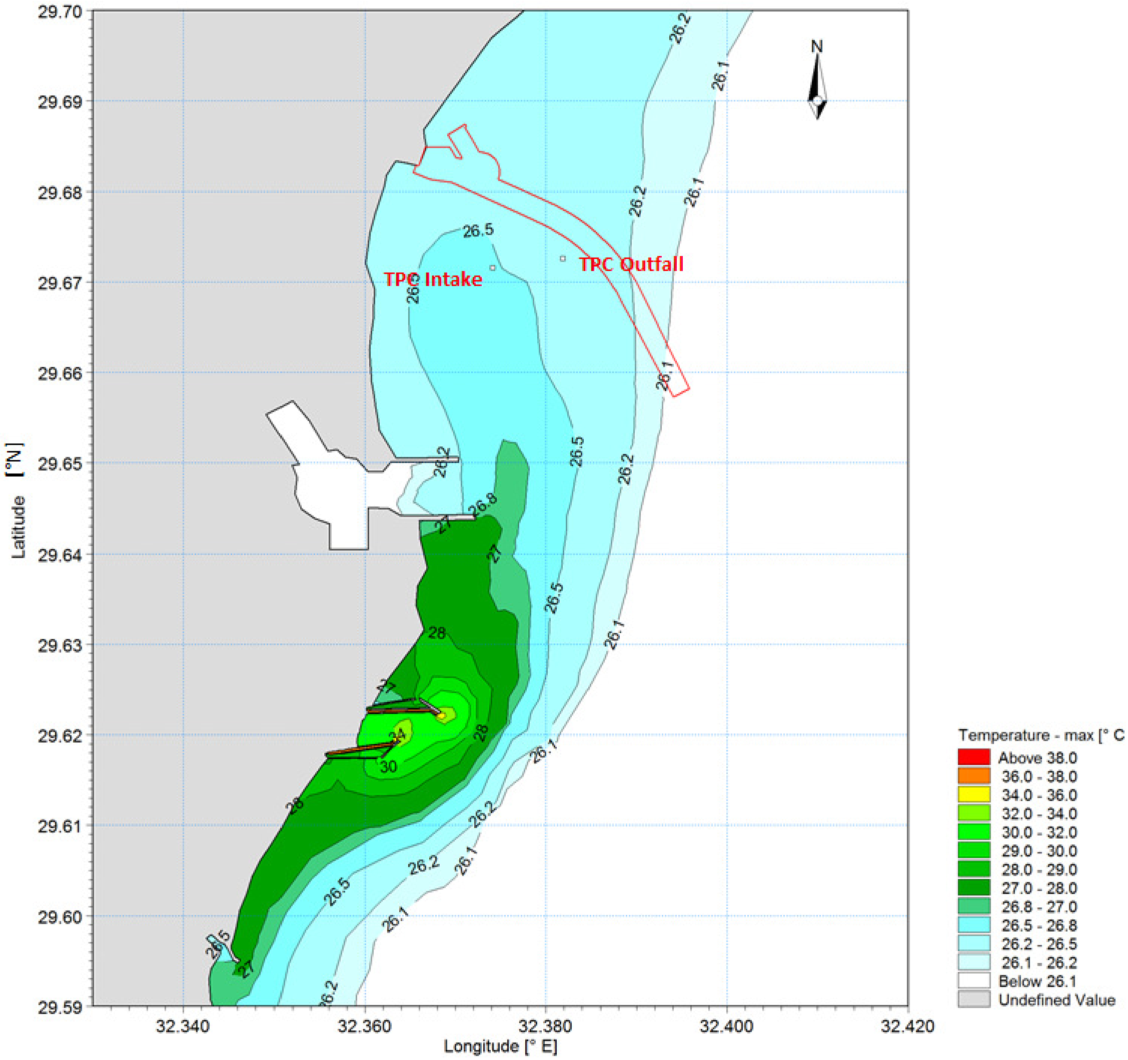

Figure 4-14: Maximum Temperature Plume at Surface for Scenario 5 (Tidal Currents and N Wind) for Single Port Diffuser

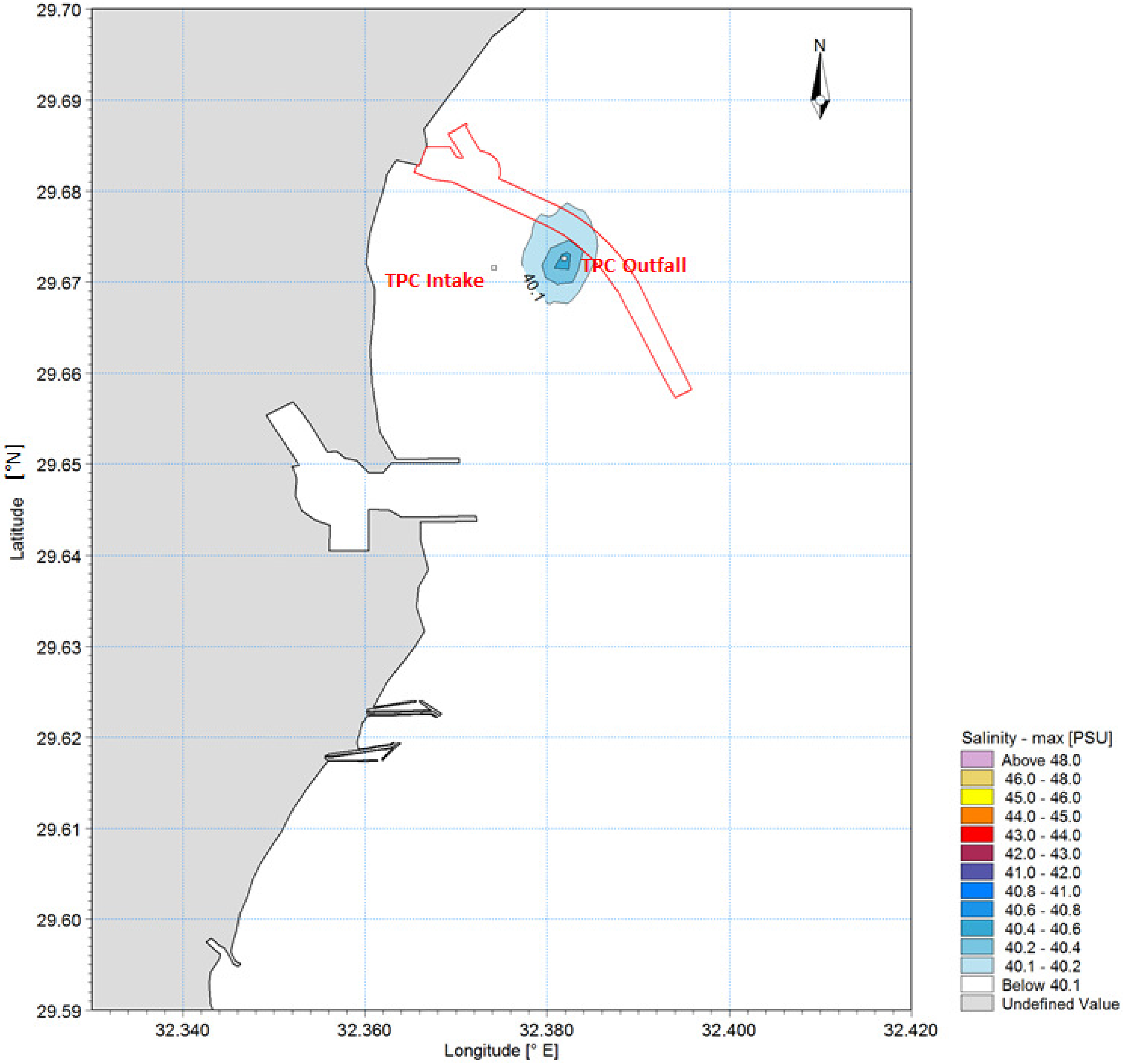

Figure 4-15: Maximum Salinity Plume at Seabed for Scenario 6 (Tidal Currents and S Wind) for Single Port Diffuser

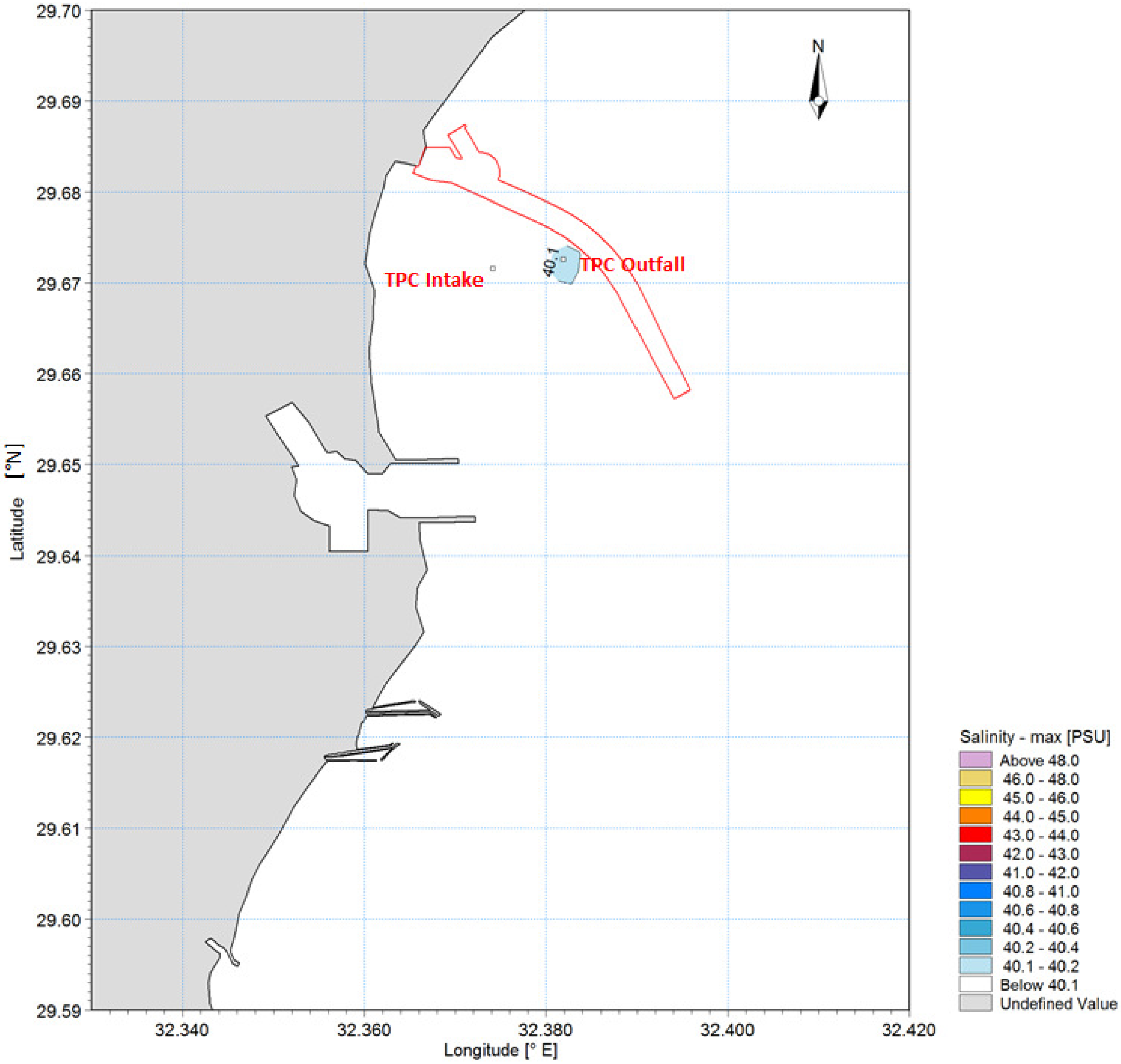

Figure 4-16: Maximum Salinity Plume at Surface for Scenario 6 (Tidal Currents and S Wind) for Single Port Diffuser

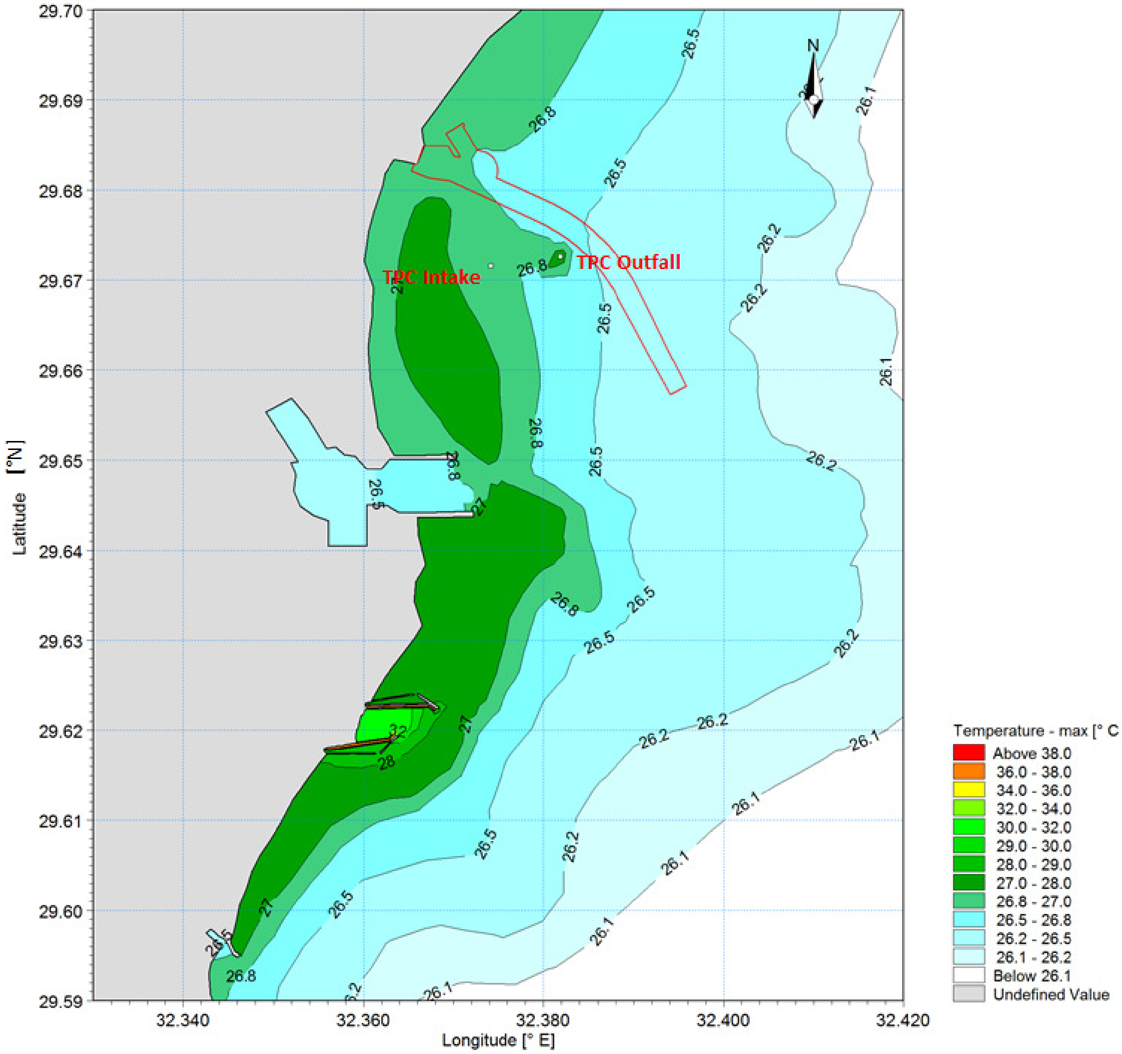

Figure 4-17: Maximum Temperature Plume at Seabed for Scenario 6 (Tidal Currents and S Wind) for Single Port Diffuser

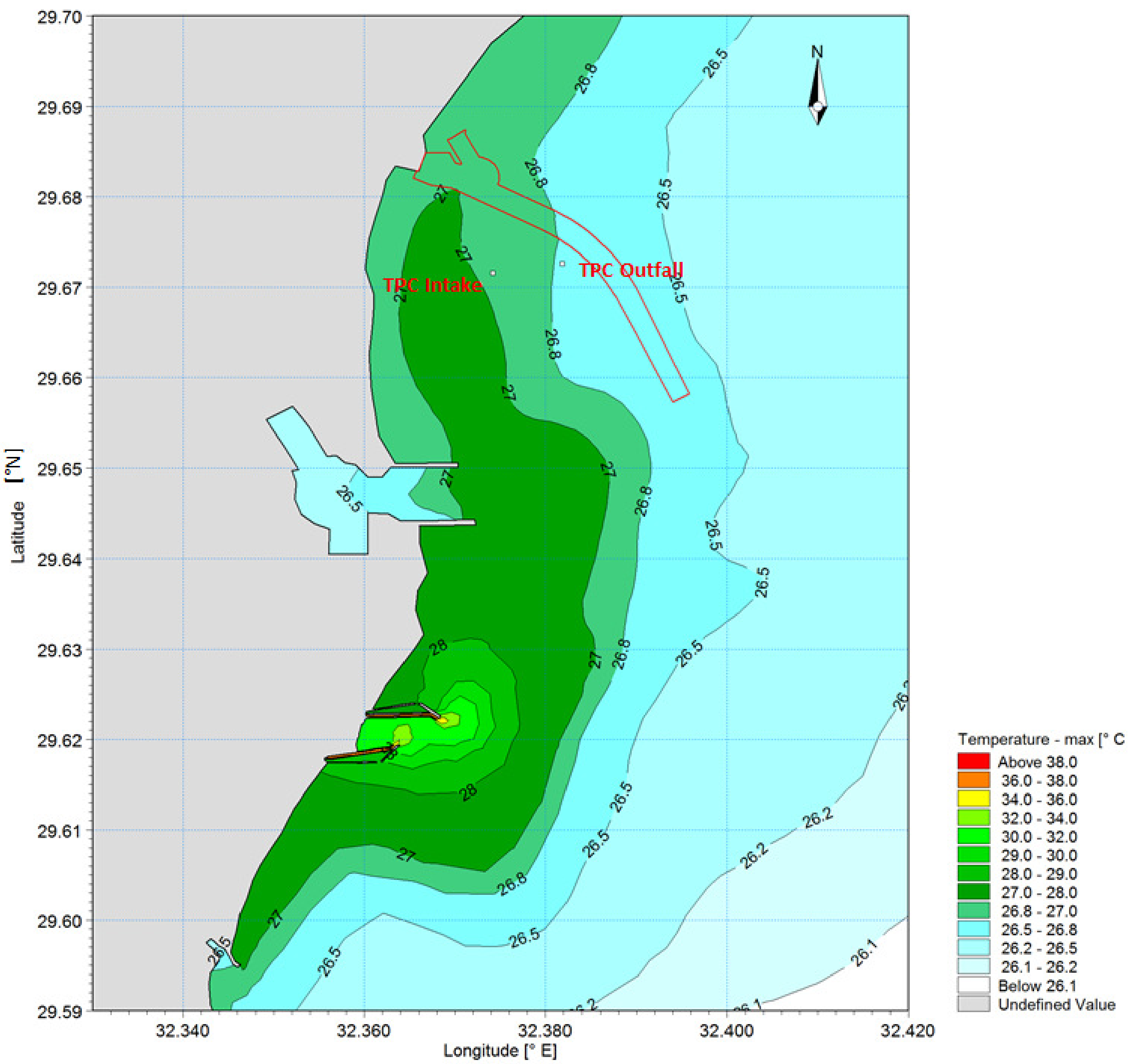

Figure 4-18: Maximum Temperature Plume at Surface for Scenario 6 (Tidal Currents and S Wind) for Single Port Diffuser

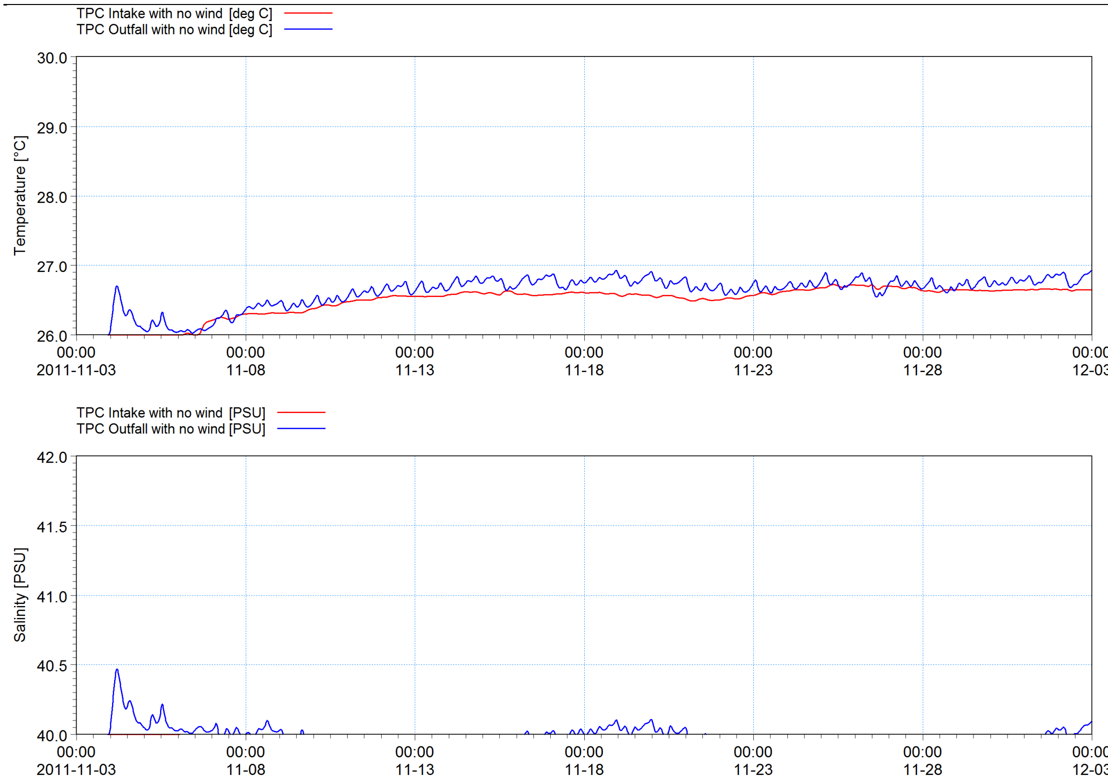

Figure 4-19: Time Series of Water Temperature and Salinity at Surface above Intake and Outfall (No Wind) for Single Port Diffuser

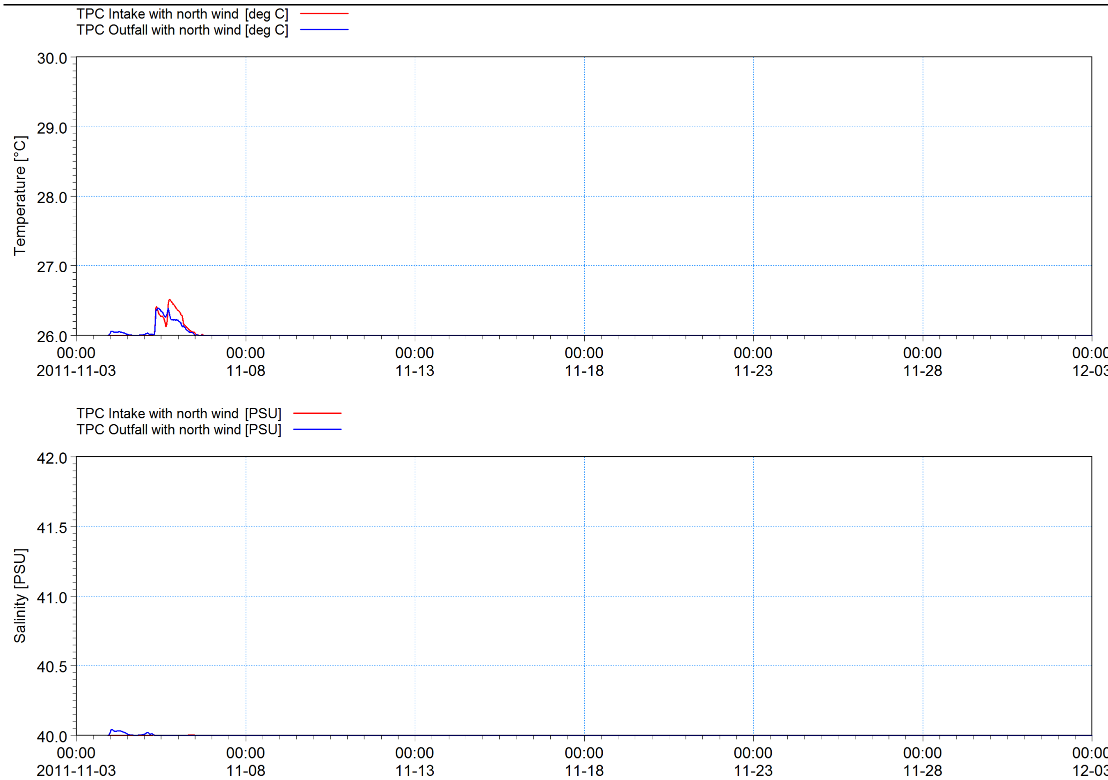

Figure 4-20: Time Series of Water Temperature and Salinity at Surface above Intake and Outfall (N Wind) for Single Port Diffuser

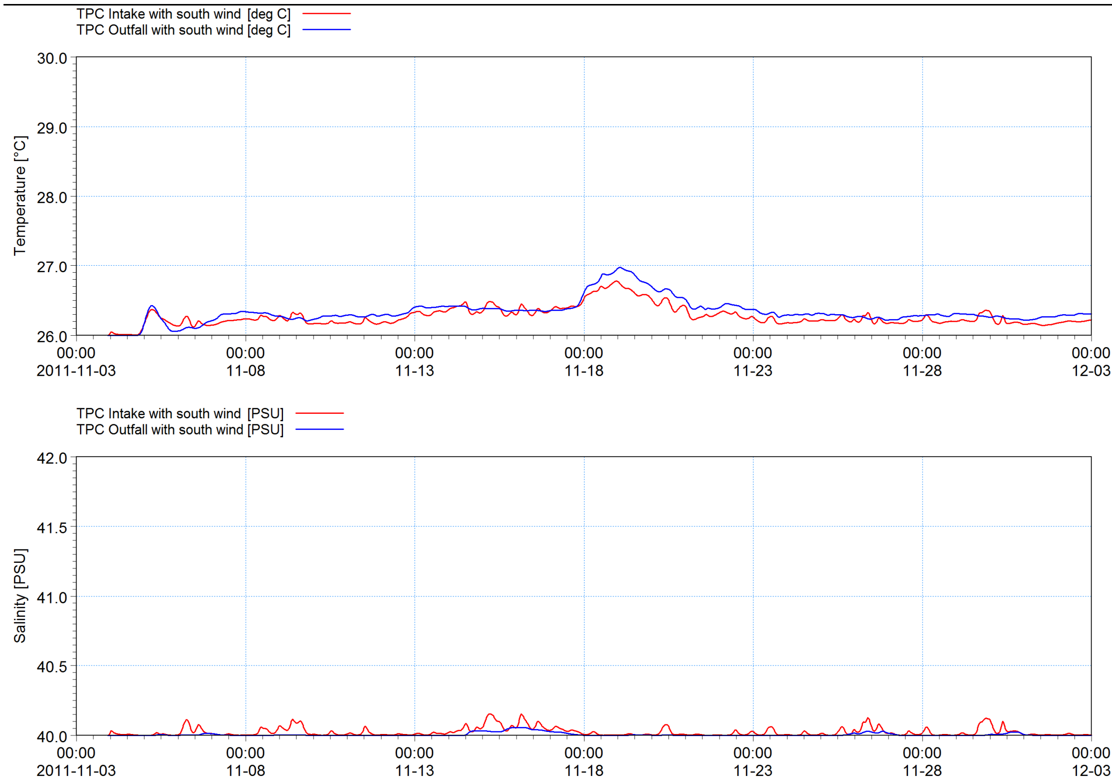

Figure 4-21: Time Series of Water Temperature and Salinity at Surface above Intake and Outfall (S Wind) for Single Port Diffuser

4.4 Existing and proposed power plant intake and outfall plus new TPC intake and outfall with Multiport Diffusers Scenario 7 (Tidal Currents and S winds)

This scenario defined the outfall system as multiport discharges (Figure 4-22) with a uniform distance between them. The discharge volume has been equally divided between the 5-points (i.e. 0.50 m^3/s).

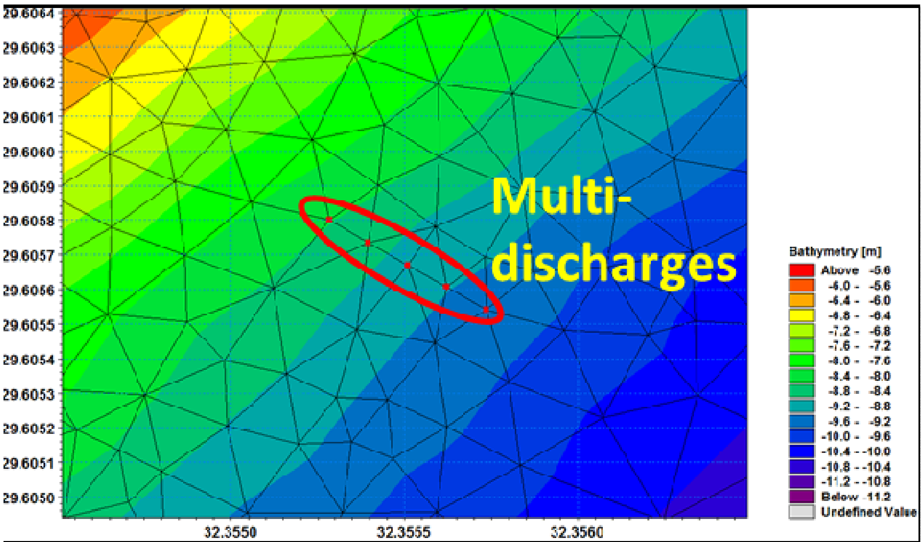

Figure 4-22: Typical Arrangement of Multi- Port Diffuser in the Model

The diffusers were proposed at the final 50 m of the outfall at 5 m intervals based on baseline simulations and previous experience with similar projects. Nevertheless, for the feasibility of model simulations, the diffusers were implemented every 10 m. Finer mesh had to be used in the model in order to keep diffusers at 5 m intervals and this would result in an increase in simulation time as well as model instability. Significant changes in results were not expected if the model was setup to keep diffusers at every 5 m.

Figure 4-23 to Figure 4-26 present the salinity plume and temperature dispersion plots.

The summary of the results are:

- As the outfall was schematized as multiport diffusers, the temperature and salinity are better mixed in the column of water;
- The selected outfall at this location has no impacts on the existing intake;
- The temperature/salinity plume from the selected outfall has a north, north-easterly trajectory and has no impacts on the existing intake;
- Results indicate that an outfall at this location with the intake to the south is feasible with no risks to the existing and proposed power plant intake/outfall;
- A comparison with single diffuser indicates that multi-point discharge is slightly more efficient than single port diffuser.

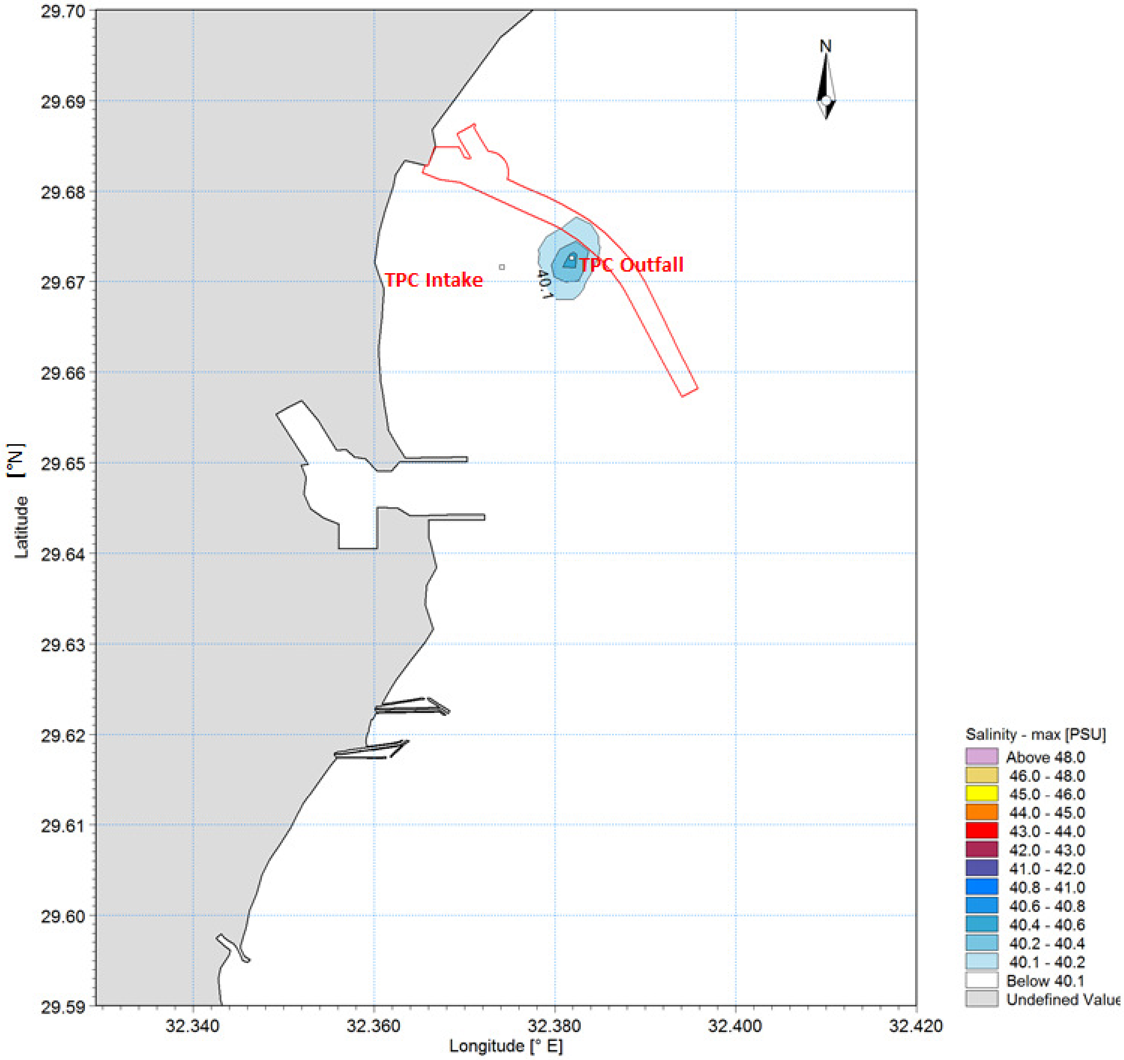

Figure 4-23: Maximum Salinity Plume at Seabed for Multi-port Diffusers

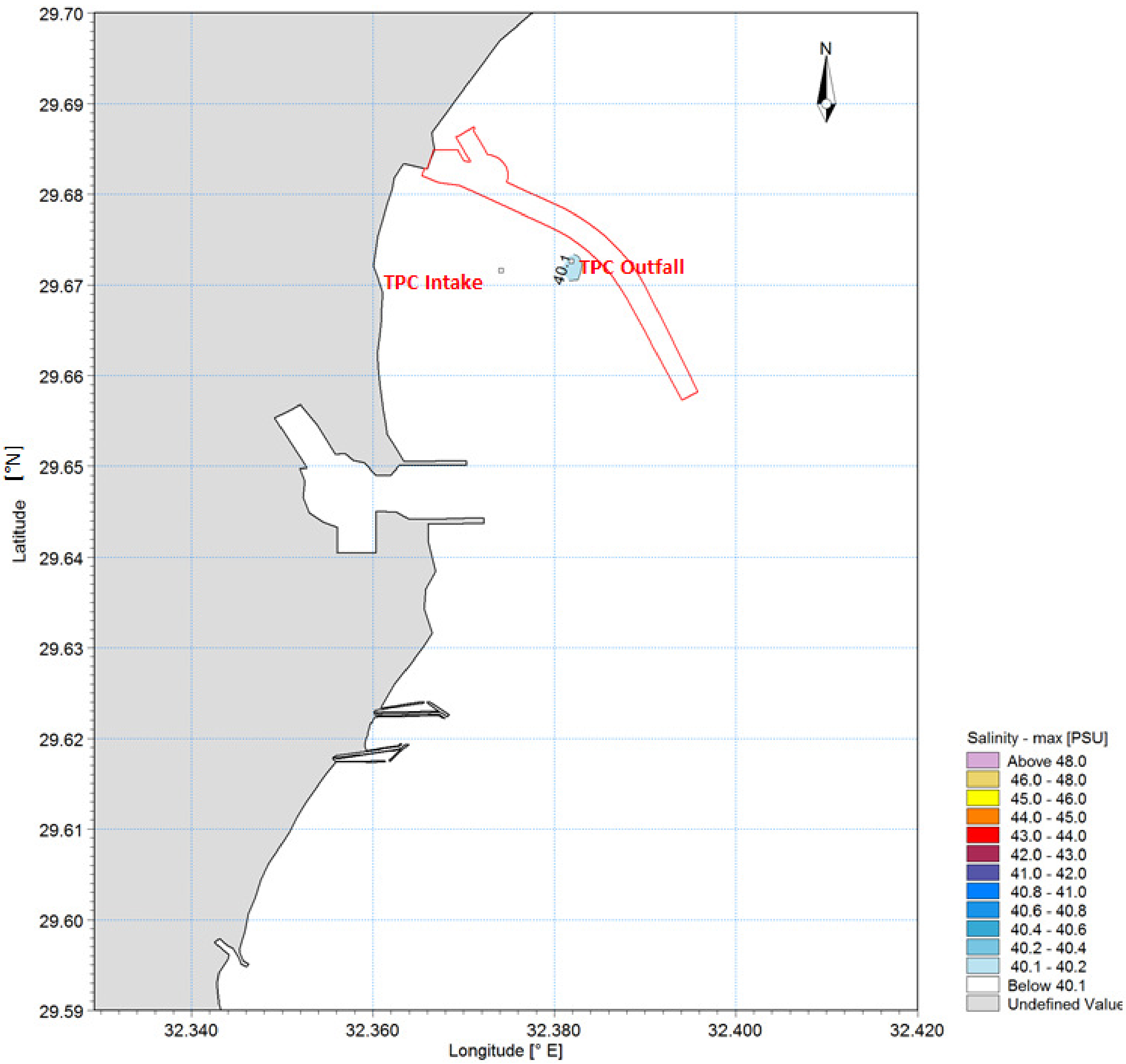

Figure 4-24: Maximum Salinity Plume at Surface for Multi-port Diffusers

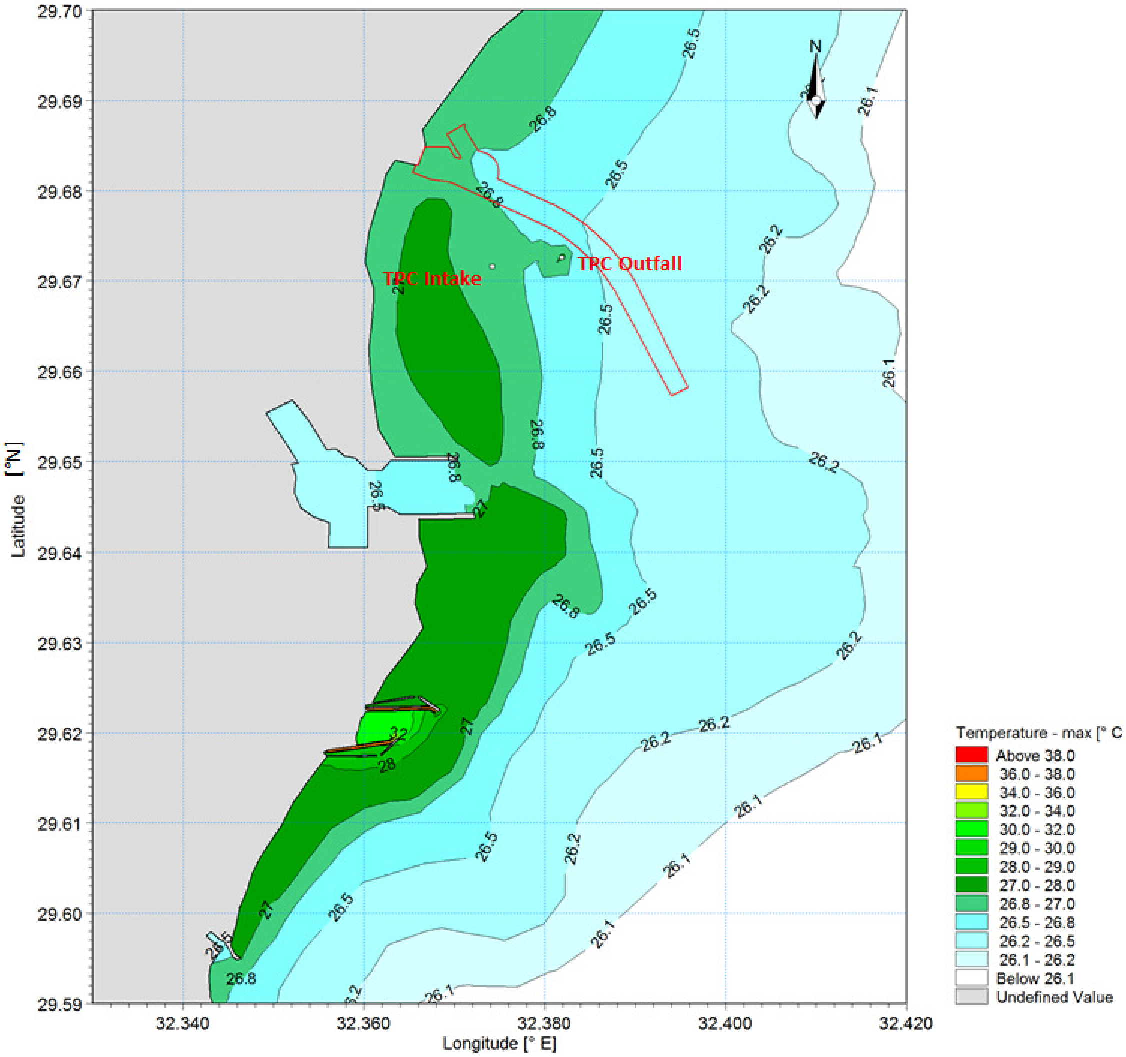

Figure 4-25: Maximum Temperature Plume at Seabed for Multi-port Diffusers

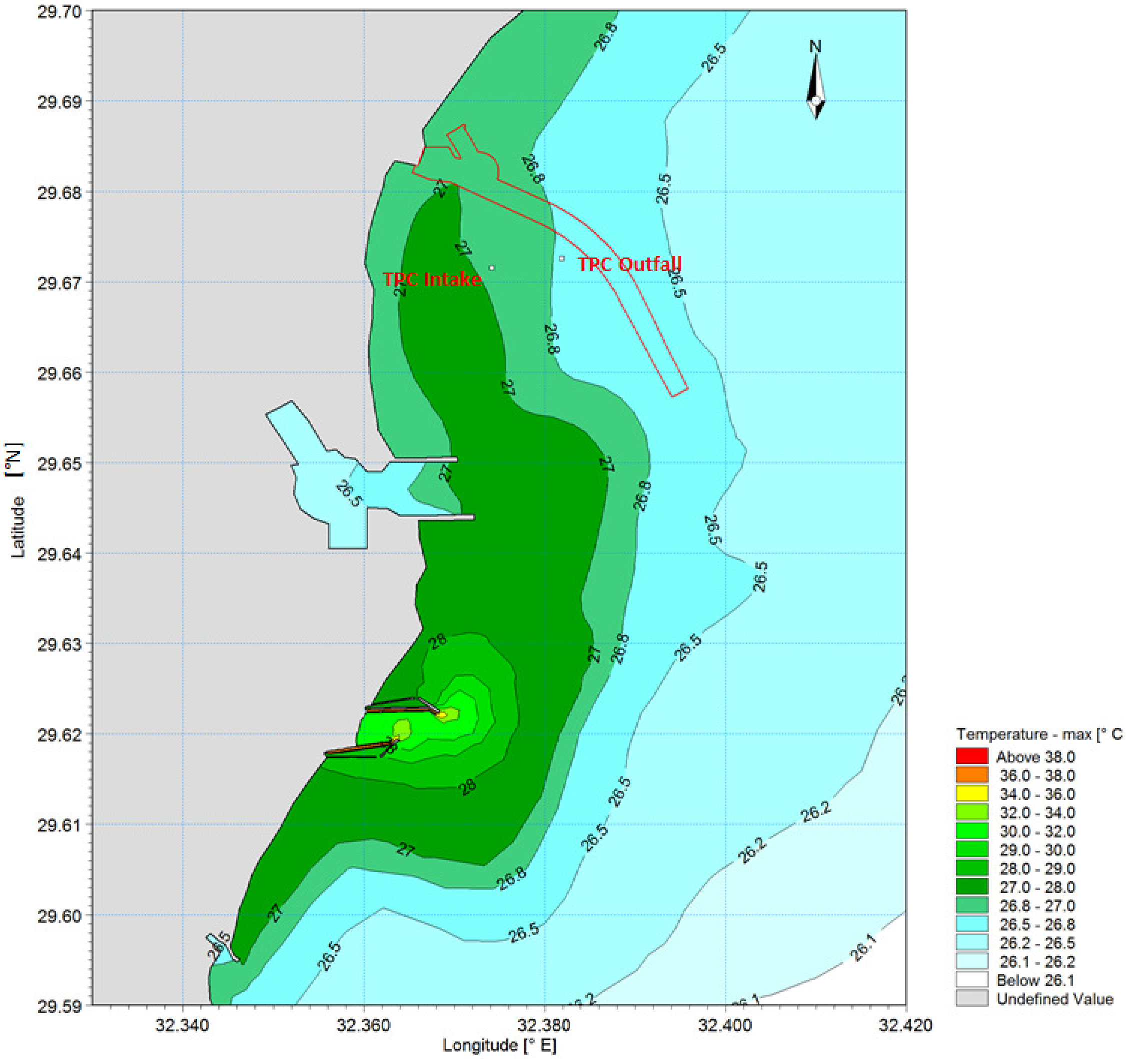

Figure 4-26: Maximum Temperature Plume at Surface for Multi-port Diffusers

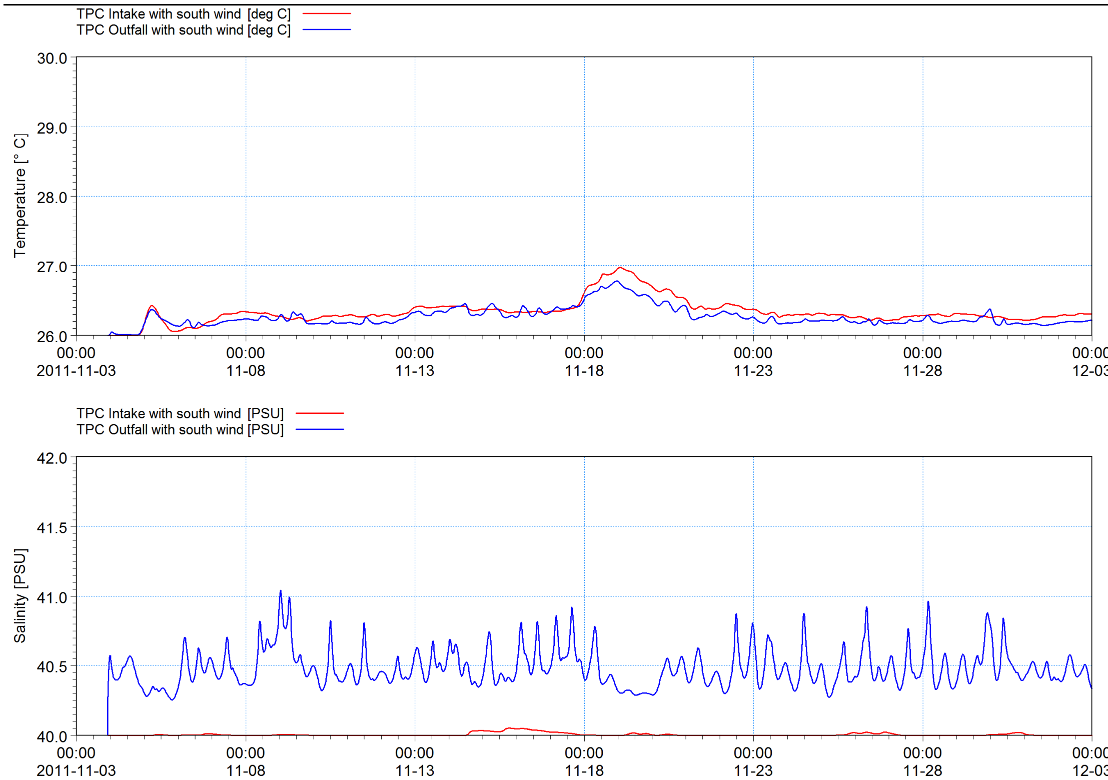

Figure 4-27: Time Series of Water Temperature and Salinity at Surface above Intake and Outfall for Multi-port Diffusers

5. COMPARISON OF MODELLING RESULTS AGAINST APPLICABLE ENVIRONMENTAL CRITERIA

This section presents the assessment of the effluent dispersion model results against environment regulations presented in Section 2.3.

5.1 Excess Salinity Plots

Figure 5-1 to Figure 5-6 presents the excess salinity plots at the seabed and surface under no wind, N wind and S wind conditions for the single and multiport diffusers. The purple circle around the selected outfall locations represents the 100 m radius of the World Bank regulations (WB) mixing zone. The results show that the selected location complies with the limit of the World Bank guidelines. It is worth noting here that there is no limit for salinity in the national regulation.

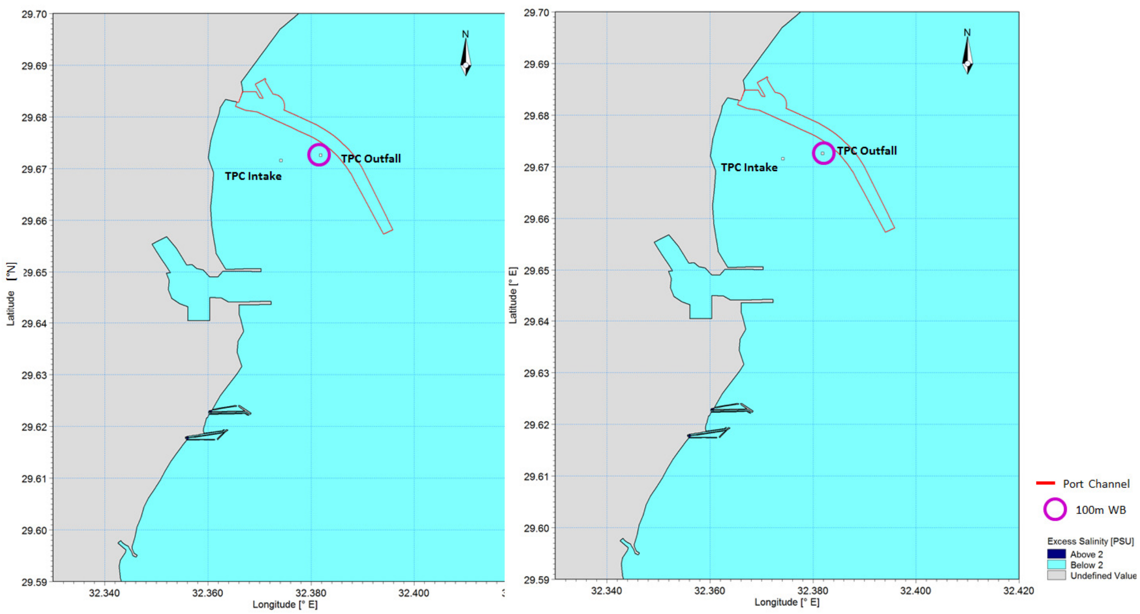

Figure 5-1: Excess Salinity at Seabed (Left) and Surface (Right) for No Wind – Single Discharge

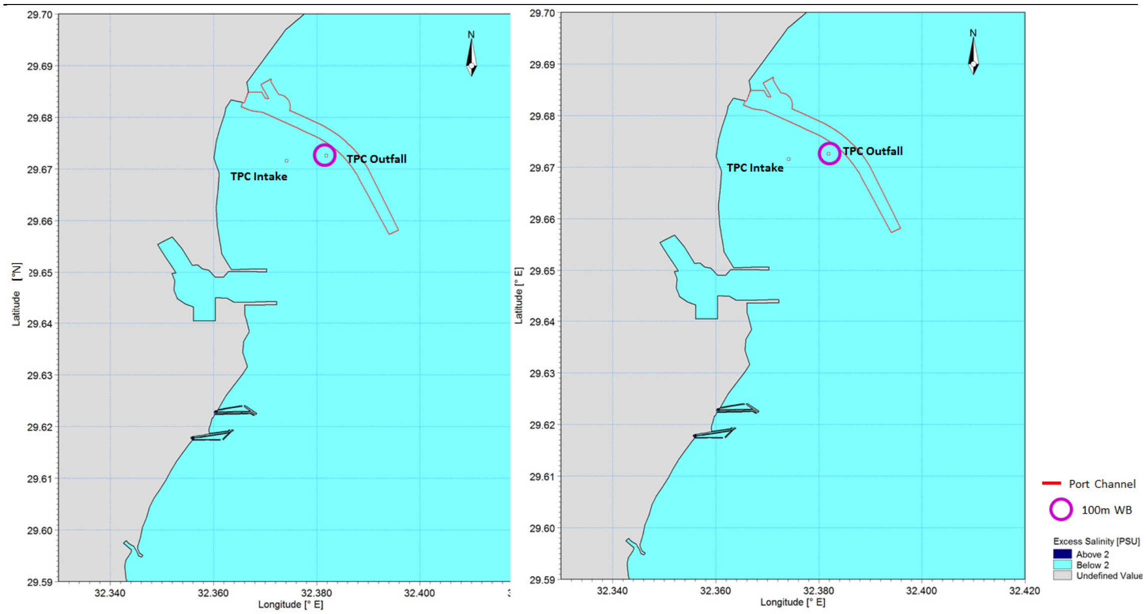

Figure 5-2: Excess Salinity at Seabed (Left) and Surface (Right) for N winds – Single Discharge

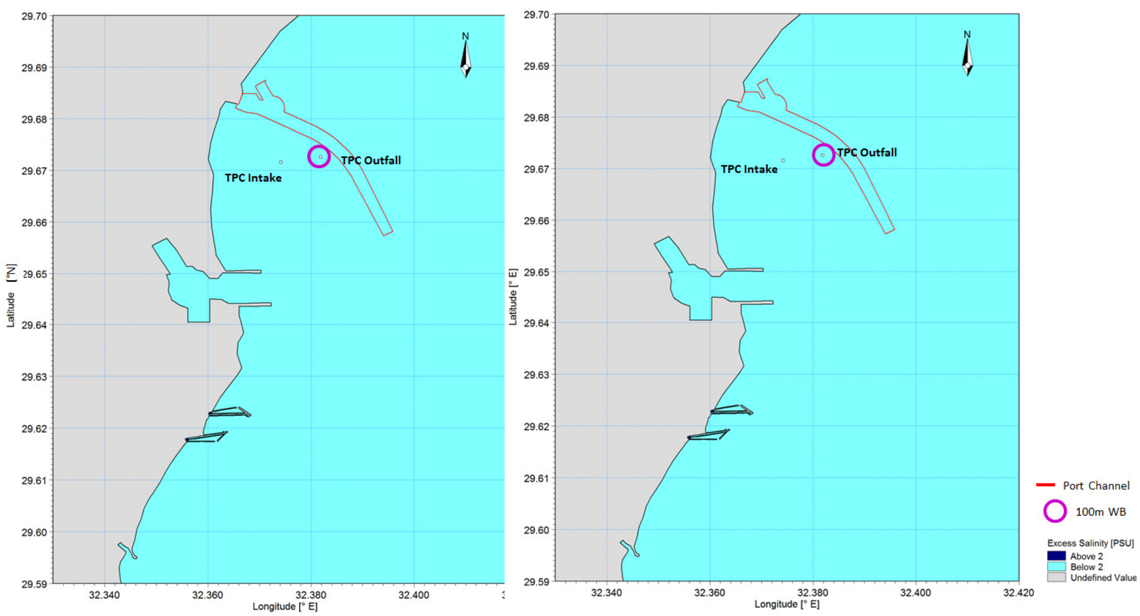

Figure 5-3: Excess Salinity at Seabed (Left) and Surface (Right) for S winds – Single Discharge

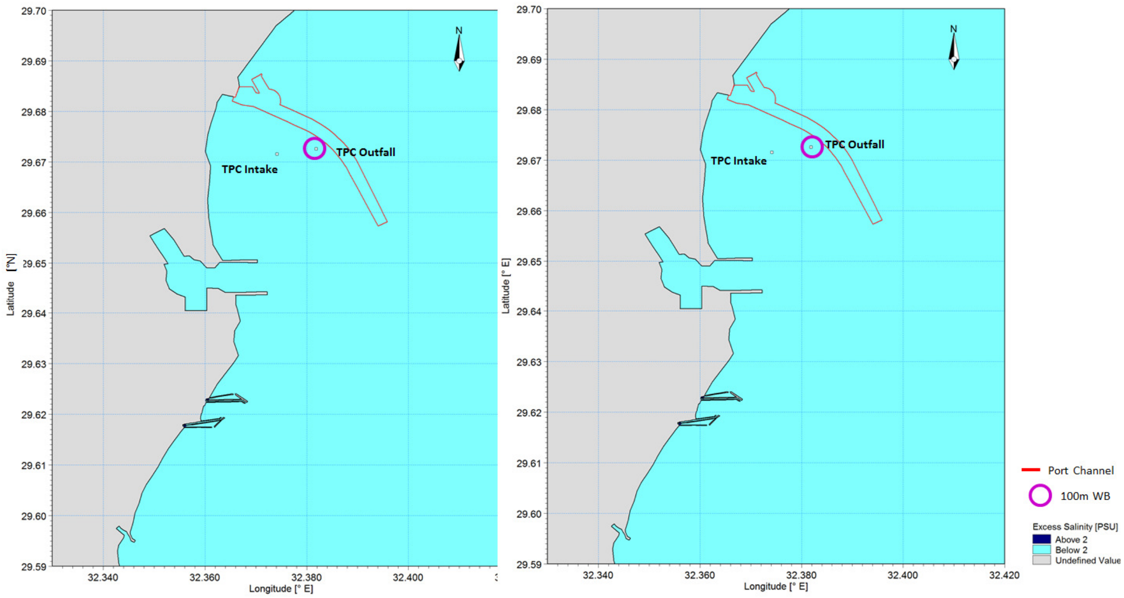

Figure 5-4: Excess Salinity at Seabed (Left) and Surface (Right) for No Wind – Multiport Diffuser

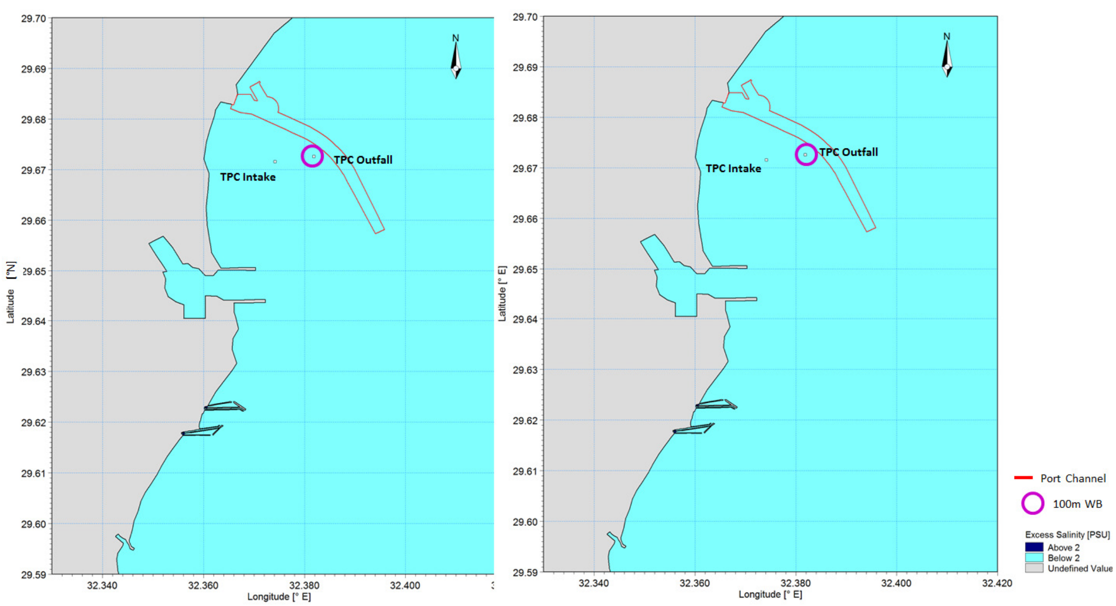

Figure 5-5: Excess Salinity at Seabed (Left) and Surface (Right) for N winds – Multiport Diffuser

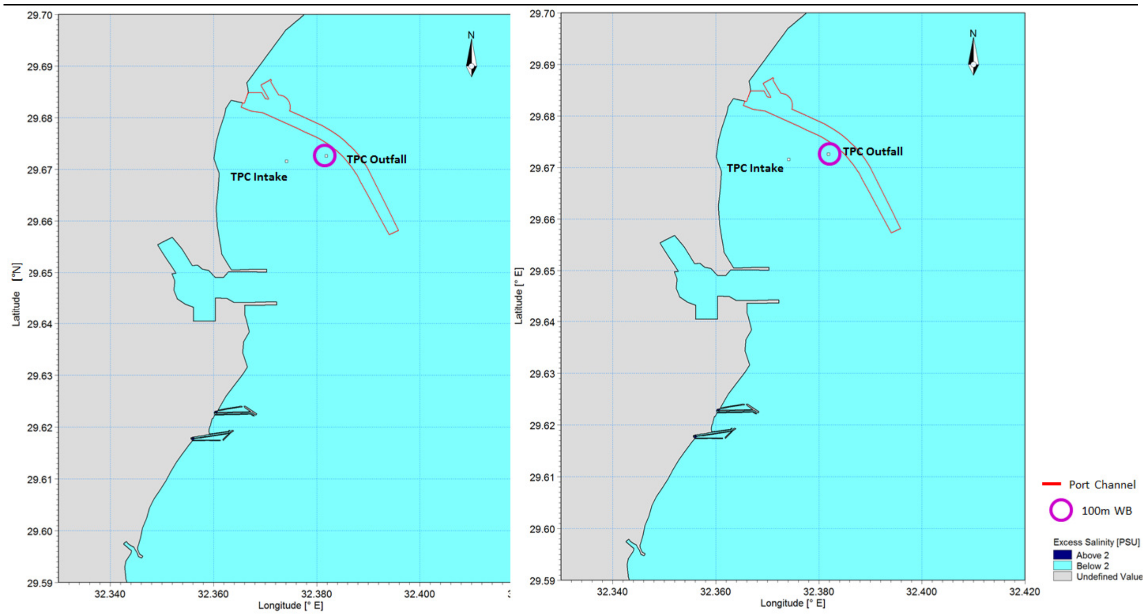

Figure 5-6: Excess Salinity at Seabed (Left) and Surface (Right) for S winds – Multiport Diffuser

5.2 Excess Temperature Plots

Figure 5–7 to Figure 5-12 present the excess temperature plots at the seabed and surface under no wind, N wind and S wind conditions for the single port and multiport diffusers. The purple circle around the selected outfall locations represents the 100 m radius of the World Bank regulations (WB) mixing zone. The results show that the selected location complies with the limit of the national regulation and the more stringent World Bank guidelines.

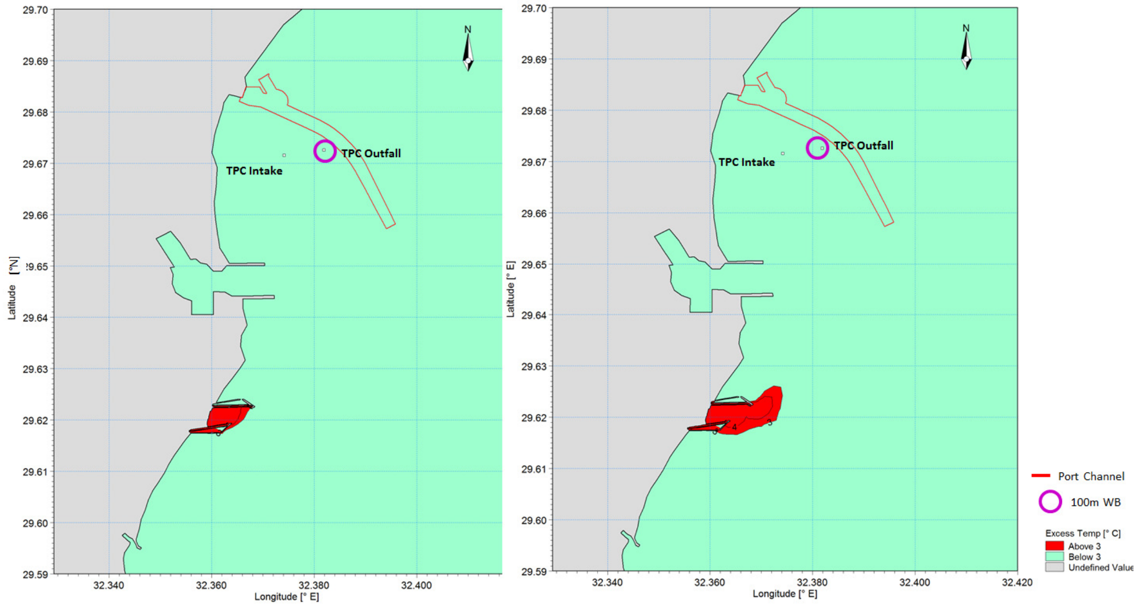

Figure 5-7: Excess Temperature at Seabed (Left) and Surface (Right) for No Wind – Single Discharge

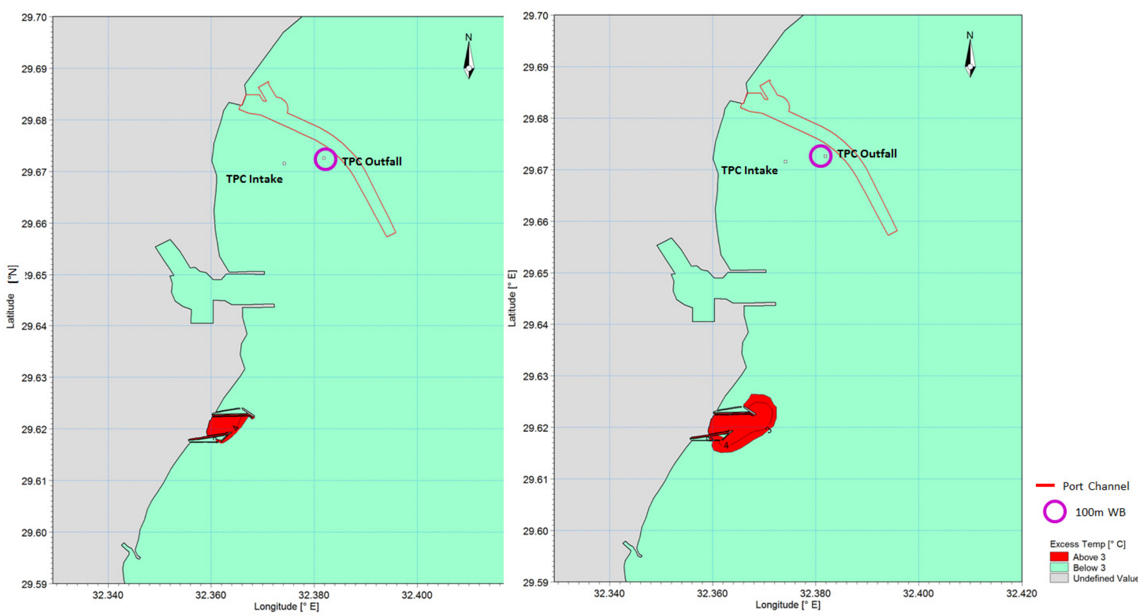

Figure 5-8: Excess Temperature at Seabed (Left) and Surface (Right) for N winds – Single Discharge

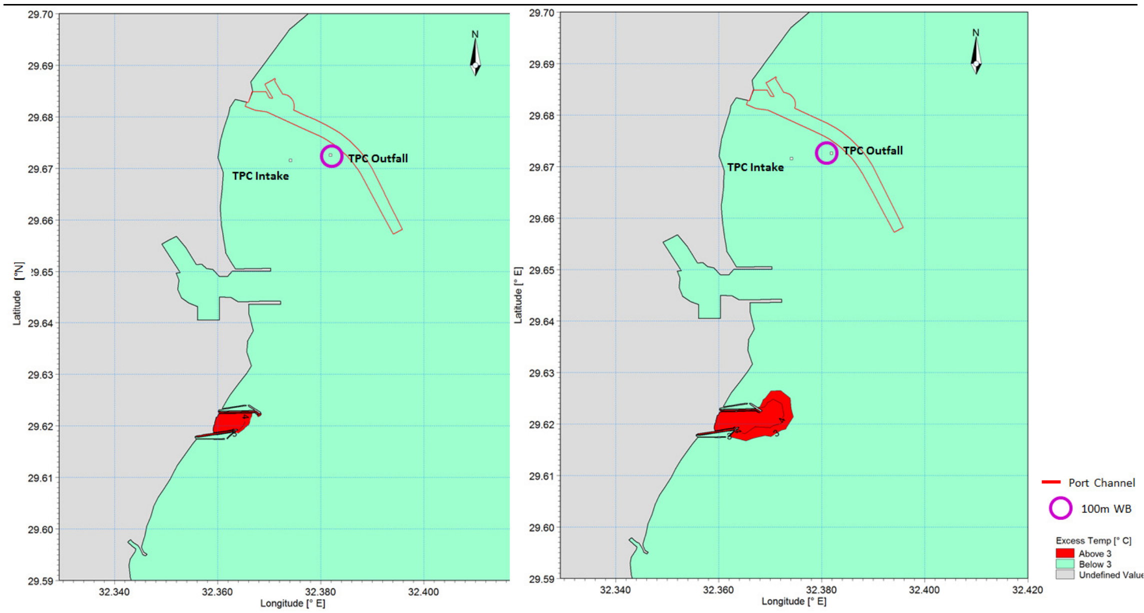

Figure 5-9: Excess Temperature at Seabed (Left) and Surface (Right) for S winds – Single Discharge

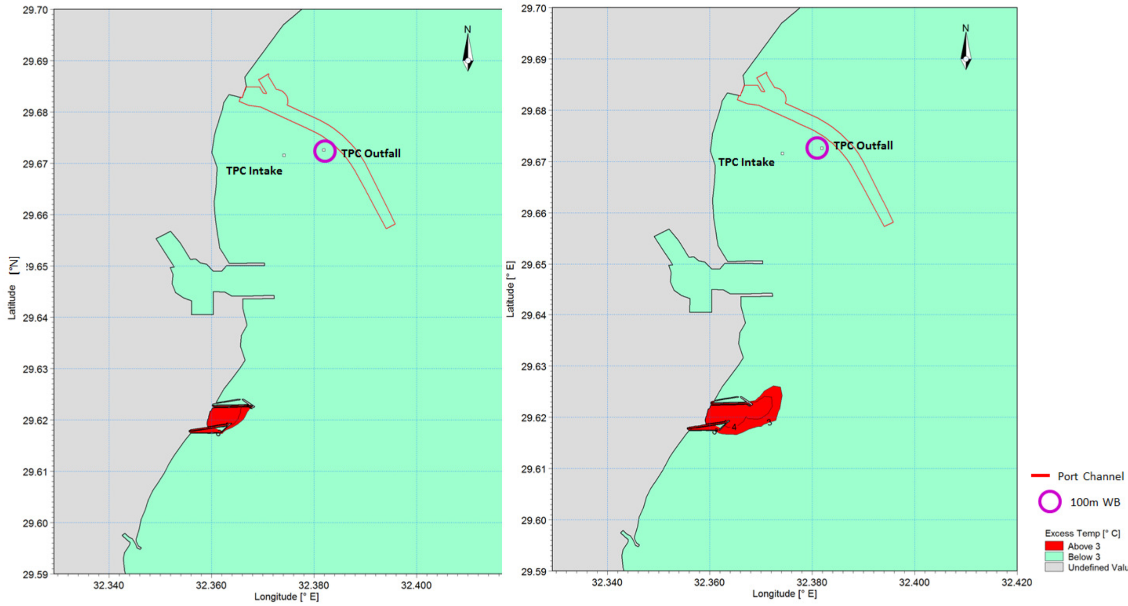

Figure 5-10: Excess Temperature at Seabed (Left) and Surface (Right) for No Wind – Multiple Diffuser

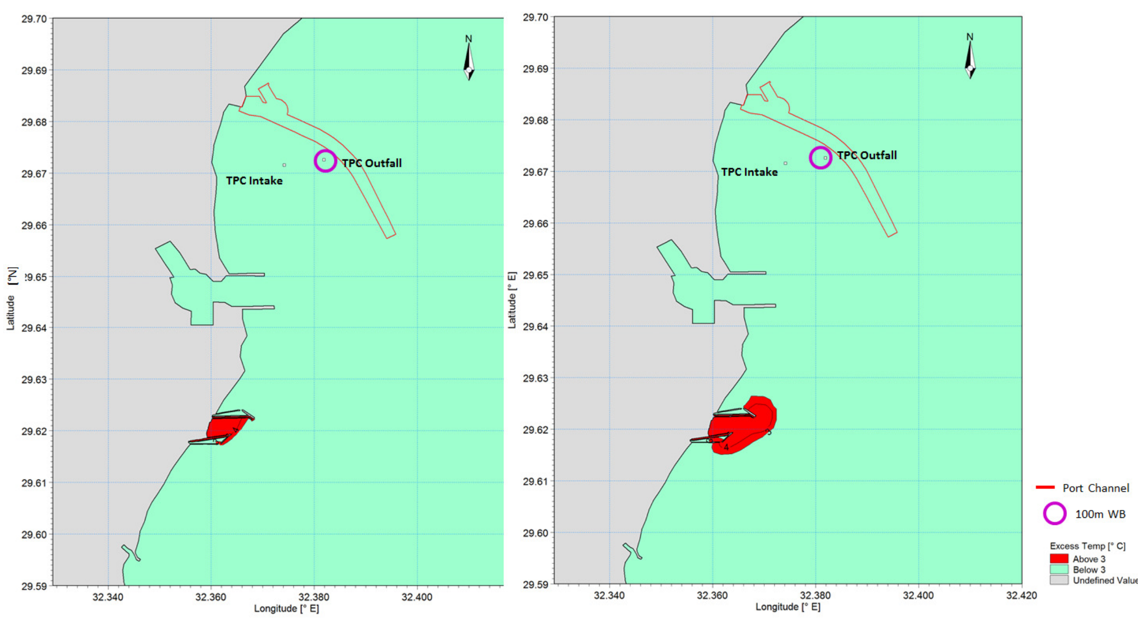

Figure 5-11: Excess Temperature at Seabed (Left) and Surface (Right) for N winds – Multiple Diffuser

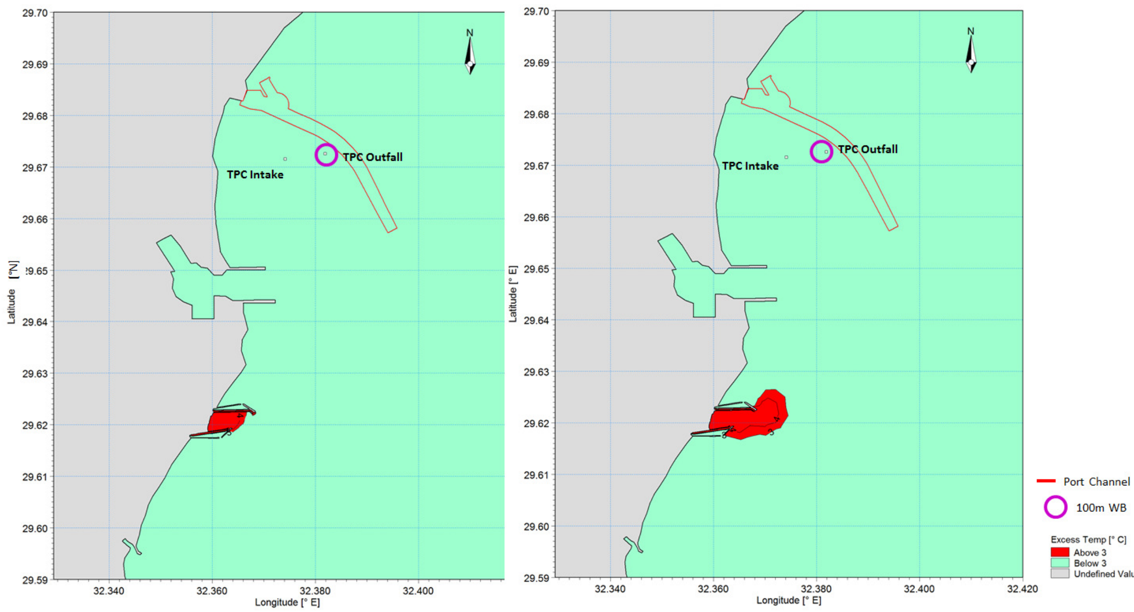

Figure 5-12: Excess Temperature at Seabed (Left) and Surface (Right) for S winds – Multiple Diffuser

5.3 Discussion

The following conclusions were drawn based on the comparison between the modelling results and environmental criteria:

- The selected intake/outfall meets the marine environmental criteria in terms of temperature and salinity under the simulated conditions and does not have any detrimental effect on the existing and proposed new power plant intakes/outfalls
- There is no increasing trend in the temperature or salinity with time indicating that the effluent is well mixed in the water column without any accumulation over the simulation period
- The selected intake/outfall is not expected to have detrimental effects on the Sokhna 1 (McDermott) Port to the north, DP World Sokhna Port to the south of the project site
- The selected outfall does not cause any recirculation of brine with the TPC intake or with the existing and proposed new power plants.

Since there is no evident increase in salinity close to the intake due to the effluent discharge being adequately diluted to the ambient salinity levels, the temperature will be the factor used to assess recirculation patterns.

The local 3D model automatically accounts for recirculation by constantly adjusting the outfall temperature (T) to be ΔT higher than the intake temperature at each time step. As discussed in

Section 3.5.2, the simulations have been performed with a constant ambient temperature of 26℃. This means that temperature build-up due to recirculation is simulated explicitly. The simulation results have been anaylsed to determine the recirculation of the thermal plume from the Complex outfall back to the Complex intake. The results Figure 4-7 to Figure 4-26 and Figure 5-1 to Figure 5-12 are used to assess the recirculation pattern between the Complex intake and outfall. These plots show that the temperature difference between intake and outfall does not increase by more than 0.5℃, which would indicates there is no significant temperature build up i.e. recirculation of heated effluent over the simulation period. Moreover, the outfall does not increase the ambient temperature of the surroundings by more than 3℃.

6. SELECTED INTAKE AND OUTFALL ROUTE IDENTIFICATION

This section presents the proposed preliminary route for the onshore and offshore intake/outfall pipelines that was selected based on the Pre-FEED data. Should there be any changes/modification in the As-built design; the proposed route is to be updated accordingly..

6.1 Upland Restrictions

The route identification considered the following restrictions that were proposed by the Client:

- The pipeline route should follow where possible existing roads;
- The pipeline route should minimize roads, highways and fences crossings.

6.2 Route Description

The proposed route for the intake/outfall is presented in Figure **6-1** and consists of:

- The pipelines leave the pumpstation to the shoreline;
- The pipelines then extend into the ocean where the intake and outfall pipes diverge at a depth of approximately -2 m CD;
- The outfall pipeline continues to the south east to a depth of -10.8 m CD;
- The intake pipeline continues to the south-south east to a depth of -7.5 m CD;
- The outfall pipeline length is 1 960 m
- The intake pipeline length is 1 450 m.

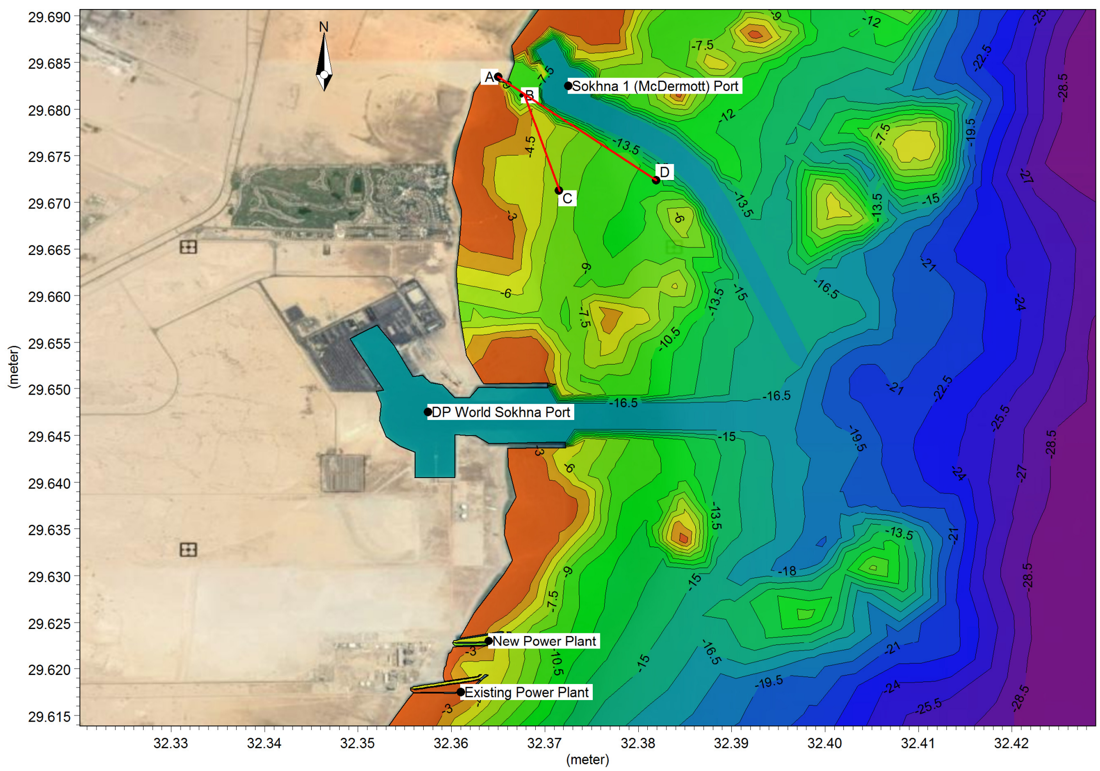

Figure 6-1: Proposed Pipeline Route for selected Intake and Outfall

Table 6-1: Coordinates of Pipeline Route Identification Points

Point	**Long (° E)**	**Lat (° N)**
A (Pump Station)	32.361076	29.681355
B	32.367500	29.681500
C (Selected Intake)	32.371500	29.671292
D (Selected Outfall)	32.381919	29.672385

7. SUMMARY OF RESULTS AND RECOMMENDATIONS

This section presents the summary of results presented in this study including a list of recommendations. It is worth mentioning that these results and recommendations are based on the Pre-FEED data. In case of changes/modification to the present data, an update of both the results and recommendations is required.

The key findings of this study are as follows:

- Currents at the site are very mild, seldom reaching values higher than 0.2 m/s and are predominantly to the North, and North West;
- The construction of the new power plant intake/outfall structure prevents the advection of the thermal plume from the existing power plant intake/outfall northwards;
- The selected intake/outfall modelling results showed that:
    - It complies with both the national and WB applicable environmental criteria in terms of salinity and temperature for the cases of single and multiple diffuser;
    - It is more than 500 m away from the shoreline as per Egyptian regulations;
    - It presents no recirculation between the selected intake and outfall (even under the assumed worst case of southerly winds);
    - It presents no risks in terms of water recirculation between the existing and proposed new power plant intakes/outfalls, and the selected intake/outfall (even under the assumed worst case of southerly winds);
    - It does not have any detrimental effect on the existing and proposed new power plant intakes/outfalls, the DP World Sokhna Port or the Sokhna 1 (McDermott) Port;
    - It is outside the environmental noncompliance area resulting from the existing and proposed new power plant thermal plume
- The onshore and offshore route for the pipeline was developed; and
- The pipeline route may possibly consist of an inter-tidal zone of ~70 m, which has to be verified during the later stages of the project with survey data.

The following recommendations are proposed:

- Present the selected intake/outfall and pipeline route to all stakeholders to confirm that the proposed location and route are feasible. The proposed pipeline route and desalination plant location will be refined as part of the next design phases;
- Perform a topographic and bathymetric survey covering the pipelines route to assess any potential obstacles that could compromise the feasibility of the proposed route;
- Conduct geotechnical and geophysical surveys along the proposed pipeline routes to assess the feasibility of excavation for the pipeline installation and definition of best shore crossing methods; and

- Conduct a detailed metocean survey covering winds, waves, currents and water quality at the selected outfall location to improve confidence in the numerical model results (Figure 7-1). This should be done using an Acoustic Doppler Current Profiler (ADCP) or similar, a meteorological station, and a CTD (Current, Temperature and Density) Profiler. The survey data will also support the establishment of more detailed design conditions.

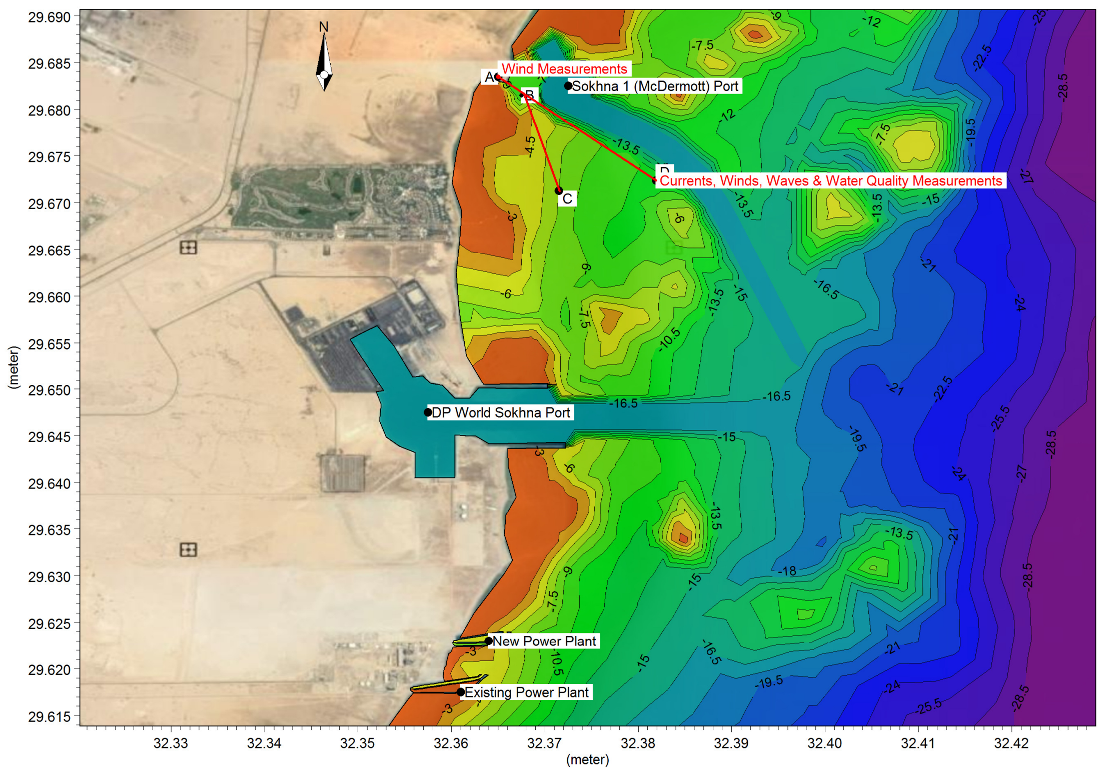

Figure 7-1: Proposed Metocean Measurement Locations

8. SUPPORTING INFORMATION FROM PREVIOUS STUDY

This section presents concept design for different components of the intake/outfall supporting structures (e.g. mixing chamber). This design is based on the Pre-FEED data and to be updated according to the As-Built design in case of any modifications/changes.

8.1 On-Land Water Mixing Chamber

8.1.1 Introduction

WorleyParsons scope of work includes investigating an on-land mixing chamber that could minimize either costs or detrimental effects to the environment. This section presents the analytical analyses performed to assess the feasibility of implementing an on-land mixing chamber at the project site. Figure 8-1 presents an example of a mixing chamber.

The study considered the alternative: Desalination Plant effluent is mixed with seawater in a mixing chamber to dilute its salinity to the levels required by the environmental authorities before discharging to the sea.

An option of using fresh water in a mixing chamber to dilute its salinity to the levels required by the environmental authorities is not considered since there are not known sources of fresh water at the project site.

Mixing chambers normally use two different homogenized effluents before discharging into the sea and not very often mixing chambers are used to dilute water from one single effluent. The on-land mixing chamber is investigated in this study as per client request.

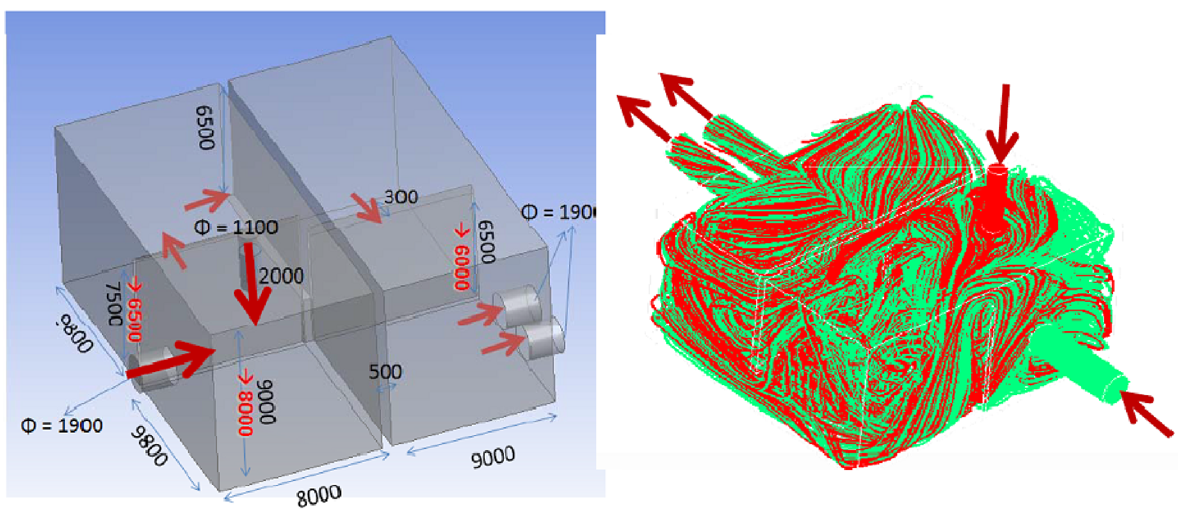

Figure 8-1: Example of Mixing Chamber

8.1.2 Methodology

The methodology followed by WorleyParsons to investigate the feasibility of implementing a mixing chamber is as follows:

- The dilution required for Desalination Plant effluent mixed with sea water was assessed via analytical calculations
- The required size of the mixing chambers is assessed based on required dilution

8.1.3 Dilution Calculations

The first step of the analysis is to evaluate the concentrations of desalination plant effluent in comparison to the effluent discharge to the ocean to meet the environmental criteria. The minimum dilution requirements depend on the effluent parameters, the ambient ocean water quality, and the water quality standards (i.e. environmental requirements). The dilution factor, S, was obtained for salinity values using the relation below:

$S = (C_d – C_s) / (C_{WQO} – C_s)$

Where C_{WQO} is the WQO concentration (regulatory requirement), C_s is the background concentration in the ambient water (i.e. concentration of the water that is discharged into the mixing chamber), C_d is the concentration in the effluent.

The dilution factor for a mixing chamber using desalination plant effluent and seawater using the effluent and ambient water values described in Table 1-2 is as follows:

- Desalination plant effluent with sea water requires a dilution of approximately 3.

Dilution factors indicate that the mixing chamber needs to be supplied by a flow 3 times higher (approx. flow of 5.64 m^3/s) than the effluent if using seawater and 1.04 times larger (approx. flow of 1.955 m^3/s) than the effluent if using fresh water. Using fresh water for the mixing chamber is, however, an unrealistic possibility that has been included for completeness of the report.

8.1.4 Size of Mixing Chamber

The mixing chamber that will fulfil the dilution requirements presented in previous section should have a volume of approximately 500 m^3 which could be achieved with a mixing chamber having the following dimensions: 15 m long, 10 m width and 5 m tall. The mixing chamber would need to be optimized with wall overpass to ensure enough mixing is achieved before leaving the chamber. A sketch of the potential mixing chamber is presented in Figure 8-2.

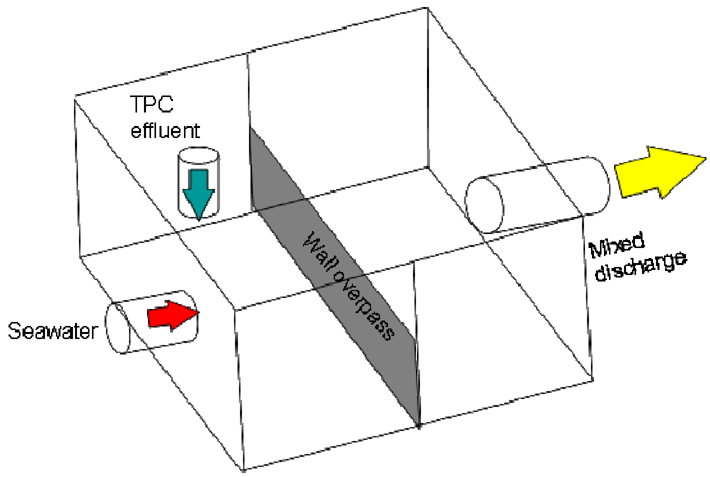

Figure 8-2: Schematic Diagram of Mixing Chamber

8.1.5 Feasibility of Mixing Chamber

The results and analyses presented in previous sections indicate that mixing the desalination plant effluent seawater in a mixing chamber will reduce the salinity levels of the effluent. Mixing the effluent with three times the flow of seawater will result in levels within the environmental criteria.

A mixing chamber, however, will require the installation of an additional intake to bring water to the chamber, which at present, appears not to be cost effective.

The implementation of a mixing chamber is, therefore, not recommended for this project due to the following reasons:

- Numerical modelling results indicate that a conventional intake and outfall subsea pipeline will meet the environmental regulations;
- The mixing chamber will require an additional intake and/or additional requirements for the planned intake pipeline resulting in additional costs.

8.2 Intake and Outfall Concept Design

Figure 8-3 presents the concept design of the selected intake and outfall structures and its main components. These components are described in the next sections in the same order as the water flowing from the ocean to the plant and back to the ocean:

- Intake structure
- Subsea intake pipeline
- Tidal zone intake pipeline
- Intake pump station
- Outfall land pipeline
- Outfall tidal zone pipeline
- Outfall subsea diffusers

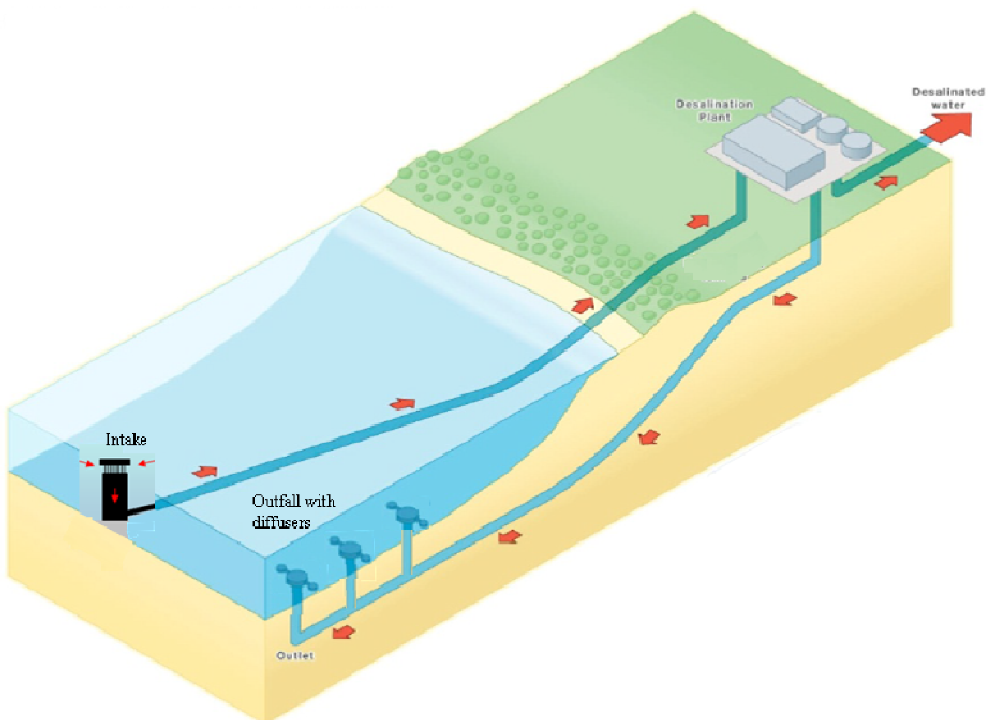

Figure 8-3: Intake and Outfall Concept

The selection of the technologies presented in the following section is based on:

- Concept level analytical calculations;
- Site conditions;
- Published sources covering similar projects;
- WorleyParsons experience in similar projects.

The selected options will be further refined as part of the preliminary design phase.

8.2.1 Intake structure

A velocity cap intake structure (Figure 8-4) and a wedge wire intake structures (Figure 8-5) are considered feasible options for the proposed intake and outfall.

The velocity cap intake structure consists of a cylindrical structure with cover that permits water flow to enter peripherally. The cap is designed to create horizontal flow path into the intake to protect fish and recommended velocity range from 0.15 to 0.45 m/s. The cover converts the vertical flow into horizontal flow to reduce fish entrapment. The size of the lower chamber should be optimized to ensure that low intake velocities at the screens are achieved.

The upper surface of the cap should be located well below the minimum water surface to minimize wave forces. The water depth of the intake structure should be below the depth limit for effect of breaking waves while the lower edge of the intake should be located at least 0.5 m above the seabed to minimize sediment intrusion.

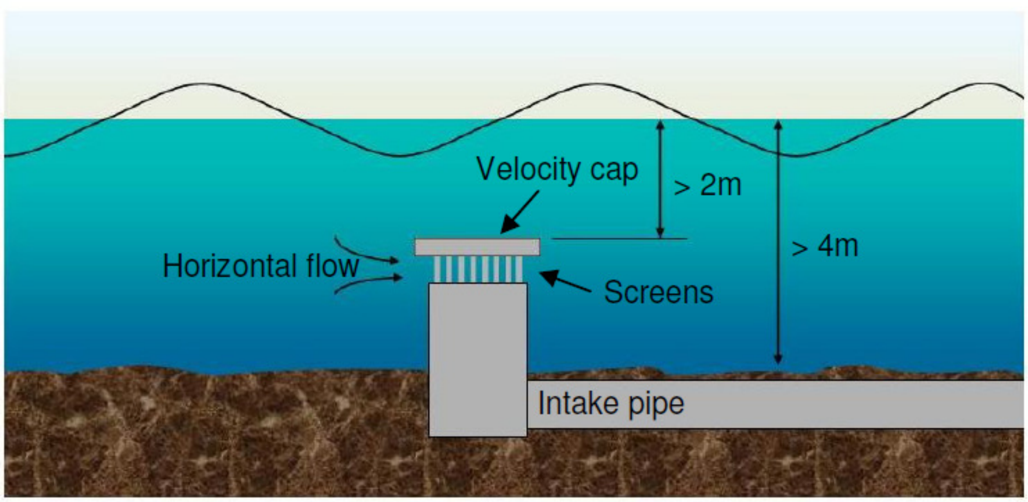

Figure 8-4: Example of Velocity Cap Seawater Intake

Wedge wire intakes or sometimes called passive screens slotted screens constructed of trapezoidal shaped “wedge wire”. The cylindrical screens have openings ranging from 0.5 to 10 mm and are oriented on a horizontal axis with screens sized to maintain a velocity normally less than 15 cm/s to minimize debris and marine life impingement. Passive screens are best suited for areas where an ambient cross flow is present.

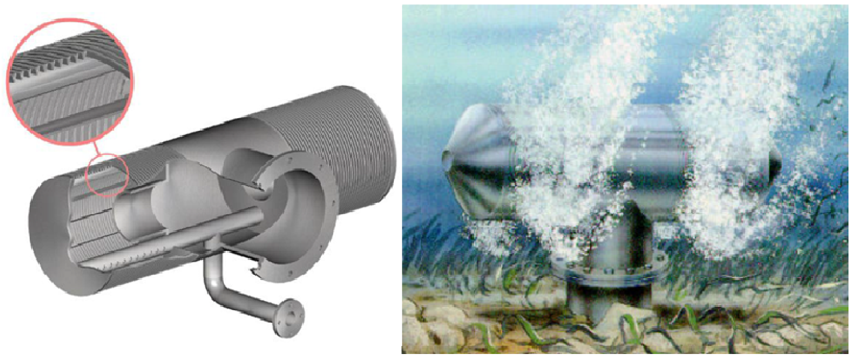

Figure 8-5: Example of Wedge wire Intake

A velocity cap seawater intake was selected for the selected intake due to the following reasons:

- The required intake flow rates are large and out of the normal range for wedge wire intakes.
- Velocity cap intake is commonly used for large intake/outfall flows.
- The intake is at a depth of 7.5 m which allows the implementation of a velocity cap intake.
- Velocity cap intakes normally have a single intake structure while wedge wire intake normally consists of 2 or more intake structures.

The concept design of the selected intake is presented in Figure 8-6.

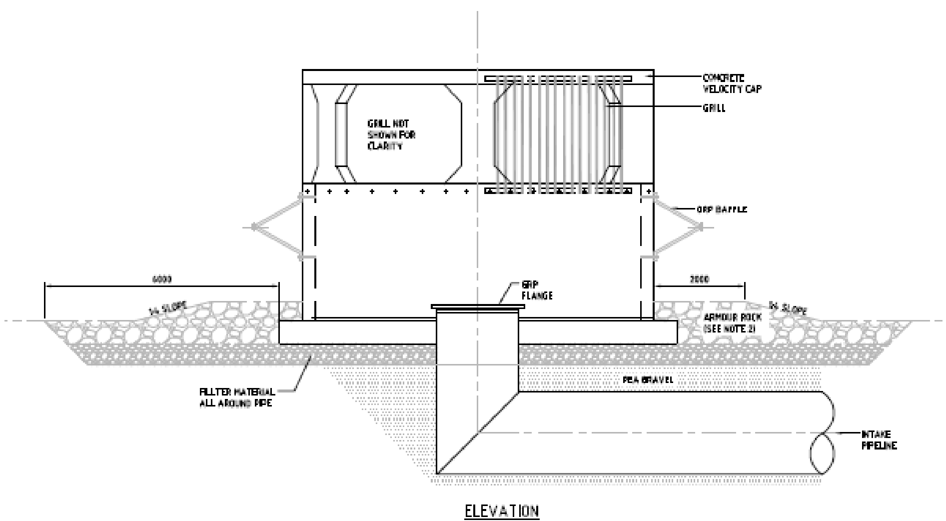

Figure 8-6: Concept of Seawater Intake Structure

8.2.2 Subsea Intake Pipeline

For the calculation of the diameter of intake pipeline, following parameters have been considered:

- Intake flow rate is considered as 3.96 m^3/s
- Velocity of intake pipeline is assumed as 1.5 m/s

The assumed velocity of 1.5 m/s inside the pipeline is within the range of minimum (1.0m/s) and maximum (3.0m/s) velocity acceptable for a flow inside a pipe under pressure.

These parameters results in internal diameter of the pipe as 1.8 m and considering HDPE pipe, the external diameter of the pipe is obtained as 2.0m.Thus, the intake subsea pipeline proposed at this stage as having a diameter of 2.0 m and made of HDPE. It is envisioned that the pipeline will be buried in the seabed by approximately 1 – 2 m and placed on top of a bedding layer and covered by PEA gravel as shown in Figure 8-7. This cross section applies from the intake structure to the surf zone. The trench for the pipeline assumes that the seabed is suitable to be excavated and slopes will be determined based on geotechnical properties. At present, a slope of 1 in 2 is proposed for the trench slopes.

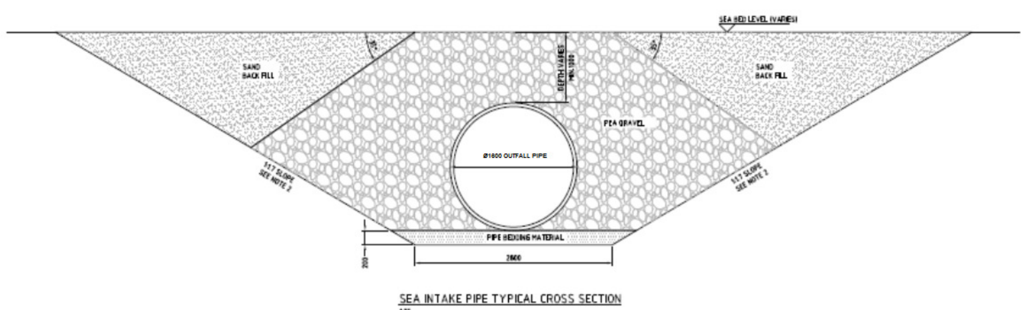

Figure 8-7: Concept of Seawater Subsea Intake Pipeline

8.2.3 Inter-tidal Intake Pipeline

A different cross section is proposed for the tidal zone where trenched slopes are normally difficult to maintain due to tidal currents and wave action. At the tidal zone a temporary vertical trench supported by temporary sheet pile is proposed as shown in Figure 8-8. The pipeline will be placed on a bedding layer made of granular material. A rip rap scour protection layer will be placed on top of the pea gravel to minimize erosion.

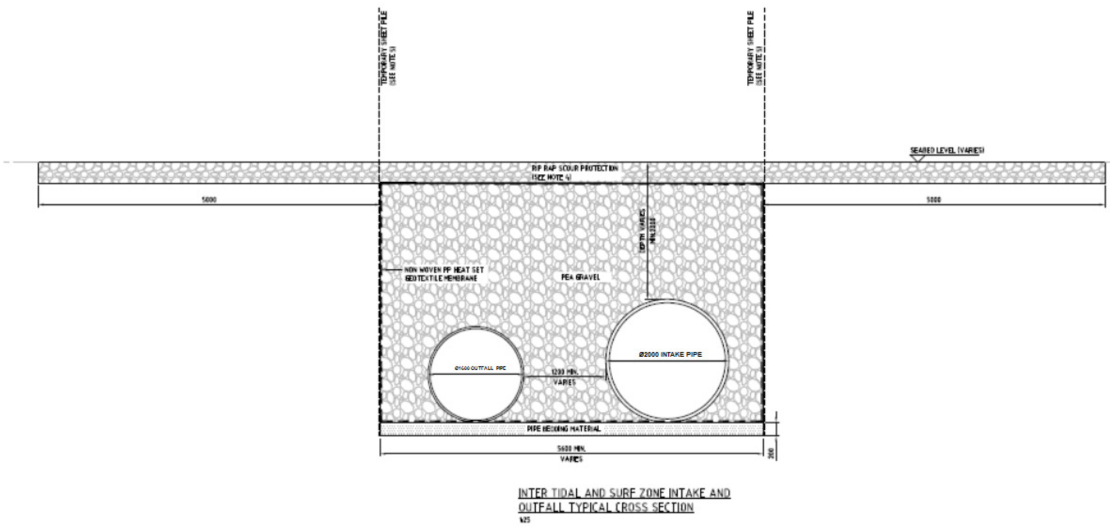

Figure 8-8: Concept of Intertidal Intake Pipeline – Surf and Intertidal Zone

8.2.4 Pump Station

As per the available information, the intake pump station design flow is around 3.96 m^3/s. The following criteria/assumptions are considered for sizing the pumps and pump station:

- A static head difference between pump and discharge point at treatment plant of 10 m is assumed
- Friction head loss due to the land intake pipe is calculated using Colebrook White equation
- Sump of the pumps will be directly below the pump station
- Pump configuration is 4 working and 2 standby, which complies with N-2 reliability criteria
- The power of each pump shall be approximately 120 KW based on WorleyParsons experience in similar projects in the region

Based on the above information, at present the minimum area requirement for the pump station is around 500 m^2, which includes pump basin, pumps and required equipment. It should be noted that the area provided will be properly assessed during the next design phases once the pump configuration is finalized.

8.2.5 Onshore Intake and Outfall Pipeline

Following criteria/assumptions are considered for sizing the intake and outfall land pipelines.

- Hydraulic calculations of head losses in the system are carried out using the Darcy-Weisbach equation as follows:

  $H = k * L/D * v^2/2g$

Where:

H = head loss	(m)
k = friction coefficient	
L = length of pipeline	(m)
D =diameter of pipe	(m)
v = flow velocity	(m/s)
g = gravity acceleration, 9.81	(m/s^2)

- For the analysis, HDPE pipe of SDR 17, PE100, PN 10 has been considered. It should be noted that internal pipe sizes is used for the analysis
- Higher friction coefficient (0.06) is considered by allowing for friction loss due to marine growth inside the pipeline
- Velocity of the flow inside the pipeline is considered to be 1.5 m/s
- The lengths of pipelines for intake and outfall on land from pumping station until desalination plant are approximately 100 m for each of them.
- Intake design flow is around 3.96 m^3/s and brine discharge flow (outfall) is around 2.50 m^3/s

As presented in Section 8.2.2, the outside diameter of intake pipeline is 2.0 m. Similarly, considering outflow flow rate of 2.50 m^3/s and 1.5 m/s of flow velocity, the internal diameter of outfall is estimated as 1.45 m, which results in external diameter of 1.6 m for HDPE pipes.

A diameter of 2.0 m and 1.6 m for the intake and outfall pipelines, respectively, is presently proposed as this diameter has been used with similar flows in the region and has been further justified by conceptual level calculations considering flows, expected velocities and expected losses. Head loss due to friction of the pipe is around 0.36 m for land intake pipe and 0.45 m for land outfall pipe. These pipe diameters also apply for the subsea intake and outfall pipelines. The exact pipeline diameter and details should be refined as part of the next design phases.

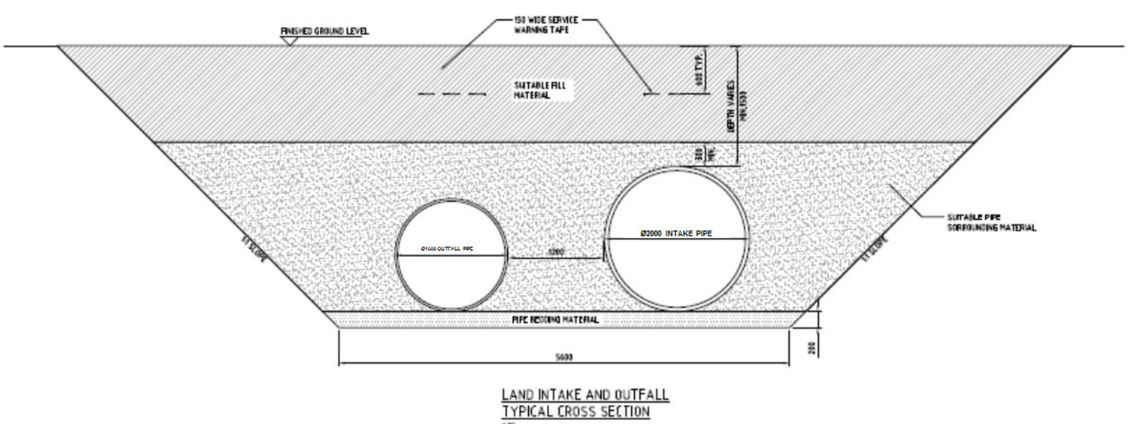

Figure 8-9: Cross Section of Standard Onshore Intake and Outfall Pipeline

8.2.6 Inter-Tidal Subsea Outfall Pipeline

The logic for the inter-tidal subsea outfall pipeline is very similar to the intake pipeline as shown in Figure 8-7.

8.2.7 Outfall Diffusers

As early discussed in Section 4.4, the concept design proposed by WorleyParsons includes implementing a series of diffusers at 5 m centres for the last 50 m of the pipelines (10 diffusers) as shown in Figure 8-10 and the concept design drawings. According to general practice, initial dilution of 20 - 30 times is considered to be sufficient and diffuser characteristics have to be designed accordingly.

WorleyParsons performed calculations using empirical methods and results indicate that a dilution of 20 to 50 times is expected at the diffuser locations depending on the final diffuser selected. The diffusers are tentatively proposed to include duckbill valves but different types of diffusers will be investigated as part of the next design phases. The orientation of the diffusers is presently proposed to be bi-directional to maximize near field dispersion considering that currents at the site are relatively mild. The advantages of using the outfall diffusers have been proved via numerical modelling.

The dispersion distance and dilution at each diffuser has to be determined in the detailed design phase. The numerical models such as CORMIX or available analytical formula shall be applied to assess dispersion characteristics.

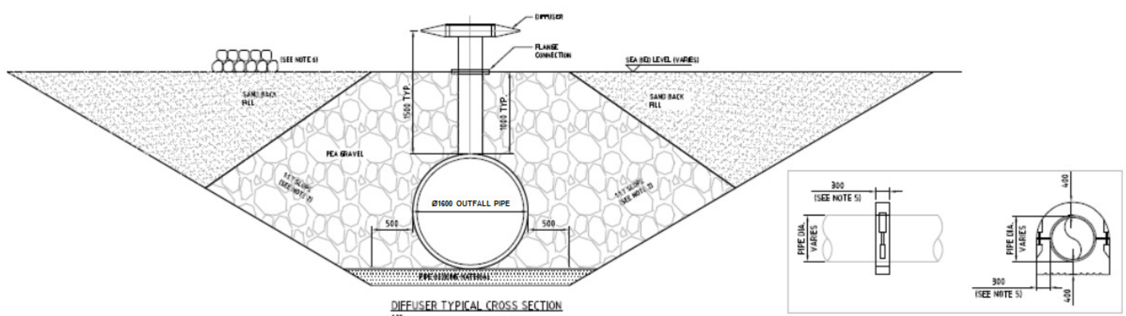

Figure 8-10: Concept of Seawater Subsea Outfall Diffusers

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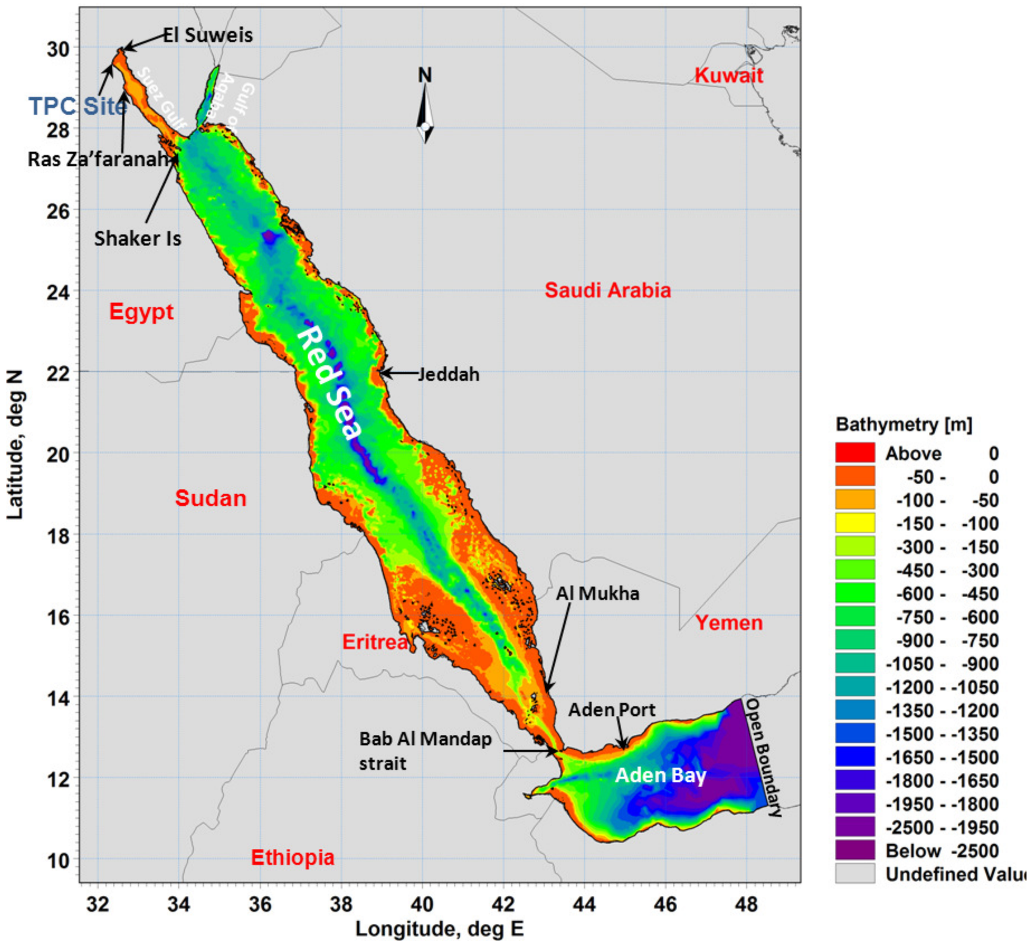
Appendix I - Regional Model Calibration & Validation

The Red Sea model domain was selected to cover the whole Red Sea and a portion of the Gulf of Aden (Appendix Figure 1) to allow for the best possible prediction of water levels and currents at the project site.



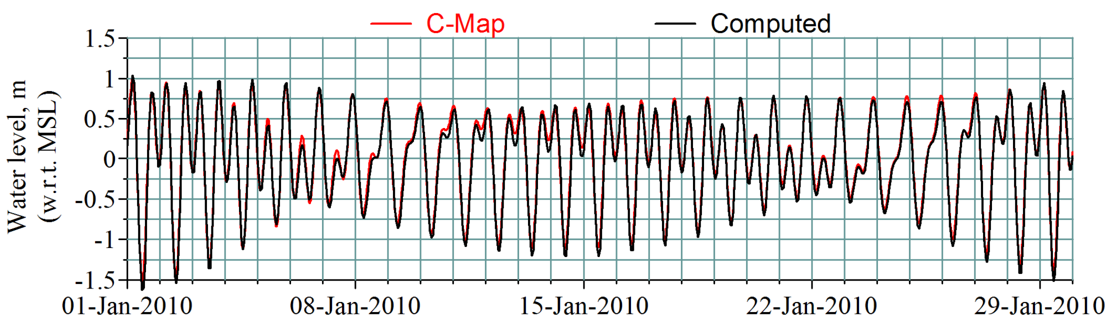
Appendix Figure 1: Extent and bathymetry of the Red Sea Model

The model is calibrated in three different stages as described in the next sections:

- The water level predictions assessed by the hydrodynamic model were initially compared to the C-Map tidal predictions (DHI, 2011b) at the tidal station of Aden to provide an initial confirmation of the boundary conditions sourced from the global astronomical tide model FES 2004 at the open boundary of the model
- The model coefficients were then tuned to obtain the best possible agreement in terms of tidal water level variations at several C-Map tidal stations including Shadwan Island (formerly known as Shaker Island) in the northern portion of the Red Sea, Jeddah in the central portion of the Red Sea and Al Mukha in the southern portion of the Red Sea
- The model predictions using the coefficients derived in the previous calibration exercises were compared to the in situ measurements available to WorleyParsons

Model Comparison against Tidal Station Close to Model Open Boundary

Water levels obtained from the hydrodynamic model were compared to predicted tidal levels at Aden (Appendix Figure 1) to verify the validity of the boundary conditions at the open boundary of the model. Aden is located relatively close to the open boundary; therefore, the good agreement of the model with this tidal station (Appendix Figure 2) confirms the validity of the boundary conditions applied at the models open boundary.



Appendix Figure 2: Comparison of Modelled Water Levels and C-Map Predictions at Aden, UTC Time

Calibration of Red Sea Model

The second stage of the model calibration consisted of trying to represent as accurately as possible the C-Map tidal water level predictions at several locations within the Red Sea including Shaker Island in the northern part of the Red Sea, Jeddah in the central part of the Red Sea and Al Mukha in the southern part of the Red Sea.

The following tasks were performed aimed at obtaining the best matching between C-Map tidal stations and the model predictions:

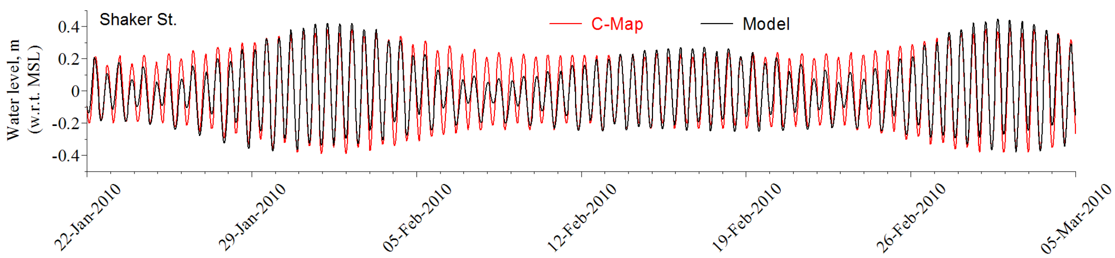
- Calibration of bottom shear stress in shallow areas (particularly straights of Bab El Mandab Strait).
- Calibration of the magnitudes of constituents in the tidal potential. This involved adjusting the magnitudes of 11 major tidal constituents in the tidal potential formulation in MIKE21 software (DHI, 2008). The tidal harmonics at the open boundary that resulted in the best agreement between C-Map and the model predictions are presented in Appendix-Table 1.

Appendix-Table 1: Calibrated Harmonics at the Open Boundary in Tidal Potential Formulation.

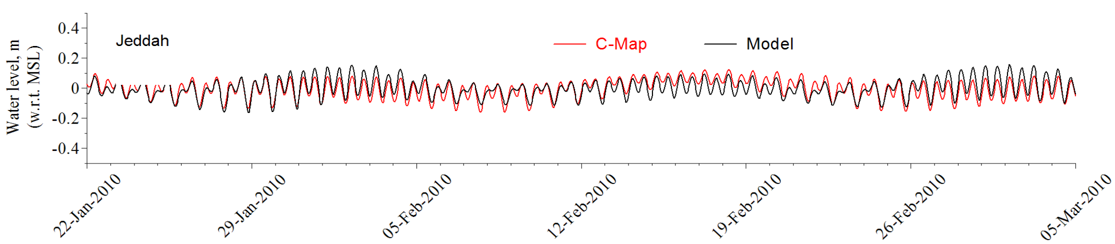
Harmonic	Period, day	Amplitude, m	Earthtide
M2	12.4206012	0.575217	0.693
O1	25.8193417	0.23858543	0.695
S2	12	0.267845459	0.693
K2	11.9672348	0.072880664	0.693

Harmonic	Period, day	Amplitude, m	Earthtide
N2	12.6583482	0.110132785	0.693
K1	23.9344696	0.336026289	0.736
P1	24.0658902	0.111189061	0.706
Q1	26.8683566	0.045707076	0.695
MF	13.660791	0.099081054	0.693
MM	27.554553	0.052282097	0.693
SSA	182.6211	0.04615807	0.693

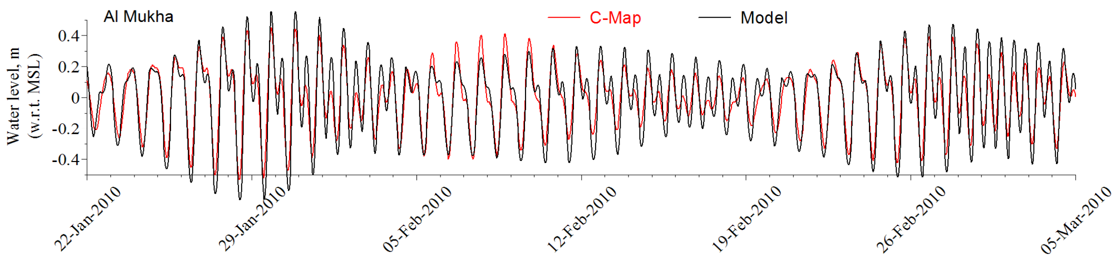
A few examples of comparisons between the Red Sea model results and C-Map prediction at several tidal stations are depicted in Appendix Figure 3, Appendix Figure 4, and Appendix Figure 5. Locations of these stations are indicated in Appendix Figure 1. The C-Map and model predictions agree relatively well, and main differences are mainly attributed to the lack of accurate SA and SSA tidal constituents, which can only be accurately resolved from long term water level measurements (i.e. SSA and SA require, 6 months and one year continuous measurements, respectively).



Appendix Figure 3: Comparison of Astronomical-Tide Red Sea Model with C-Map Prediction of Tide at Shaker IS Station (Northern Red Sea)



Appendix Figure 4: Comparison of Astronomical-Tide Red Sea Model with C-Map Prediction of Tide at Jeddah



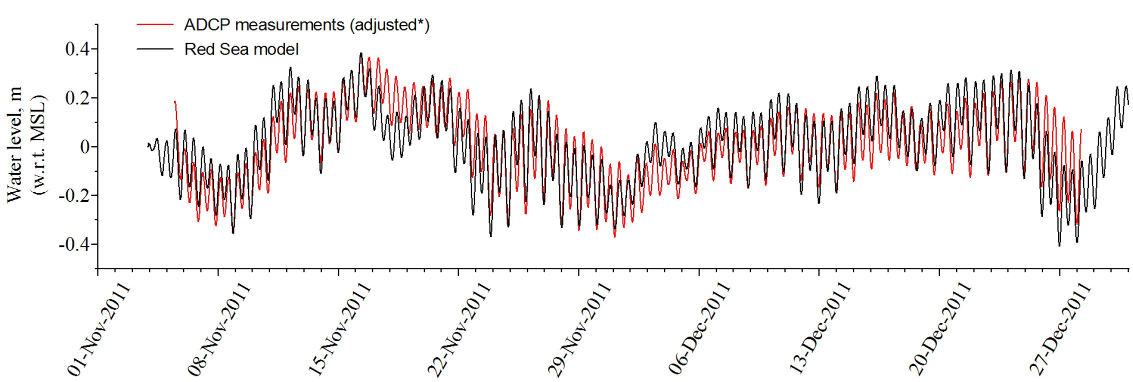
Appendix Figure 5: Comparison of Astronomical-Tide Red Sea Model with C-Map Prediction of Tide at Al Mukha (South of the Red Sea)

Model Calibration and Validation against In-situ Measurements

The model was also calibrated in terms of wind friction coefficients using wind and pressure maps to achieve the best agreement with the measured water levels recorded by FUGRO (FUGRO 2008) and WorleyParsons 2011. The relation between wind friction τ and wind speed W was obtained based on an iterative process considering the wind speed and friction relations recommended in the MIKE 21 software manual. The best results were obtained with the following relation:

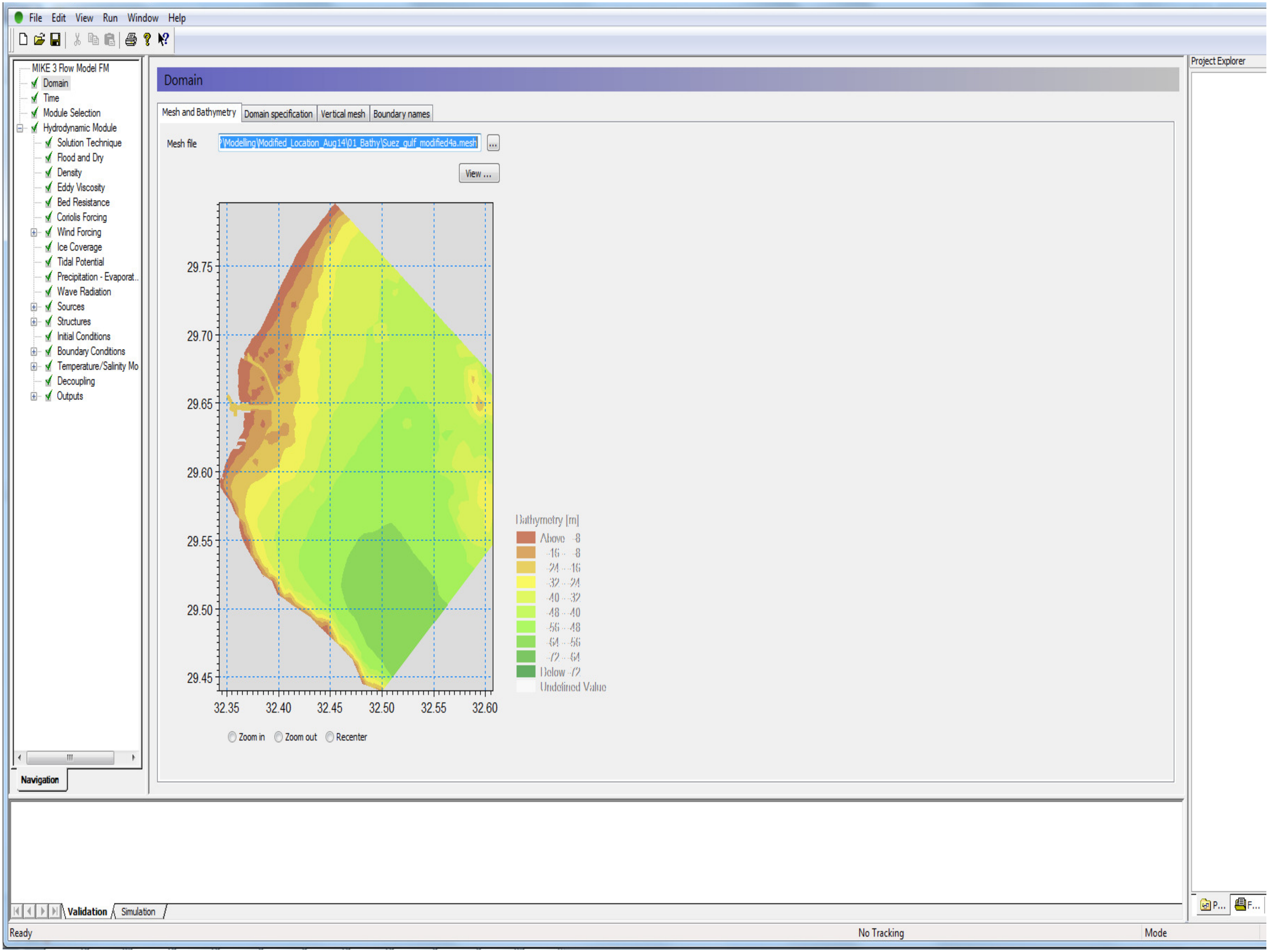
$$\tau = W^2 \cdot \begin{cases} 0.0036375, & \mathrm{W} \le 7\ \mathrm{m/s} \\ (0.0036375 + 0.007275 \cdot (\mathrm{W} - 7)/18), & 7 < \mathrm{W} \le 25\ \mathrm{m/s} \\ 0.0036375 + 0.007275, & \mathrm{W} > 25\ \mathrm{m/s} \end{cases}$$

Modelled water levels and currents were also compared with the water levels derived from the (WorleyParsons, 2011) offshore and nearshore ADCP measurements. Appendix Figure 6 shows the model results and the in-situ measurements are in relatively good agreement indicating that the model is able to predict water levels at the Jeddah site in KSA reasonably well.



Appendix Figure 6: Comparison of Measured and Modelled Water Levels at OS1 WorleyParsons ADCP Location (period 1st Nov 2011 to 27 Dec 2011)

Appendix II - Local 3D Model Setup



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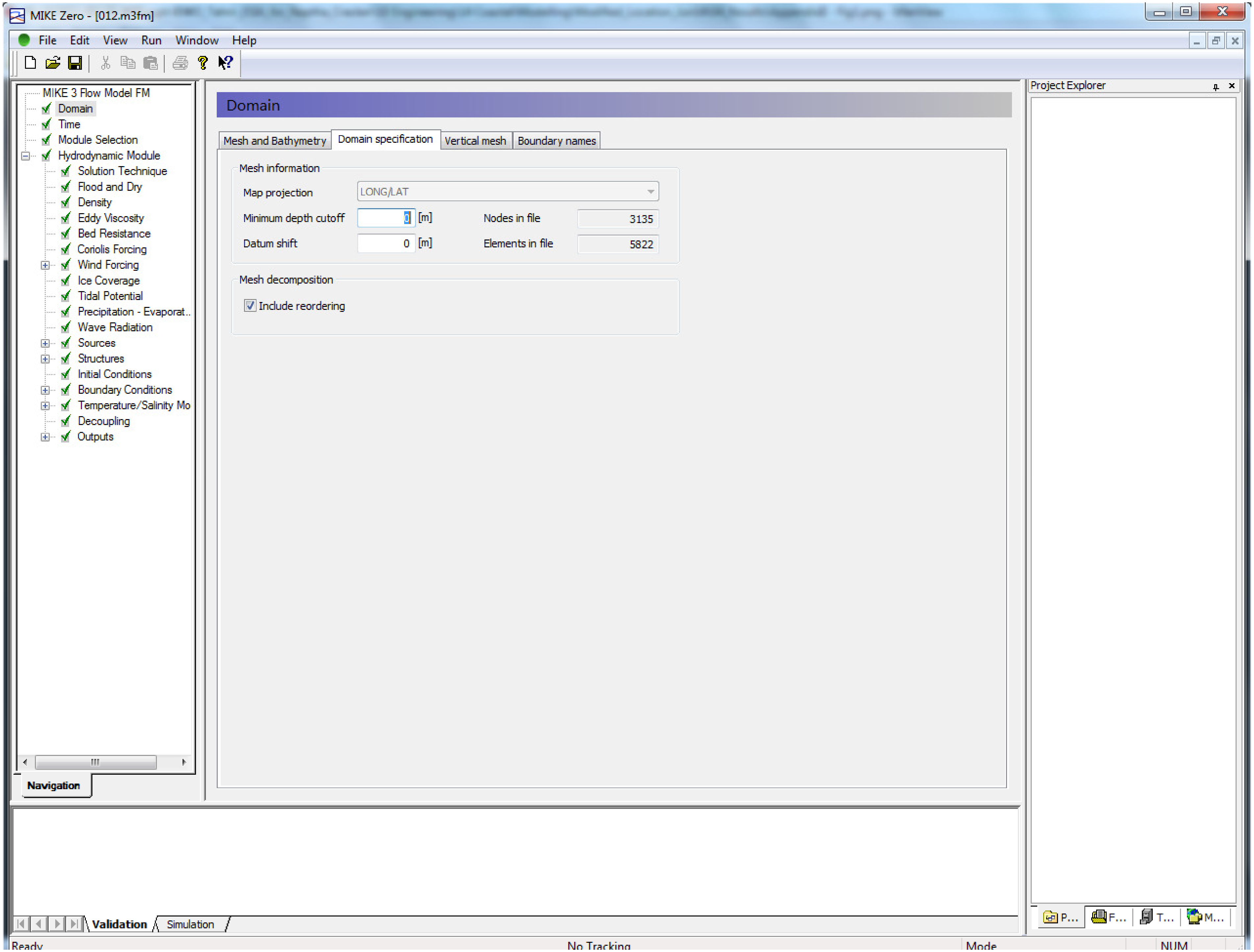
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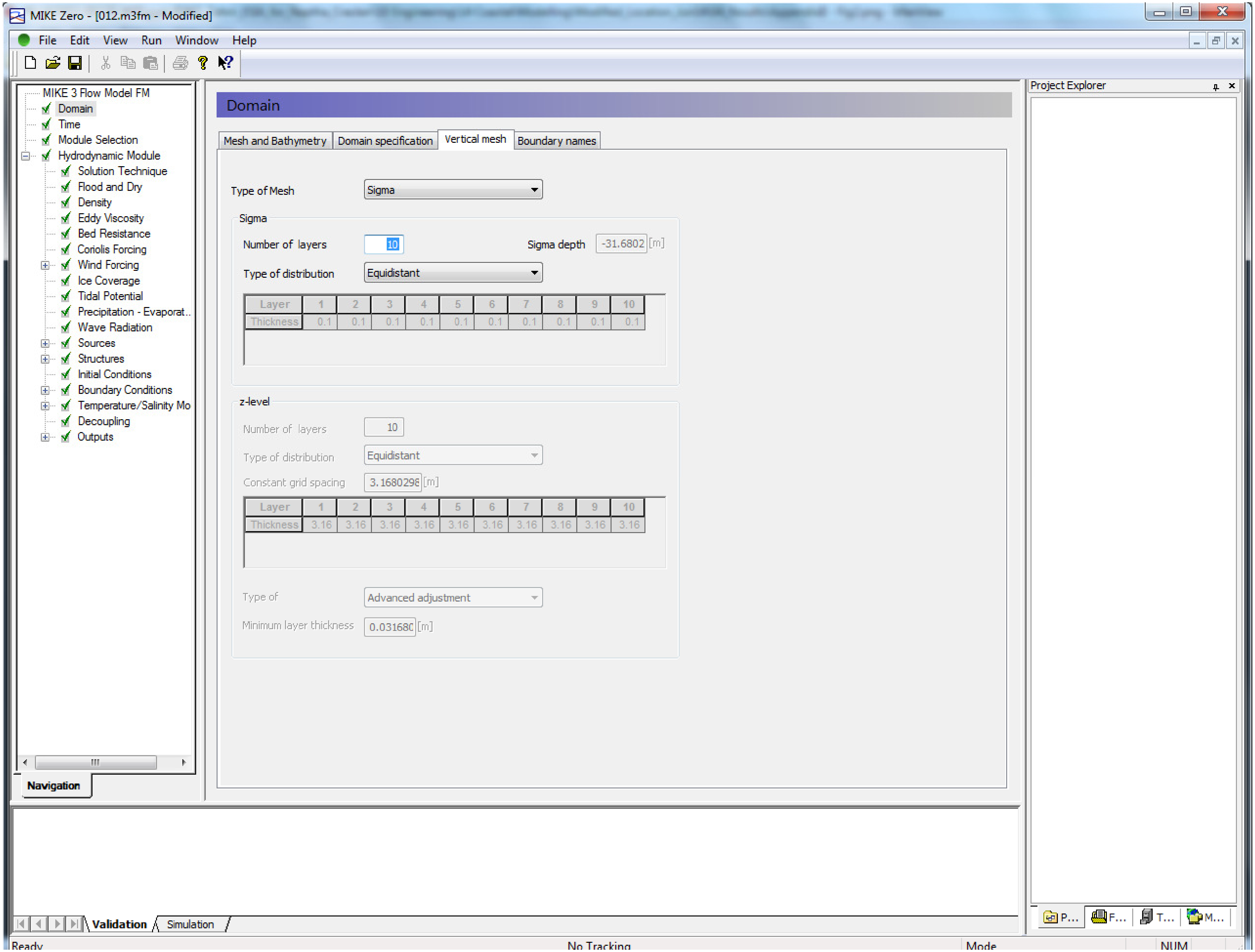
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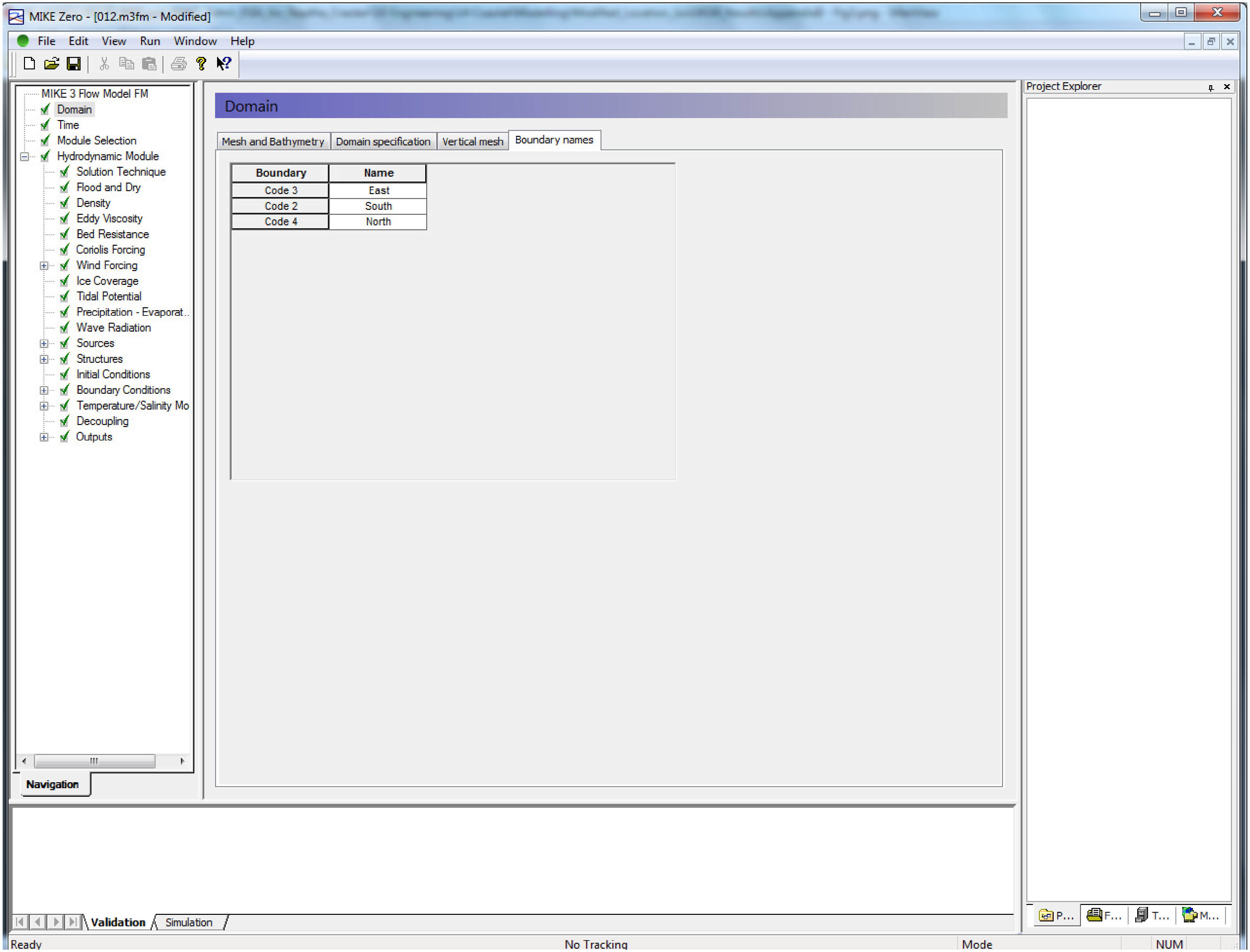

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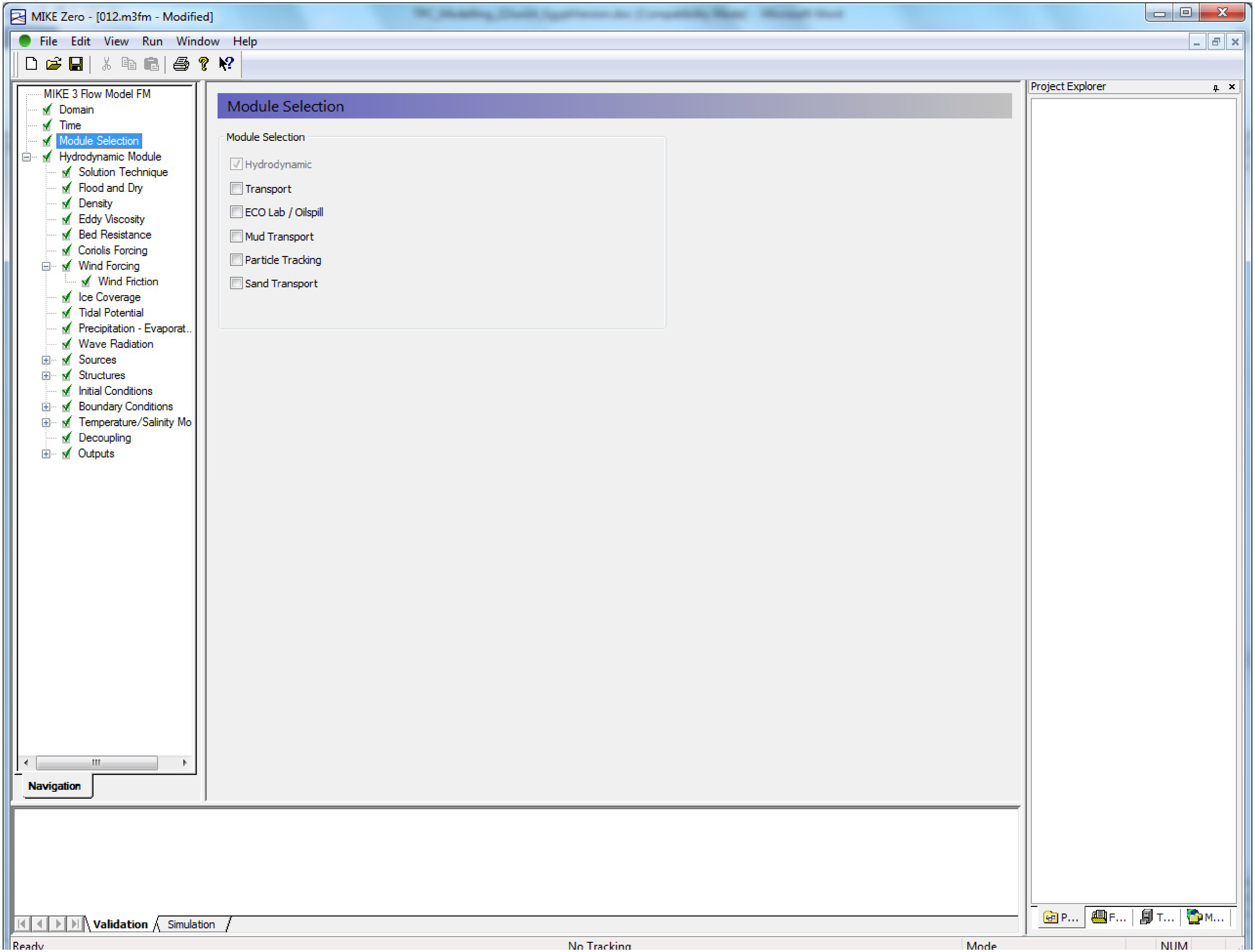
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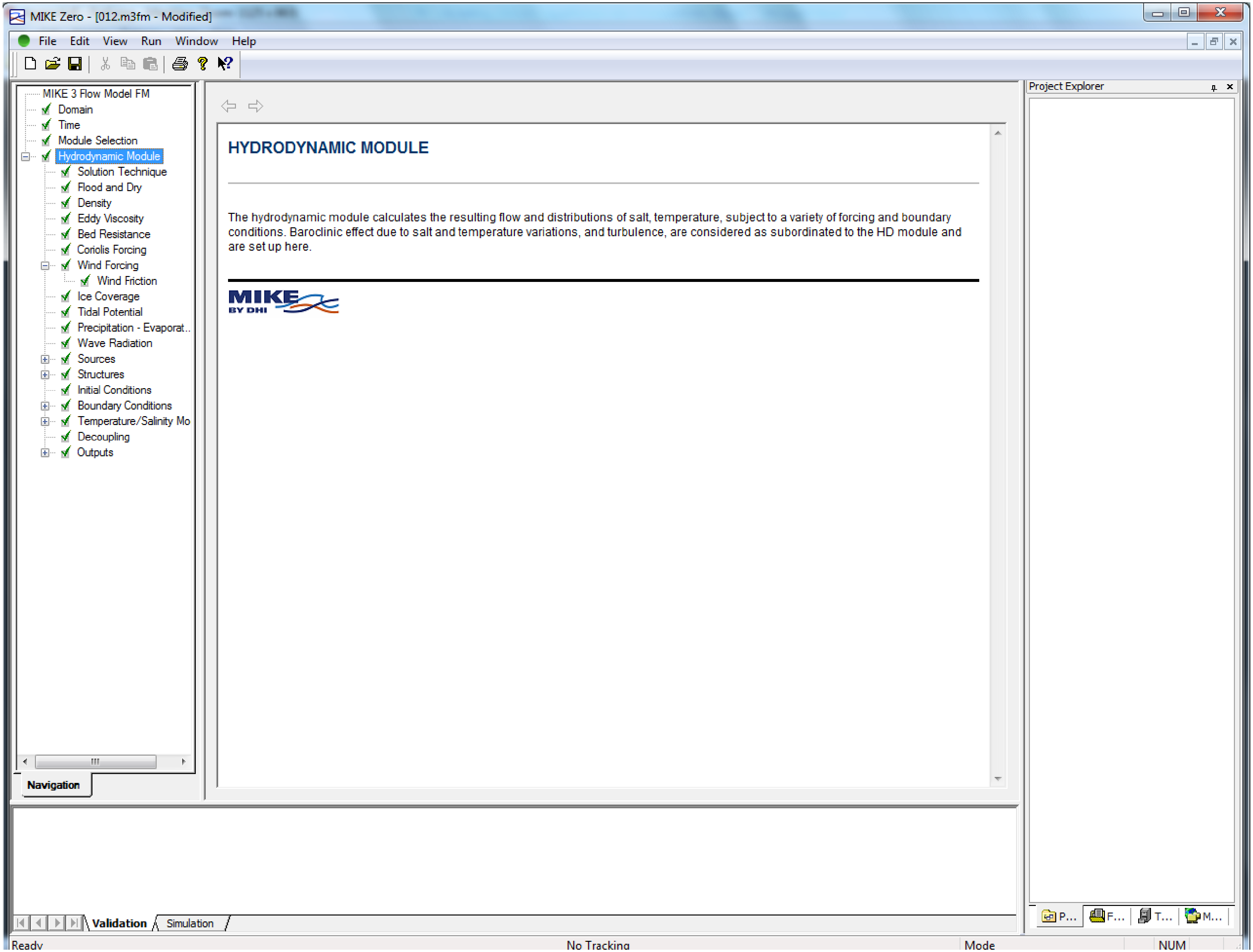

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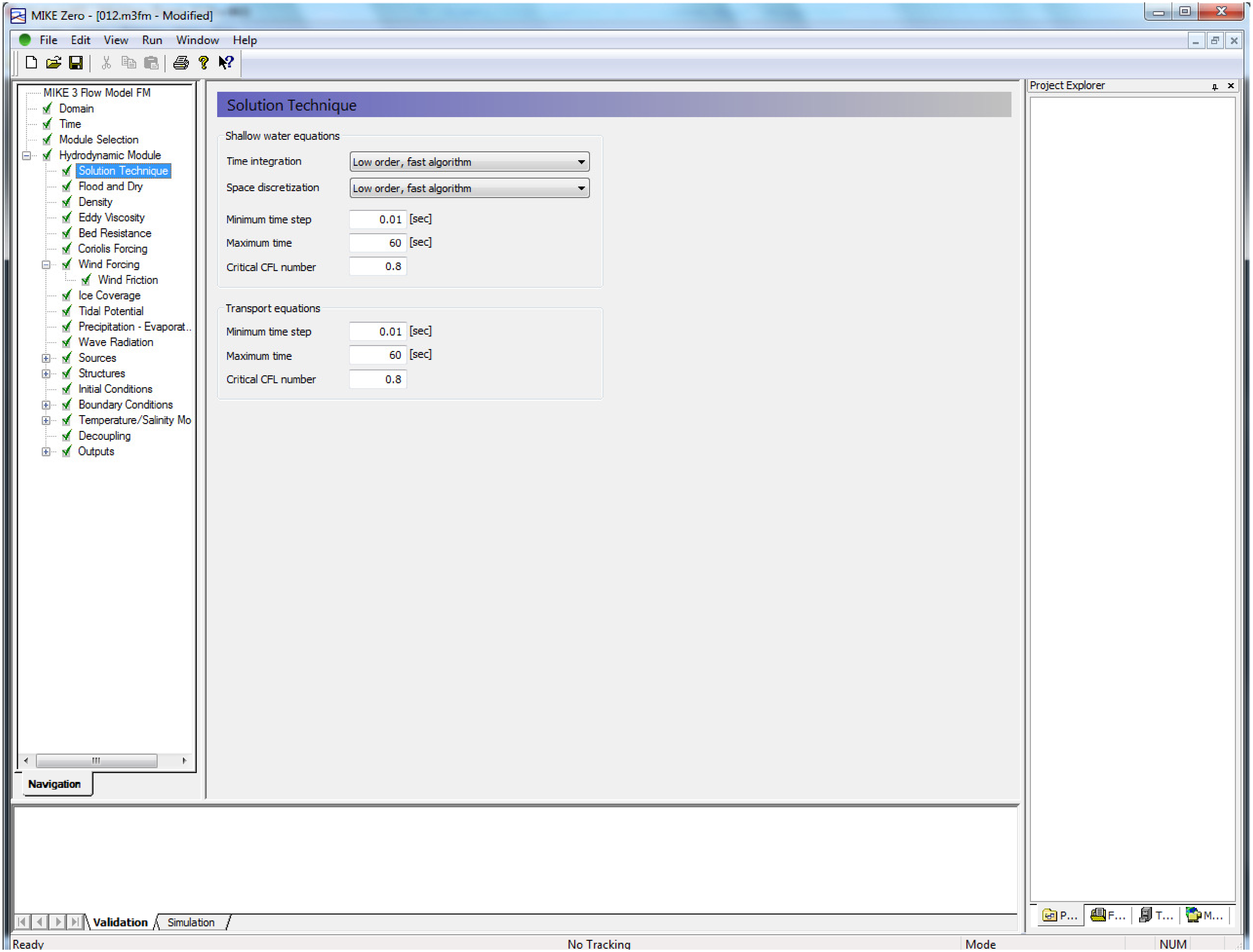
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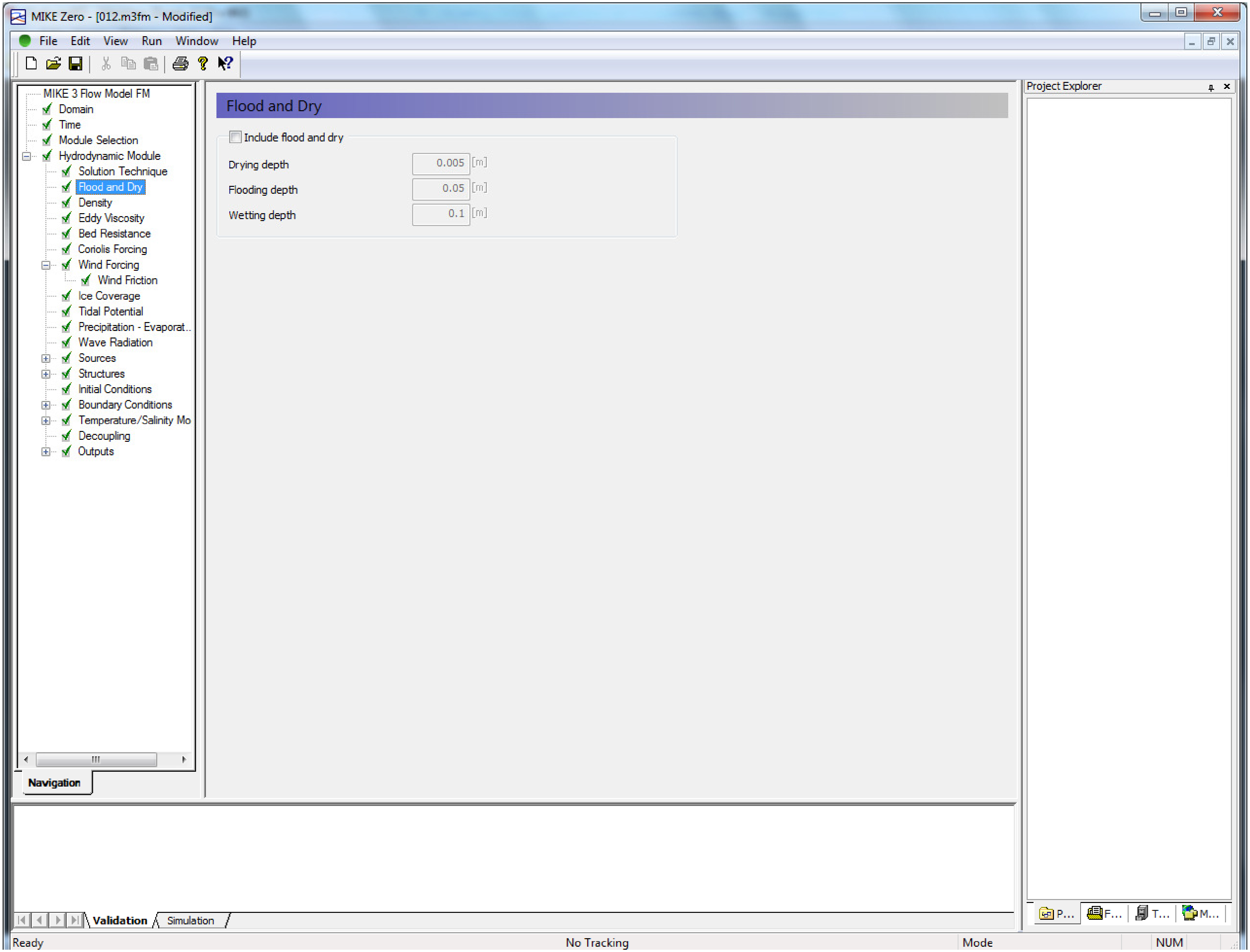
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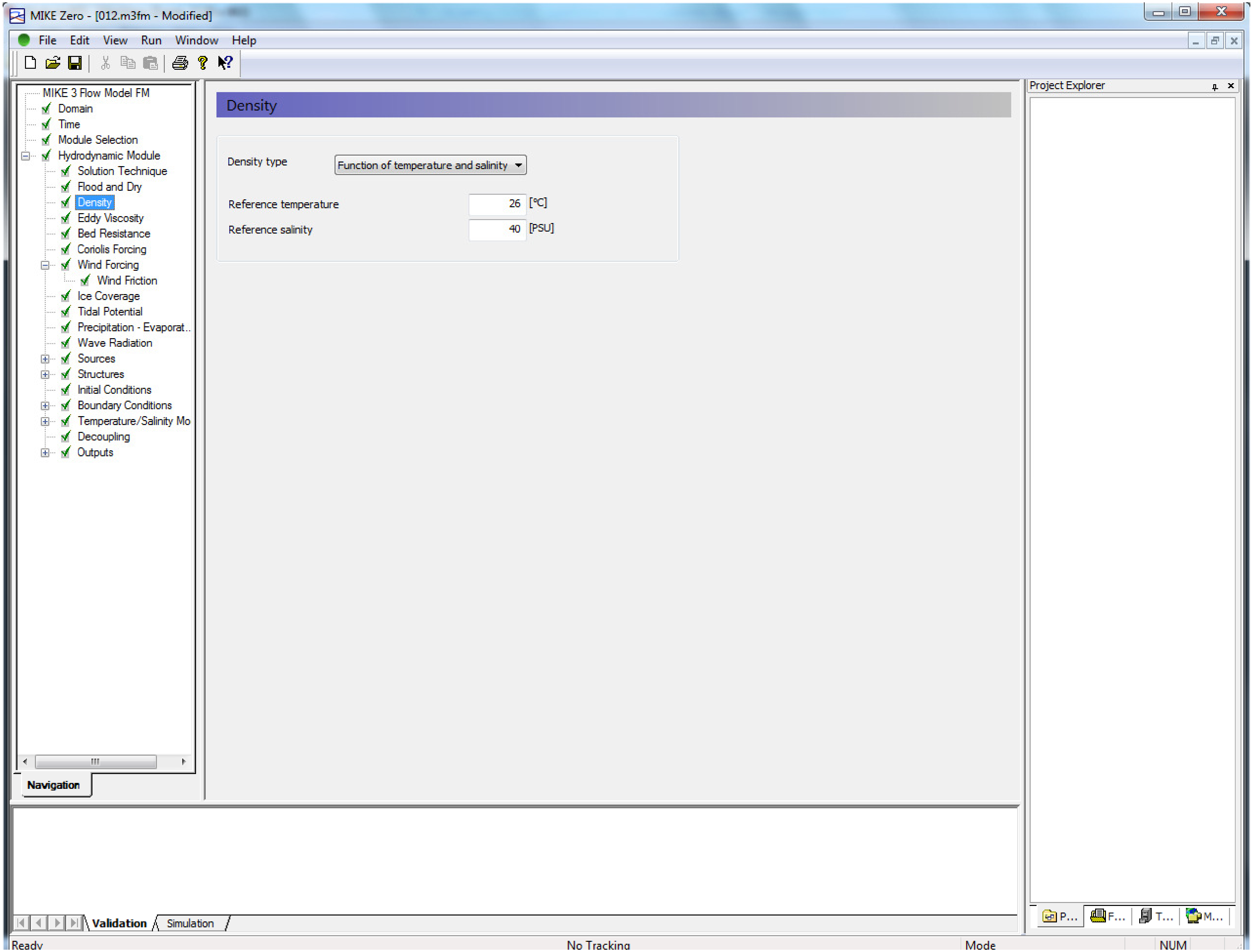
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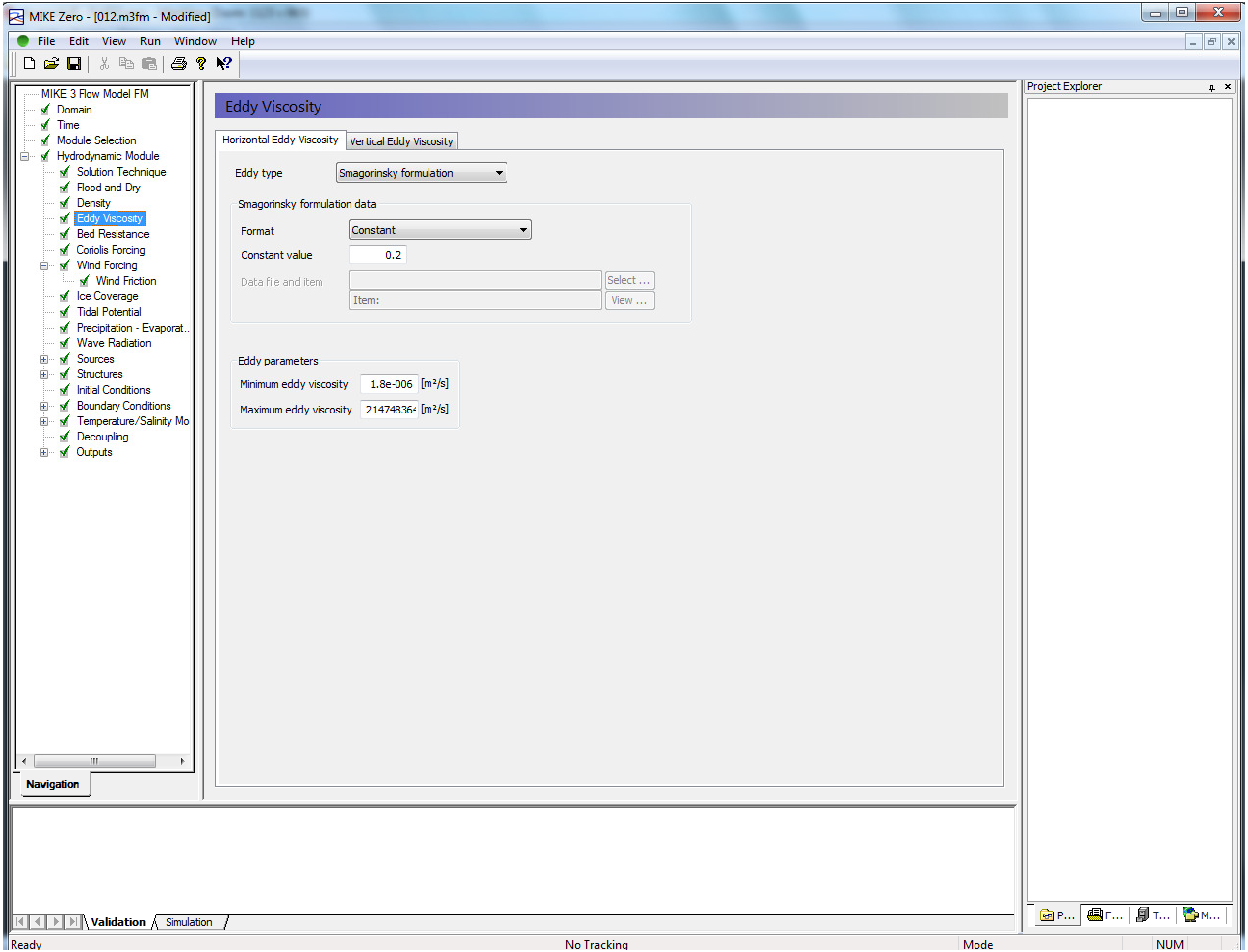
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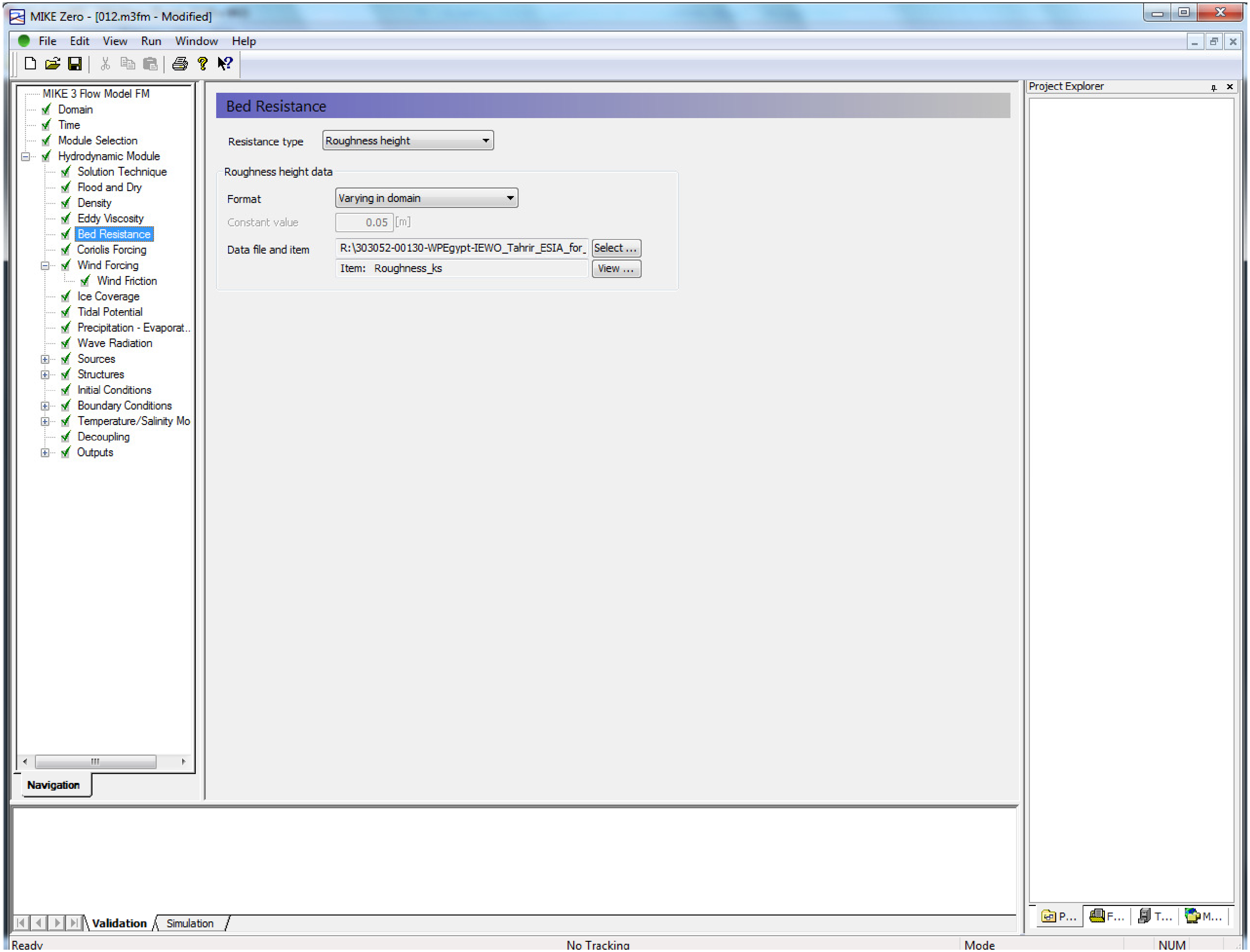

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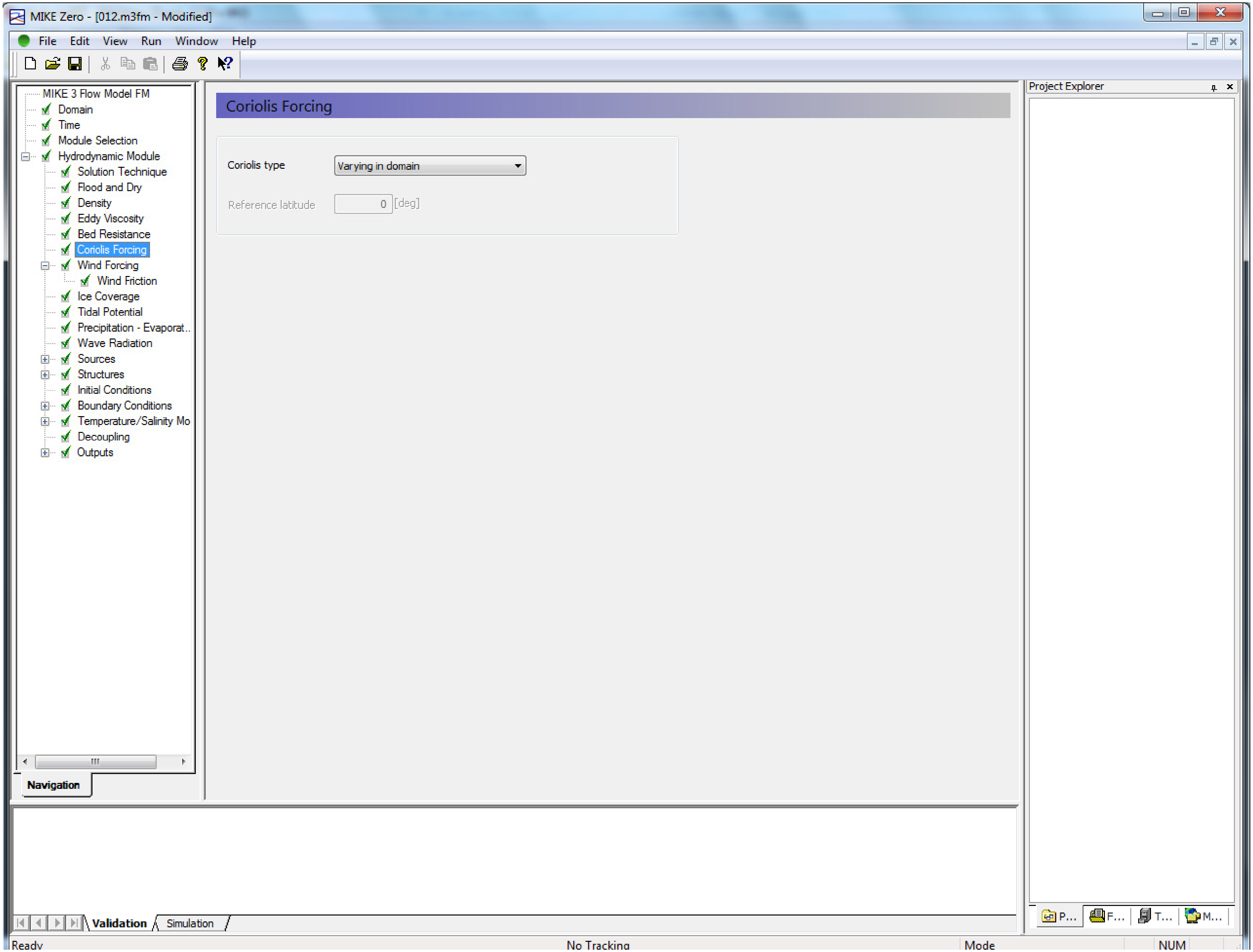
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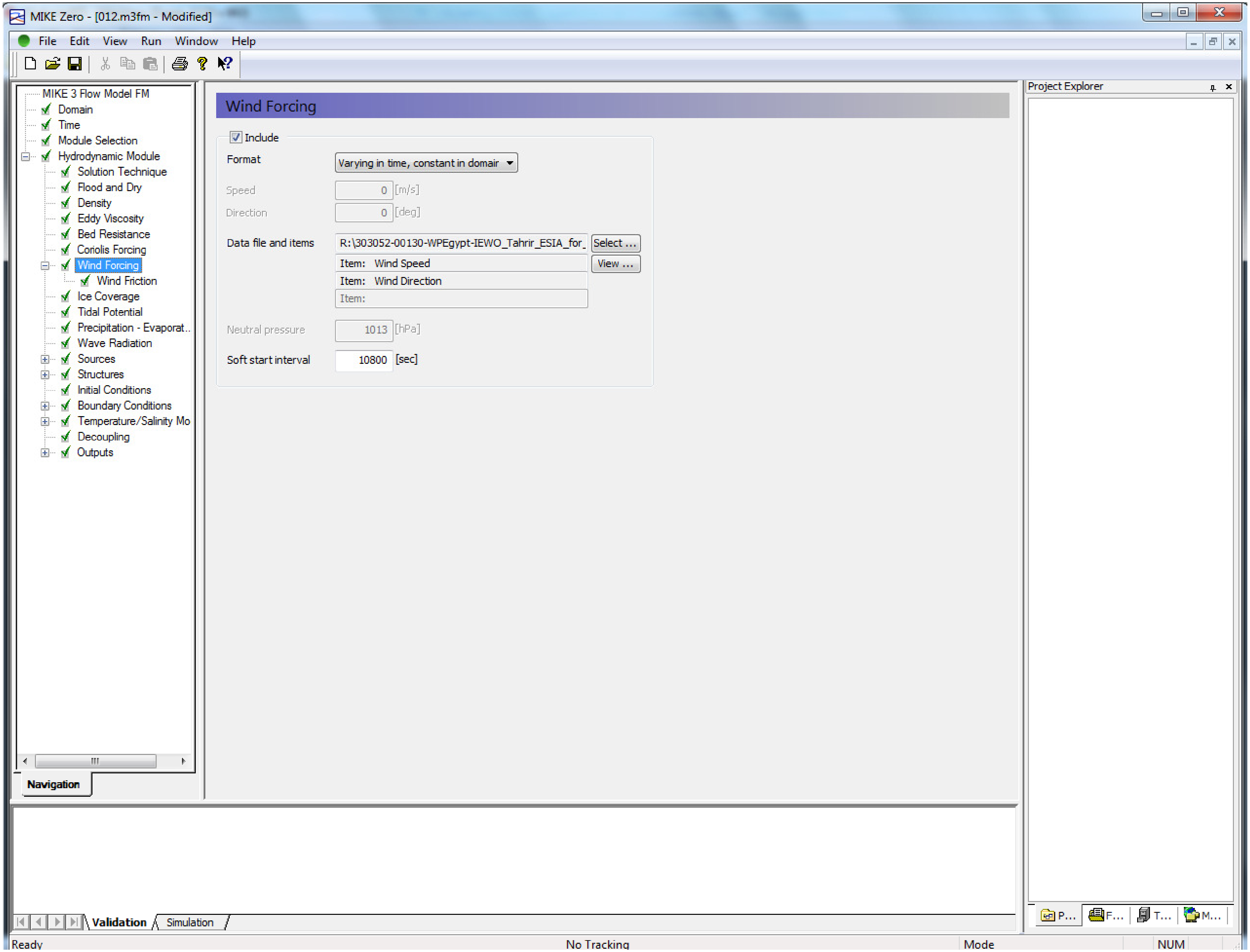

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Module Selection
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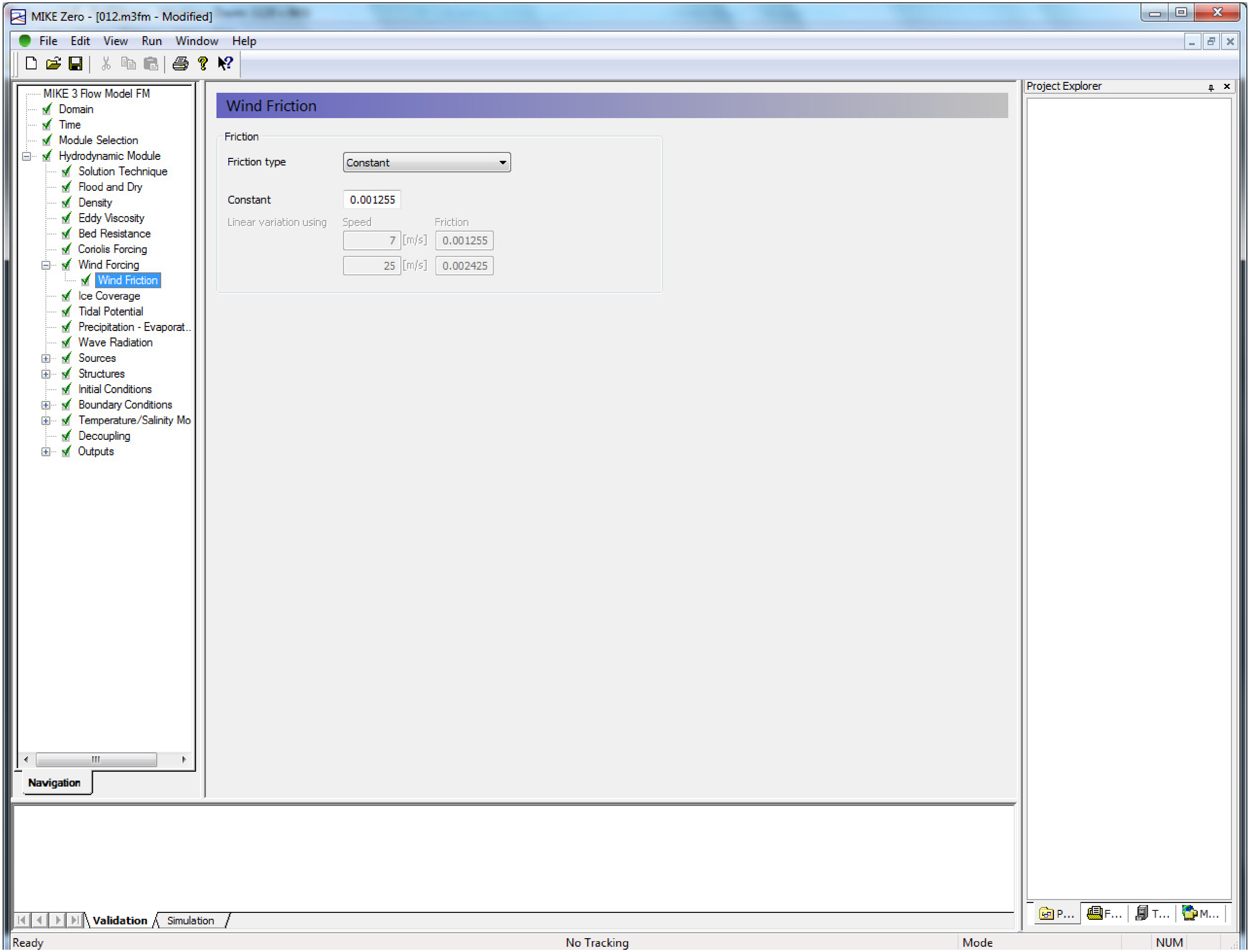
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
Wind Forcing
Wind Friction
Ice Coverage
Tidal Potential
Precipitation - Evaporat..
Wave Radiation
Sources
Structures
Initial Conditions
Boundary Conditions
Temperature/Salinity Mo
Decoupling
Outputs
Navigation
Wind Forcing
Include
Format
Varying in time, constant in domair
Speed
0 [m/s]
Direction
0 [deg]
Data file and items
R:\303052-00130-WPEgypt-IEWO_Tahrir_ESIA_for_
Select ...
Item: Wind Speed
View ...
Item: Wind Direction
Item:
Neutral pressure
1013 [hPa]
Soft start interval
10800 [sec]
Project Explorer
P... F... T... M...
Validation
Simulation
Ready
No Tracking
Mode
NUM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File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
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Wind Friction
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Boundary Conditions
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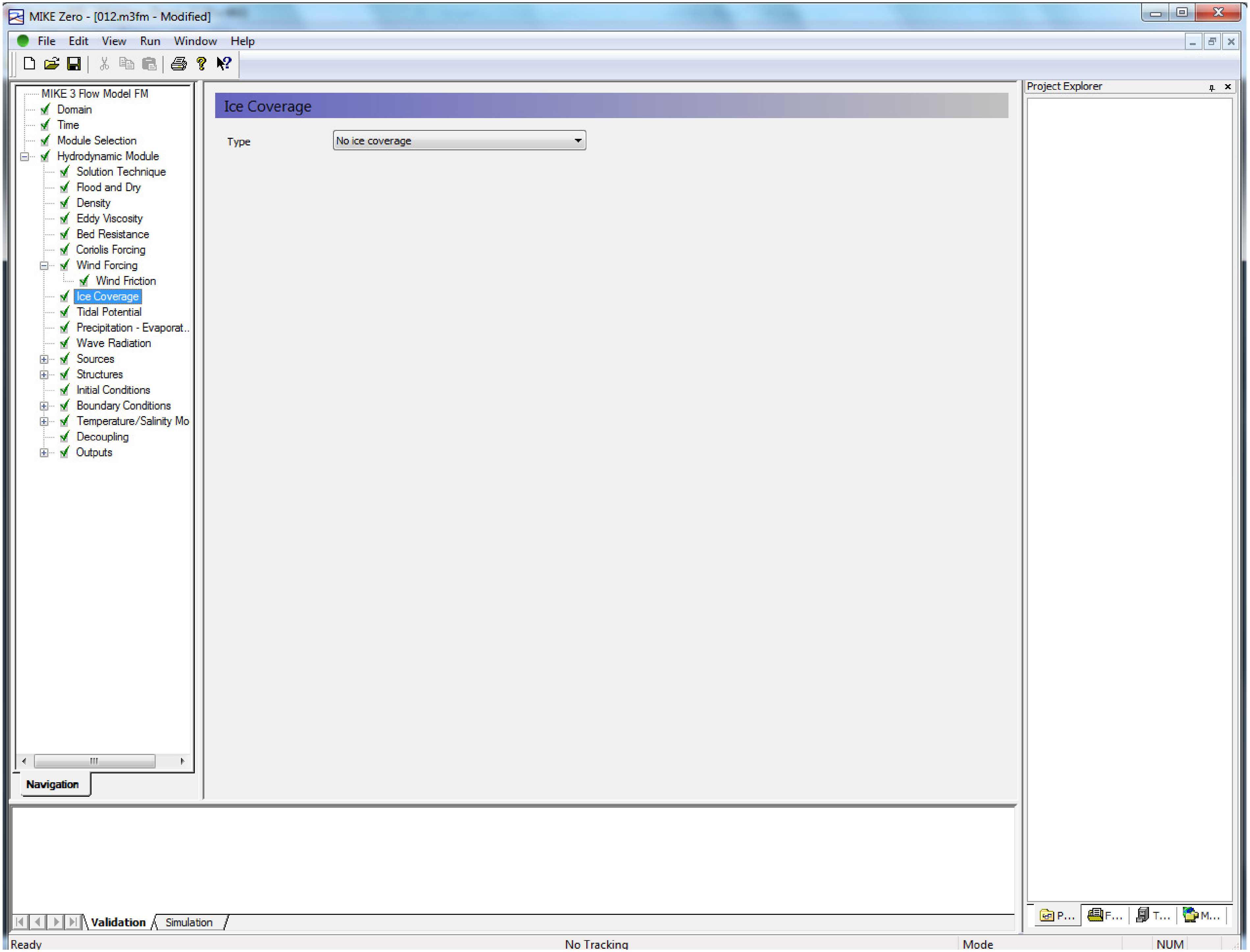
Navigation
Wind Friction
Friction
Friction type
Constant
Constant
0.001255
Linear variation using
Speed
Friction
7 [m/s]
0.001255
25 [m/s]
0.002425
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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File Edit View Run Window Help
MIKE 3 Flow Model FM
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Wave Radiation
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Boundary Conditions
Temperature/Salinity Mo
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Outputs
Navigation
Ice Coverage
Type
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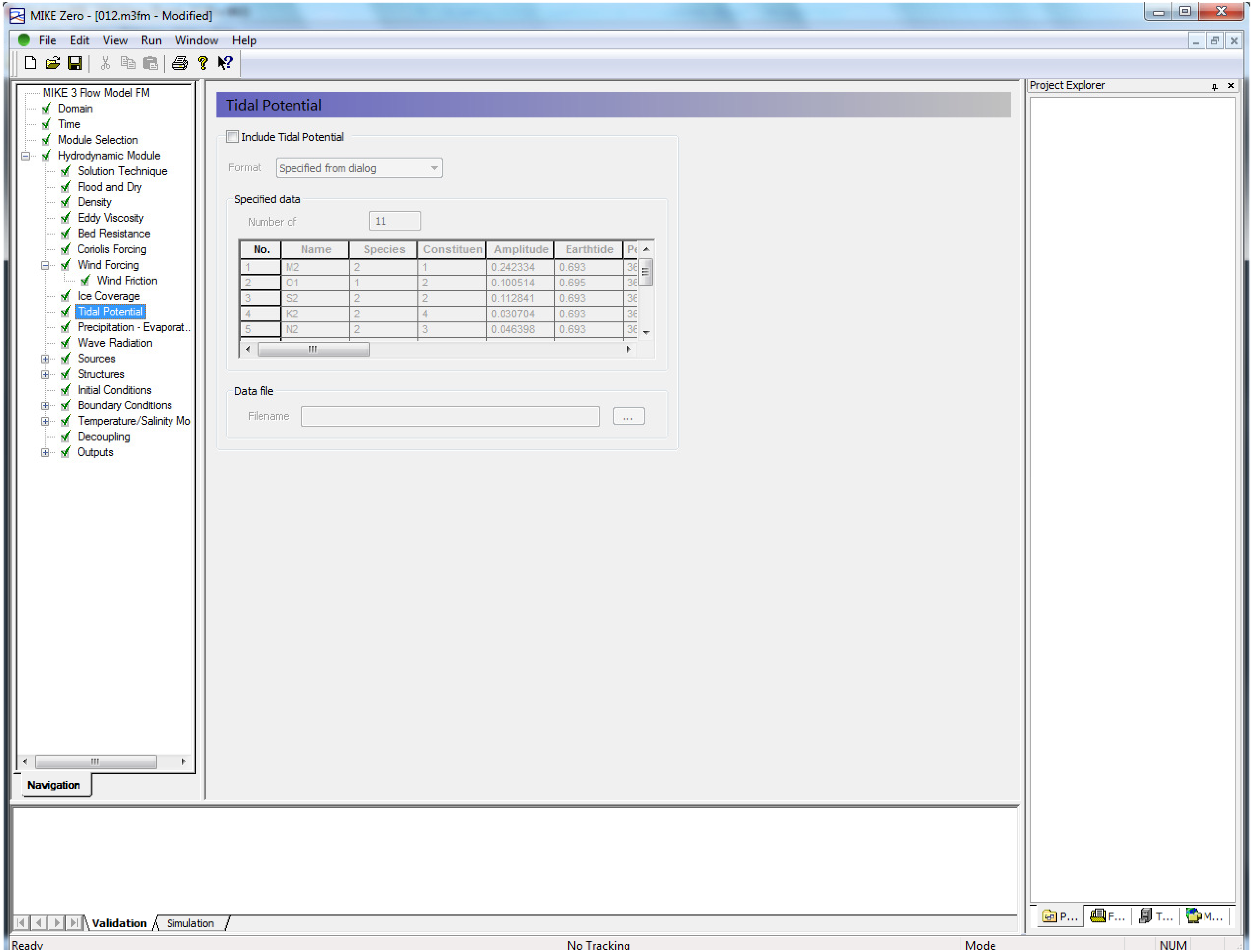
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM



MIKE Zero - [012.m3fm - Modified]
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MIKE 3 Flow Model FM
Domain
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Module Selection
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Solution Technique
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Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
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Precipitation - Evaporat..
Wave Radiation
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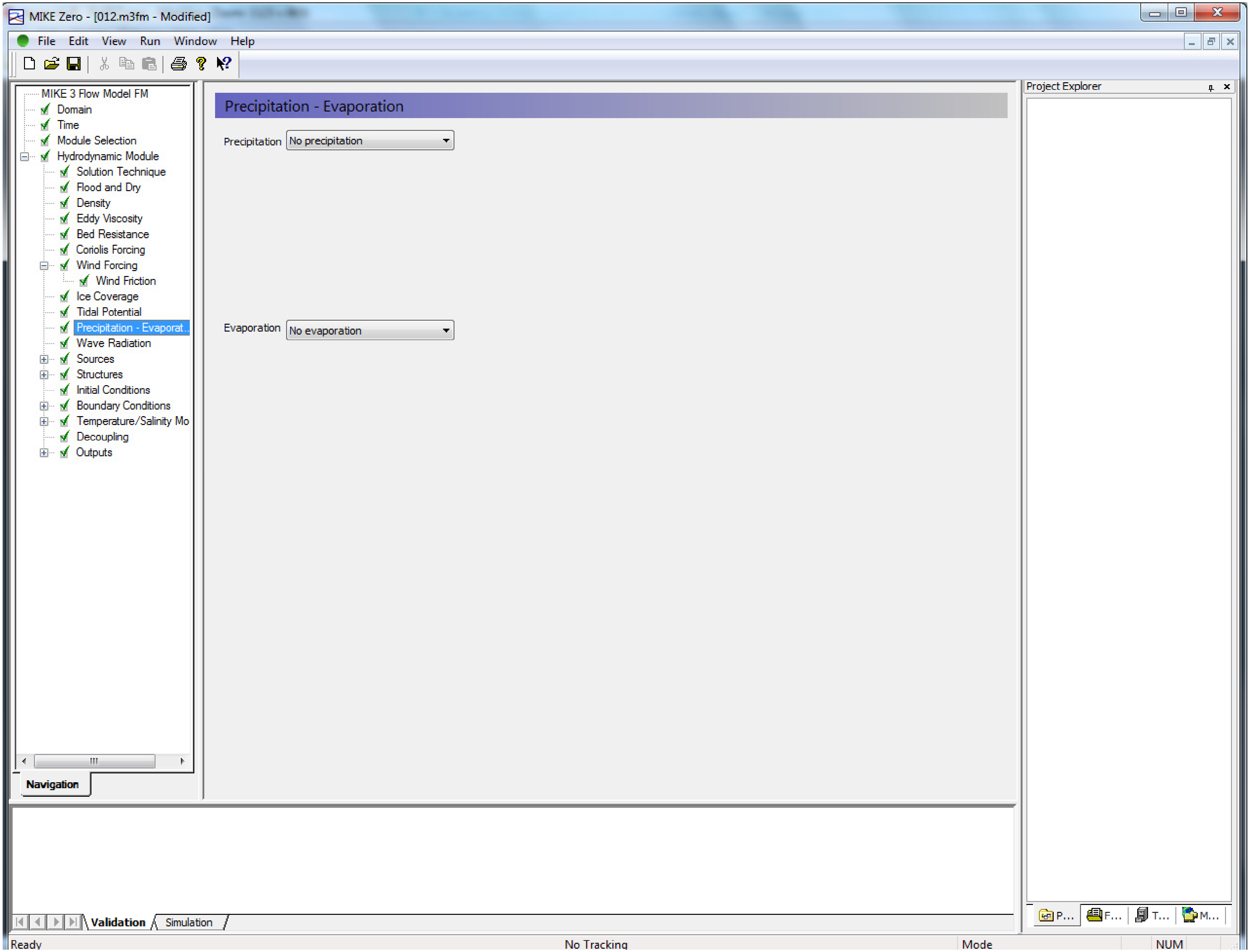
Structures
Initial Conditions
Boundary Conditions
Temperature/Salinity Mo
Decoupling
Outputs
Navigation
Tidal Potential
Include Tidal Potential
Format
Specified from dialog
Specified data
Number of
11
No. Name Species Constituen Amplitude Earthtide
1 M2 2 1 0.242334 0.693
2 O1 1 2 0.100514 0.695
3 S2 2 2 0.112841 0.693
4 K2 2 4 0.030704 0.693
5 N2 2 3 0.046398 0.693
Data file
Filename
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
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Module Selection
Hydrodynamic Module
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Density
Eddy Viscosity
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Coriolis Forcing
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Wave Radiation
Sources
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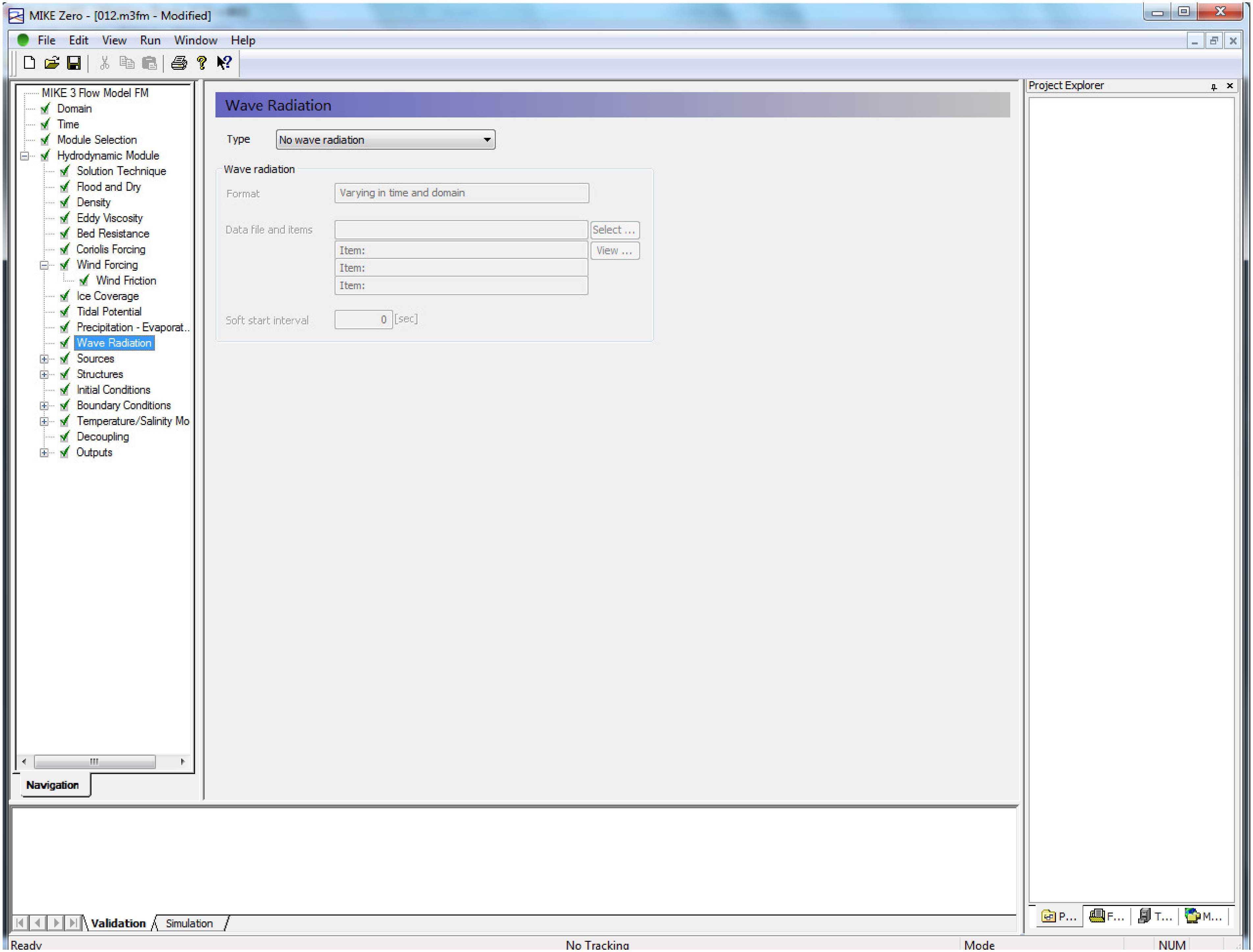
Boundary Conditions
Temperature/Salinity Mo
Decoupling
Outputs
Navigation
Precipitation - Evaporation
Precipitation
No precipitation
Evaporation
No evaporation
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
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Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
Wind Forcing
Wind Friction
Ice Coverage
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Precipitation - Evaporat...
Wave Radiation
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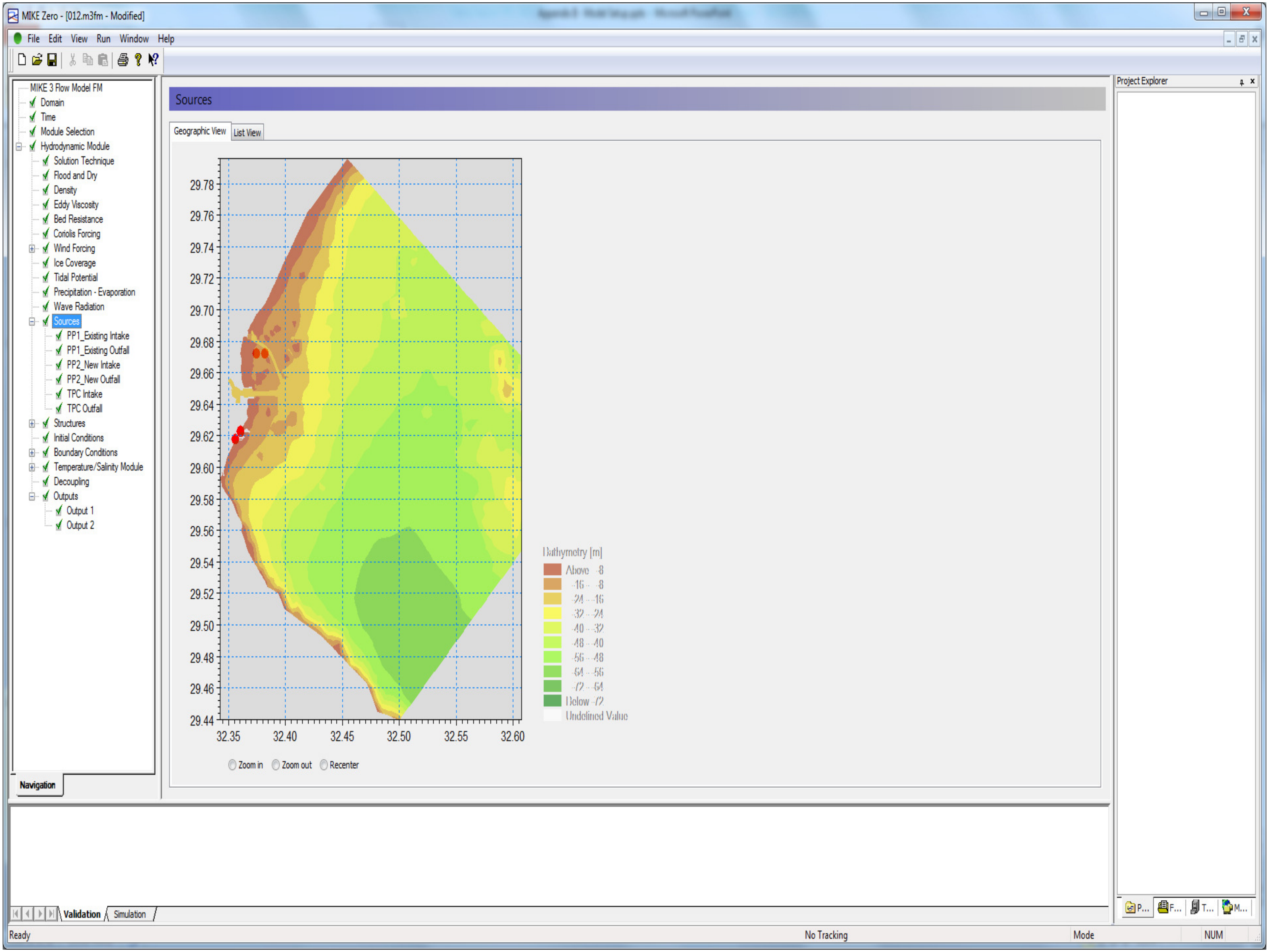
Initial Conditions
Boundary Conditions
Temperature/Salinity Mo
Decoupling
Outputs
Navigation
Wave Radiation
Type
No wave radiation
Wave radiation
Format
Varying in time and domain
Data file and items
Select ...
Item:
View ...
Item:
Item:
Soft start interval
0
[sec]
Project Explorer
P...
F...
T...
M...
Validation
Simulation
Ready
No Tracking
Mode
NUM



MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
Wind Forcing
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Precipitation - Evaporation
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PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
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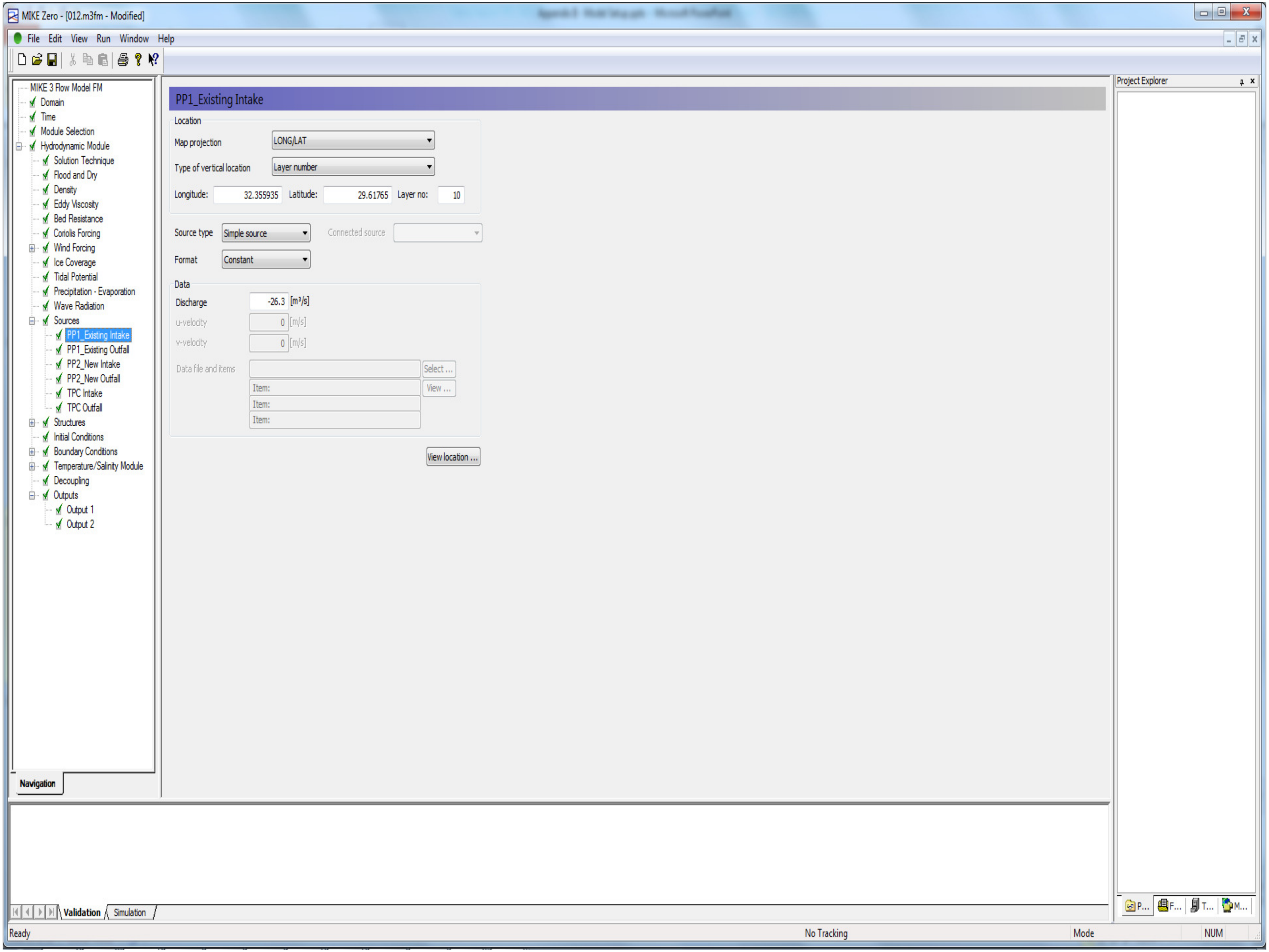
Boundary Conditions
Temperature/Salinity Module
Decoupling
Outputs
Output 1
Output 2
Navigation
Sources
Geographic View
List View
Bathymetry [m]
Above -8
-16 - -8
-24 - -16
-32 - -24
-40 - -32
-48 - -40
-56 - -48
-64 - -56
-72 - -64
Below -72
Undefined Value
Zoom in
Zoom out
Recenter
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
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Eddy Viscosity
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PP2_New Outfall
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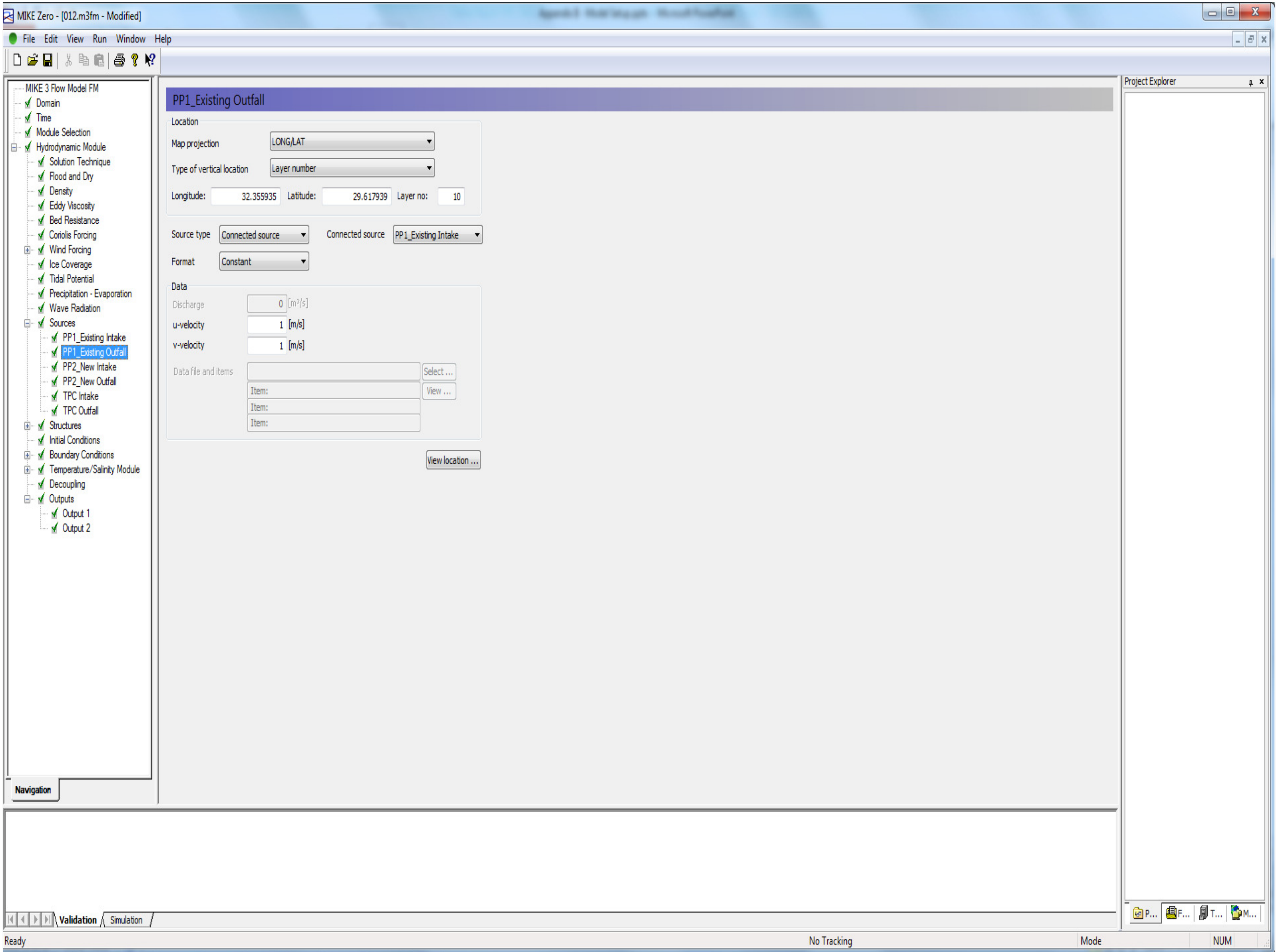
Outputs
Output 1
Output 2
Navigation
PP1_Existing Intake
Location
Map projection
LONG/LAT
Type of vertical location
Layer number
Longitude: 32.355935
Latitude: 29.61765
Layer no: 10
Source type
Simple source
Connected source
Format
Constant
Data
Discharge -26.3 [m³/s]
u-velocity 0 [m/s]
v-velocity 0 [m/s]
Data file and items
Select ...
Item:
View ...
Item:
Item:
View location ...
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
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Module Selection
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Density
Eddy Viscosity
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PP2_New Intake
PP2_New Outfall
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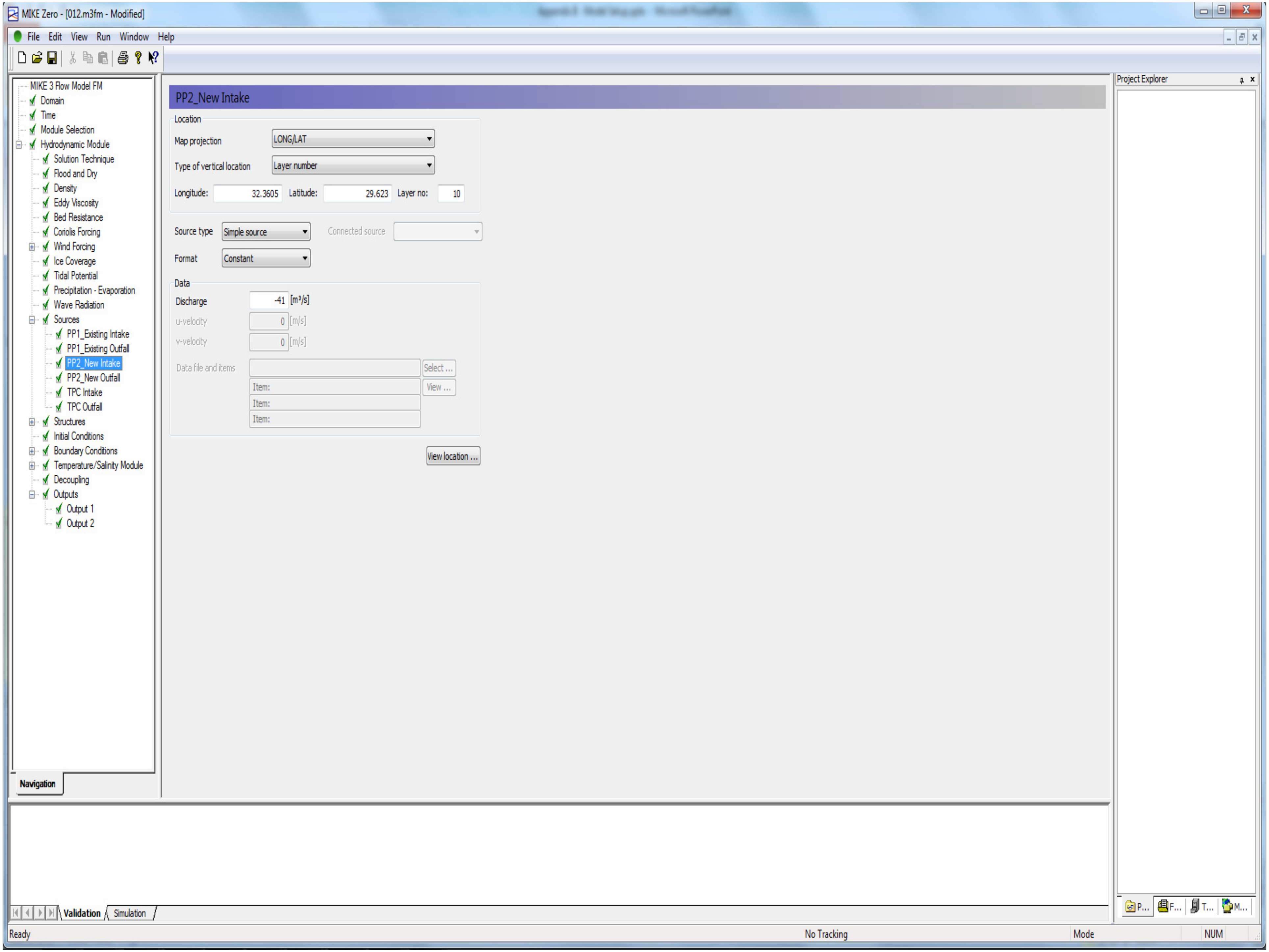
Outputs
Output 1
Output 2
Navigation
PP1_Existing Outfall
Location
Map projection
LONG/LAT
Type of vertical location
Layer number
Longitude: 32.355935
Latitude: 29.617939
Layer no: 10
Source type
Connected source
Connected source
PP1_Existing Intake
Format
Constant
Data
Discharge 0 [m³/s]
u-velocity 1 [m/s]
v-velocity 1 [m/s]
Data file and items
Select ...
Item:
View ...
Item:
Item:
View location ...
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
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PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
Structures
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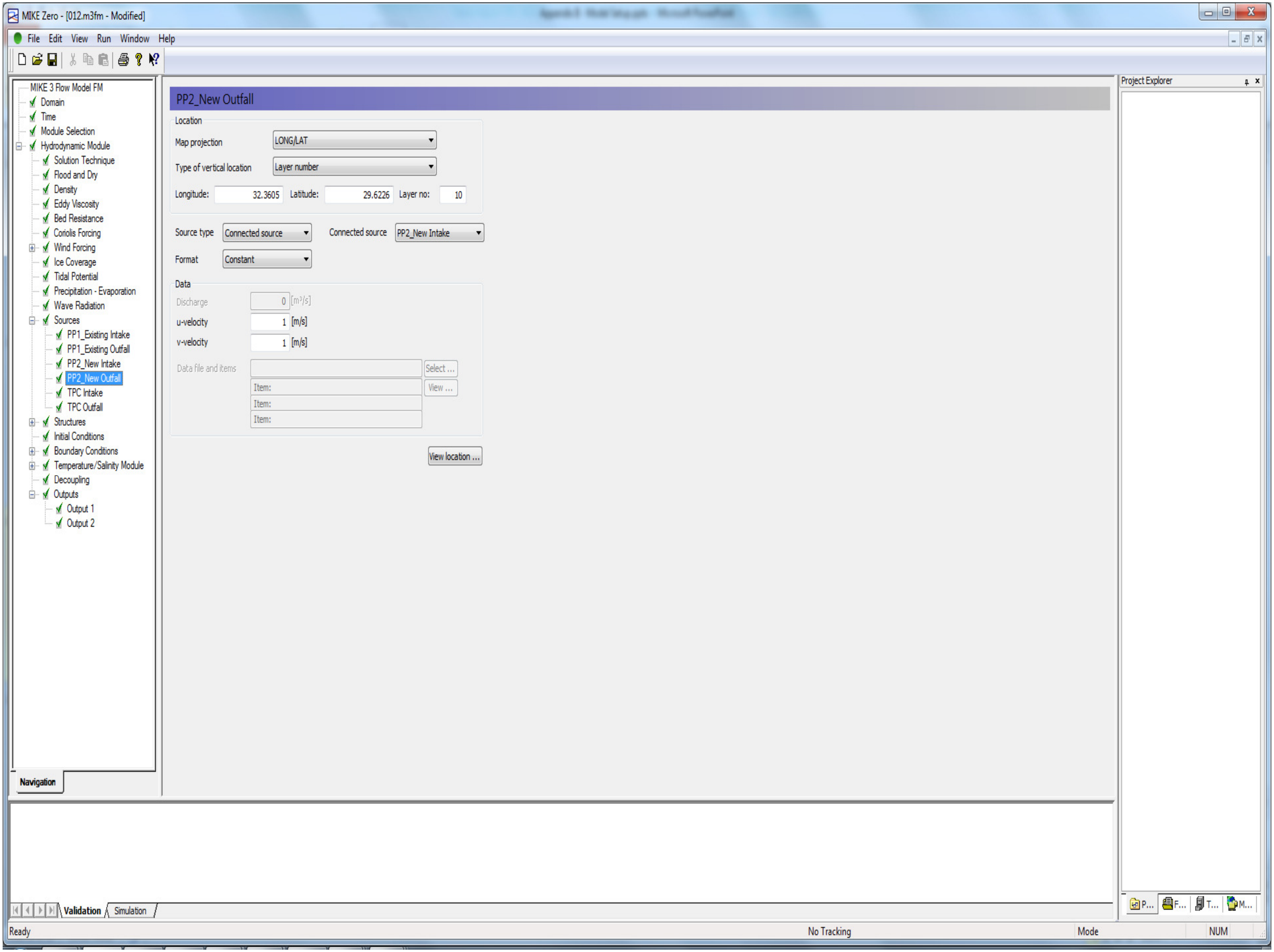
Boundary Conditions
Temperature/Salinity Module
Decoupling
Outputs
Output 1
Output 2
Navigation
PP2_New Intake
Location
Map projection
LONG/LAT
Type of vertical location
Layer number
Longitude: 32.3605
Latitude: 29.623
Layer no: 10
Source type
Simple source
Connected source
Format
Constant
Data
Discharge -41 [m³/s]
u-velocity 0 [m/s]
v-velocity 0 [m/s]
Data file and items
Select ...
Item:
View ...
Item:
Item:
View location ...
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
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PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
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TPC Outfall
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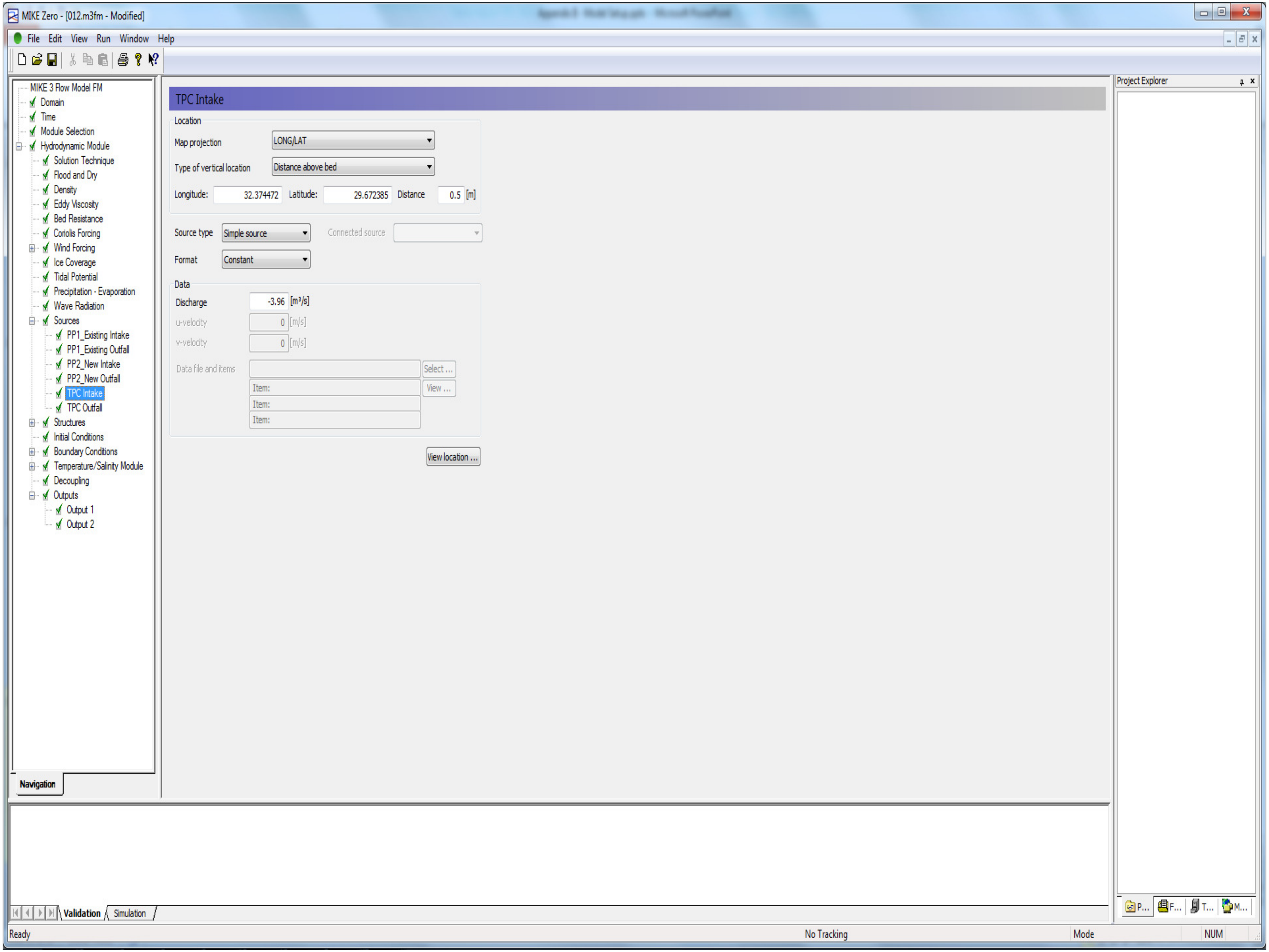
Outputs
Output 1
Output 2
Navigation
PP2_New Outfall
Location
Map projection
LONG/LAT
Type of vertical location
Layer number
Longitude: 32.3605
Latitude: 29.6226
Layer no: 10
Source type
Connected source
Connected source
PP2_New Intake
Format
Constant
Data
Discharge 0 [m³/s]
u-velocity 1 [m/s]
v-velocity 1 [m/s]
Data file and items
Select ...
Item:
View ...
Item:
Item:
View location ...
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM



MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
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PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
Structures
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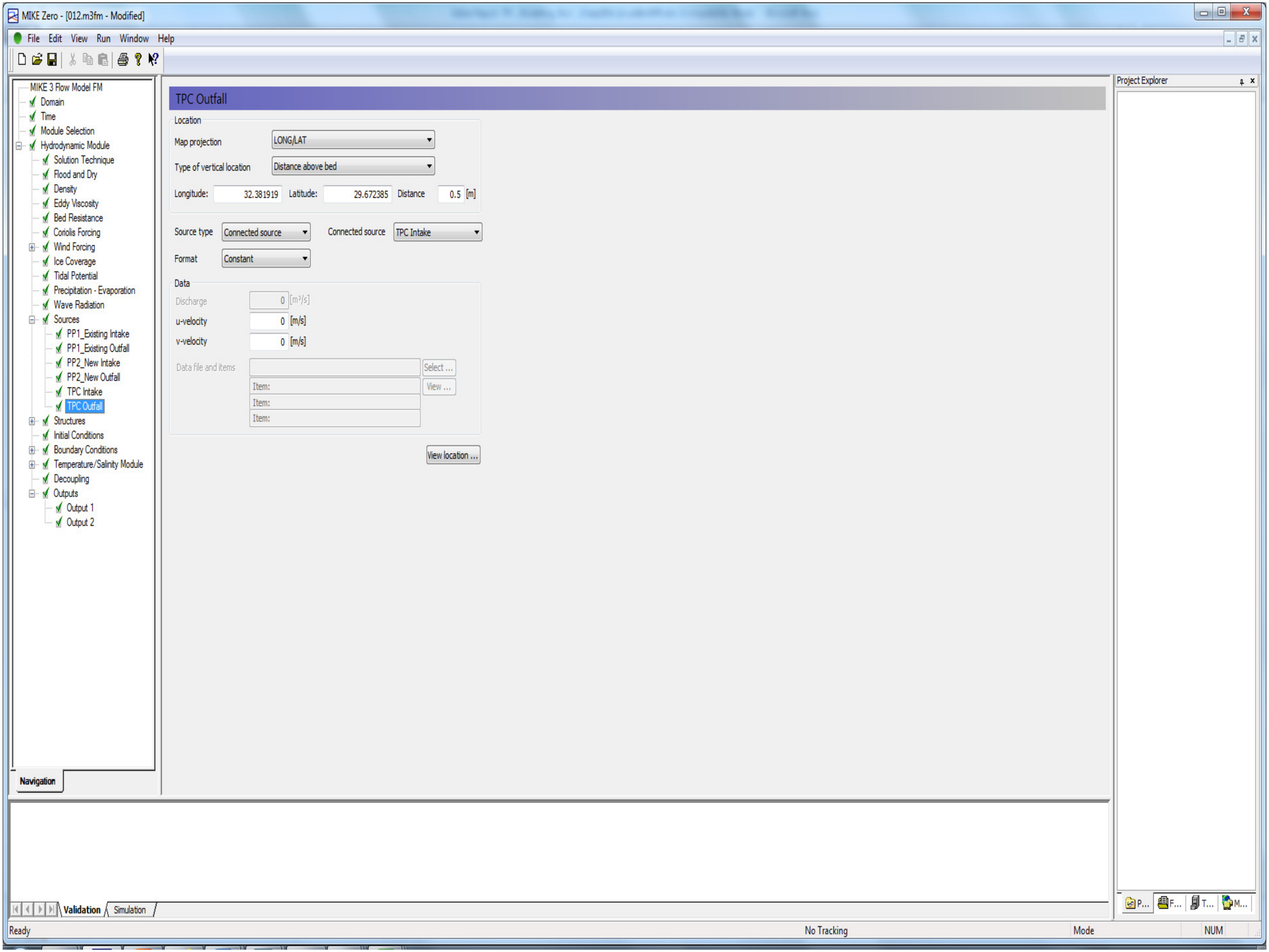
Boundary Conditions
Temperature/Salinity Module
Decoupling
Outputs
Output 1
Output 2
Navigation
TPC Intake
Location
Map projection LONG/LAT
Type of vertical location Distance above bed
Longitude: 32.374472 Latitude: 29.672385 Distance 0.5 [m]
Source type Simple source
Connected source
Format Constant
Data
Discharge -3.96 [m³/s]
u-velocity 0 [m/s]
v-velocity 0 [m/s]
Data file and items
Select ...
Item:
View ...
Item:
Item:
View location ...
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
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Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
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PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
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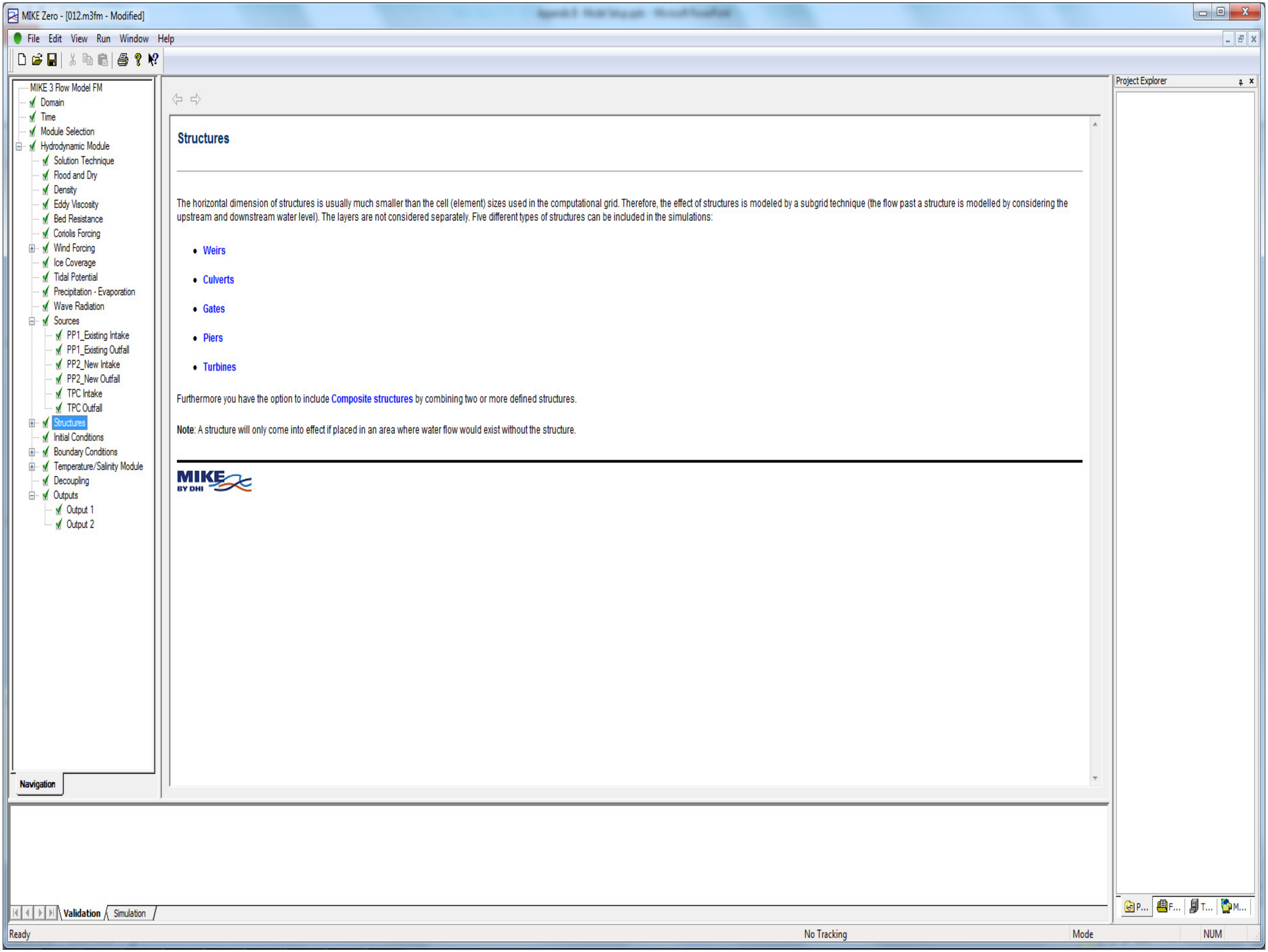
Decoupling
Outputs
Output 1
Output 2
Navigation
TPC Outfall
Location
Map projection LONG/LAT
Type of vertical location Distance above bed
Longitude: 32.381919 Latitude: 29.672385 Distance 0.5 [m]
Source type Connected source Connected source TPC Intake
Format Constant
Data
Discharge 0 [m³/s]
u-velocity 0 [m/s]
v-velocity 0 [m/s]
Data file and items
Select ...
Item:
View ...
Item:
Item:
View location ...
Project Explorer
Validation Simulation
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
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Output 1
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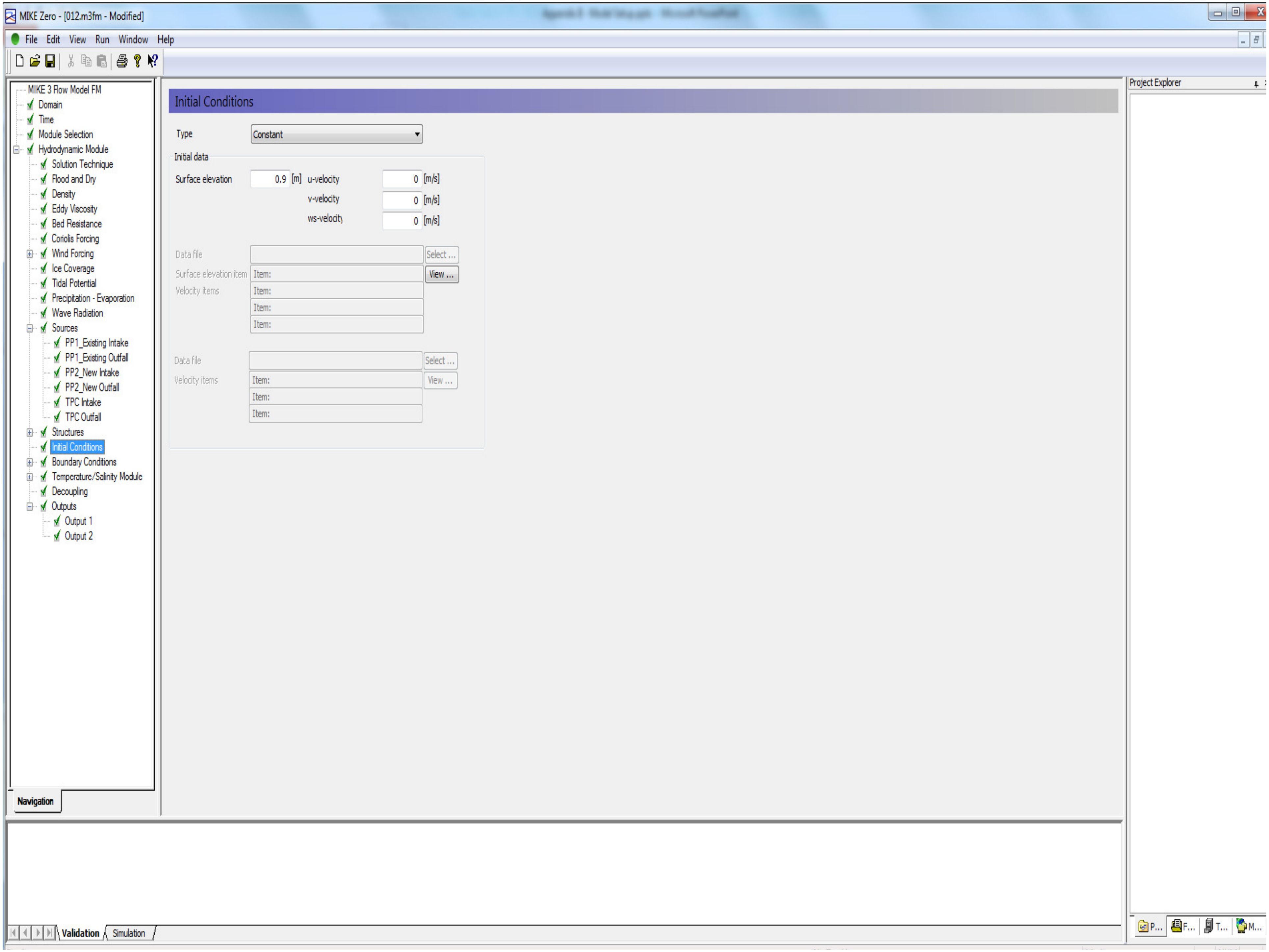
Navigation
Project Explorer
Structures
The horizontal dimension of structures is usually much smaller than the cell (element) sizes used in the computational grid. Therefore, the effect of structures is modeled by a subgrid technique (the flow past a structure is modelled by considering the upstream and downstream water level). The layers are not considered separately. Five different types of structures can be included in the simulations:
Weirs
Culverts
Gates
Piers
Turbines
Furthermore you have the option to include Composite structures by combining two or more defined structures.
Note: A structure will only come into effect if placed in an area where water flow would exist without the structure.
MIKE BY DHI
Validation
Simulation
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
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Module Selection
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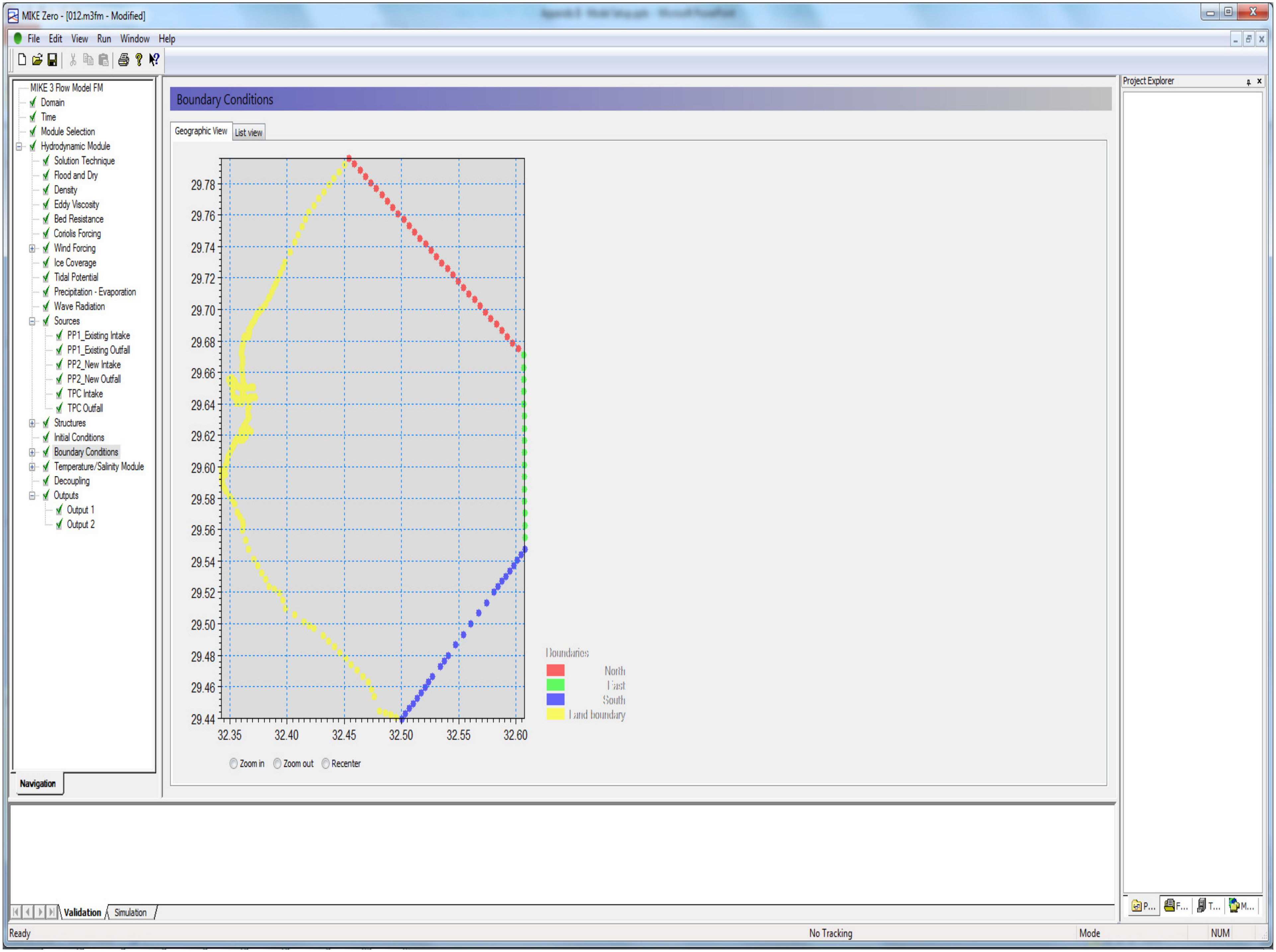
PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
Structures
Initial Conditions
Boundary Conditions
Temperature/Salinity Module
Decoupling
Outputs
Output 1
Output 2
Navigation
Initial Conditions
Type
Constant
Initial data
Surface elevation
0.9
[m]
u-velocity
0
[m/s]
v-velocity
0
[m/s]
ws-velocity
0
[m/s]
Data file
Select ...
Surface elevation item
Item:
View ...
Velocity items
Item:
Item:
Item:
Data file
Select ...
Velocity items
Item:
View ...
Item:
Item:
Project Explorer
Validation
Simulation



MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
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Time
Module Selection
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PP2_New Outfall
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TPC Outfall
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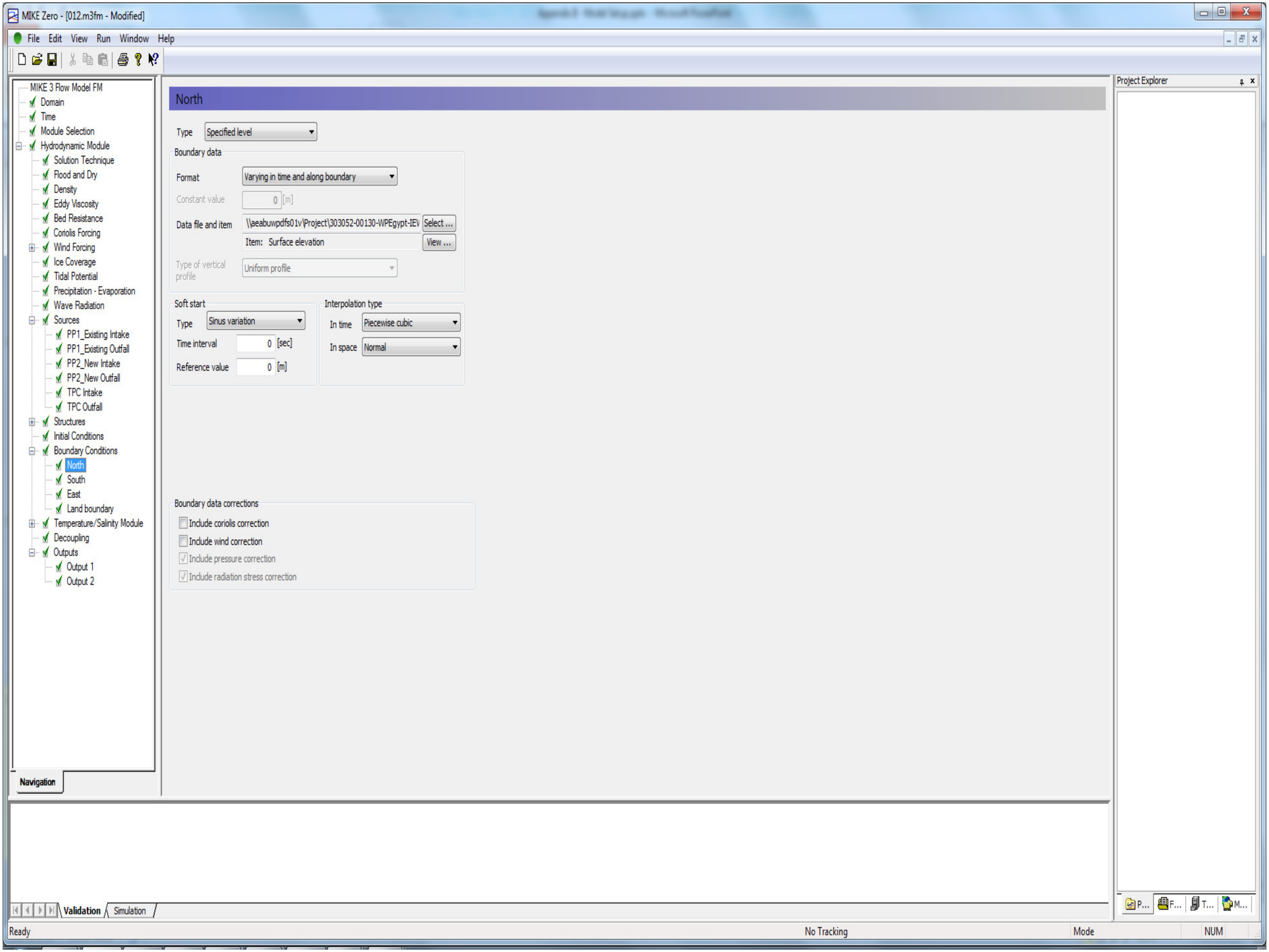
Geographic View
List view
29.78
29.76
29.74
29.72
29.70
29.68
29.66
29.64
29.62
29.60
29.58
29.56
29.54
29.52
29.50
29.48
29.46
29.44
32.35
32.40
32.45
32.50
32.55
32.60
Boundaries
North
East
South
Land boundary
Zoom in
Zoom out
Recenter
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
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PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
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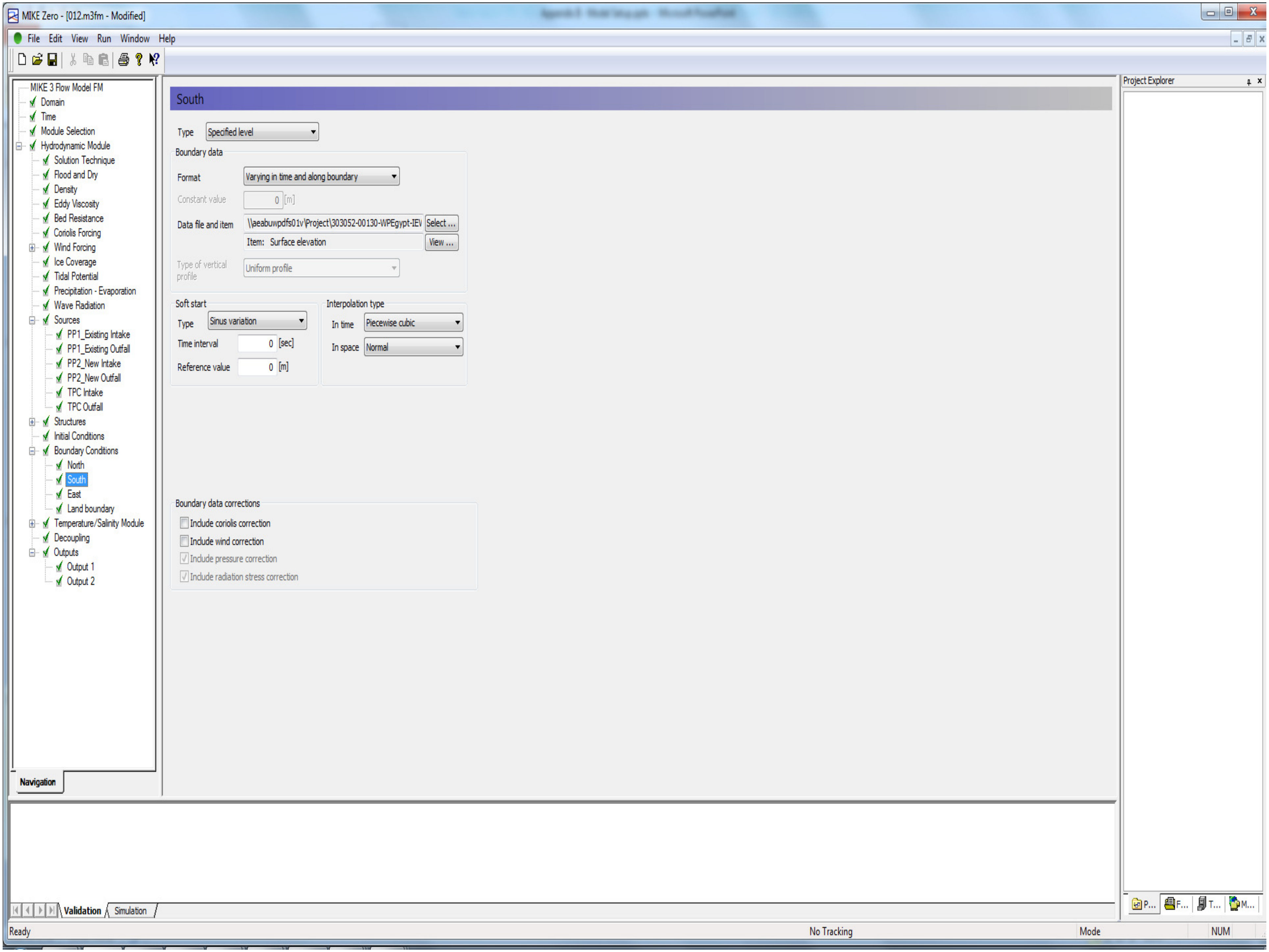
Boundary Conditions
North
South
East
Land boundary
Temperature/Salinity Module
Decoupling
Outputs
Output 1
Output 2
Navigation
North
Type
Specified level
Boundary data
Format
Varying in time and along boundary
Constant value
0 [m]
Data file and item
\\aeabuwpdfs01v\Project\303052-00130-WPEgypt-IEV
Select ...
Item: Surface elevation
View ...
Type of vertical profile
Uniform profile
Soft start
Type
Sinus variation
Time interval
0 [sec]
Reference value
0 [m]
Interpolation type
In time
Piecewise cubic
In space
Normal
Boundary data corrections
Include coriolis correction
Include wind correction
Include pressure correction
Include radiation stress correction
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
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Eddy Viscosity
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PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
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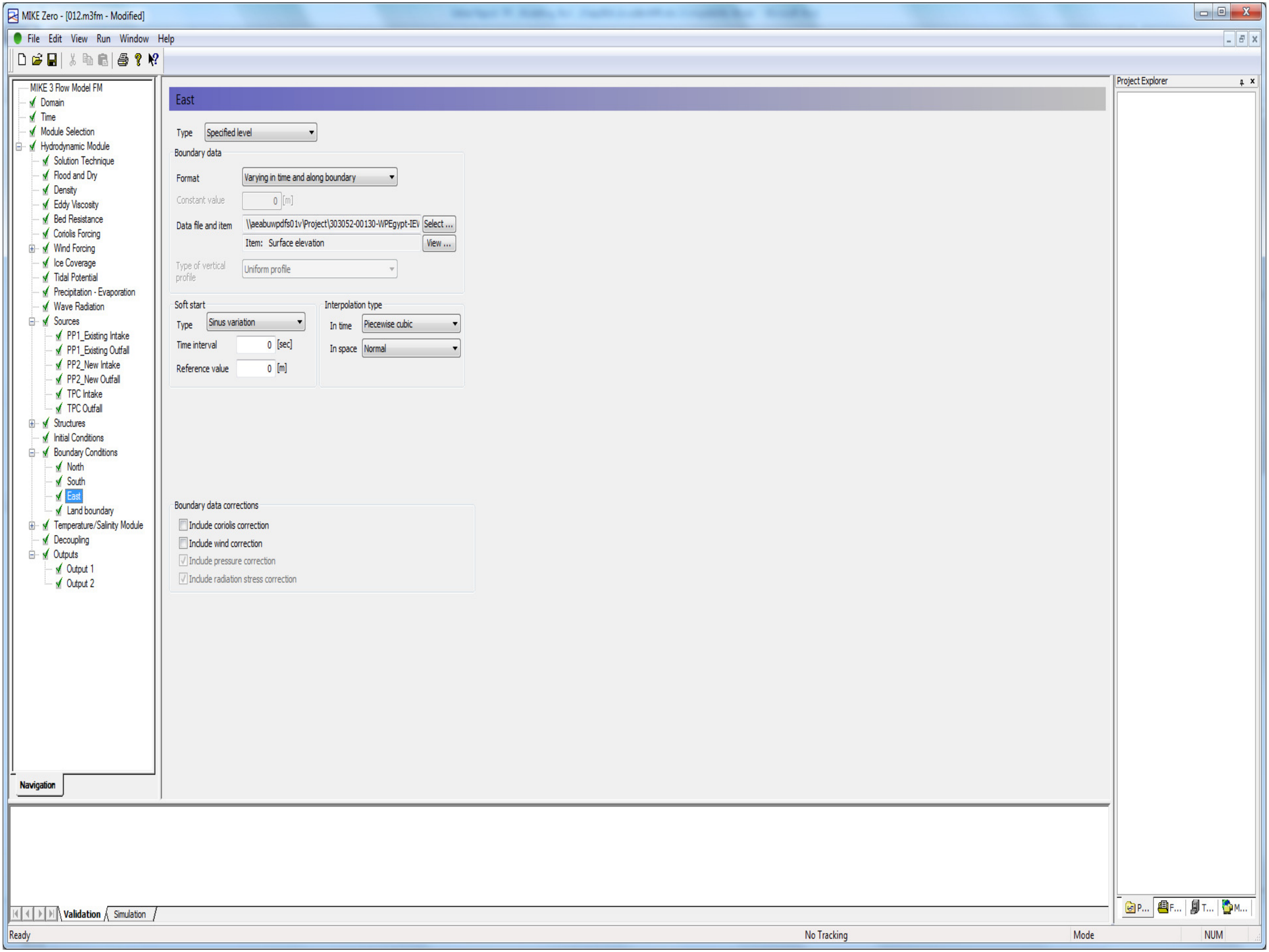
Initial Conditions
Boundary Conditions
North
South
East
Land boundary
Temperature/Salinity Module
Decoupling
Outputs
Output 1
Output 2
Navigation
South
Type Specified level
Boundary data
Format Varying in time and along boundary
Constant value 0 [m]
Data file and item \\aeabuwpdfs01v\Project\303052-00130-WPEgypt-IEV Select ...
Item: Surface elevation View ...
Type of vertical profile Uniform profile
Soft start
Type Sinus variation
Time interval 0 [sec]
Reference value 0 [m]
Interpolation type
In time Piecewise cubic
In space Normal
Boundary data corrections
Include coriolis correction
Include wind correction
Include pressure correction
Include radiation stress correction
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
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PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
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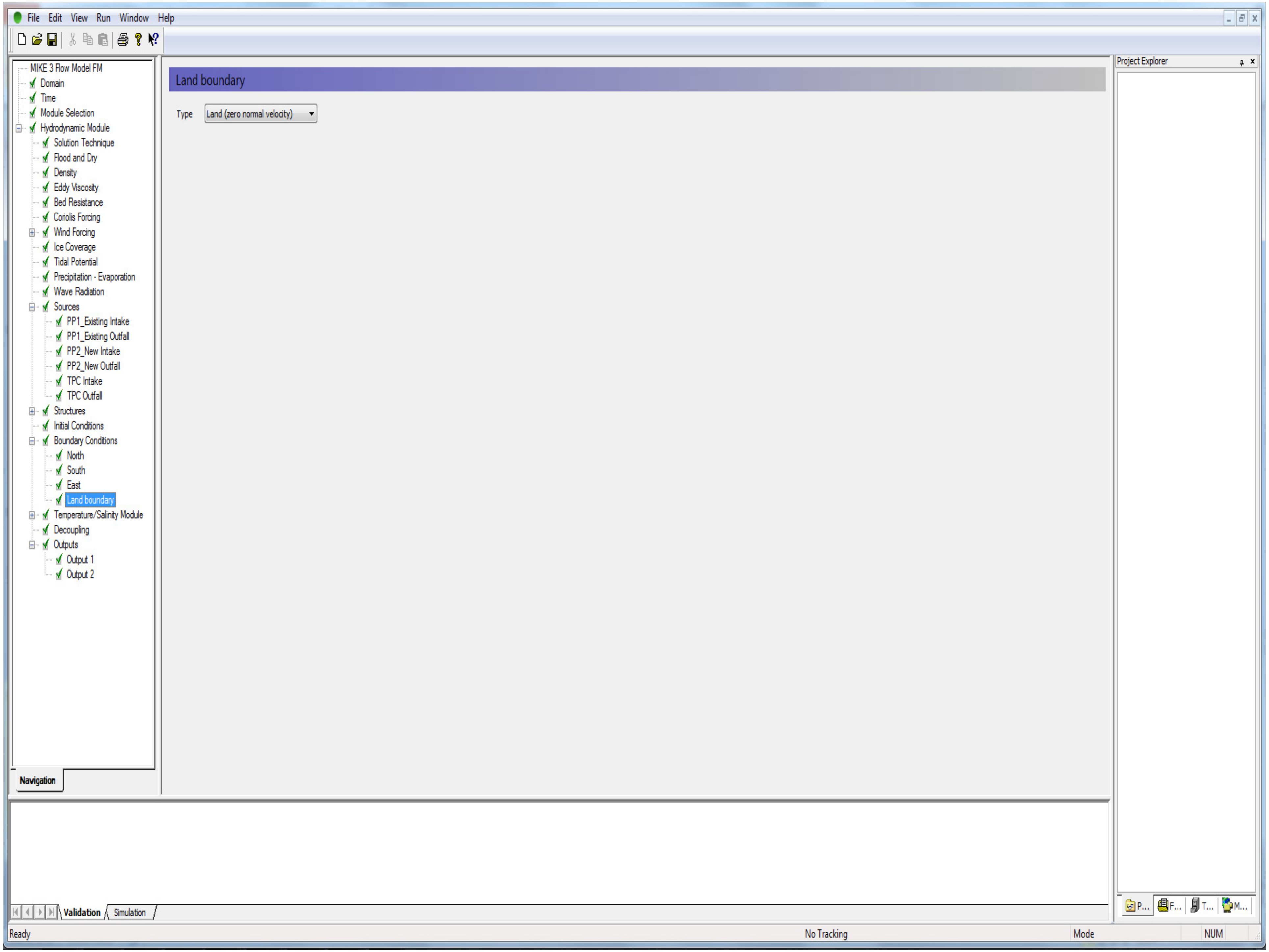
Boundary Conditions
North
South
East
Land boundary
Temperature/Salinity Module
Decoupling
Outputs
Output 1
Output 2
Navigation
East
Type Specified level
Boundary data
Format Varying in time and along boundary
Constant value 0 [m]
Data file and item \\aeabuwpdfs01v\Project\303052-00130-WPEgypt-IEV Select ...
Item: Surface elevation View ...
Type of vertical profile Uniform profile
Soft start
Type Sinus variation
Time interval 0 [sec]
Reference value 0 [m]
Interpolation type
In time Piecewise cubic
In space Normal
Boundary data corrections
Include coriolis correction
Include wind correction
Include pressure correction
Include radiation stress correction
Project Explorer
Validation Simulation
Ready
No Tracking
Mode
NUM


File Edit View Run Window Help
MIKE 3 Flow Model FM
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Bed Resistance
Coriolis Forcing
Wind Forcing
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PP2_New Outfall
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Outputs
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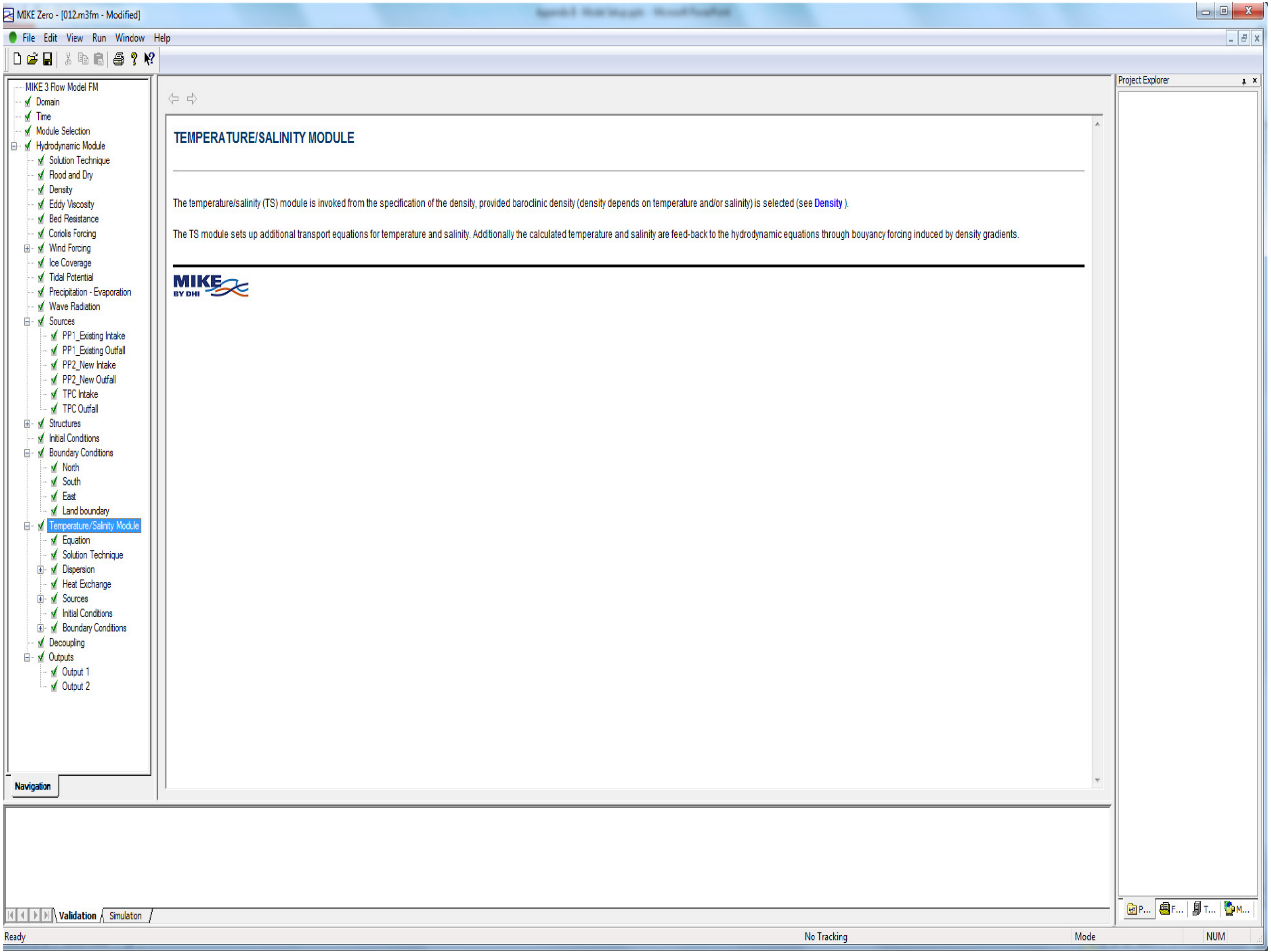
Output 2
Navigation
Land boundary
Type
Land (zero normal velocity)
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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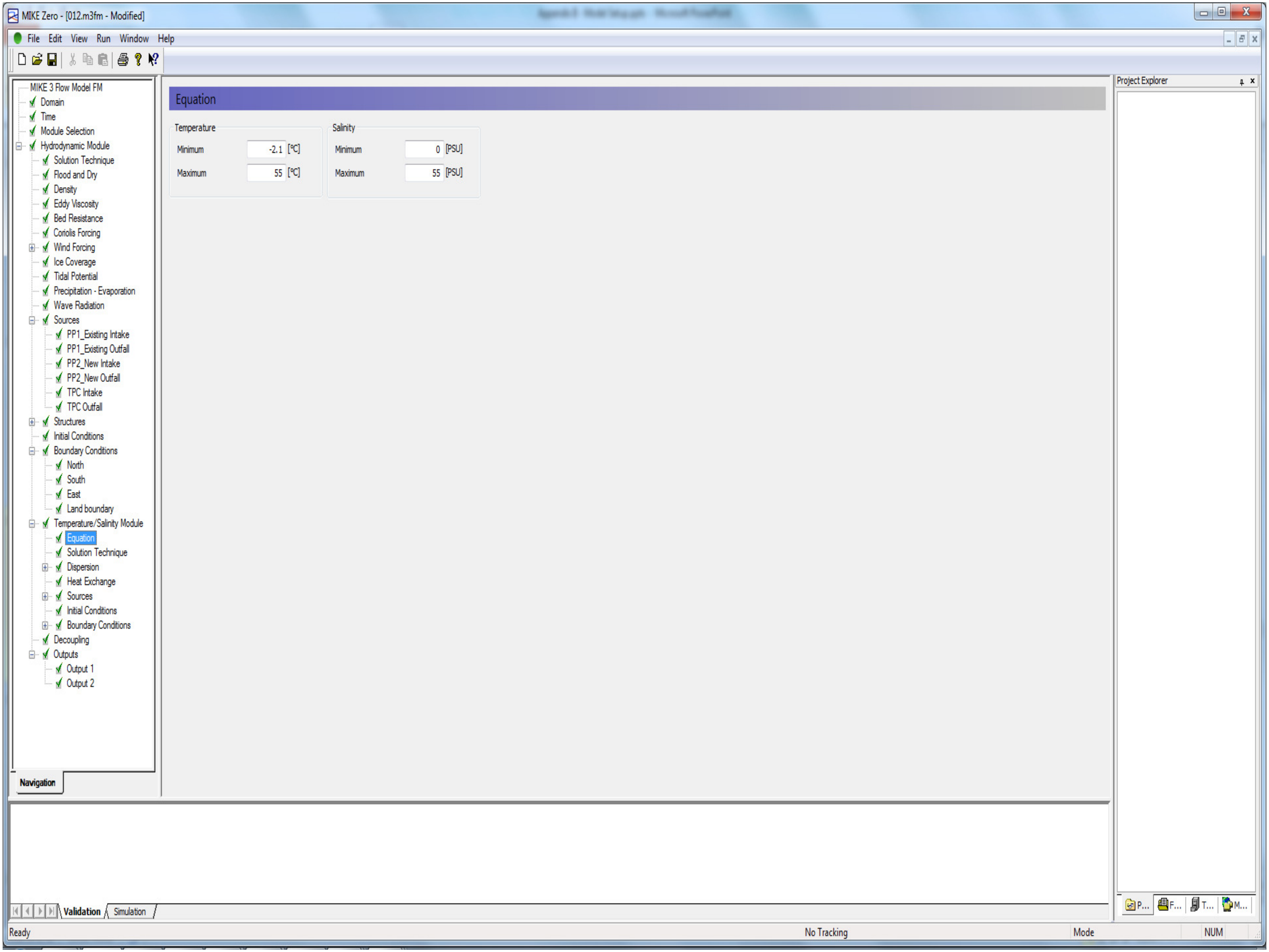
TEMPERATURE/SALINITY MODULE
The temperature/salinity (TS) module is invoked from the specification of the density, provided baroclinic density (density depends on temperature and/or salinity) is selected (see Density).
The TS module sets up additional transport equations for temperature and salinity. Additionally the calculated temperature and salinity are feed-back to the hydrodynamic equations through bouyancy forcing induced by density gradients.
MIKE BY DHI
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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File Edit View Run Window Help
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Outputs
Output 1
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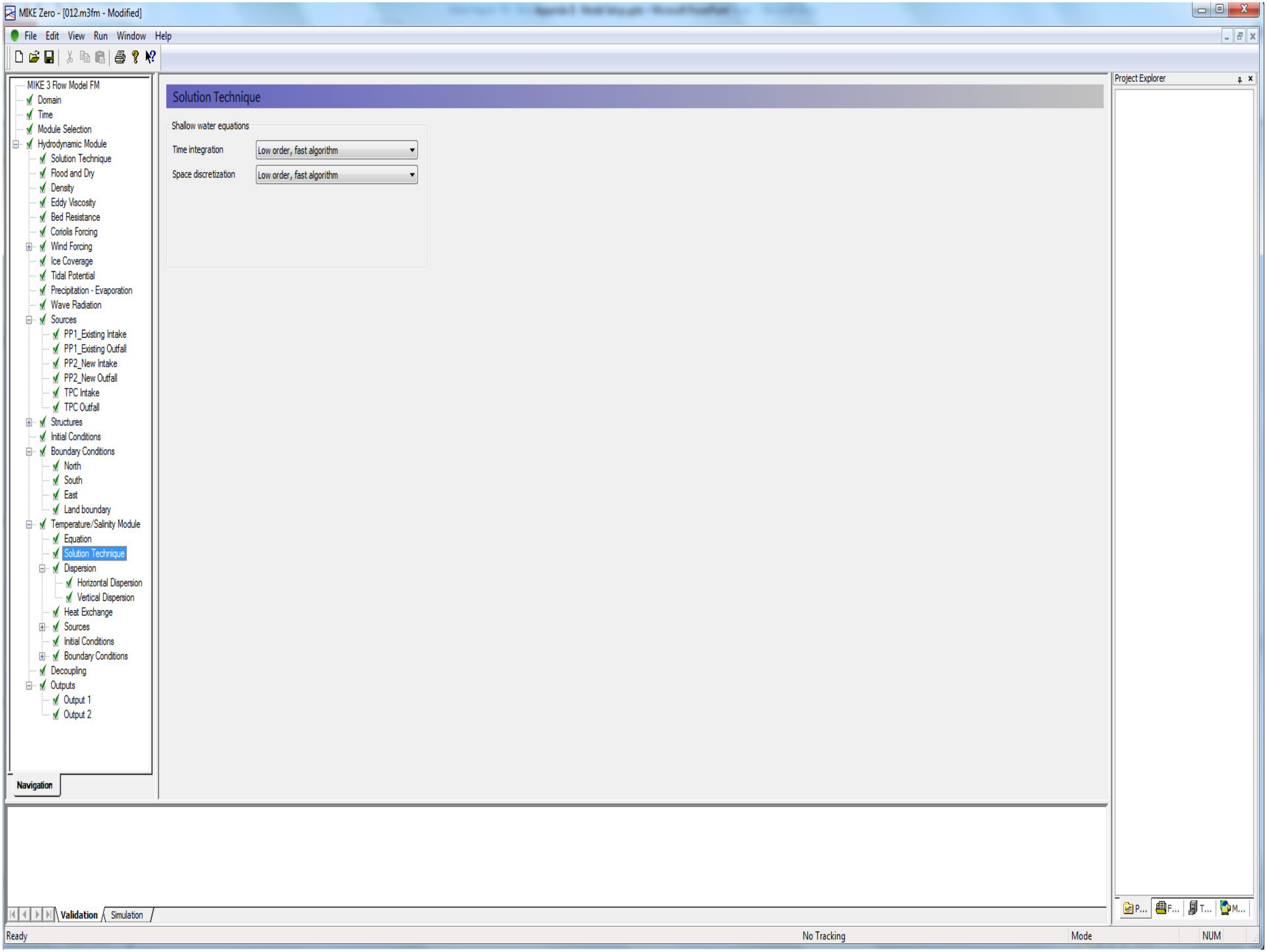
Navigation
Equation
Temperature
Minimum -2.1 [°C]
Maximum 55 [°C]
Salinity
Minimum 0 [PSU]
Maximum 55 [PSU]
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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File Edit View Run Window Help
MIKE 3 Flow Model FM
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Solution Technique
Shallow water equations
Time integration
Low order, fast algorithm
Space discretization
Low order, fast algorithm
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Validation
Simulation
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No Tracking
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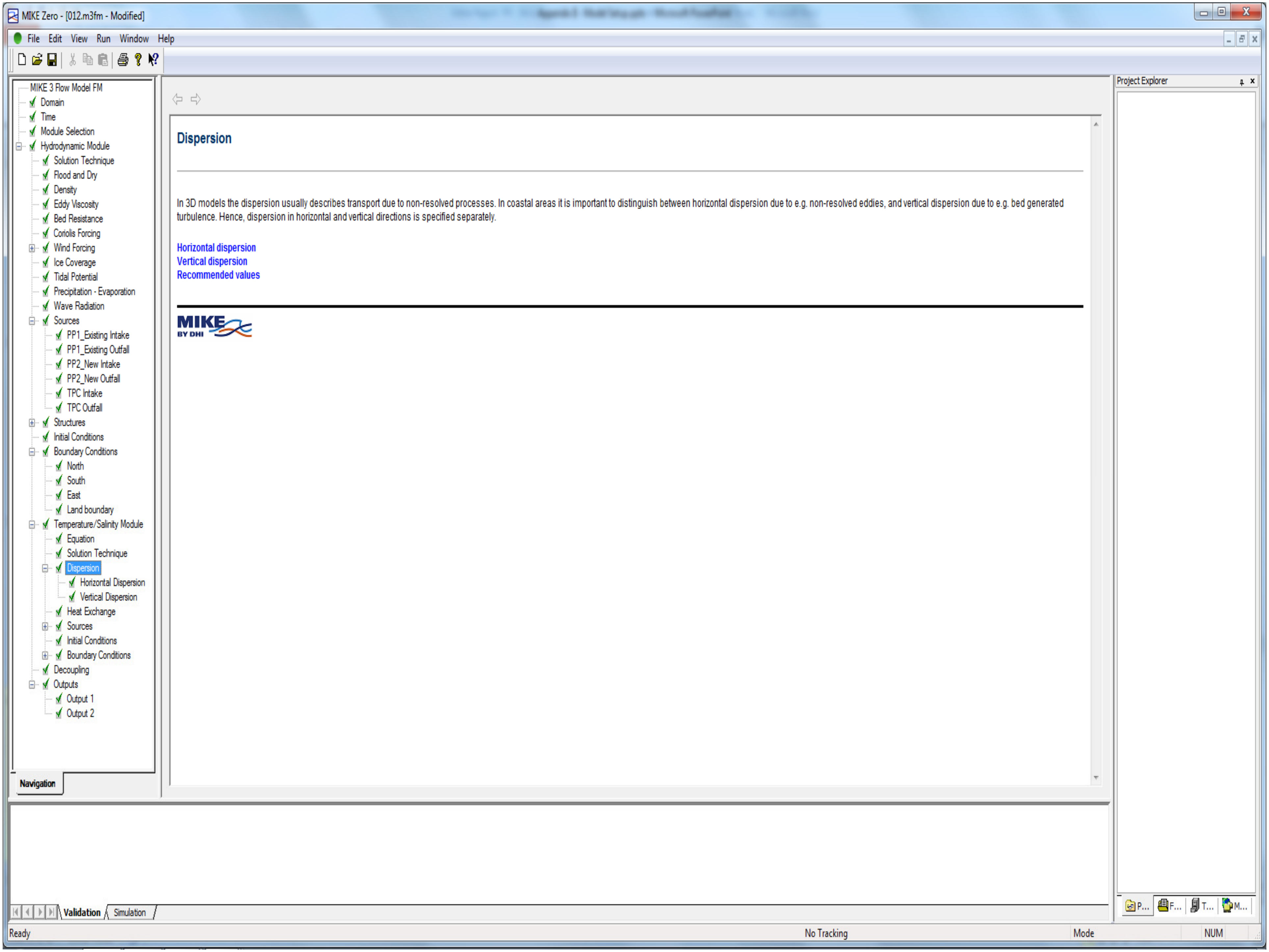
NUM



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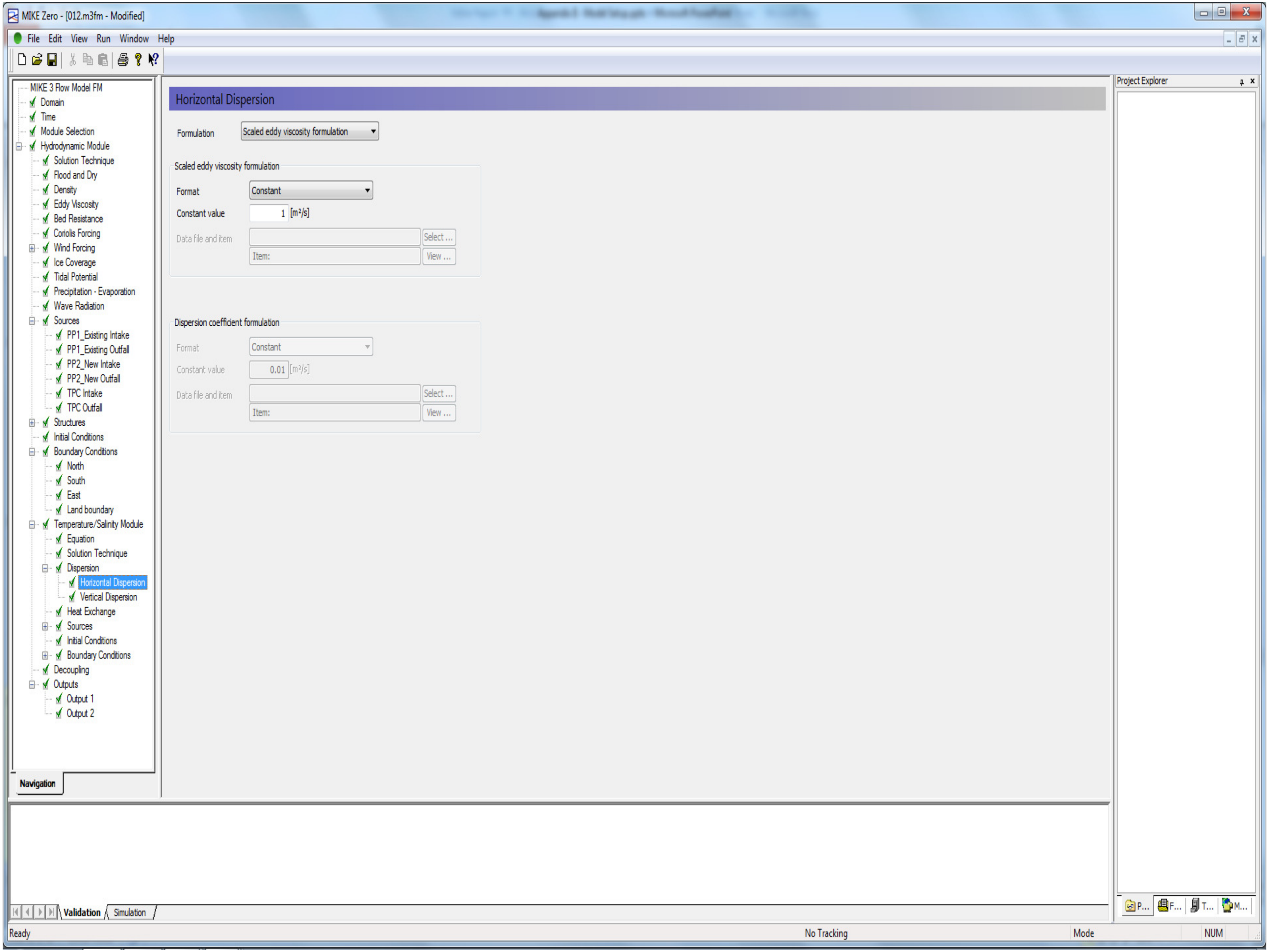
Dispersion
In 3D models the dispersion usually describes transport due to non-resolved processes. In coastal areas it is important to distinguish between horizontal dispersion due to e.g. non-resolved eddies, and vertical dispersion due to e.g. bed generated turbulence. Hence, dispersion in horizontal and vertical directions is specified separately.
Horizontal dispersion
Vertical dispersion
Recommended values
MIKE BY DHI
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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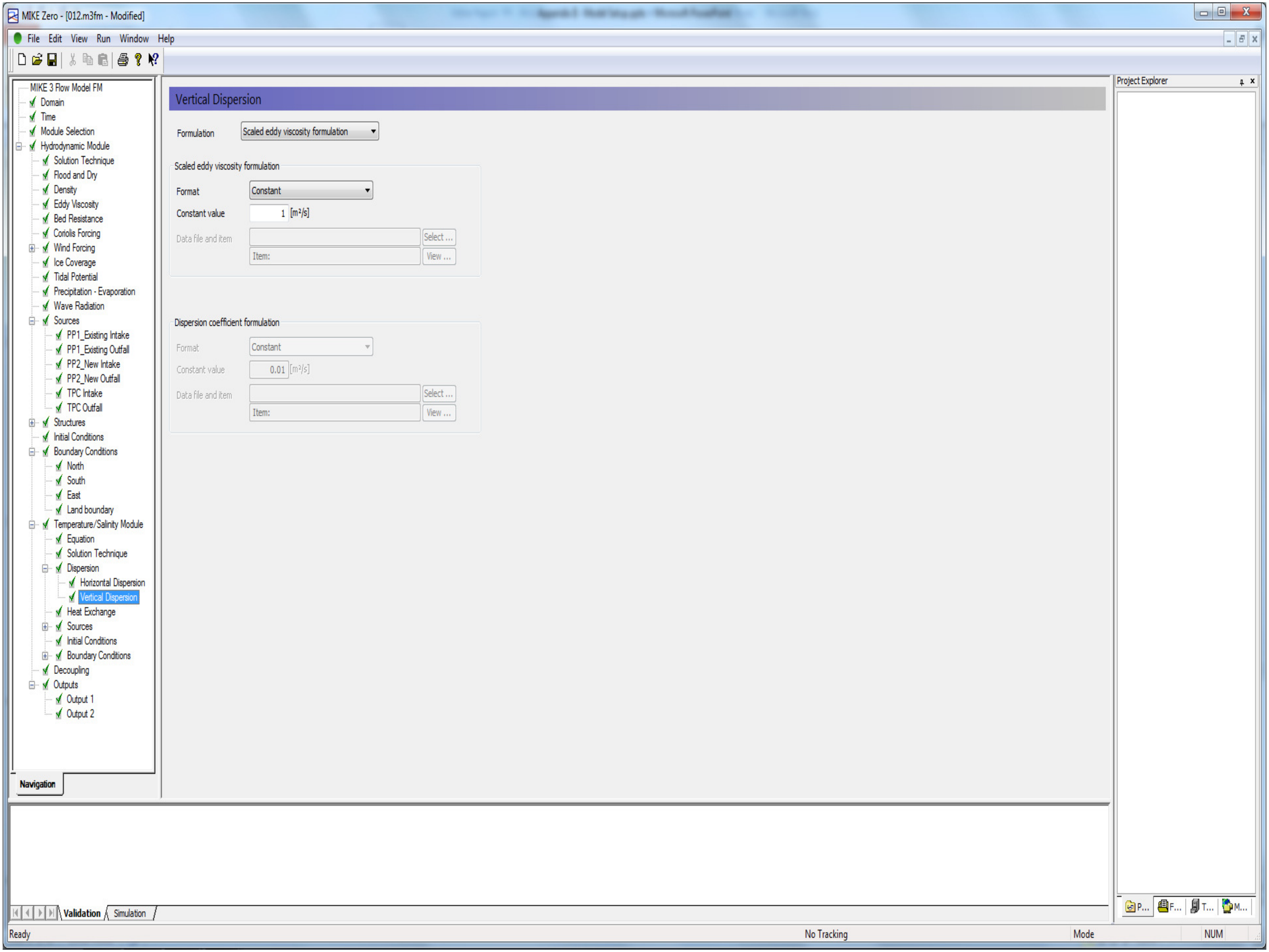
Horizontal Dispersion
Formulation
Scaled eddy viscosity formulation
Scaled eddy viscosity formulation
Format
Constant
Constant value
1 [m²/s]
Data file and item
Select ...
Item:
View ...
Dispersion coefficient formulation
Format
Constant
Constant value
0.01 [m²/s]
Data file and item
Select ...
Item:
View ...
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM



MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
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Formulation
Scaled eddy viscosity formulation
Scaled eddy viscosity formulation
Format
Constant
Constant value
1 [m²/s]
Data file and item
Select ...
Item:
View ...
Dispersion coefficient formulation
Format
Constant
Constant value
0.01 [m²/s]
Data file and item
Select ...
Item:
View ...
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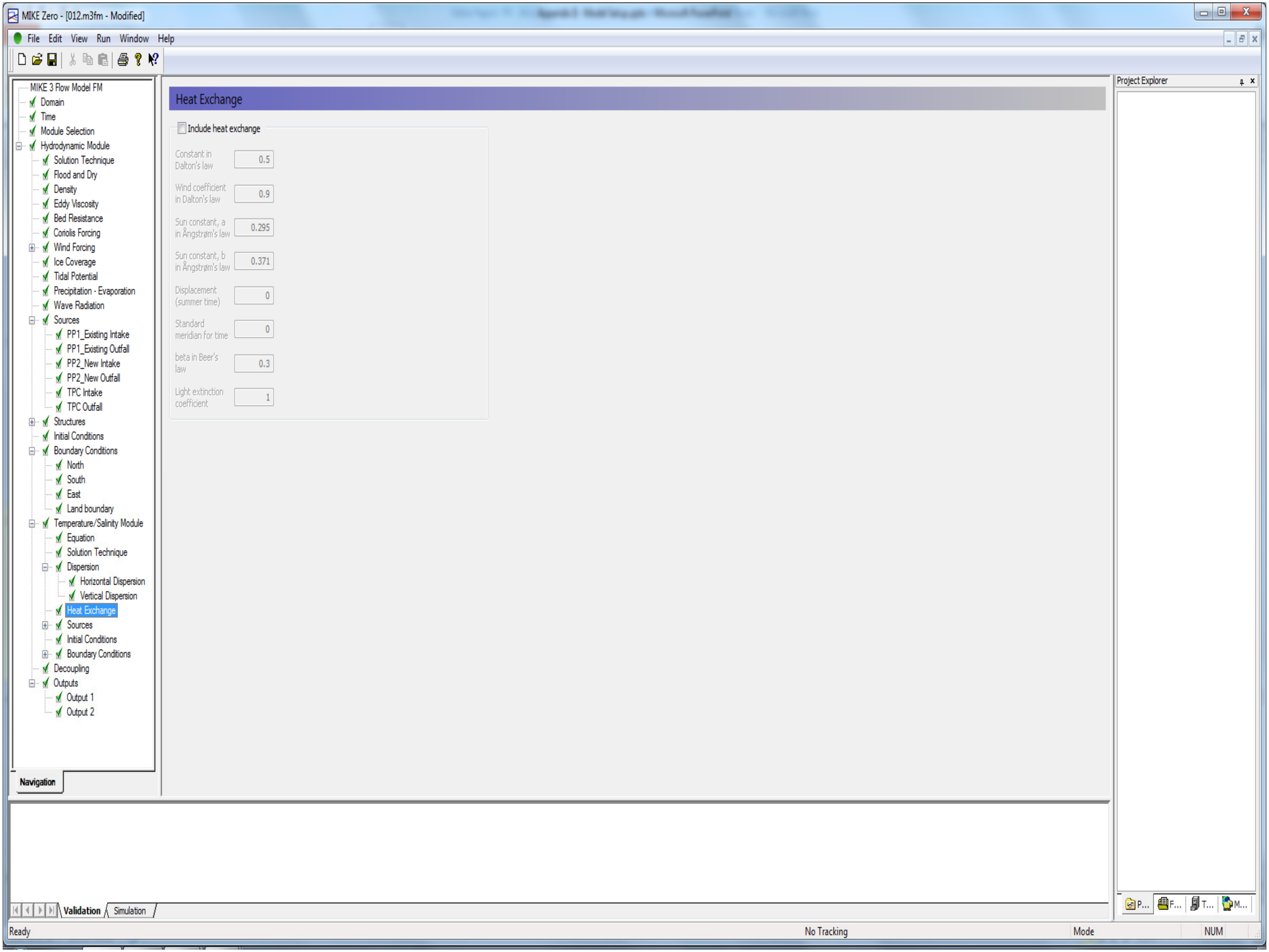
Ready
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
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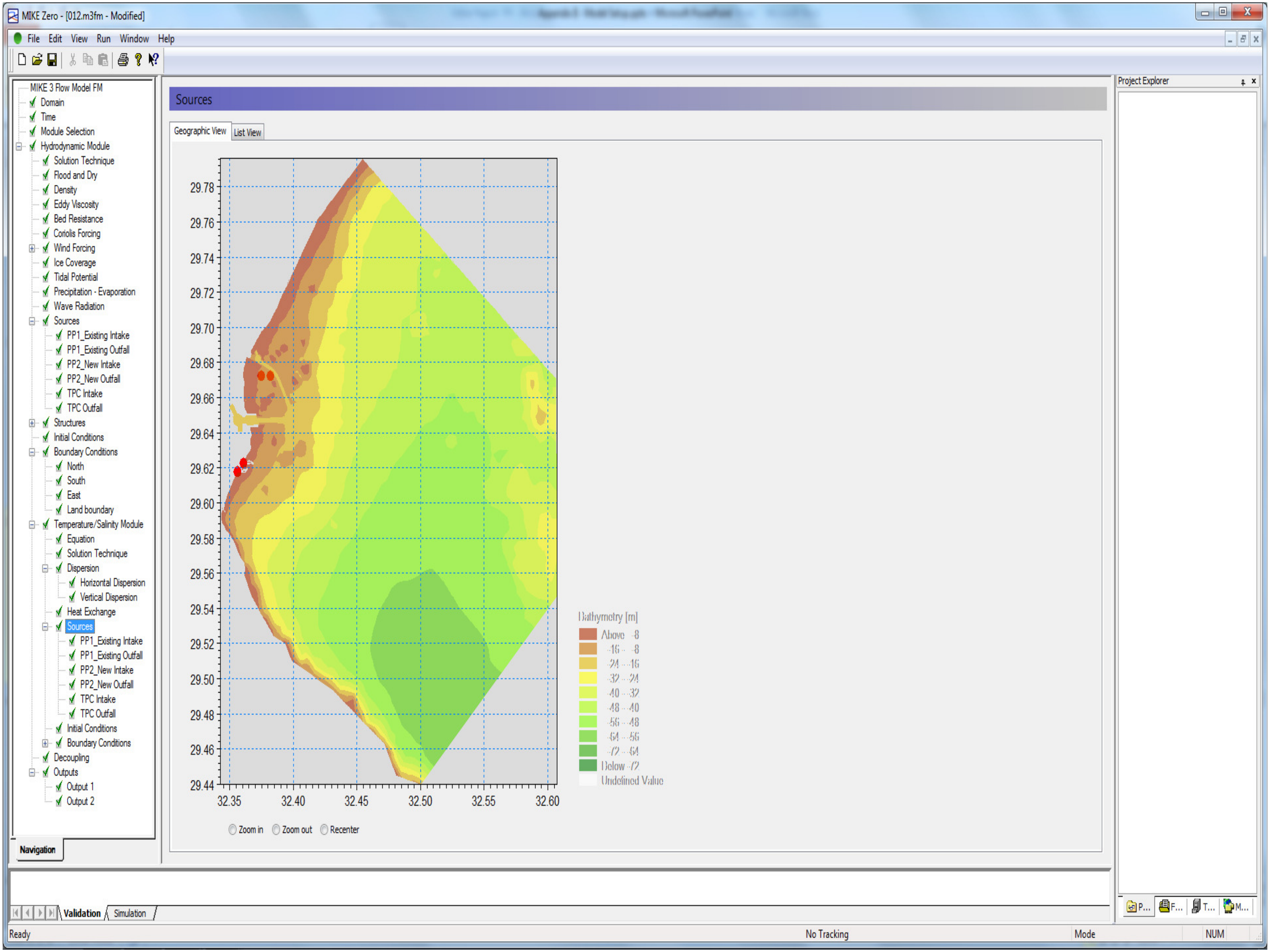
Heat Exchange
Include heat exchange
Constant in Dalton's law 0.5
Wind coefficient in Dalton's law 0.9
Sun constant, a in Ångstrøm's law 0.295
Sun constant, b in Ångstrøm's law 0.371
Displacement (summer time) 0
Standard meridian for time 0
beta in Beer's law 0.3
Light extinction coefficient 1
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM



MIKE Zero - [012.m3fm - Modified]
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PP2_New Outfall
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Geographic View
List View
29.78
29.76
29.74
29.72
29.70
29.68
29.66
29.64
29.62
29.60
29.58
29.56
29.54
29.52
29.50
29.48
29.46
29.44
32.35
32.40
32.45
32.50
32.55
32.60
Bathymetry [m]
Above -8
-16 - -8
-24 - -16
-32 - -24
-40 - -32
-48 - -40
-56 - -48
-64 - -56
-72 - -64
Below -72
Undefined Value
Zoom in
Zoom out
Recenter
Project Explorer
Validation
Simulation
Ready
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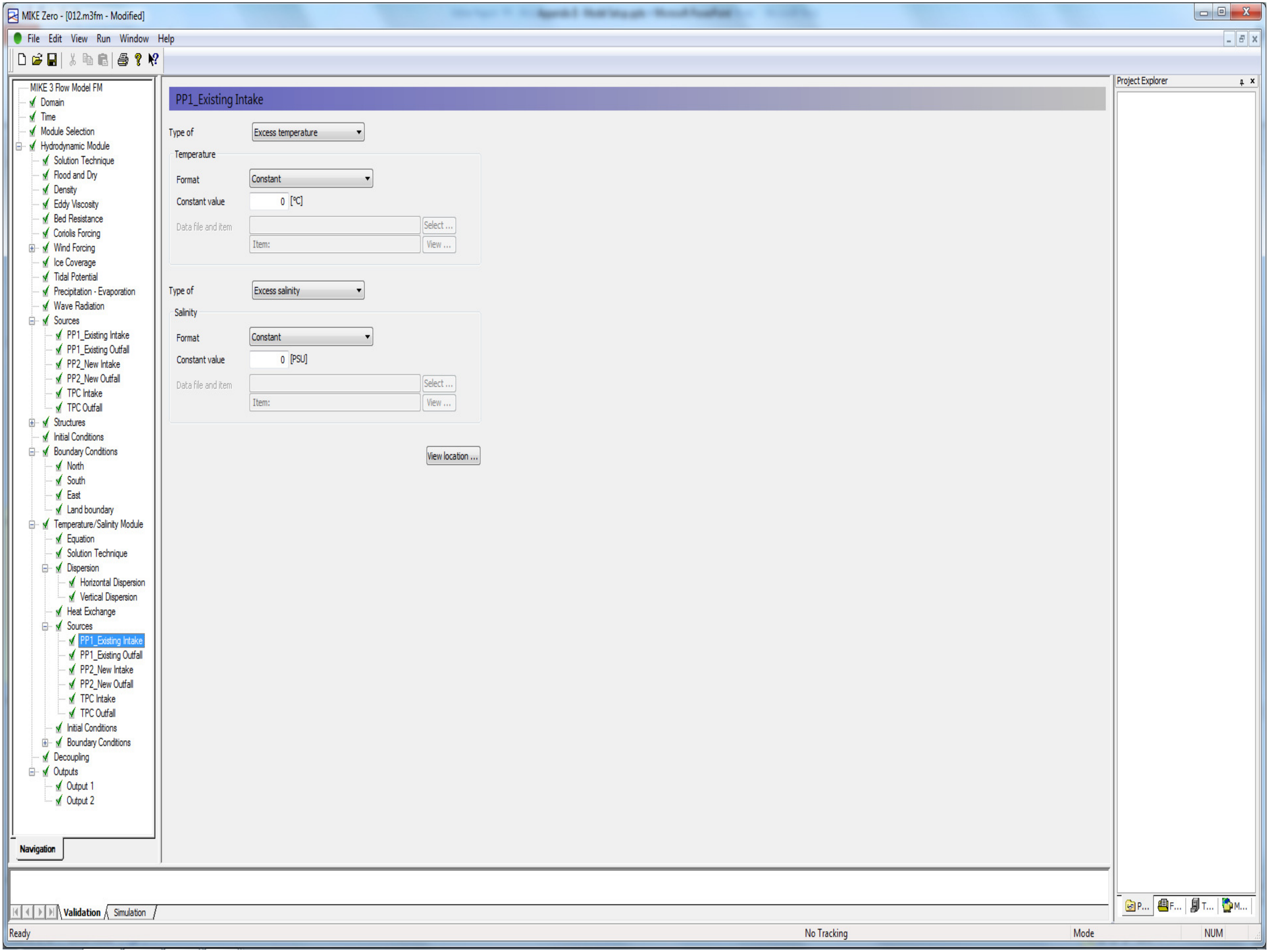
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
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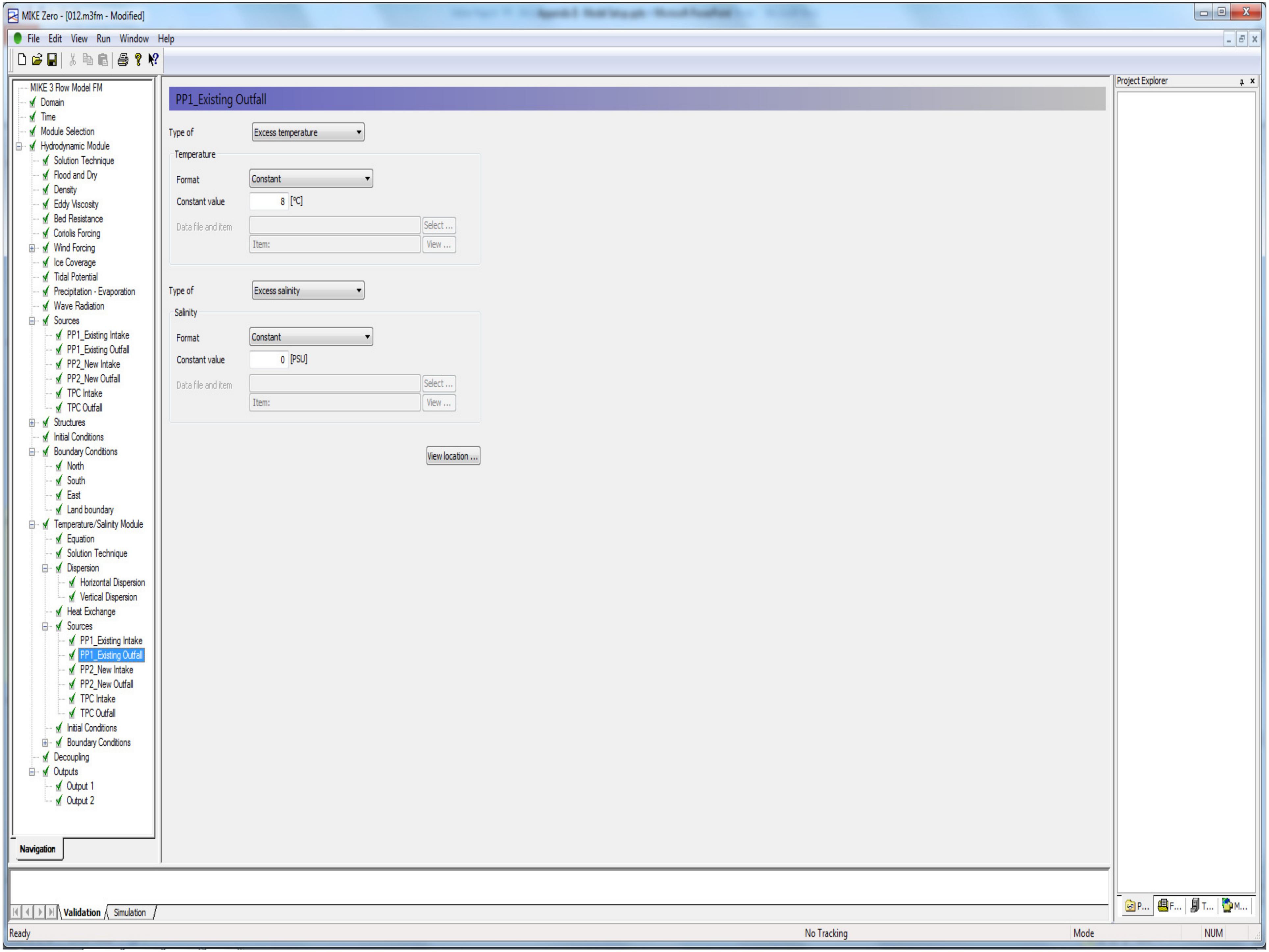
Output 2
Navigation
PP1_Existing Intake
Type of
Excess temperature
Temperature
Format
Constant
Constant value
0
[°C]
Data file and item
Select ...
Item:
View ...
Type of
Excess salinity
Salinity
Format
Constant
Constant value
0
[PSU]
Data file and item
Select ...
Item:
View ...
View location ...
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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PP1_Existing Outfall
Type of
Excess temperature
Temperature
Format
Constant
Constant value
8
[°C]
Data file and item
Select ...
Item:
View ...
Type of
Excess salinity
Salinity
Format
Constant
Constant value
0
[PSU]
Data file and item
Select ...
Item:
View ...
View location ...
Project Explorer
P...
F...
T...
M...
Validation
Simulation
Ready
No Tracking
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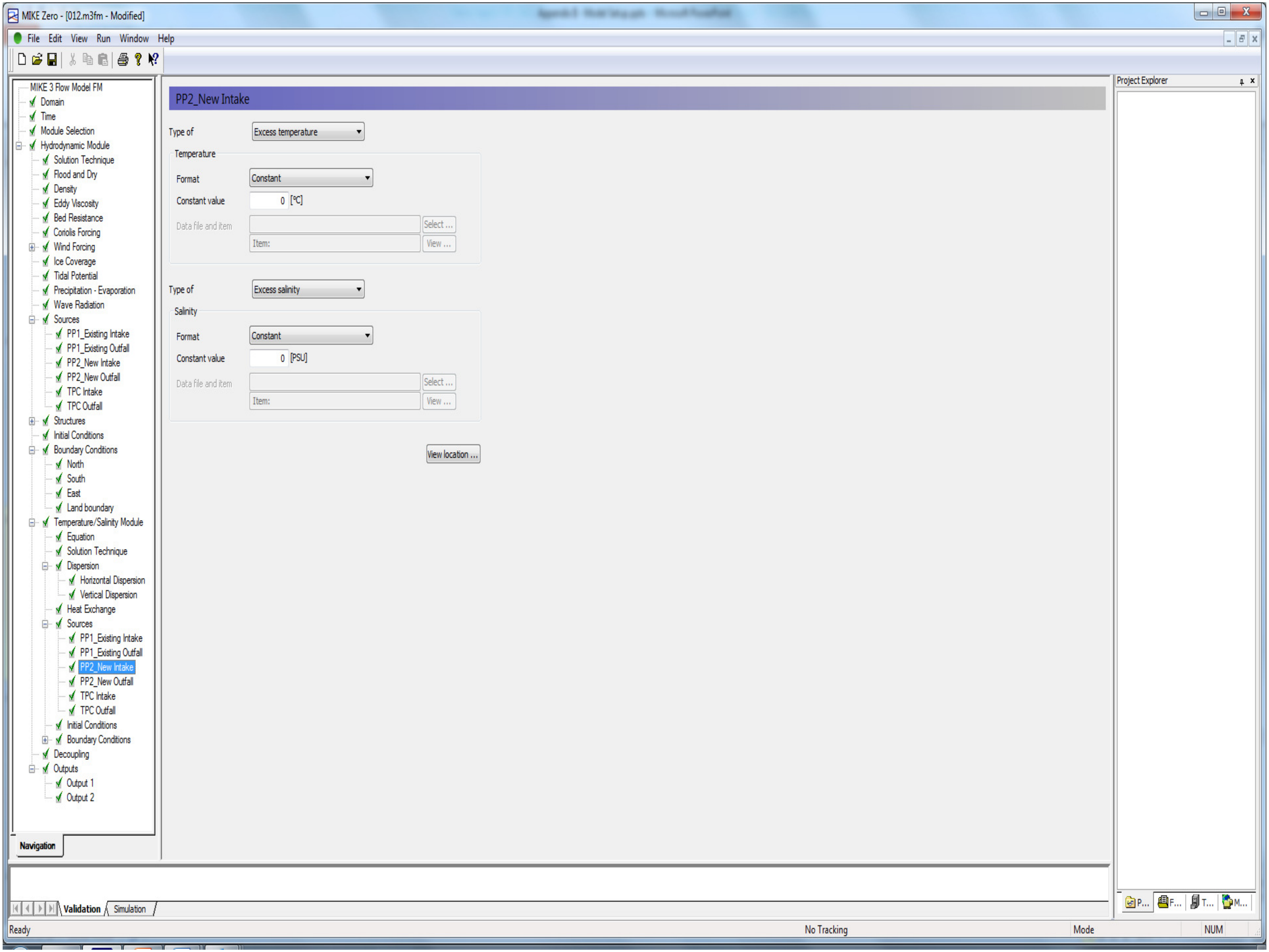
NUM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Excess temperature
Temperature
Format
Constant
Constant value
0 [°C]
Data file and item
Select ...
Item:
View ...
Type of
Excess salinity
Salinity
Format
Constant
Constant value
0 [PSU]
Data file and item
Select ...
Item:
View ...
View location ...
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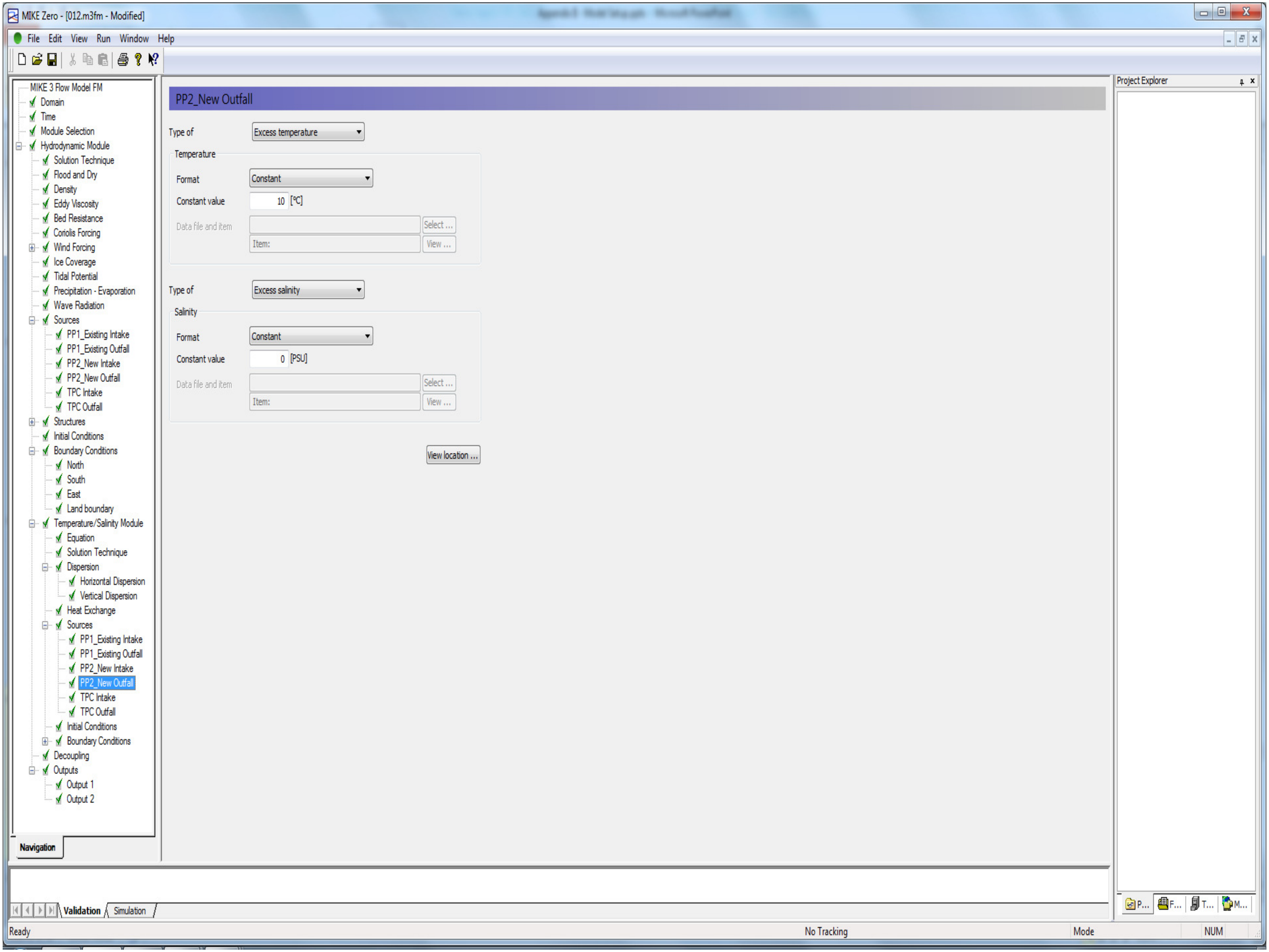
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Type of
Excess temperature
Temperature
Format
Constant
Constant value
10 [°C]
Data file and item
Select ...
Item:
View ...
Type of
Excess salinity
Salinity
Format
Constant
Constant value
0 [PSU]
Data file and item
Select ...
Item:
View ...
View location ...
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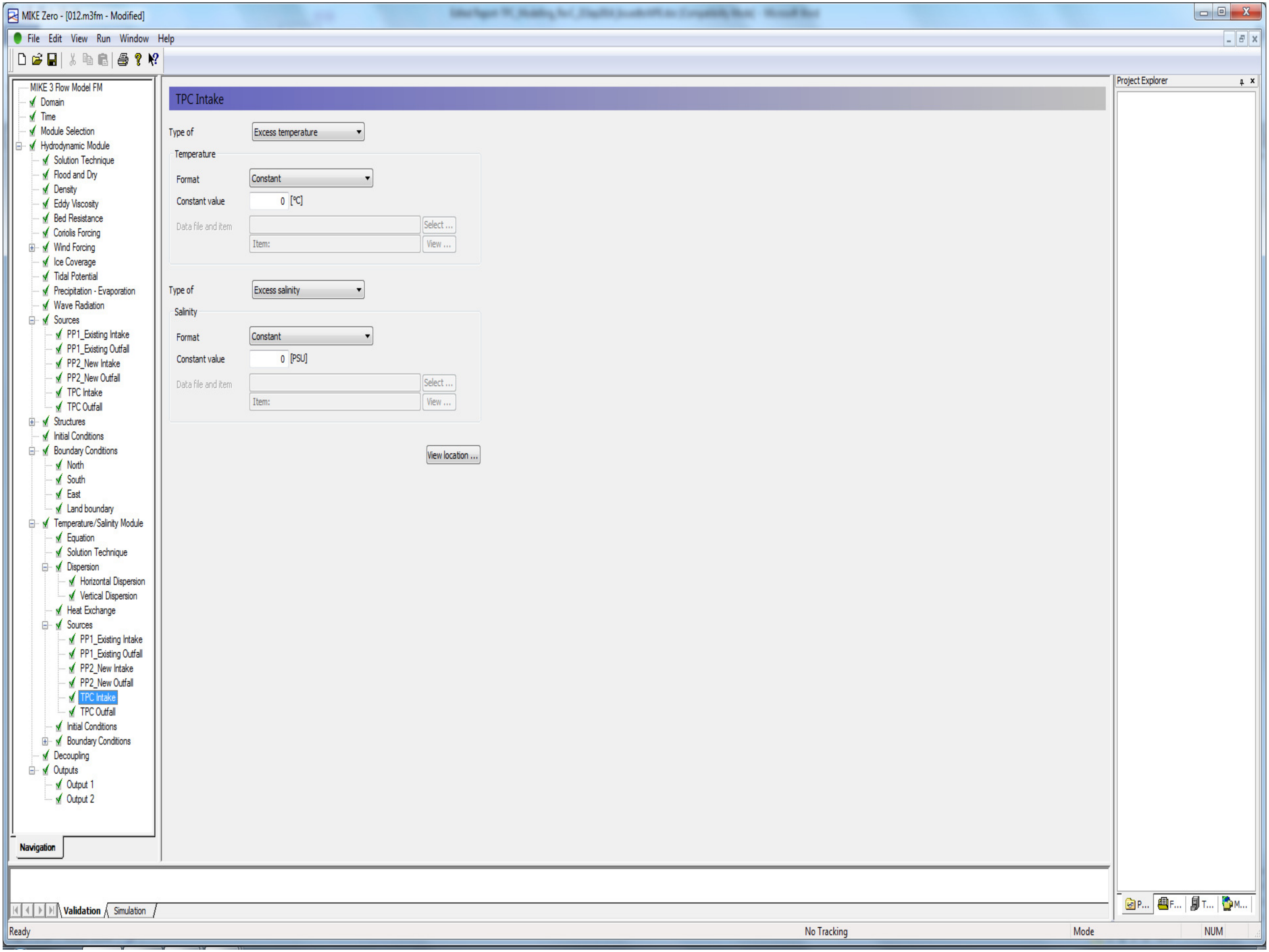
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Excess temperature
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Constant
Constant value
0
[°C]
Data file and item
Select ...
Item:
View ...
Type of
Excess salinity
Salinity
Format
Constant
Constant value
0
[PSU]
Data file and item
Select ...
Item:
View ...
View location ...
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F...
T...
M...
Validation
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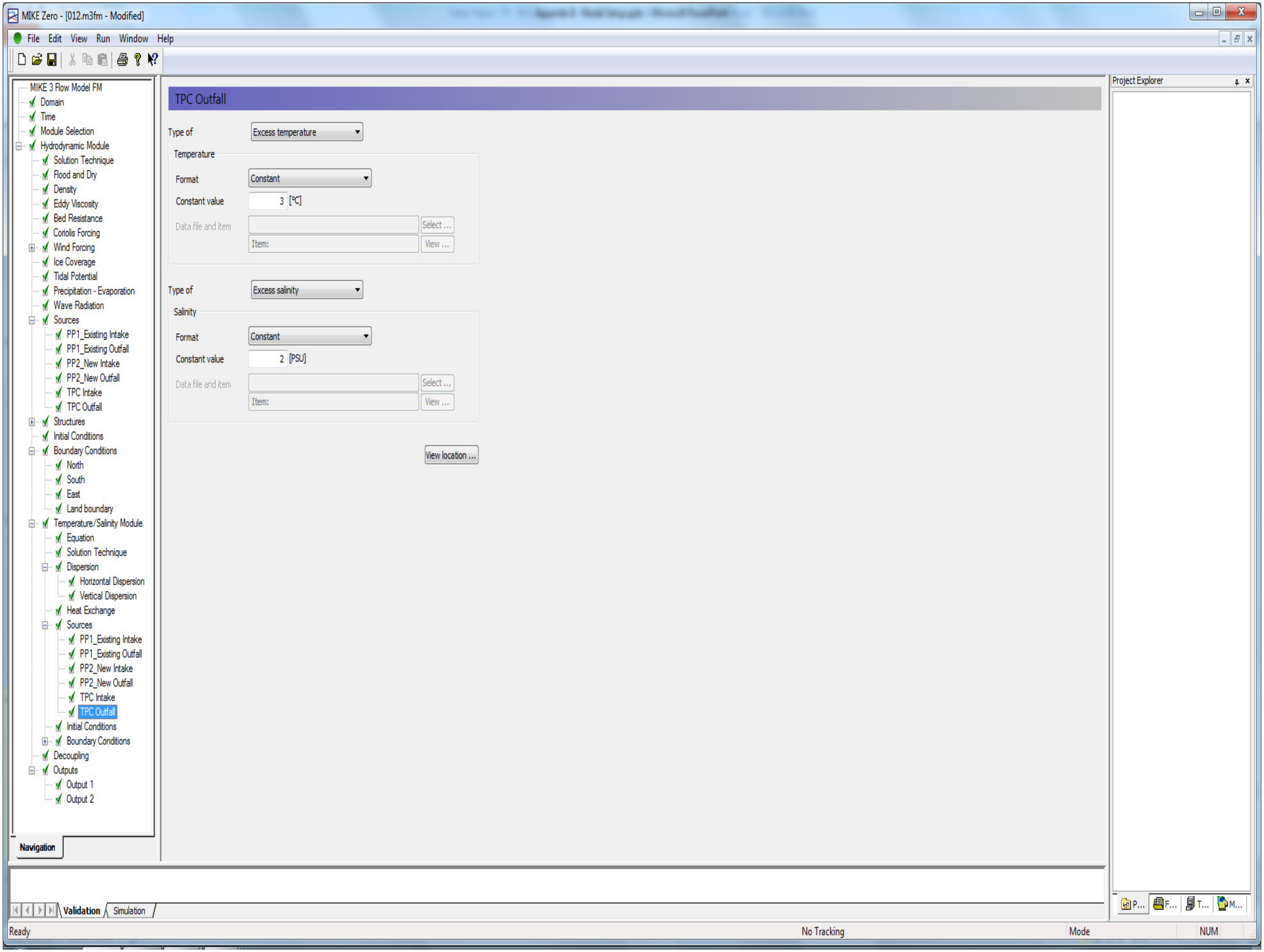
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PP2_New Outfall
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Type of
Excess temperature
Temperature
Format
Constant
Constant value
3 [°C]
Data file and item
Select ...
Item:
View ...
Type of
Excess salinity
Salinity
Format
Constant
Constant value
2 [PSU]
Data file and item
Select ...
Item:
View ...
View location ...
Project Explorer
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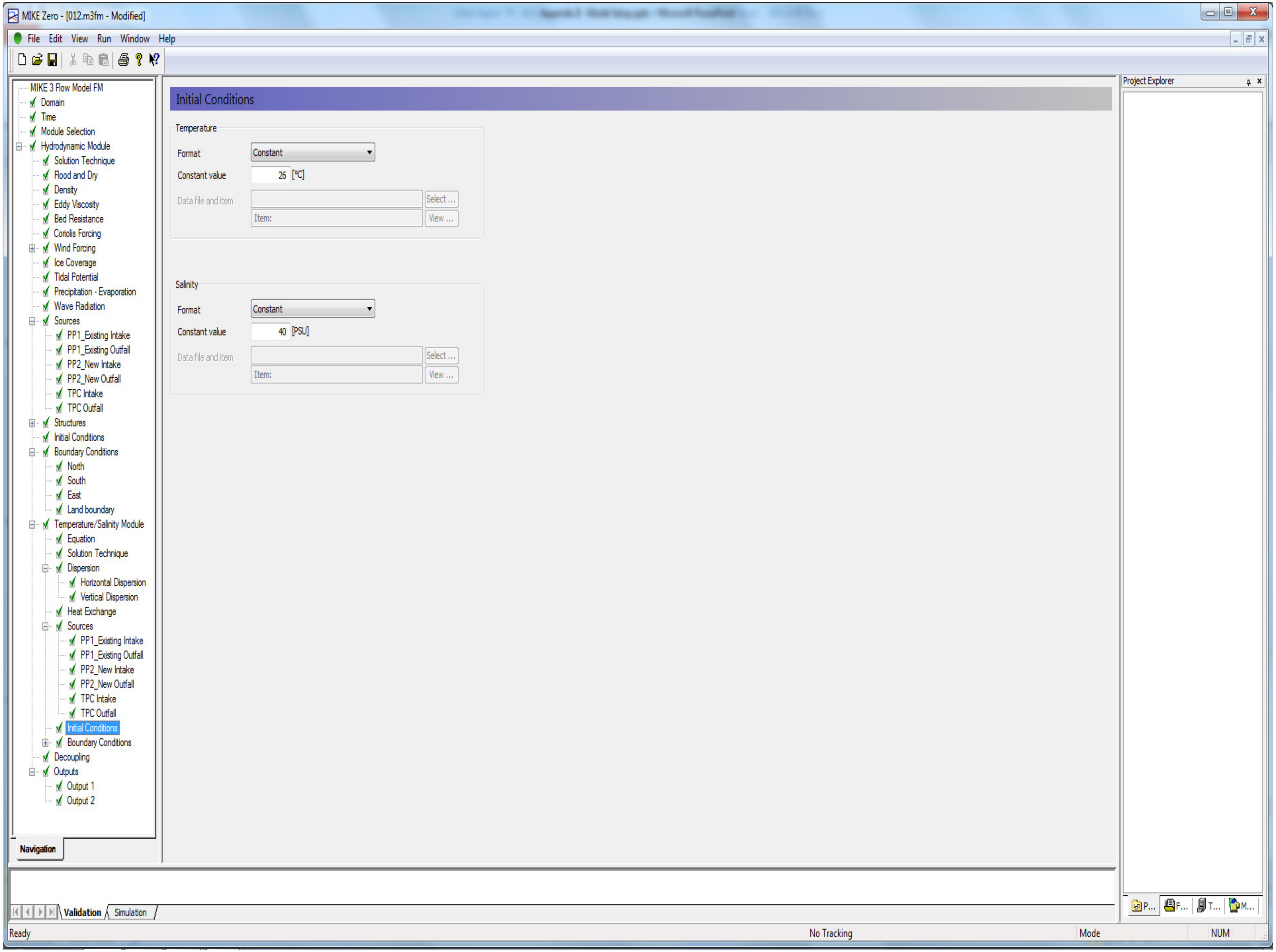
No Tracking
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
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Initial Conditions
Temperature
Format
Constant
Constant value
26 [°C]
Data file and item
Select ...
Item:
View ...
Salinity
Format
Constant
Constant value
40 [PSU]
Data file and item
Select ...
Item:
View ...
Project Explorer
Validation
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Ready
No Tracking
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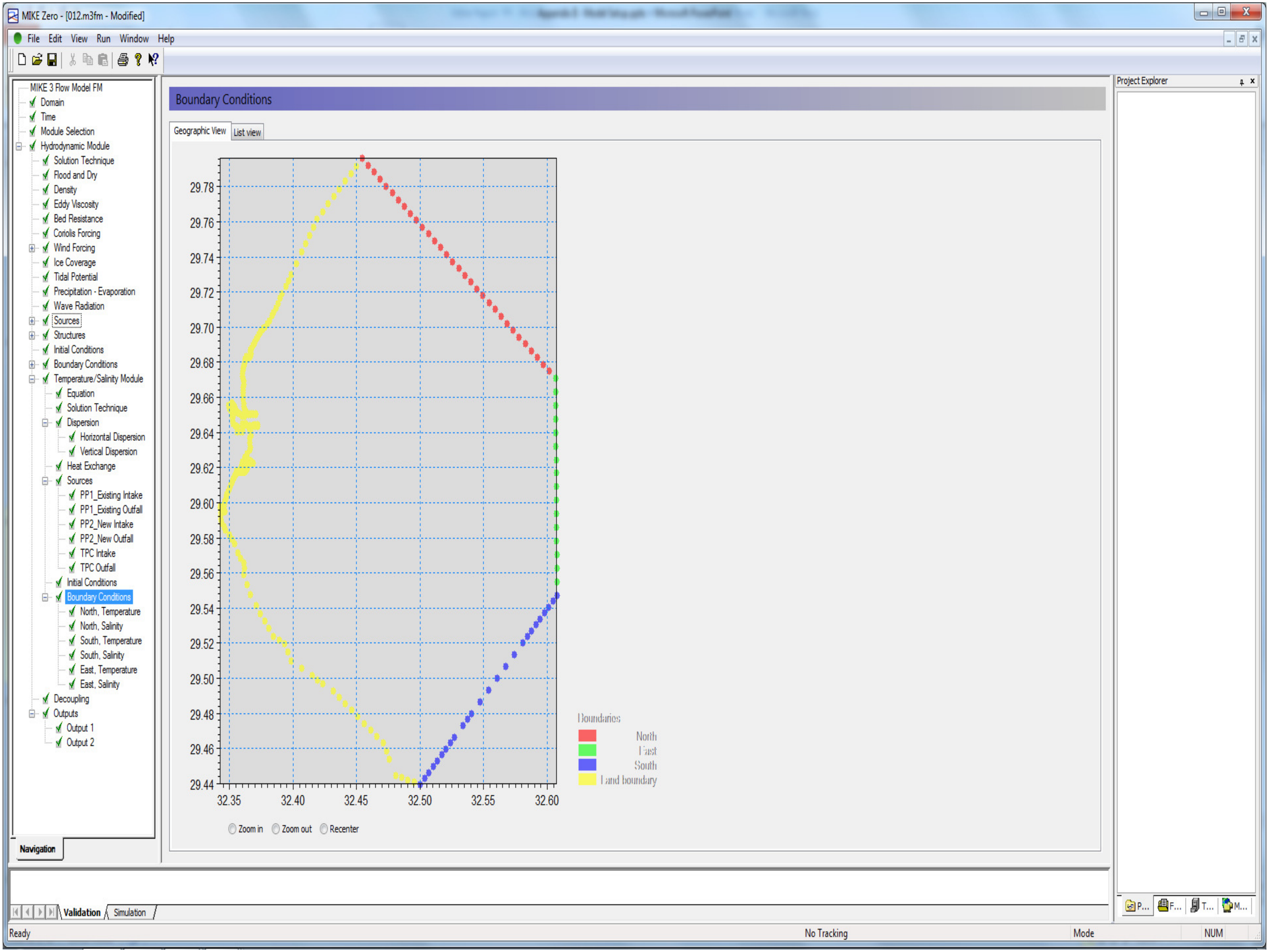
MIKE Zero - [012.m3fm - Modified]
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Bed Resistance
Coriolis Forcing
Wind Forcing
Ice Coverage
Tidal Potential
Precipitation - Evaporation
Wave Radiation
Sources
Structures
Initial Conditions
Boundary Conditions
Temperature/Salinity Module
Equation
Solution Technique
Dispersion
Horizontal Dispersion
Vertical Dispersion
Heat Exchange
Sources
PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
Initial Conditions
Boundary Conditions
North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
Boundary Conditions
Geographic View
List view
29.78
29.76
29.74
29.72
29.70
29.68
29.66
29.64
29.62
29.60
29.58
29.56
29.54
29.52
29.50
29.48
29.46
29.44
32.35
32.40
32.45
32.50
32.55
32.60
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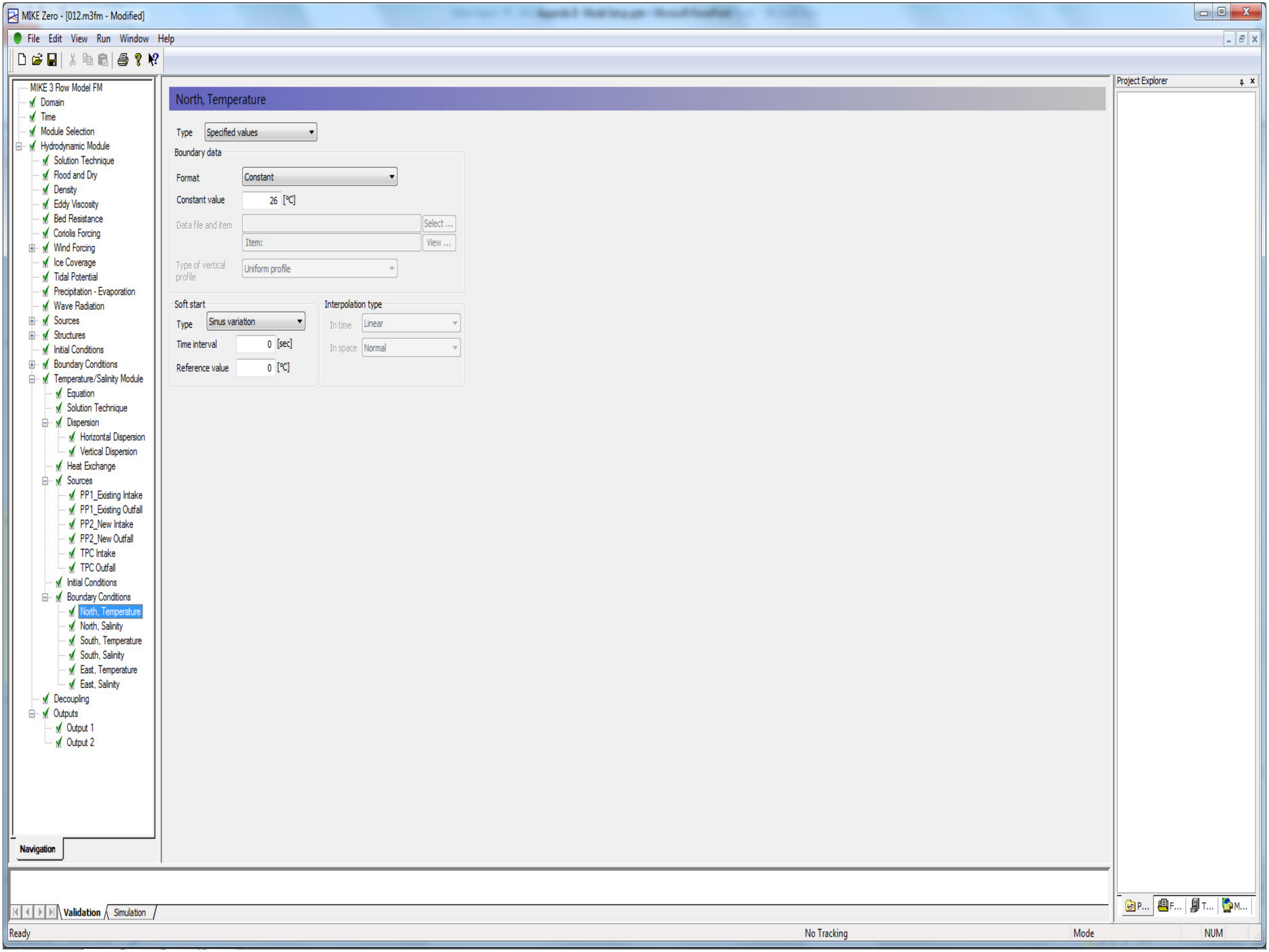
North
East
South
Land boundary
Zoom in
Zoom out
Recenter
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
Wind Forcing
Ice Coverage
Tidal Potential
Precipitation - Evaporation
Wave Radiation
Sources
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Initial Conditions
Boundary Conditions
Temperature/Salinity Module
Equation
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Vertical Dispersion
Heat Exchange
Sources
PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
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Initial Conditions
Boundary Conditions
North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
North, Temperature
Type
Specified values
Boundary data
Format
Constant
Constant value
26 [°C]
Data file and item
Select ...
Item:
View ...
Type of vertical profile
Uniform profile
Soft start
Type
Sinus variation
Time interval
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Reference value
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Linear
In space
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Project Explorer
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Simulation
Ready
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Mode
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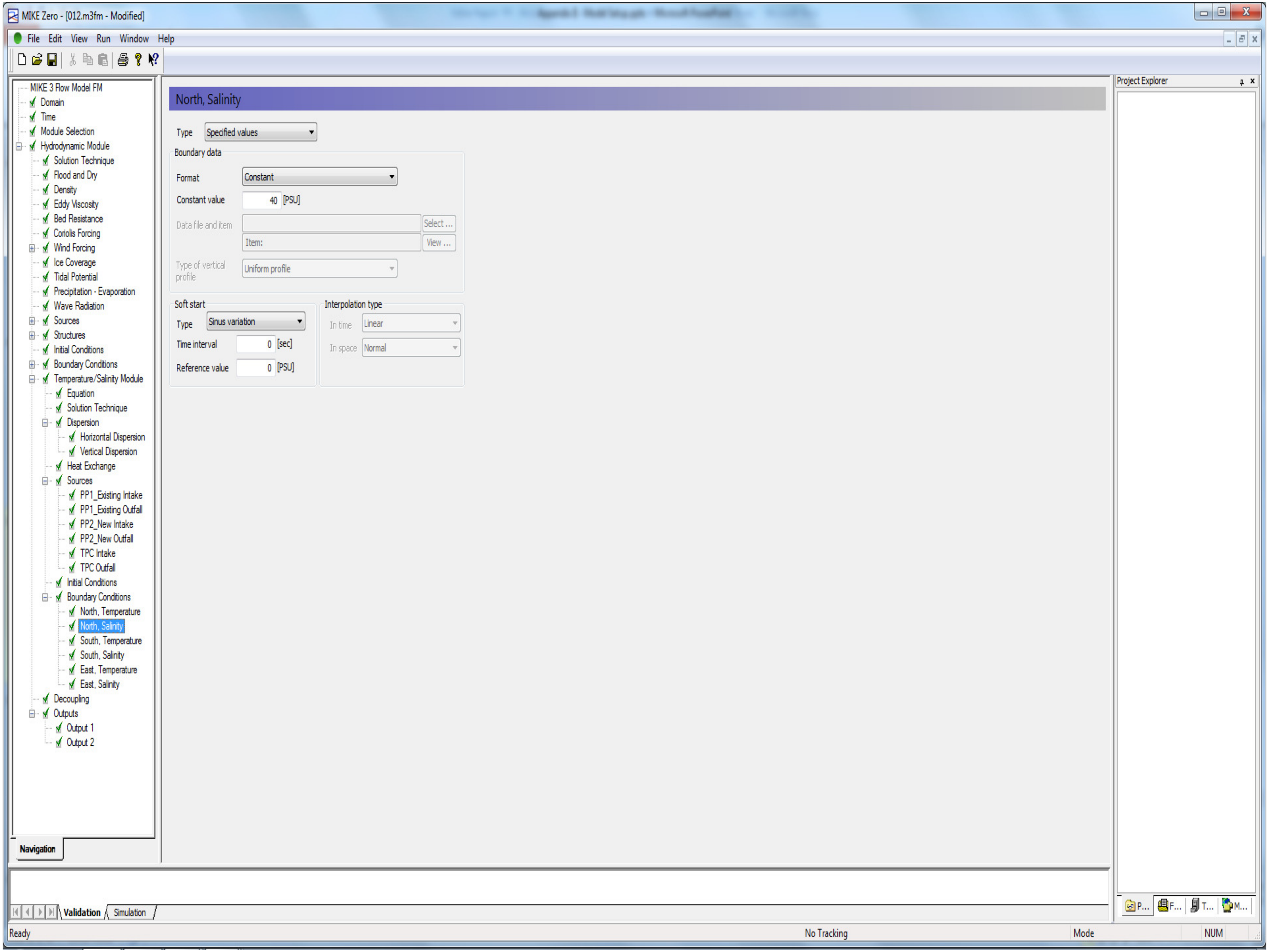
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Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
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Boundary Conditions
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PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
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North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
North, Salinity
Type Specified values
Boundary data
Format Constant
Constant value 40 [PSU]
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Select ...
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View ...
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Uniform profile
Soft start
Type Sinus variation
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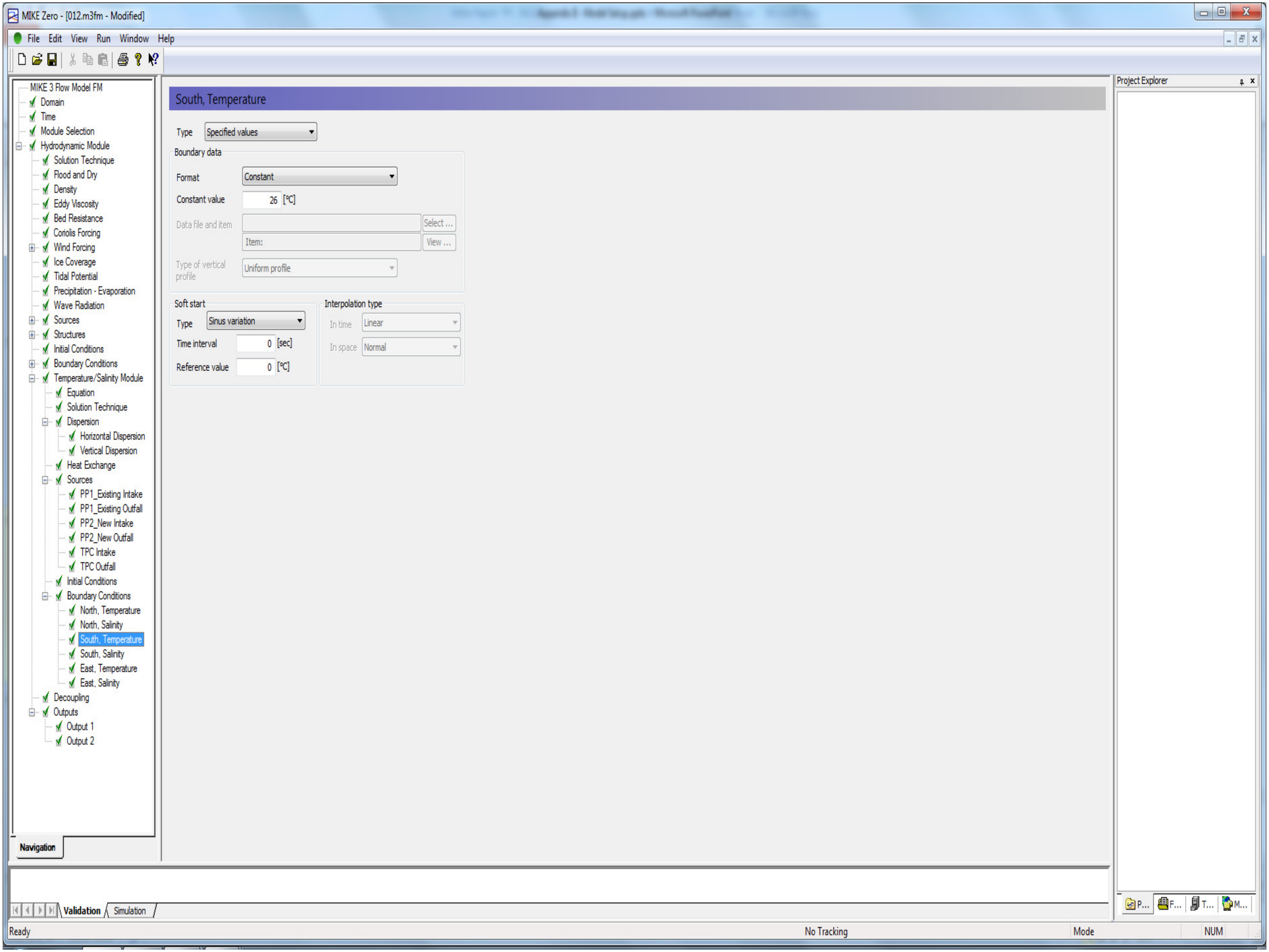

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Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
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Vertical Dispersion
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PP1_Existing Outfall
PP2_New Intake
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North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
South, Temperature
Type Specified values
Boundary data
Format Constant
Constant value 26 [°C]
Data file and item Select ...
Item: View ...
Type of vertical profile Uniform profile
Soft start
Type Sinus variation
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Mode
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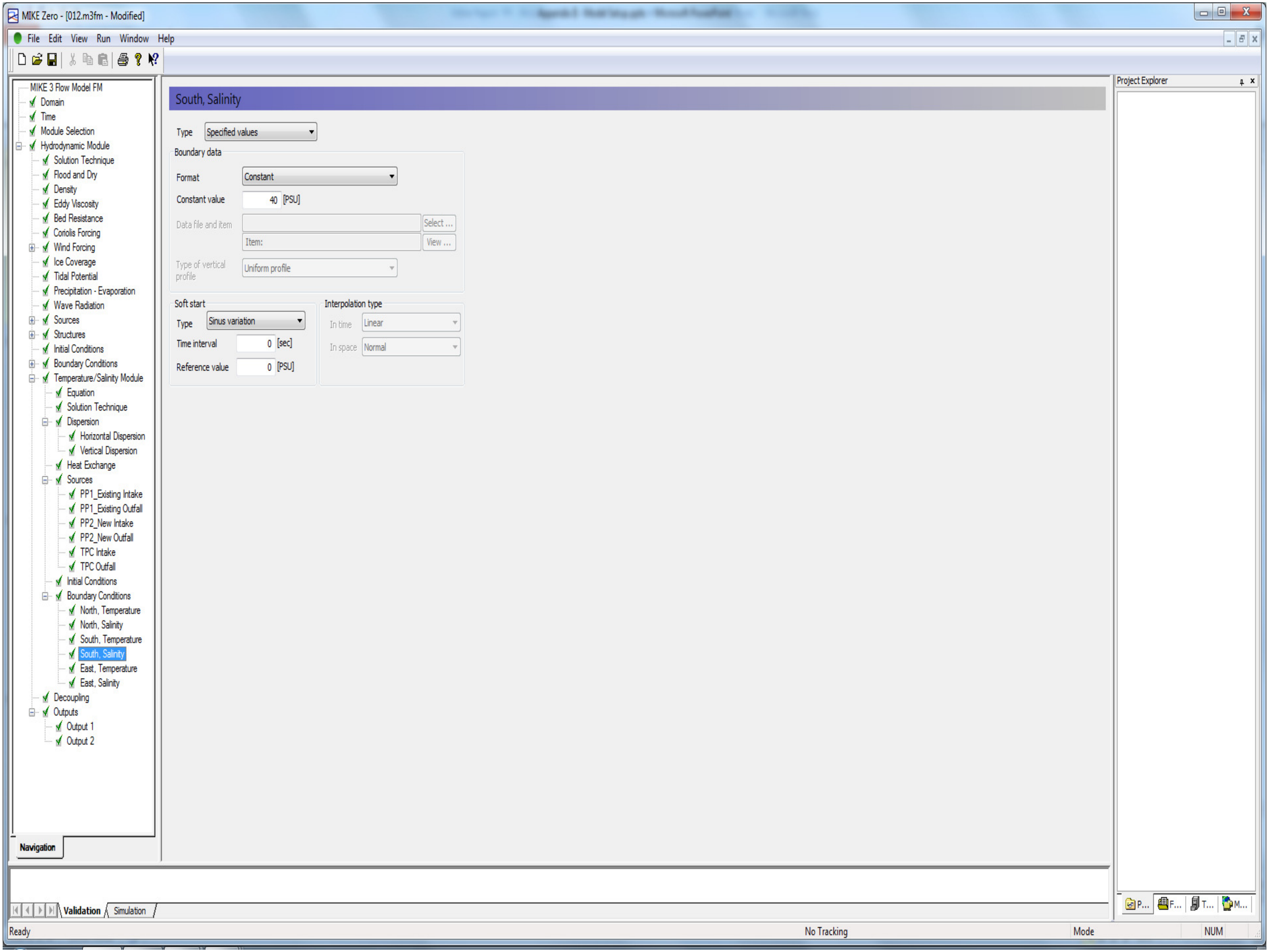
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MIKE 3 Flow Model FM
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Time
Module Selection
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Solution Technique
Flood and Dry
Density
Eddy Viscosity
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PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
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North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
South, Salinity
Type
Specified values
Boundary data
Format
Constant
Constant value
40
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Select ...
Item:
View ...
Type of vertical profile
Uniform profile
Soft start
Type
Sinus variation
Time interval
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[sec]
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In time
Linear
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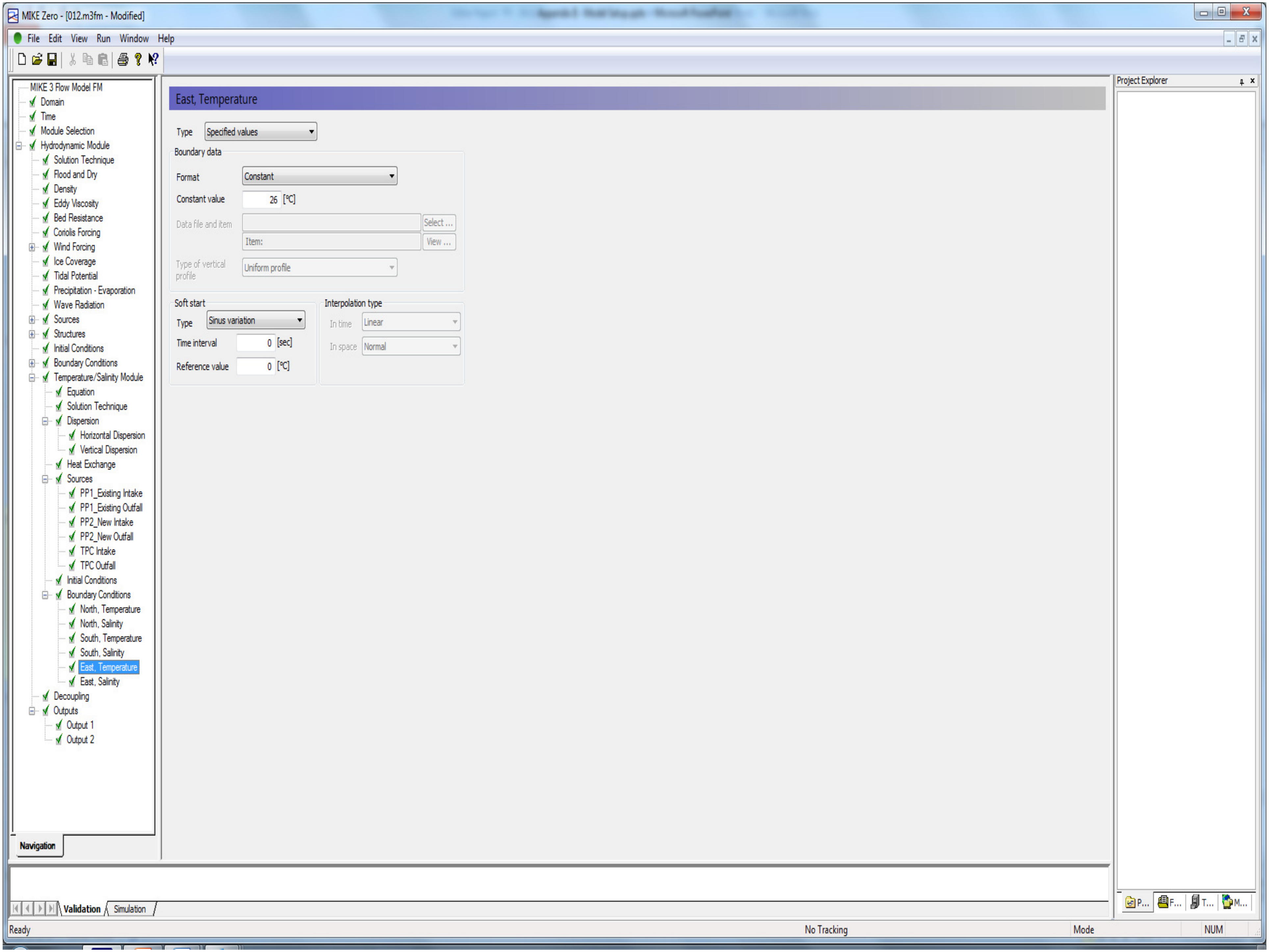
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Flood and Dry
Density
Eddy Viscosity
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PP1_Existing Outfall
PP2_New Intake
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Boundary Conditions
North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
East, Temperature
Type Specified values
Boundary data
Format Constant
Constant value 26 [°C]
Data file and item Select ...
Item: View ...
Type of vertical profile Uniform profile
Soft start
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In space Normal
Project Explorer
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Ready
No Tracking
Mode
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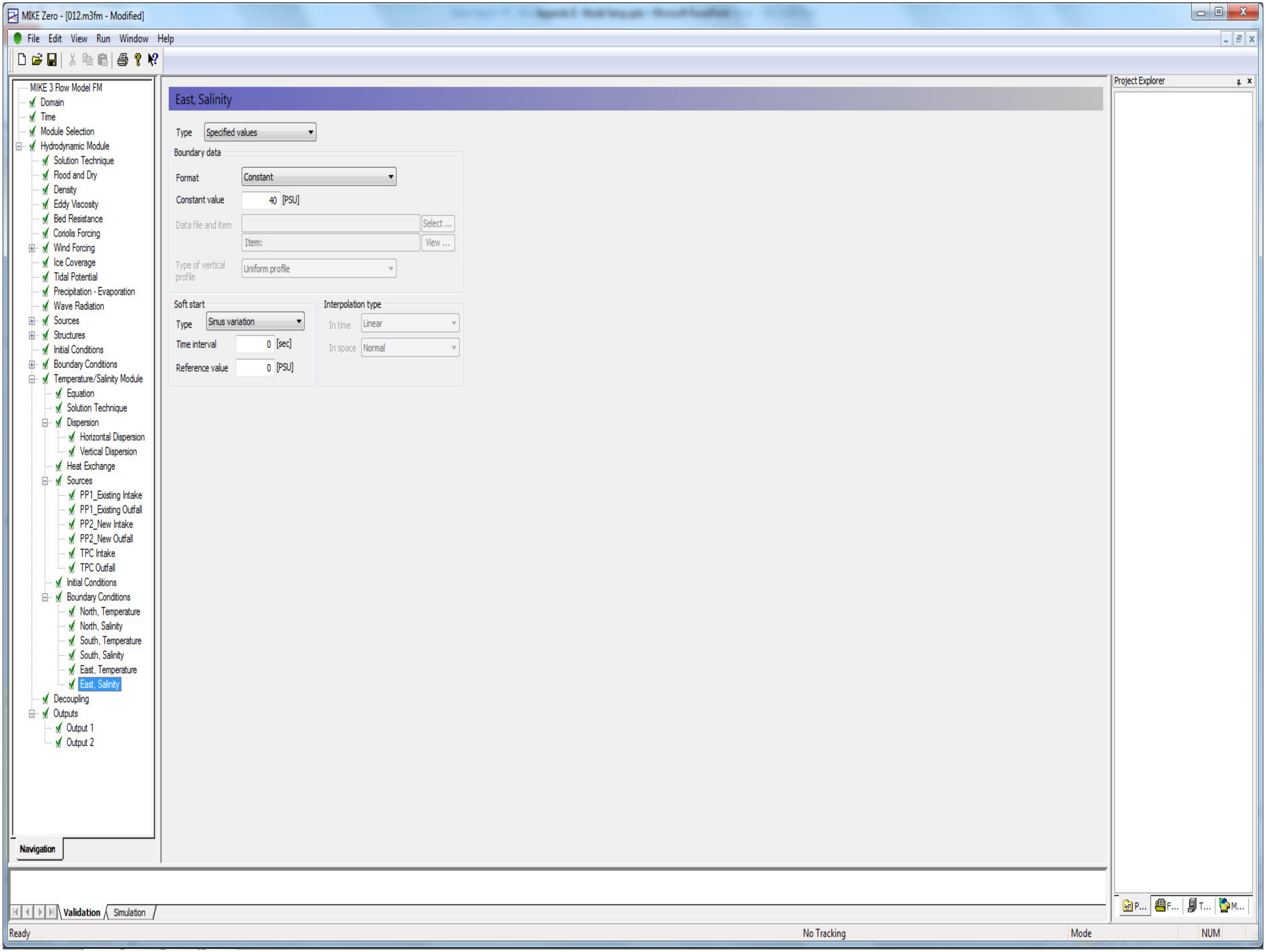

MIKE Zero - [012.m3fm - Modified]
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MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
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Vertical Dispersion
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Sources
PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
Initial Conditions
Boundary Conditions
North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
East, Salinity
Type Specified values
Boundary data
Format Constant
Constant value 40 [PSU]
Data file and item
Select ...
Item:
View ...
Type of vertical profile
Uniform profile
Soft start
Type Sinus variation
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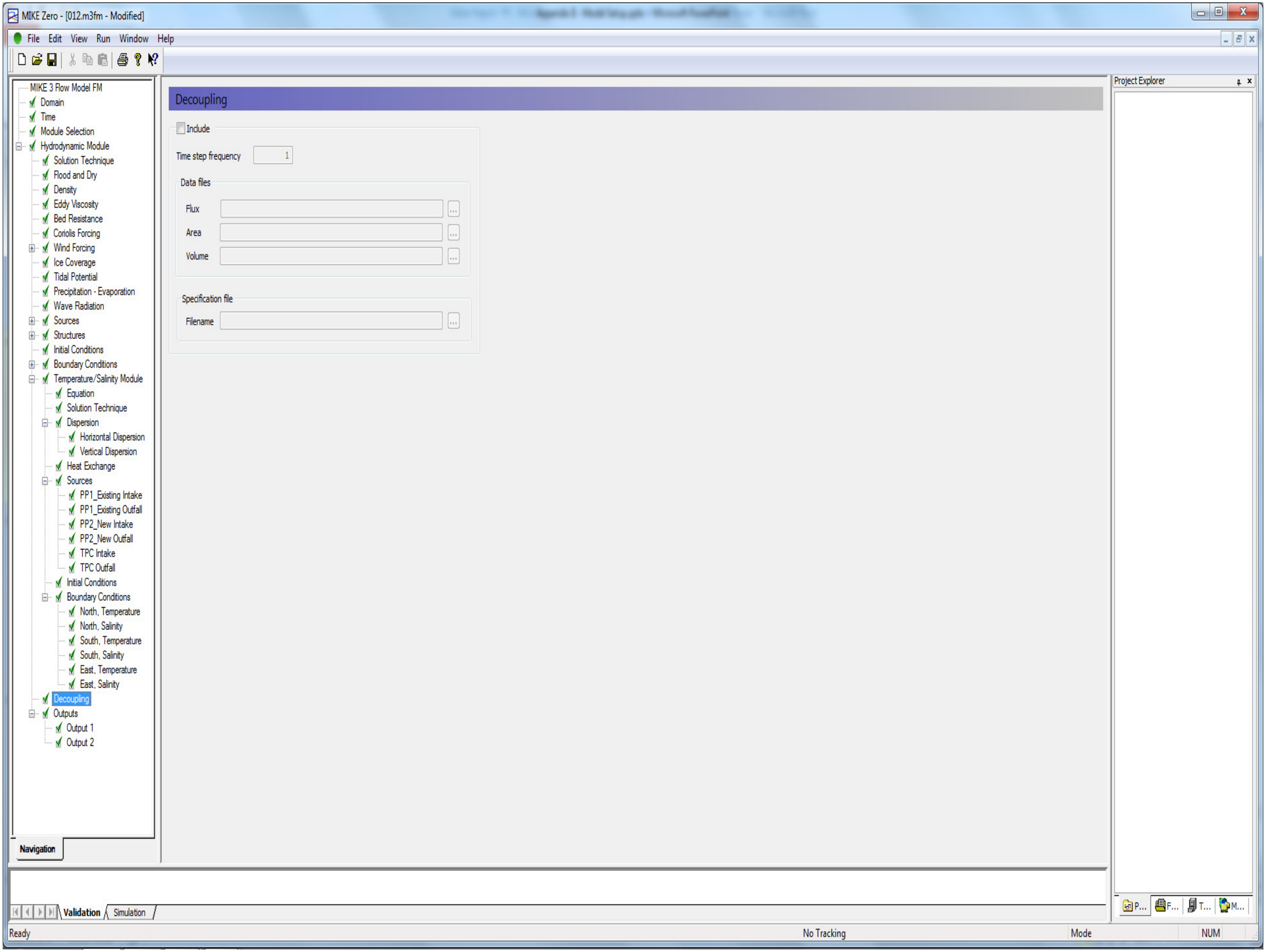
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Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
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Vertical Dispersion
Heat Exchange
Sources
PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
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Boundary Conditions
North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
Decoupling
Include
Time step frequency
1
Data files
Flux
Area
Volume
Specification file
Filename
Project Explorer
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Simulation
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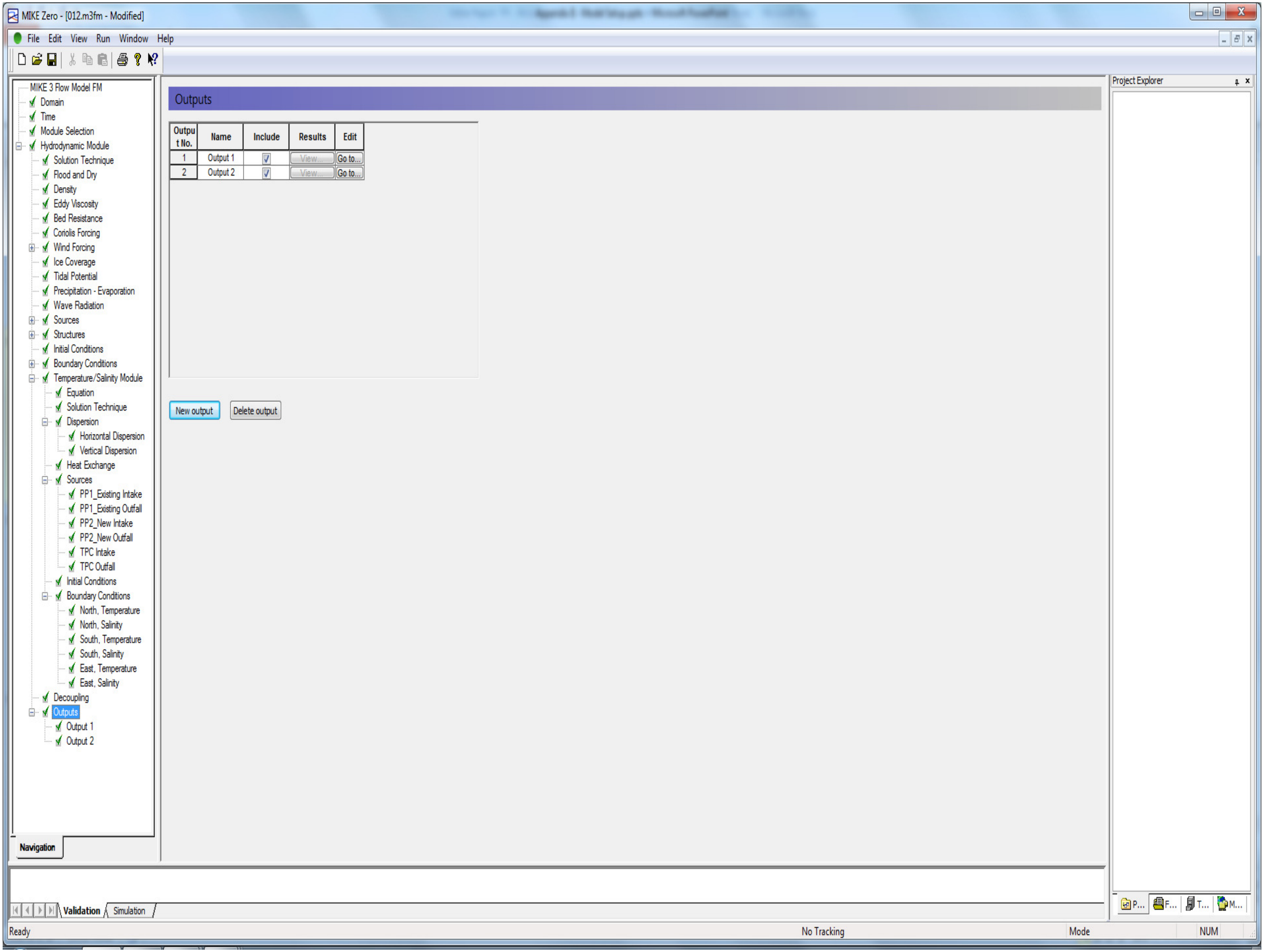
Mode
NUM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Time
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Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
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Boundary Conditions
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PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
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North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
Outputs
Output No.
Name
Include
Results
Edit
1
Output 1
View...
Go to...
2
Output 2
View...
Go to...
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Delete output
Project Explorer
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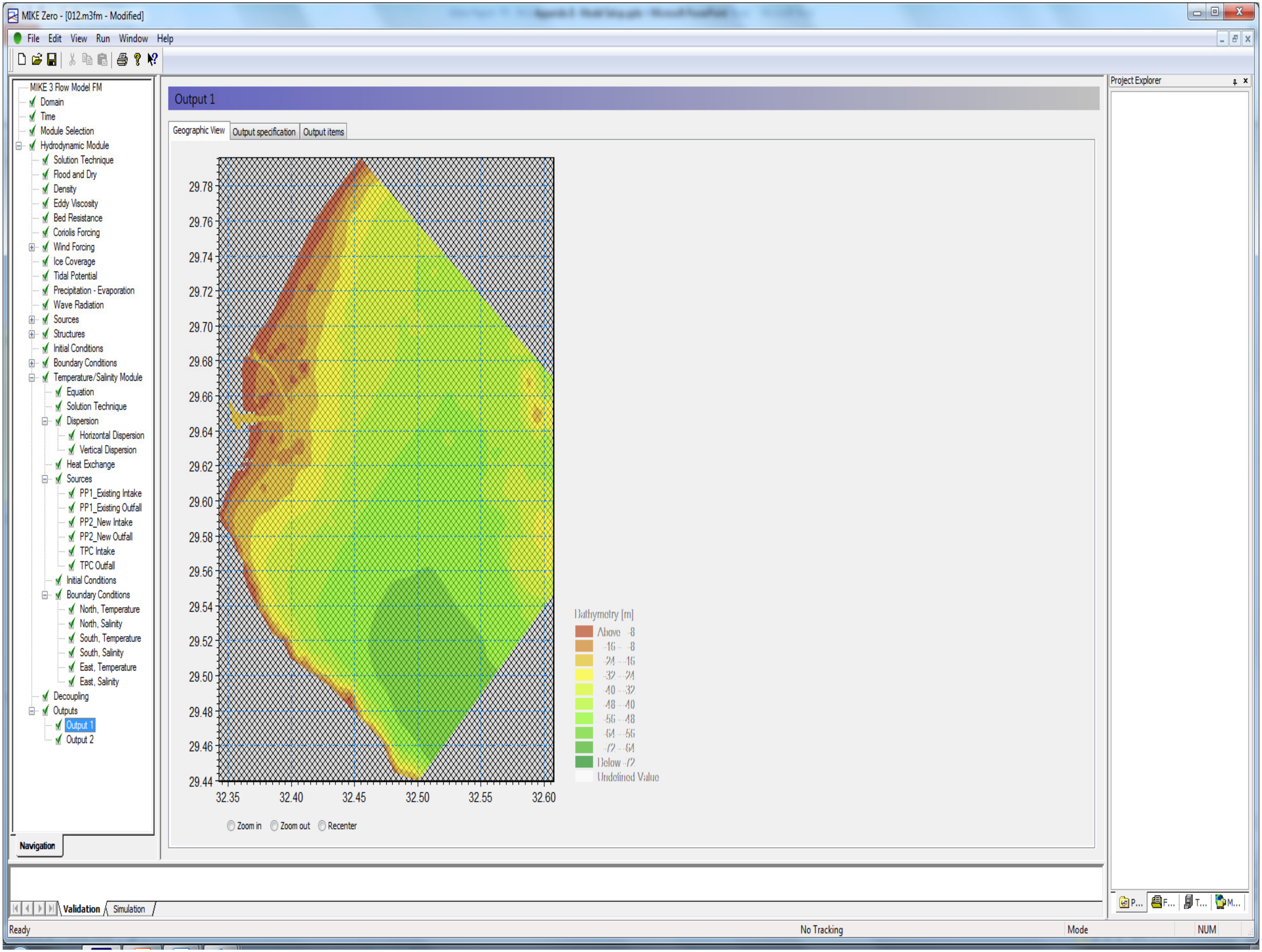
Simulation
Ready
No Tracking
Mode
NUM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Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
Wind Forcing
Ice Coverage
Tidal Potential
Precipitation - Evaporation
Wave Radiation
Sources
Structures
Initial Conditions
Boundary Conditions
Temperature/Salinity Module
Equation
Solution Technique
Dispersion
Horizontal Dispersion
Vertical Dispersion
Heat Exchange
Sources
PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
Initial Conditions
Boundary Conditions
North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
Output 1
Geographic View
Output specification
Output items
Bathymetry [m]
Above -8
-16 - -8
-24 - -16
-32 - -24
-40 - -32
-48 - -40
-56 - -48
-64 - -56
-72 - -64
Below -72
Undefined Value
Zoom in
Zoom out
Recenter
Project Explorer
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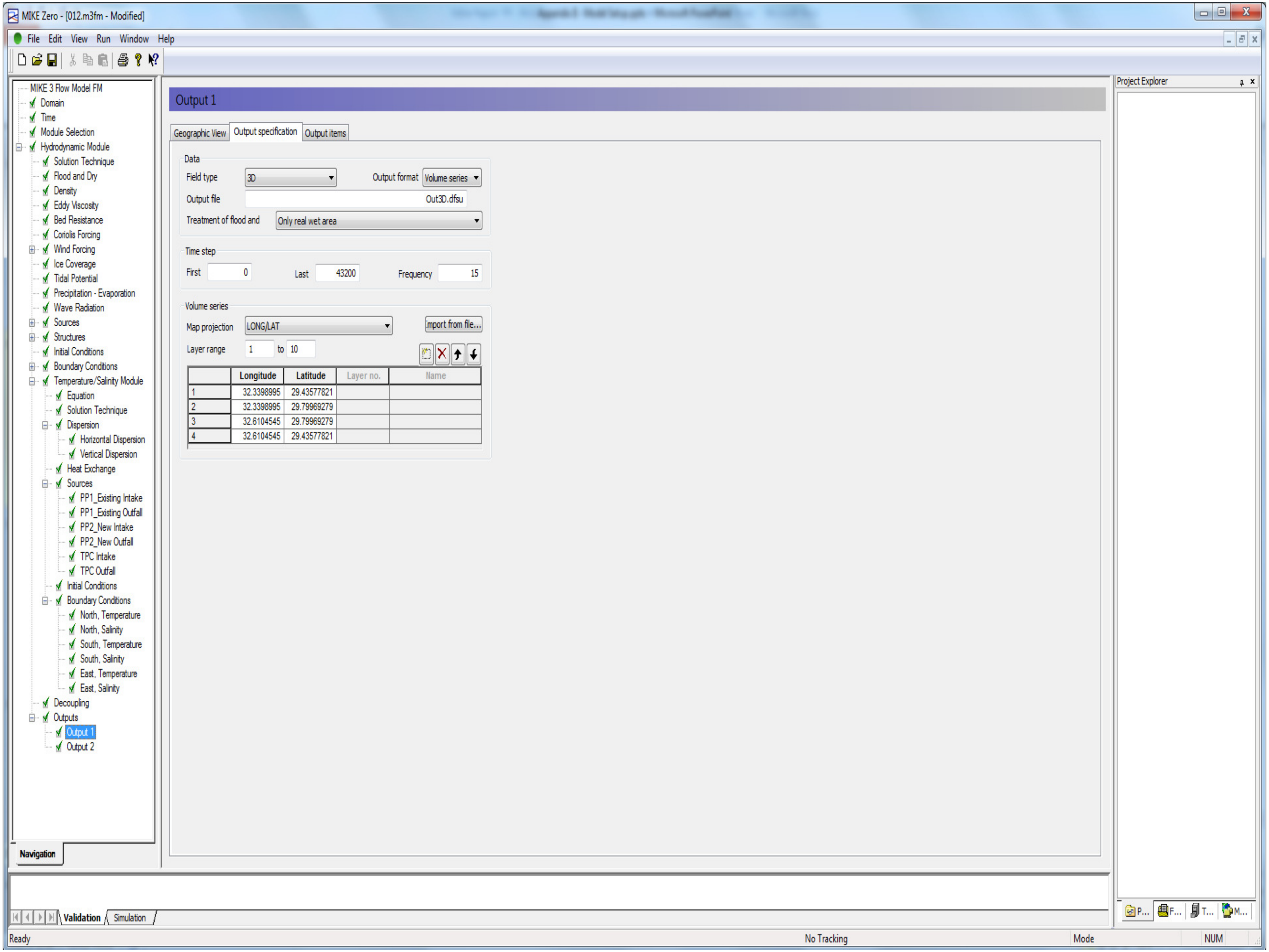
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MIKE 3 Flow Model FM
Domain
Time
Module Selection
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Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
Wind Forcing
Ice Coverage
Tidal Potential
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Wave Radiation
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Dispersion
Horizontal Dispersion
Vertical Dispersion
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Sources
PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
Initial Conditions
Boundary Conditions
North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
Output 1
Geographic View
Output specification
Output items
Data
Field type
3D
Output format
Volume series
Output file
Out3D.dfsu
Treatment of flood and
Only real wet area
Time step
First
0
Last
43200
Frequency
15
Volume series
Map projection
LONG/LAT
Import from file...
Layer range
1
to
10
Longitude
Latitude
Layer no.
Name
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29.43577821
2
32.3398995
29.79969279
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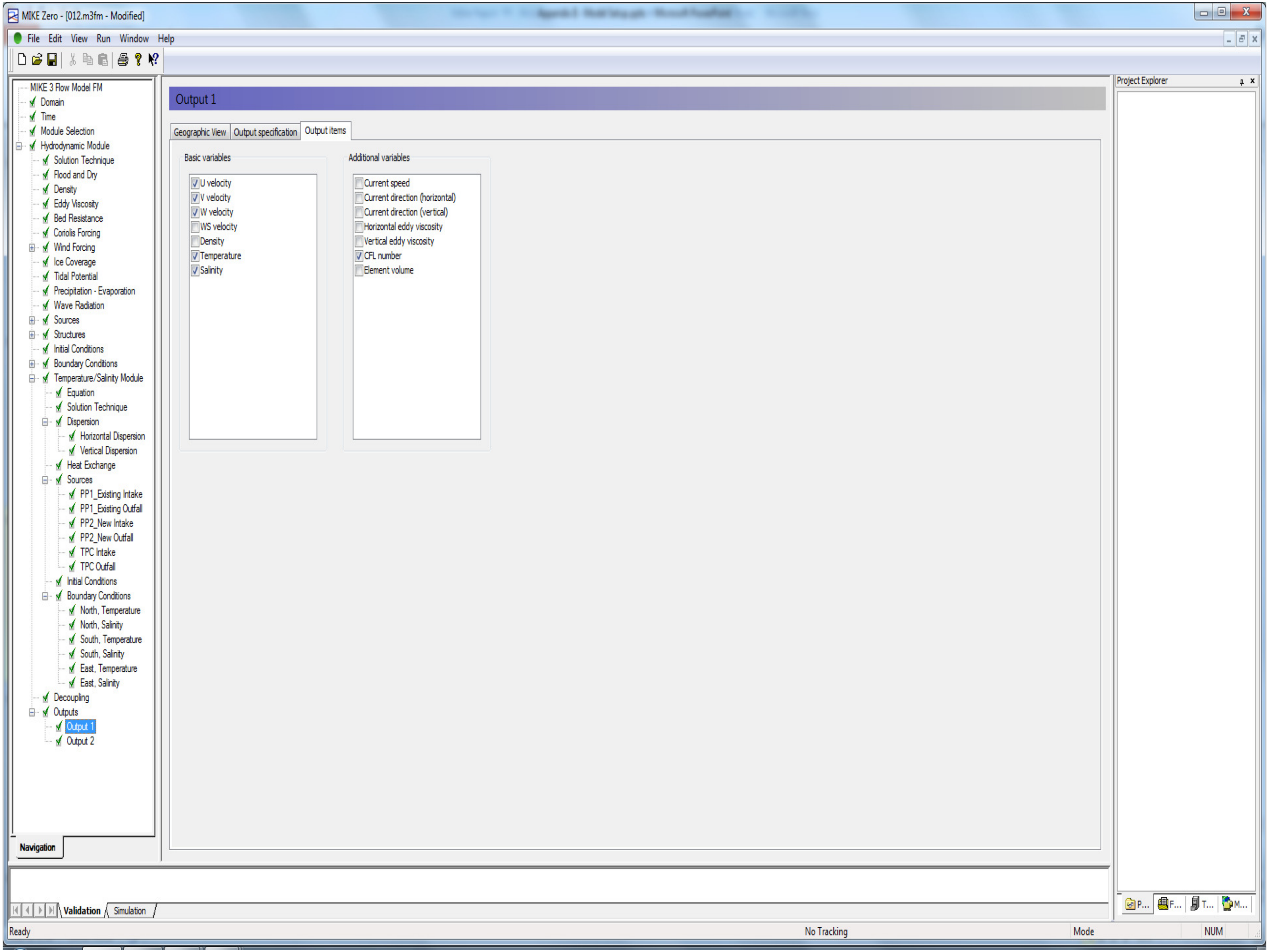
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
Wind Forcing
Ice Coverage
Tidal Potential
Precipitation - Evaporation
Wave Radiation
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Initial Conditions
Boundary Conditions
Temperature/Salinity Module
Equation
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Horizontal Dispersion
Vertical Dispersion
Heat Exchange
Sources
PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
PP2_New Outfall
TPC Intake
TPC Outfall
Initial Conditions
Boundary Conditions
North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
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Output 1
Output 2
Navigation
Output 1
Geographic View
Output specification
Output items
Basic variables
U velocity
V velocity
W velocity
WS velocity
Density
Temperature
Salinity
Additional variables
Current speed
Current direction (horizontal)
Current direction (vertical)
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Vertical eddy viscosity
CFL number
Element volume
Project Explorer
Validation
Simulation
Ready
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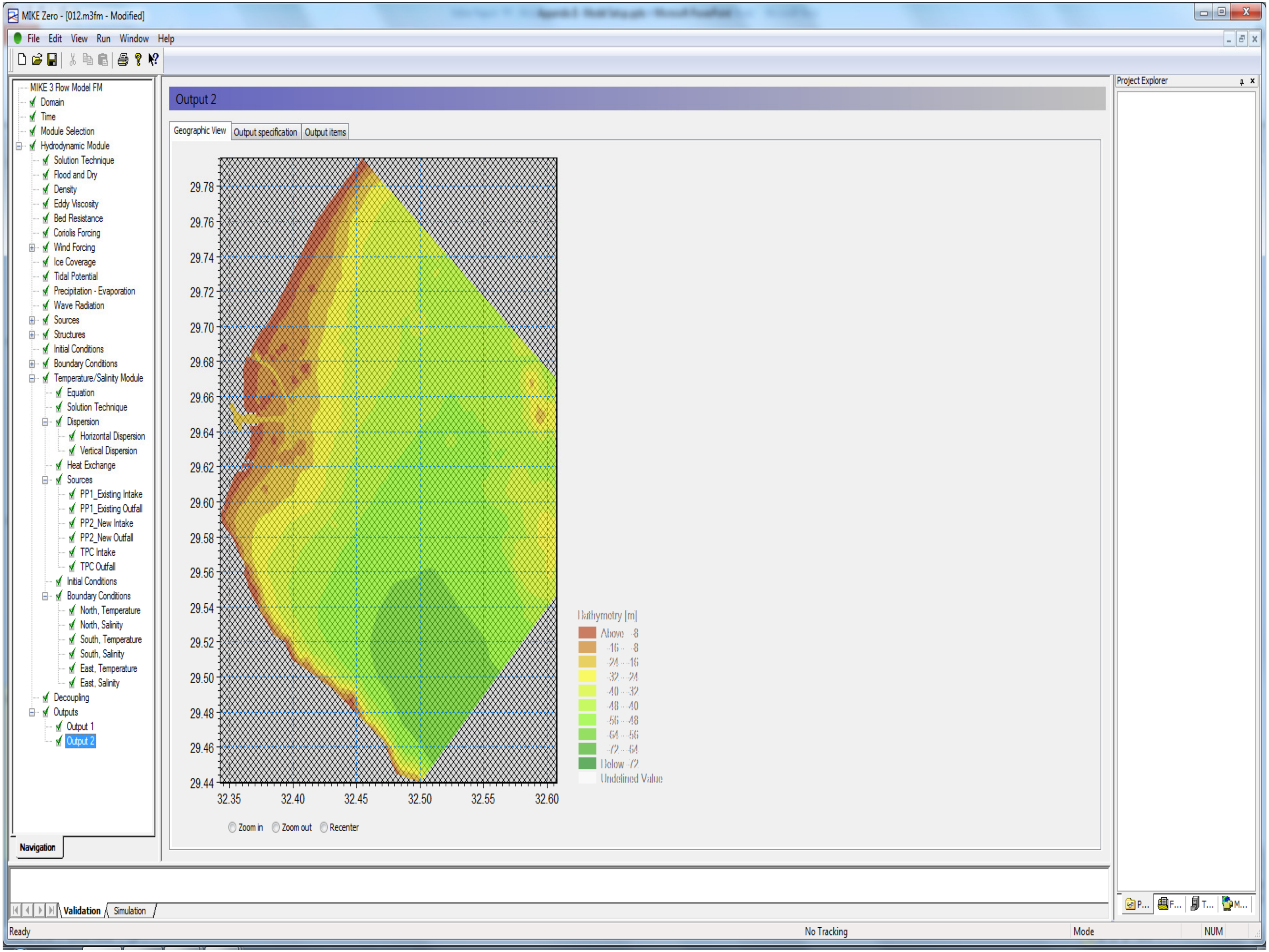
Mode
NUM


MIKE Zero - [012.m3fm - Modified]
File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
Wind Forcing
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PP1_Existing Intake
PP1_Existing Outfall
PP2_New Intake
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North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
Output 2
Geographic View
Output specification
Output items
29.78
29.76
29.74
29.72
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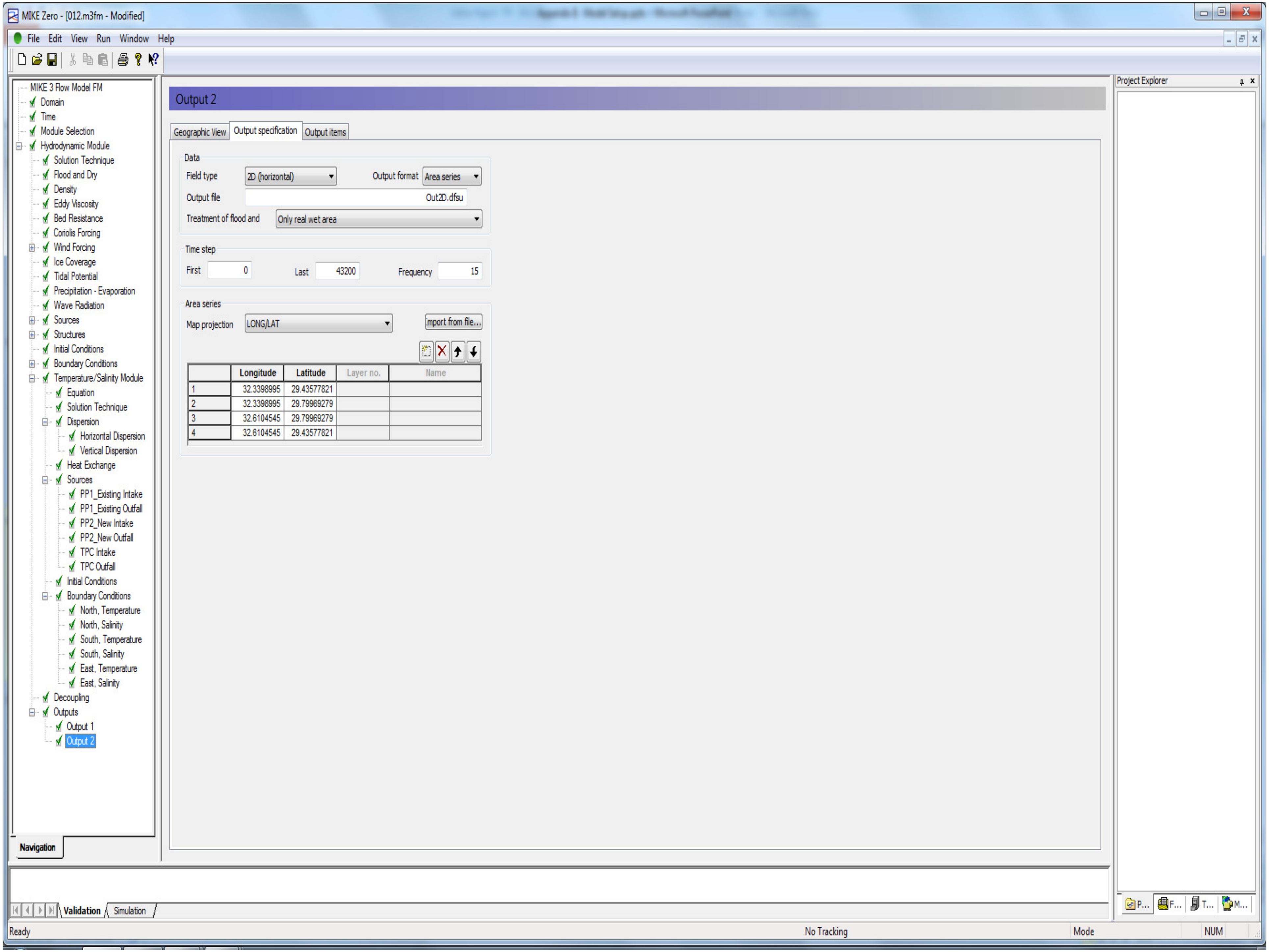
29.56
29.54
29.52
29.50
29.48
29.46
29.44
32.35
32.40
32.45
32.50
32.55
32.60
Bathymetry [m]
Above -8
-16 - -8
-24 - -16
-32 - -24
-40 - -32
-48 - -40
-56 - -48
-64 - -56
-72 - -64
Below -72
Undefined Value
Zoom in
Zoom out
Recenter
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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File Edit View Run Window Help
MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
Flood and Dry
Density
Eddy Viscosity
Bed Resistance
Coriolis Forcing
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PP2_New Intake
PP2_New Outfall
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Initial Conditions
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North, Temperature
North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
Decoupling
Outputs
Output 1
Output 2
Navigation
Output 2
Geographic View
Output specification
Output items
Data
Field type
2D (horizontal)
Output format
Area series
Output file
Out2D.dfsu
Treatment of flood and
Only real wet area
Time step
First
0
Last
43200
Frequency
15
Area series
Map projection
LONG/LAT
Import from file...
Longitude
Latitude
Layer no.
Name
1 32.3398995 29.43577821
2 32.3398995 29.79969279
3 32.6104545 29.79969279
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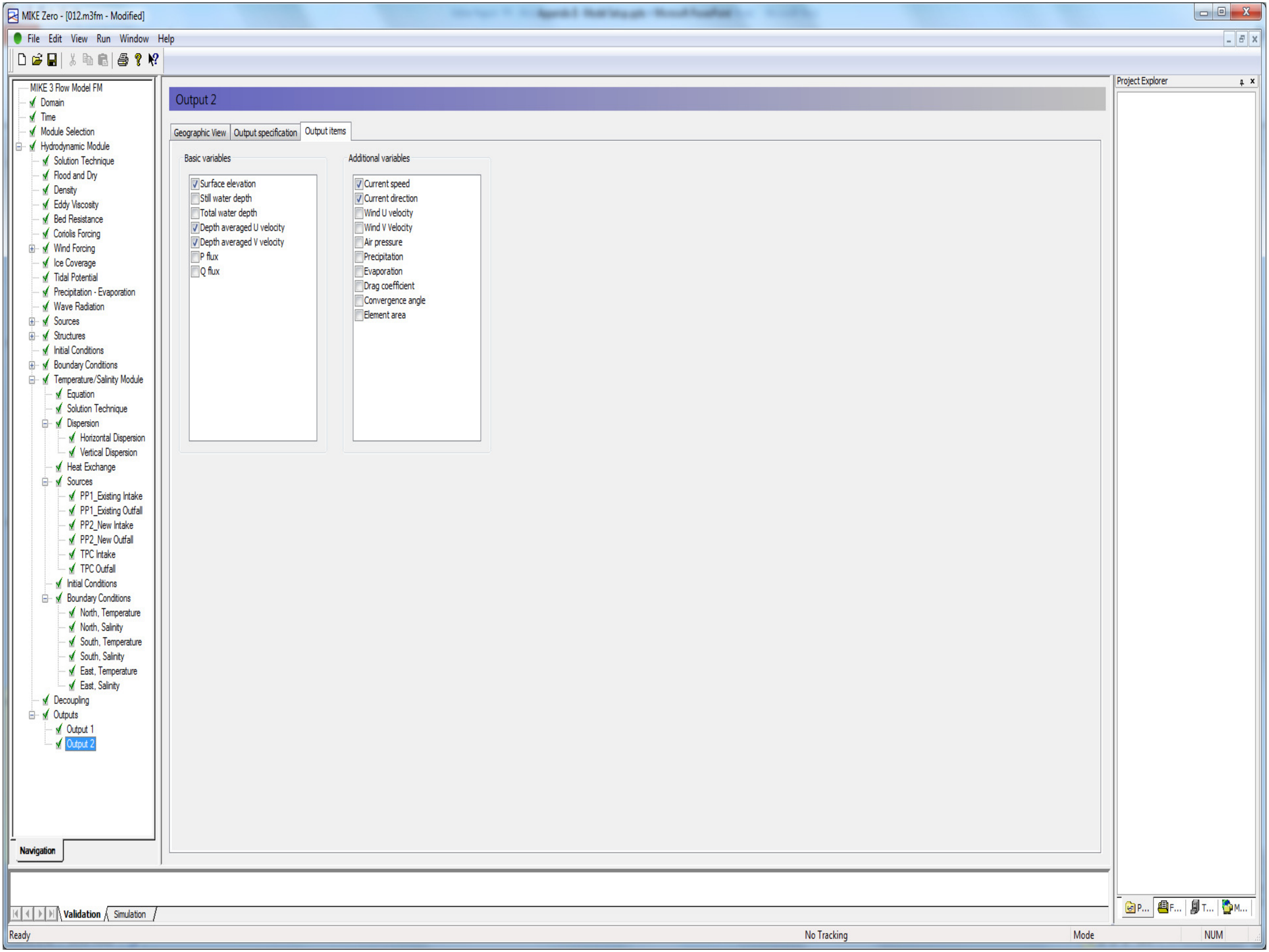
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM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MIKE 3 Flow Model FM
Domain
Time
Module Selection
Hydrodynamic Module
Solution Technique
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Density
Eddy Viscosity
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North, Salinity
South, Temperature
South, Salinity
East, Temperature
East, Salinity
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Output 1
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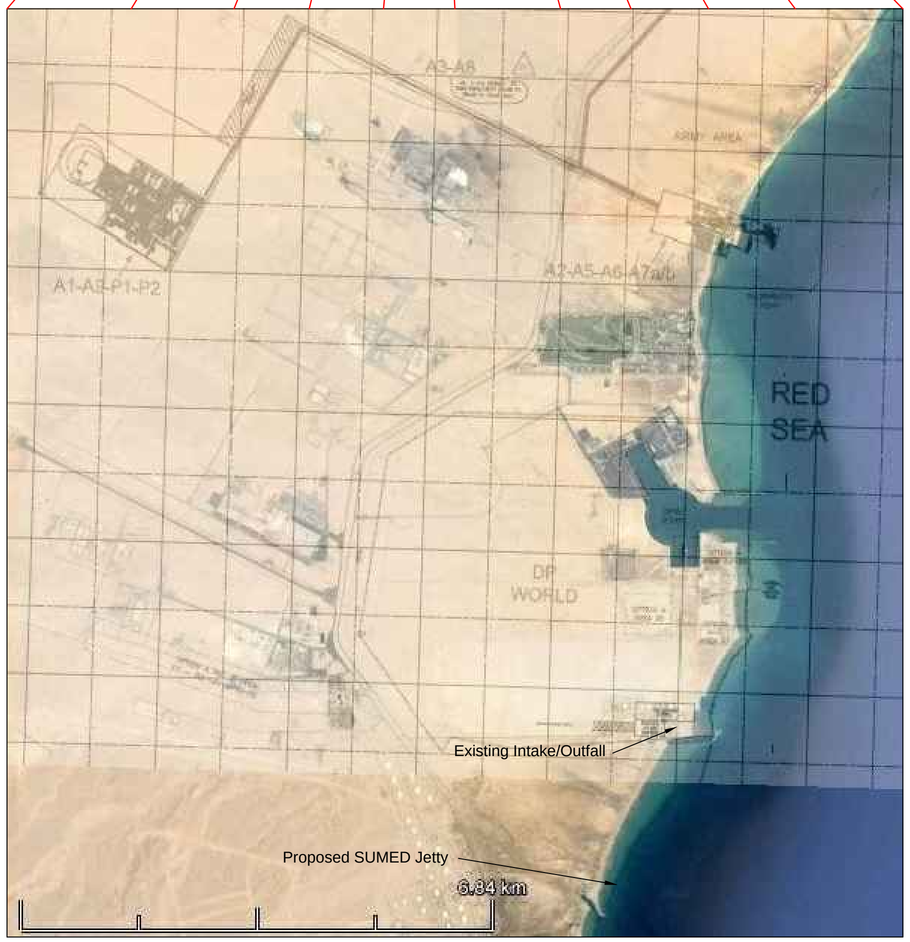
Output 2
Geographic View
Output specification
Output items
Basic variables
Surface elevation
Still water depth
Total water depth
Depth averaged U velocity
Depth averaged V velocity
P flux
Q flux
Additional variables
Current speed
Current direction
Wind U velocity
Wind V Velocity
Air pressure
Precipitation
Evaporation
Drag coefficient
Convergence angle
Element area
Project Explorer
Validation
Simulation
Ready
No Tracking
Mode
NUM

Appendix III - Concept Design Drawings

TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN-REVISED LOCATION



DRAWING LIST

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303052-00130-DRG-0002	GENERAL NOTES
303052-00130-DRG-0004	EXISTING BATHYMETRIC SURVEY
303052-00130-DRG-0005	GENERAL ARRANGEMENT
303052-00130-DRG-0010	LAND INTAKE AND OUTFALL TYPICAL CROSS SECTIONS
303052-00130-DRG-0011	SEA INTAKE AND OUTFALL TYPICAL CROSS SECTIONS
303052-00130-DRG-0012	SURF ZONE AND INTER TIDAL SEA INTAKE AND OUTFALL TYPICAL CROSS SECTIONS
303052-00130-DRG-0013	SEA DIFFUSER PLAN AND DETAILS
303052-00130-DRG-0014	CONCRETE INTAKE STRUCTURE PLAN AND ELEVATION

CONCEPT

INFORMATION ONLY
NOT TO BE USED
FOR CONSTRUCTION

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Fax : (+971) 4 339 7341
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DRAWING No	REFERENCE DRAWINGS	REV No	DATE	REVISION DESCRIPTION	DRAWN	CHECKED	DESIGNED	APPROVED	CLIENT
		C	22.09.14	REISSUED FOR CLIENT REVIEW	SAHB	KARA	MABS	FLOJ	TPC
		B	11.08.14	REISSUED FOR CLIENT REVIEW	TOME	KARA	MABS	FLOJ	TPC
		A	27.02.14	ISSUED FOR CLIENT REVIEW	MOHA	KARA	SURM	RECJ	TPC

CLIENT: TAHRIR PETROCHEMICALS

DRAWN:	MOHA	DATE: 25.02.14
CHECKED:	KARA	DATE: 25.02.14
DESIGNED:	SURM	DATE: 25.02.14
APPROVED:	RECJ	DATE: 25.02.14
CLIENT:	TPC	DATE:

TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN REVISED LOCATION
COVER SHEET AND DRAWING LIST

SCALE: N.T.S | DRG No 303052-00130-DRG-0001 | REV C

1. GENERAL

1.1. THESE DRAWINGS ARE PROVIDED FOR INFORMATION ONLY AND SHOULD NOT BE USED FOR CONSTRUCTION.

1.2. THESE DRAWINGS PRESENT THE CONCEPT DETAILS OF THE INTAKE AND OUTFALL; THE DETAILS WILL BE REFINED AS PART OF THE NEXT DESIGN PHASES.

1.3. ALL ARRANGEMENTS AND DIMENSIONS SHOWN IN THE DRAWINGS ARE INDICATIVE AND WILL BE REFINED AS PART OF THE NEXT DESIGN PHASES.

1.4. SEABED LEVEL SHOWN ON THE DRAWING MAY BE DIFFERENT FROM LEVELS ON SITE. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND ELEVATIONS ON SITE BEFORE THE WORKS COMMENCE.

1.5. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED.

1.6. ALL CHAINAGES AND LEVELS ARE IN METRES, UNLES OTHERWISE NOTED.

1.7. REFER TO CONCEPT DESIGN REPORT FOR MORE DETAILS.

2. CODES/STANDARDS

2.1 AS2033:2008

3. DATUM & COORDINATE

3.1 ALL COORDINATES SHOWN ARE RELATIVE TO WGS 84, UTM ZONE 36R.

3.2 UNLESS NOTED OTHERWISE ALL LEVELS ARE IN METRES RELATIVE TO CHART DATUM.

4. DESIGN CRITERIA

4.1. THE DESIGN LIFE SHALL BE 50 YEARS.

4.2. SURVEY:
THE EXISTING BATHYMETRY IS ACCORDING TO THE SURVEY CONDUCTED BY EGYPTIAN NAVY HYDROGRAPHIC DEPARTMENT IN 19 DEC 2006.

4.3 C-MAP NAUTICAL CHARTS DATE USED WHERE THE SURVEY DATA IS UNAVAILABLE.

5. PIPING

5.1. HDPE PIPES ARE PROPOSED FOR THE SEA AND LAND INTAKE AND OUTFALL PIPELINES.

5.2. HDPE PIPES TO BE PE 100, SDR 17, PD 10, HDPE PIPES ARE TO BE JOINED USING BUTT FUSION.

5.3. BENDING RADIUS OF HDPE PIPES SHALL NOT EXCEED MANUFACTURERS RECOMMENDATIONS,

5.4. REFER TO CONCEPT DESIGN REPORT FOR ADDITIONAL INFORMATION.

6. EARTH WORK

6.1. TRENCH BATTERS SHOWN IN THE DRAWINGS ARE INDICATIVE AND WILL BE REFINED UPON RECEIVING GEOTECHNICAL INVESTIGATIONS.

6.2. A NON-WOVEN GEOTEXTILE 600gr/m^2 IS PROPOSED AS UNDERLAY FOR THE ROCKFILL/BACKFILL SCOUR PROTECTION - AT THE INTER TIDAL ZONE.

7. ROCK WORK

7.1. REVETMENT WORKS SHALL COMPLY WITH CIRIA ROCK MANUAL 2007, BS 6349, LOCAL REGULATIONS AND SHALL BE IN ACCORDANCE WITH THE DRAWINGS AND SPECIFICATIONS.

7.2. THE AVERAGE SATURATED SURFACE-DRY RELATIVE ROCK DENSITY SHALL BE GREATER THAN 2600 kg/m3 WITH 90 PERCENT OF THE STONES HAVING A DENSITY OF AT LEAST 2500 kg/m3 WHEN SAMPLED, TESTED AND REPORTED IN ACCORDANCE WITH CIRIA ROCK MANUAL (2007).

7.3. ROCK SHALL BE NATURALLY OCCURRING, DENSE, SOUND MATERIAL QUARRIED FROM AN APPROVED SOURCE. IT SHALL BE FREE FROM WEATHERING, MECHANICAL WEAKNESS AND CHEMICAL DECOMPOSITION. ROCK SHALL ALSO BE FREE FROM DIRT, SOIL, PEAT, LOAM, CLAY OR ANY ORGANIC MATTER AND ALL HOLES DRILLED FOR BLASTING PURPOSES.

7.4. ROCK PLACING TOLERANCES SHALL BE 0.3 D_{50} IS THE NOMINAL STONE DIAMETER FOR THE MEDIAN ROCK SIZE.

7.5. THE GEOTEXTILE FOR THE REVETMENT SHALL HAVE THE FOLLOWING PROPERTIES: MINIMUM MASS PER UNIT AREA 600 g/m2; MINIMUM TENSILE STRENGTH 12 kN/m; CHARACTERISTIC OPENING SIZE 0.09mm, MINIMUM PUNCTURE FORCE RESISTANCE 1,750 N AND MINIMUM PERMIABILITY OF 0.01m/s.

7.6. THE GEOTEXTILES SHALL BE NON-BIODEGRADABLE AND ULTRAVIOLENT STABILISED.

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		A	27.02.14	ISSUED FOR CLIENT REVIEW	MOHA	KARA	SURM	RECJ	TPC

CLIENT
TAHRIR PETROCHEMICALS

DRAWN:	MOHA	DATE: 25.02.14
CHECKED:	KARA	DATE: 25.02.14
DESIGNED:	SURM	DATE: 25.02.14
APPROVED:	RECJ	DATE: 25.02.14
CLIENT:	TPC	DATE:

TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN-REVISED LOCATION
GENERAL NOTES

SCALE: N.T.S | DRG No 303052-00130-DRG-0002 | REV C

EXISTING BATHYMETRIC SURVEY

NOTES

1. REFER DRG. 0002 FOR GENERAL NOTES.
2. THE EXISTING BATHYMETRY IS ACCORDING TO THE SURVEY CONDUCTED BY EGYPTIAN NAVY HYDROGRAPHIC DEPARTMENT IN 19 DEC 2006.
3. LEVELS COULD VARY. CONTRACTOR TO VERIFY LEVELS BEFORE ANY SITE WORK.

LEGEND

APPROX. SHORELINE

EXISTING SURVEY LINE

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DRAWING No	REFERENCE DRAWINGS	REV No	DATE	REVISION DESCRIPTION	DRAWN	CHECKED	DESIGNED	APPROVED	CLIENT
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		C	22.09.14	REISSUED FOR CLIENT REVIEW	SAHB	KARA	MABS	FLOJ	TPC
		B	11.08.14	REISSUED FOR CLIENT REVIEW	TOME	FLOJ	MABS	FLOJ	TPC
		A	07.08.2014	ISSUED FOR CLIENT REVIEW	MOHA	KARA	RECJ	FARU	TPC

CLIENT
TAHRIR PETROCHEMICALS

DRAWN:	MOHA	DATE:	26.02.14
CHECKED:	KARA	DATE:	26.02.14
DESIGNED:	RECJ	DATE:	26.02.14
APPROVED:	FARU	DATE:	26.02.14
CLIENT:	TPC	DATE:	

TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN-REVISED LOCATION EXISTING BATHYMETRIC SURVEY

SCALE: N.T.S
DRG No 303052-00130-DRG-0004
REV D

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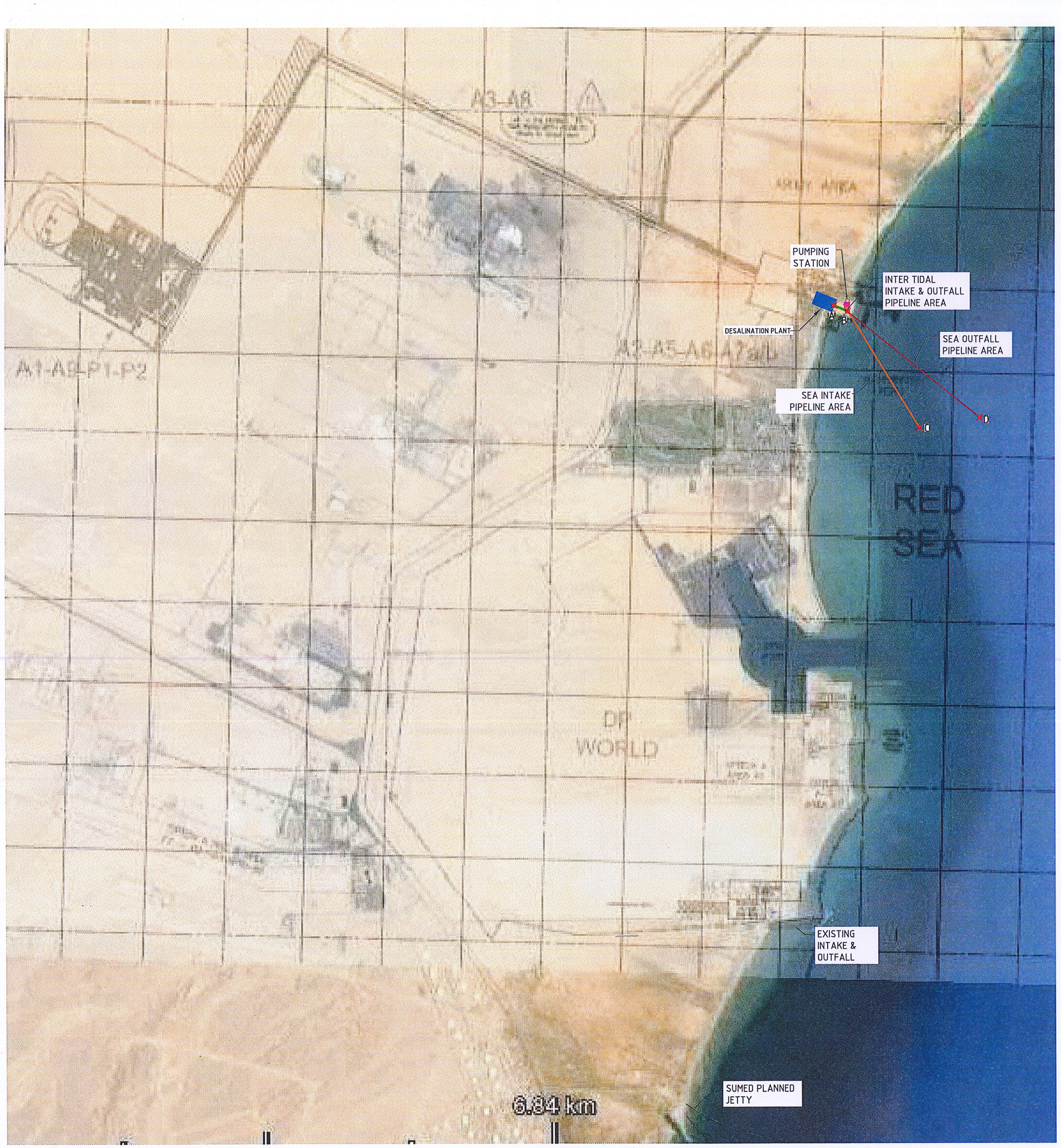

GENERAL ARRANGEMENT

NOTES

1. REFER DRG-0002 FOR GENERAL NOTES.
2. TOPOGRAPHIC LEVELS ARE NOT AVAILABLE. IT IS RECOMMENDED TO PERFORM A TOPOGRAPHIC SURVEY OF THE PIPELINE ROUTE BEFORE MOVING TO THE NEXT DESIGN PHASE.
3. PUMP STATION AREA HAS BEEN ASSESSED BASED ON EXPERIENCE WITH SIMILAR PROJECT. A DETAILED PUMP STATION ASSESSMENT WILL BE PERFORMED AS PART OF THE NEXT DESIGN PHASE.

LEGEND

- OUTFALL
- SEA INTAKE
- SERVICE CORRIDOR FOR INTAKE AND OUTFALL
- A — REF. POINT
- PUMP STATION
- DESALINATION PLANT

PIPELINE COORDINATES

REF. POINT	CENTRE LINE OF SERVICE CORRIDOR CHAINAGE	EASTING	NORTHING
A	000.000	438459.594	3283970.182
B	175.000	438621.470	3283903.690
C	1793.194	439470.821	3282526.318
D	2187.859	440192.091	3282643.558

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		B	11.08.14	REISSUED FOR CLIENT REVIEW	TOME	FLOJ	MABS	FLOJ	TPC
		A	27.02.14	ISSUED FOR CLIENT REVIEW	MOA	KARA	RECJ	FARU	TPC

CLIENT: TAHRIR PETROCHEMICALS

DRAWN:	MOHA	DATE:	23.02.14
CHECKED:	KARA	DATE:	23.02.14
DESIGNED:	RECJ	DATE:	23.02.14
APPROVED:	FARU	DATE:	23.02.14
CLIENT:	TPC	DATE:	

TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN-REVISED LOCATION DESALINATION PLANT GENERAL ARRANGEMENT

SCALE: N.T.S. | DRG No 303052-00130-DRG-0005 | REV D

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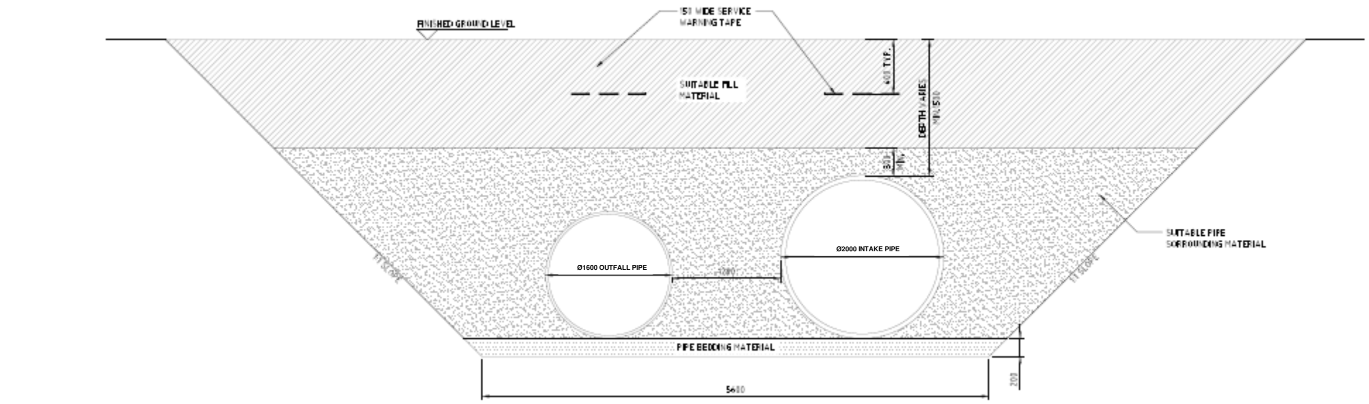
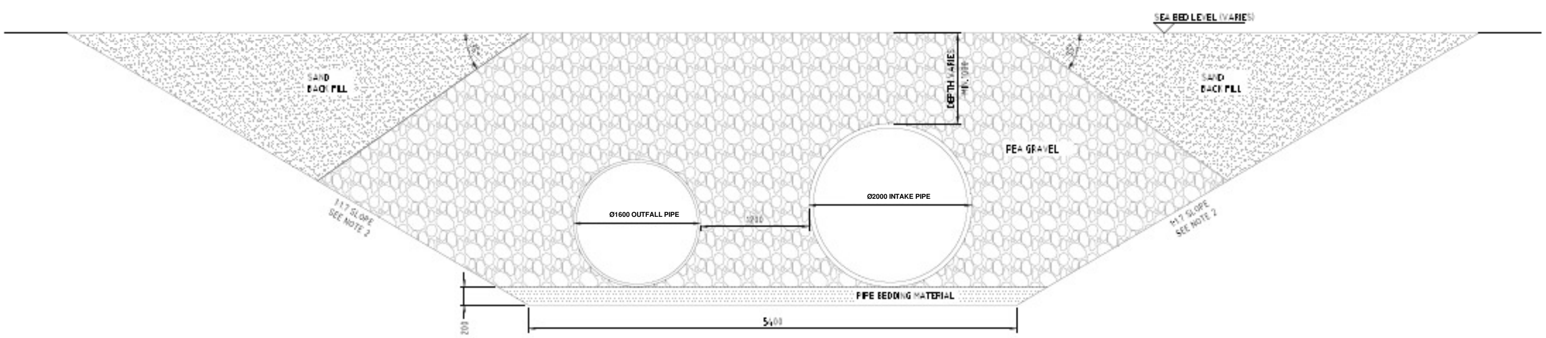


LAND INTAKE AND OUTFALL
TYPICAL CROSS SECTION
1:25



SEA INTAKE & SEA OUTFALL PIPE TYPICAL CROSS SECTION
1:25

NOTE:

1. REFER DRG 0002 FOR GENERAL NOTES.
2. SLOPES ARE INDICATIVE AND WILL BE REFINED UPON RECEIVING GEOTECHNICAL INFORMATION.
3. CONCEPT DESIGN ASSUMES THAT GEOTECHNICAL CONDITIONS ALONG THE PIPELINE ROUTE ALLOW FOR EXCAVATION.
4. ON LAND LEVELS AND GEOTECHNICAL CONDITIONS ARE NOT AVAILABLE. IT IS RECOMMENDED TO PERFORM GEOTECHNICAL INVESTIGATIONS INCLUDING EXCAVATION PITS TO ASSESS THE SOIL PROPERTIES.
5. THE GAP BETWEEN TWO CASING PIPES AT NDRC IS INDICATIVE.
6. REFER TO CONCEPT DESIGN REPORT FOR MORE DETAILS.

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		C	22.05.14	REISSUED FOR CLIENT REVIEW	SAHB	KARA	MABS	FLOU	TPC
		B	15.05.14	REISSUED FOR CLIENT REVIEW	TOMIE	KARA	MABS	FLOU	TPC
		A	27.03.14	ISSUED FOR CLIENT REVIEW	MOHA	KARA	SURH	RECJ	TPC

CLIENT: TAHRIR PETROCHEMICALS

DRAWN:	MOHA	DATE:	26.02.14
CHECKED:	MOHA	DATE:	26.02.14
DESIGNED:	SURH	DATE:	26.02.14
APPROVED:	RECJ	DATE:	26.02.14
CLIENT:	TPC	DATE:	

TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN-REVISED LOCATION
LAND INTAKE AND OUTFALL
TYPICAL CROSS SECTIONS

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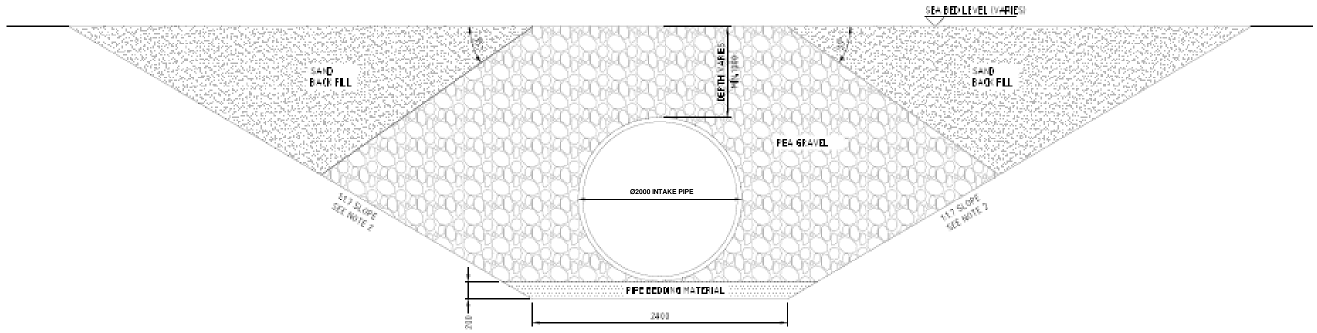

SEA INTAKE PIPE TYPICAL CROSS SECTION
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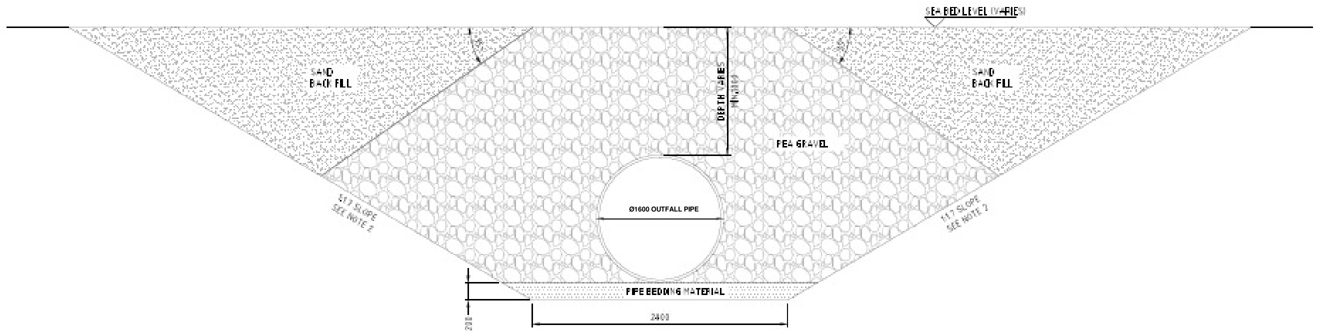

SEA OUTFALL PIPE TYPICAL CROSS SECTION
1:25

NOTE:

1. REFER DRG 0002 FOR GENERAL NOTES.
2. SLOPES ARE INDICATIVE AND WILL BE REFINED UPON RECEIVING GEOTECHNICAL INFORMATION.
3. THE MINIMUM COVER FOR THE INTAKE AND OUTFALL IS INDICATIVE AND WILL BE REFINED UPON RECEIVING WAVE CONDITIONS AND GEOTECHNICAL DATA.
4. A MINIMUM COVER OF 1m IS PRESENTLY PROPOSED FOR THE LOCATIONS AWAY FROM THE INTER TIDAL AND SURF ZONE.
5. AT LATER DESIGN PHASES, IT WILL BE INVESTIGATED WETHER IT IS FEASIBLE TO INSTALL SOME SECTIONS OF THE PIPELINE DIRECTLY ON THE SEA BED.

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		C	[illegible]	REVISED FOR CLIENT REVIEW	SAHB	KARA	HABS	FLOU	TPC
		B	[illegible]	REVISED FOR CLIENT REVIEW	TOME	KARA	HABS	FLOU	TPC
		A	[illegible]	ISSUED FOR CLIENT REVIEW	MOHA	KARA	SURH	RECJ	TPC

CLIENT
TAHRIR PETROCHEMICALS

DRAWN: MOHA	DATE: [illegible]	
CHECKED: KARA	DATE: [illegible]	
DESIGNED: SURH	DATE: [illegible]	
APPROVED: RECJ	DATE: [illegible]	
CLIENT: TPC	DATE:	

TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN-REVISED LOCATION
SEA INTAKE AND OUTFALL
TYPICAL CROSS SECTIONS

SCALE	DWG No	REV
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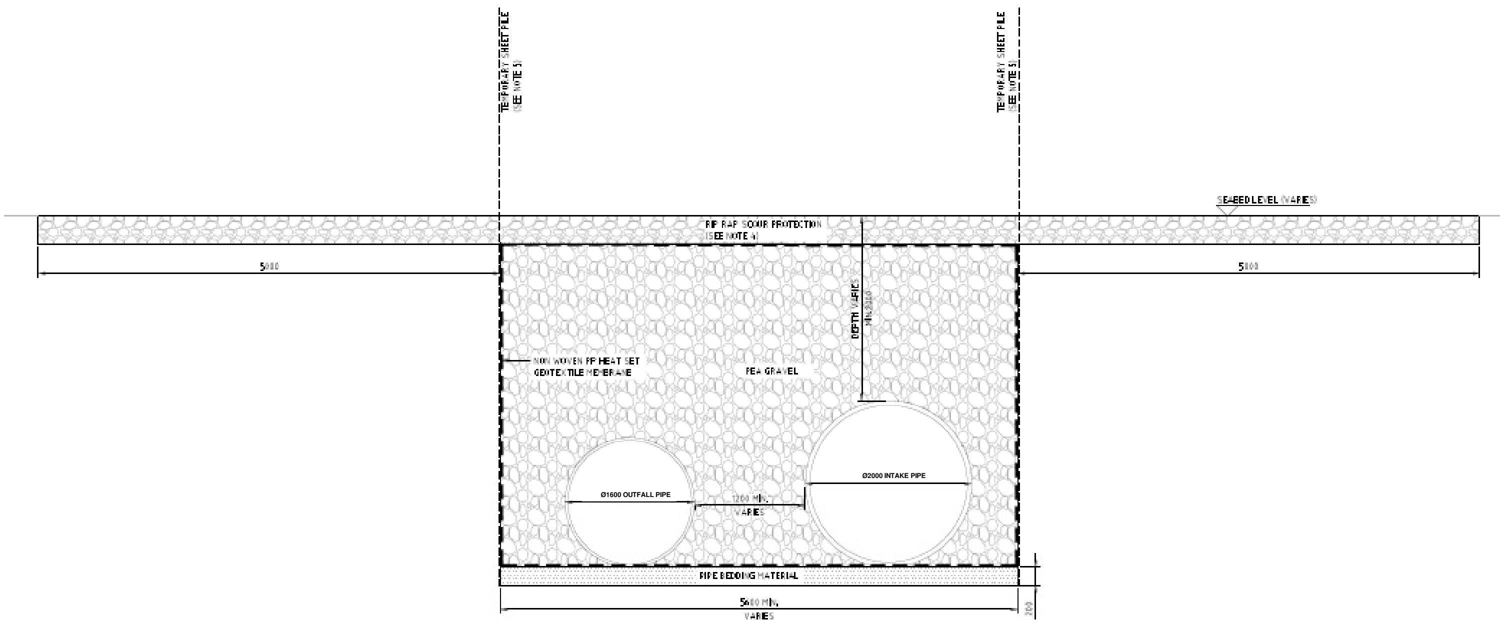

INTER TIDAL AND SURF ZONE INTAKE AND OUTFALL TYPICAL CROSS SECTION

1:25

NOTE:

1. REFER DRG 0012 FOR GENERAL NOTES.
2. THE MINIMUM COVER FOR THE INTAKE AND OUTFALL IS INDICATIVE AND WILL BE REFINED UPON RECEIVING WAVE CONDITIONS AND GEOTECHNICAL DATA.
3. THE MINIMUM COVER OF 2m IS PRESENTLY PROPOSED FOR THE LOCATIONS WITHIN THE TIDAL AND SURF ZONES.
4. DIMENSIONS OF RIP RAP WILL BE DETERMINED DURING NEXT DESIGN PHASES UPON ASSESSING WAVE CONDITIONS AT THE SITE.
5. A TEMPORARY SHEET PILE TRENCH MAY BE REQUIRED TO ALLOW INSTALLATION OF THE PIPES. THE SHEET PILE SHOULD BE REMOVED AFTER INSTALLATION OF THE PIPE.
6. TRENCH DESIGN WILL BE REFINED UPON RECEIVING GEOTECHNICAL INFORMATION.
7. ADDITIONAL OPTIONS FOR SURF AND TIDAL ZONE CROSS SECTIONS SUCH AS HORIZONTAL DRILLING WILL BE INVESTIGATED AS PART OF THE NEXT DESIGN PHASES. SHEET PILE TRENCH SEEMS AT THE MOMENT, THE MOST COST EFFECTIVE SOLUTION.

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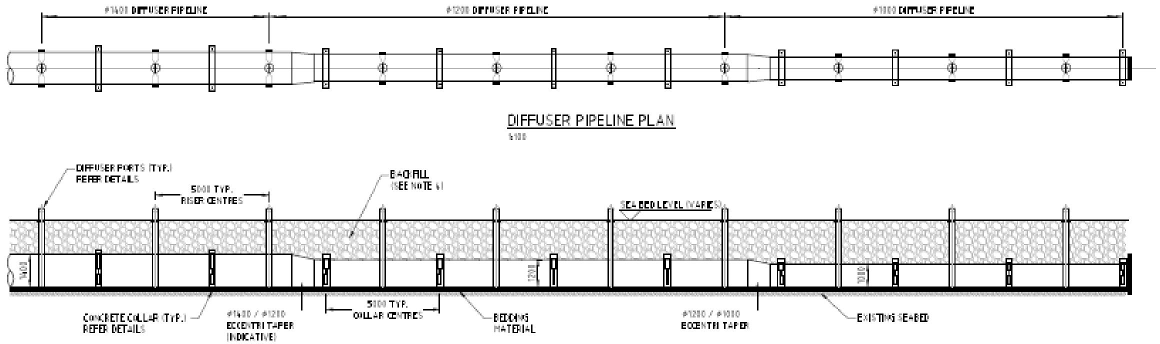
		C		REISSUED FOR CLIENT REVIEW	SAHB	KARA	HABS	FLOU	TPC
		B		REISSUED FOR CLIENT REVIEW	TOME	KARA	HABS	FLOU	TPC
		A		ISSUED FOR CLIENT REVIEW	MOHA	KARA	SURH	RECJ	TPC

CLIENT: TAHRIR PETROCHEMICALS

DRAWN	MOHA	DATE	
CHECKED	KARA	DATE	
DESIGNED	SURH	DATE	
APPROVED	RECJ	DATE	
CLIENT	TPC	DATE	

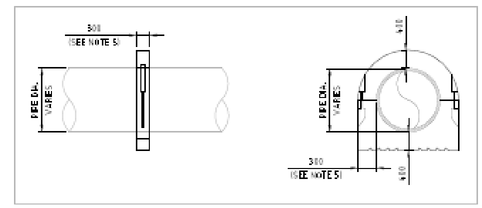
TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN-REVISED LOCATION SURF ZONE AND INTER TIDAL INTAKE AND OUTFALL TYPICAL CROSS SECTIONS

SCALE 1:25 | DRG No 303052-00130-DRG-0012 | REV C



DIFFUSER PIPELINE PLAN
1:100

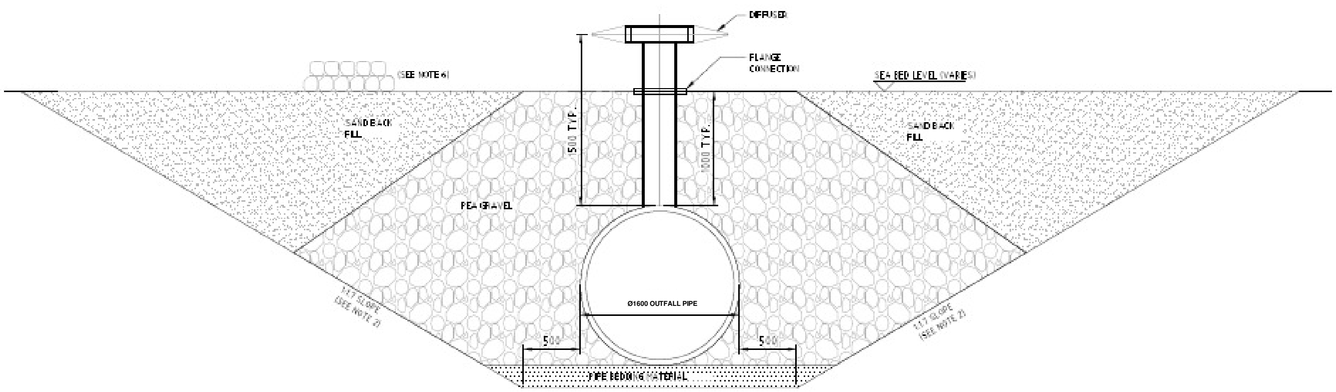
DIFFUSER PIPELINE PLAN
LONGITUDINAL CROSS SECTION
1:100



FRONT VIEW

SIDE VIEW

CONCRETE COLLAR
1:50



DIFFUSER TYPICAL CROSS SECTION
1:20

NOTE:

1. REFER DRG 0002 FOR GENERAL NOTES.
2. SLOPES ARE INDICATIVE AND WILL BE REFINED UPON RECEIVING GEOTECHNICAL INFORMATION.
3. PIPELINE DIAMETERS AT THE DIFFUSER SECTIONS ARE PRELIMINARY AND WILL BE CONFIRM DURING THE NEXT DESIGN PHASES UPON PERFORMING HYDRAULIC ANALYSIS.
4. BACKFILL REQUIREMENTS TO BE ASSESSED AS PART OF THE NEXT DESIGN PHASES.
5. DIMENSIONS OF CONCRETE COLLARS ARE PRELIMANRY.
6. A RIPRAP ROCK SCOUR PROTECTION MAY BE REQUIRED TO PROTECT AGAINST EROSION INDUCED BY THE DIFFUSERS. SCOUR PROTECTION REQUIREMENTS WILL BE ASSESSED AS PART OF THE NEXT DESIGN PHASES.
7. PIPELINE DIAMETER AT DIFFUSER LOCATION TO BE OPTIMIZED DURING DETAILED DESIGN.

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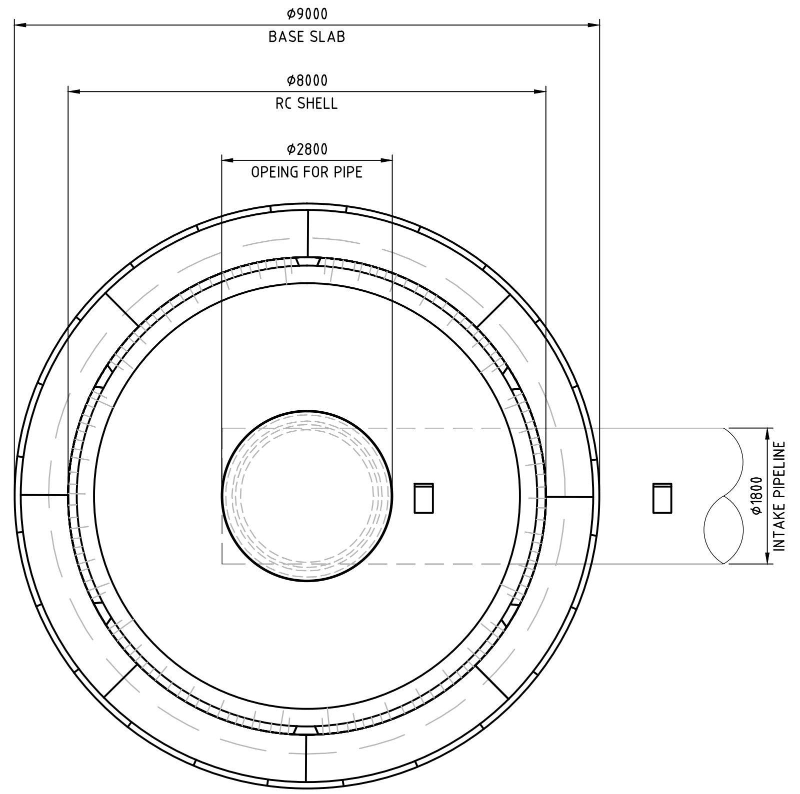
CLIENT
TAHRIR PETROCHEMICALS

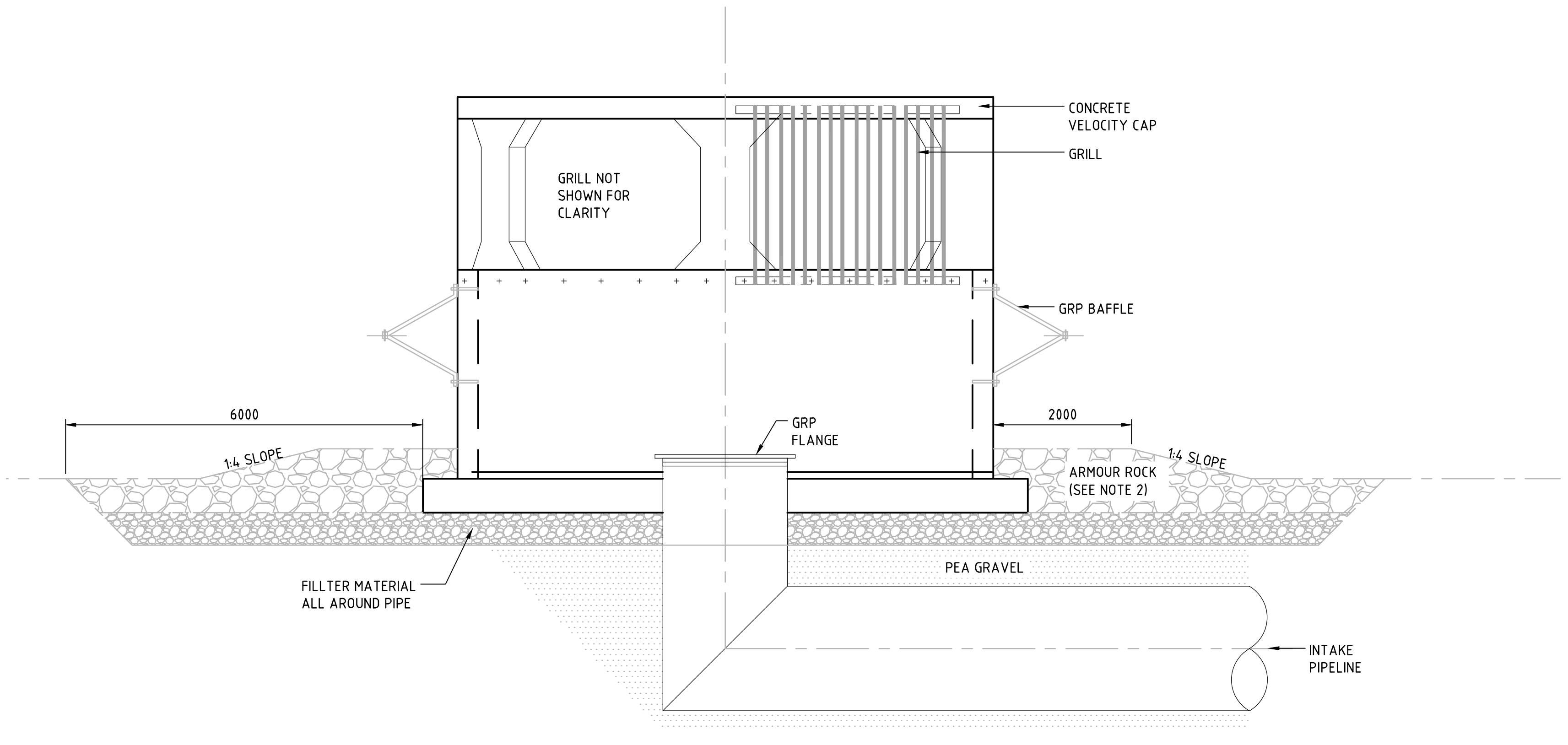
DRAWN:	MOHA	DATE:	[illegible]
CHECKED:	KARA	DATE:	[illegible]
DESIGNED:	SURH	DATE:	[illegible]
APPROVED:	RECI	DATE:	[illegible]
CLIENT:	TPC	DATE:	

TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN-REVISED LOCATION
SEA DIFFUSER PLAN
AND DETAILS

SCALE: AS SHOWN | DRG No: 303052-00130-DRG-0013 | REV: C



PLAN
1:50



ELEVATION
1:50

NOTE:

1. REFER DRG 0002 FOR GENERAL NOTES.
2. ROCK ARMOUR REQUIREMENTS TO BE ASSESSED UPON ASSESSING WAVE CONDITIOND.
3. INTAKE STRUCTURE DIMENSIONS ARE PRELIMINARY.
4. HEIGHT OF THE SEA WATER STRUCTURE TO BE REFINED AS PART OF NEXT DESIGN PHASES.

CONCEPT

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CLIENT
TAHRIR
PETROCHEMICALS

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CHECKED:	KARA	DATE:	24.02.14
DESIGNED:	SURM	DATE:	24.02.14
APPROVED:	RECJ	DATE:	24.02.14
CLIENT:	TPC	DATE:	

TAHRIR PETROCHEMICALS INTAKE AND OUTFALL CONCEPT DESIGN-REVISED LOCATION
CONCRETE INTAKE STRUCTURE
PLAN AND ELEVATION

SCALE: 1:25 | DRG No 303052-00130-DRG-0014 | REV C

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