TA-6697 REG

Project Readiness Support for the Environment, Natural Resources and Agriculture Sector in Central and West Asia

Flood Early Warning System for Kugart Basin, Kyrgyzstan

Terms of Reference

REPORT PREPARED FOR

ASIAN DEVELOPMENT BANK

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Abbreviations

1D	One dimensional
2D	Two dimensional
1D-2D	Combined 1D and 2D (hydrodynamic model)
ADB	Asian Development Bank
AEP	Annual Exceedance Probability
ALOS	Advanced Land Observing Satellite
API	Application Programming Interface
CCDRWR	Climate Change and Disaster Resilient Water Resources
DA	Data Assimilation
DEM	Digital Elevation Model
ECMWF	European Centre for Medium-Term Weather Forecasting
FFEWS	Flood Forecasting And Early Warning System
GIS	Geographic Information System
GPM	Global Precipitation Measurement Mission
GSMAP	Global Satellite Mapping of Precipitation
IMERG	Integrated Multi-satellitE Retrievals for the Global Precipitation Measurement
LiDAR	Light Detection and Ranging
MAP	Mean Areal Precipitation
MoA	Ministry of Agriculture
MES	Ministry of Emergency Situations
NHMS	National Hydro-Meteorological Services
NWP	Numerical Weather Prediction
ODCC	Observational Data Collection Center
PET	Potential evapotranspiration
PIU	Project Implementation Unit
TOR	Terms of Reference
WMO	World Meteorological Organization

1 Introduction

1.1 Background

The Asian Development Bank (ADB) is currently supporting the Kyrgyz Republic in the implementation of the Climate Change and Disaster Resilient Water Resources (CCDRWR) sector project under the Ministry of Agriculture (MoA) and Ministry of Emergency Situations (MES). The project commenced in July 2019 and is due for completion in September 2025. The Project Implementation Unit (PIU) has been established under the Ministry of Emergency Situations (MES).

Output 3 of the project focusses on strengthening disaster management capacity at the national level. As part of this implementation new, hydrological posts (comprising a mix of meteorological and hydrometric measurement stations) will be installed at 21 project target sites to be managed by KyrgyzHydromet. and a Flood Forecasting and Early Warning System (FFEWS) will be pilot tested to assess future feasibility and the potential to improve the efficiency and accuracy of the current manual warning system.

The target river basin for the FFEWS pilot is the Kugart basin which flows through the city of Jalal-Abad and joins the transboundary Kara Darya river a short distance downstream, see Figure 1. The Kugart basin has historically been well instrumented with precipitation and streamflow gauges and will benefit from new gauges to be installed as part of the CCDRWR project. A report undertaken by an independent ADB expert has confirmed the suitability of the Kugart basin for the pilot FFEWS (report details are provided at the end of this chapter).

The consultancy involves the development of hydrological and hydrodynamic models of the Kugart basin and implementing these in a suitable flood forecasting platform to provide timely flood warning to the downstream populations in Jalal-Abad and flood inundation extents in Suzak.

The FFEWS will be installed on existing servers and operated by KyrgyzHydromet from their national office in Bishkek. The system will need to be integrated to the existing real time observation database and Numerical Weather Prediction (NWP) models to enable these data sources to drive the FFEWS models.

1.2 Aim, objectives and expected results

Aim

The aim is to complete the implementation of the Kugart River Basin Flood Forecasting and Early Warning system and enable its connection to KyrgyzHydromet’s existing data collection and meteorological forecasting systems.

Objectives

The objectives of consultancy services are:

- Establish the pilot FFEWS at KyrgyzHydromet to allow for early warning of flood levels in the lower reaches of the Kugart River
- Forecasting of inundation depths and extents in the Suzak urban area
- Strengthen the capacities of KyrgyzHydromet for hydrological and hydrodynamic modelling, flood mapping and flood forecasting

Duration

The duration of the consultancy is 31 months including 7 months for the establishment of the FFEWS at KyrgyzHydromet followed by 24 months of remote support.

Results to be achieved by the Contractor

- Development and calibration of a new hydrological model for the Kugart Basin incorporating the capability to model runoff from both rainfall and snowmelt.
- Development and calibration of a new 1D-2D model of the mid-lower floodplain reach of the Kugart River down to the confluence with the Kara Darya River. The 2D component covers the Suzak urban area downstream of Jalal-Abad (an area of approximately 40km^2)
- Development of flood hazard maps for Suzak for 50%, 20%, 10%, 5%, 2%, 1%, 0.4%, 0.2 % AEP.
- Incorporating the above models into a suitable flood forecasting platform, installation on the KyrgyzHydromet server and integration with their real time observation network in the Kugart River basin and NWP forecasts
- Configuration of the forecast platform to allow for automated and regular flood forecasts in the Kugart River basin, including data assimilation of the hydrometric observations and inundation forecasts for the Suzak sub-area.
- Commissioning and testing of the forecast system and performance over an extended period.
- KyrgyzHydromet staff trained in hydrological and hydrodynamic modelling and the operation and maintenance of the developed FFEWS
- Provision of training manuals and a system user manual (Russian language)
- Remote support to KyrgyzHydromet from commissioning to the end of the contract.

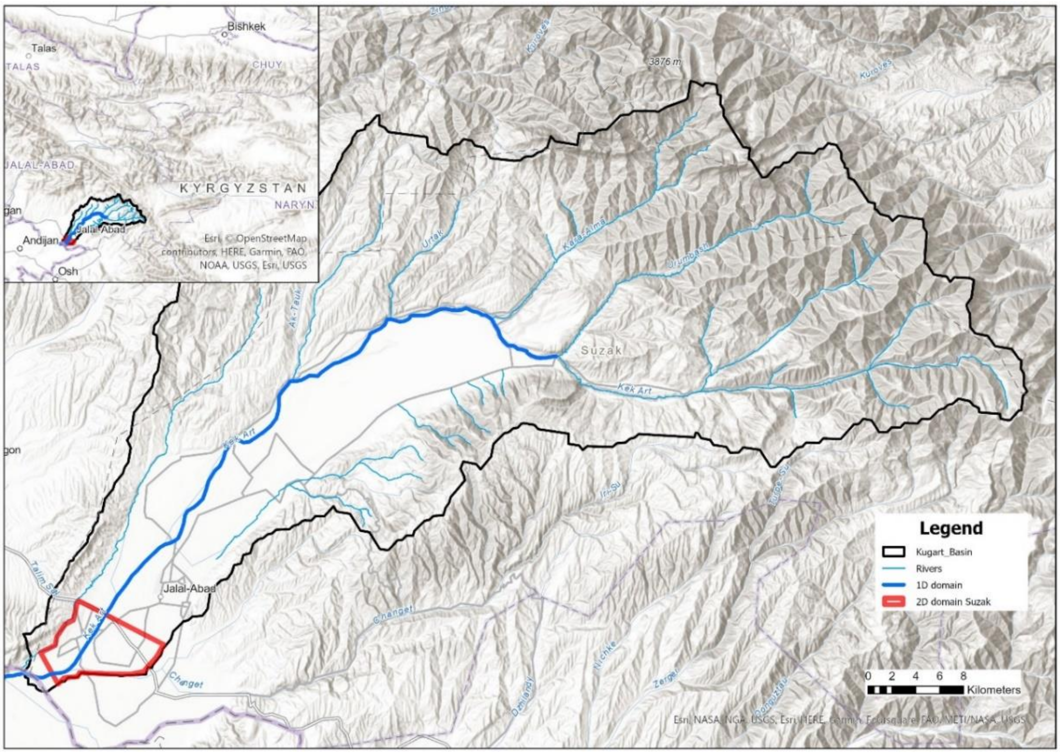

Figure 1: Location map of Kugart basin and scope of hydrodynamic models

For further information on the Kugart River basin characteristics, existing data and systems, bidders are referred to the *"Report On Flood Early Warning System for Kugart Basin, Kyrgyzstan"*[1] (T. van Kalken, ADB Consultant, Final Report, 4-22 Oct. 2023).

[1] T. van Kalken, ADB Consultant, Final Report, 22 Oct. 2023).

2 Procurement Packages

2.1 Overview

The provision of the necessary services and materials will likely involve both national and international resources. Table 1 summarizes the services and materials to be procured for the establishment of the FFEWS, lists the likely source (national/international) and options for the supply.

Table 1 List of services and materials to be procured with sources and supply options

No.	Nature of Procurement	Item	Method of Procurement	Source	Supply Options
1	Procurement of Consulting Services and Software	Hydrologic and hydrodynamic model development and calibration	Quality- and Cost-Based Selection for Consulting Firm (90:10)	International	Consulting firm with international and national specialists
		Forecast platform establishment and FFEWS commissioning			
		Capacity building and maintenance support			
		Model software	Included with Consulting Services	International	International supplier
		Forecast platform software			
2	Procurement of Goods and Services	River cross section surveys at 70 locations along Kugart River	Provided via sub-cotract	National	National survey company
		Detailed land elevation (aerial and land-based (LiDAR) survey of Suzak settlement (40 km^2)			
3	Procurement of Works	Jalal-Abad water level radar supply and installation	To be included in a contract of the ongoing CCWRDR project	International	

Notes regarding the above table:

1. Consulting services are expected to be led by a suitably qualified and experienced international consultant but utilizing national experts as far as possible. It is envisaged the Consultant will also supply the necessary software to establish and operate the FFEWS.
2. The necessary topographic surveys will be undertaken through a separate contract by the PIU with a local survey company. The survey locations and specifications provided herein will be valid for whichever procurement method is adopted.
3. The FFEWS server hardware is available within the existing server room at KyrgyzHydromet.. The Consultant shall confirm with the PIU that the specifications provided herein are adequate for the proposed FFEWS operation.
4. An additional water level radar has been recommended to be installed in Jalal-Abad. The supply and installation will be handled as an addendum to the current CCWRDR contract.

The following sections provide further details of the individual procurement packages.

2.2 Consulting services and software

2.2.1 Hydrological modelling

A hydrological model covering the entire Kugart river basis needs to be developed in order to compute river inflows from observed and forecast precipitation. The model needs to include a snowmelt component given the climatological conditions of the basin and should run on a continuous basis to ensure that soil moisture and snow conditions are continually accounted for. Minimum specifications for the modelling software are provided in Annex 1. Model calibration should utilize the available precipitation, evaporation, temperature and streamflow records from the ground stations in the basin, see Figure 2. Refer to the ADB Consultants report for details of the data availability at each site which should be confirmed by the Consultant.

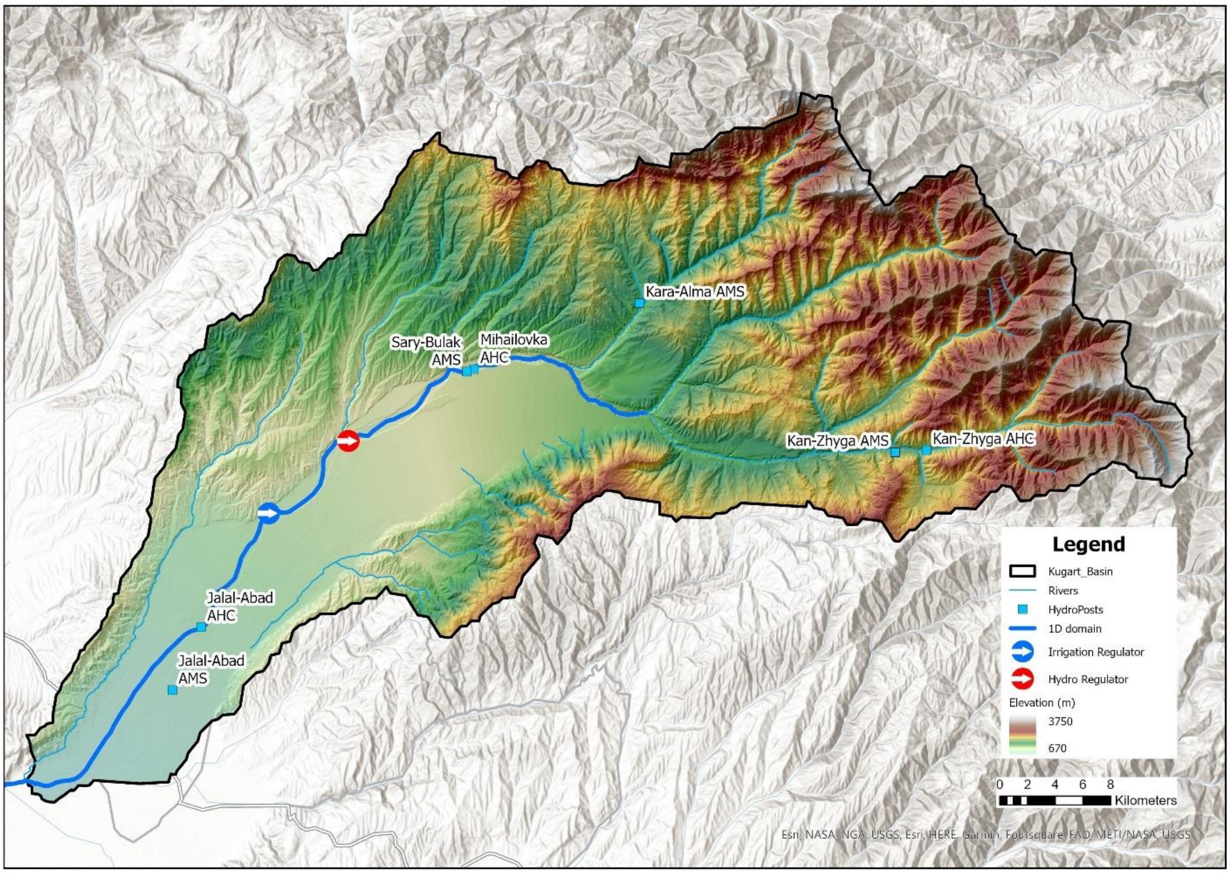

Figure 2: Location of hydrometeorological gauges in the Kugart Basin.

As the available hydrometeorological data cover different historical eras, a careful selection of the periods to be used for model calibration and validation is needed. Selected periods should include high flood events and the focus on the calibration should be on and around the flood peaks aiming to reproduce both the magnitude and importantly the timing. The Consultant shall clearly state the modelling approach proposed for the FFEWS and the methodology for model development, calibration and verification.

The model calibration performance should be quantitatively assessed using Nash-Sutcliff Efficiency (NSE) and Root Mean Squared Error (RMSE) indicators as a minimum. The NSE and RMSE values should be calculated for both the overall continuous simulation result as well as selected flood events.

2.2.2 Hydrodynamic modelling

A hydrodynamic model covering the lower floodplain area of the Kugart basin is required to provide water level forecasts. In order to provide a forecast of the inundation depth and extent in the Suzak target area a 2D model representation is required, linked to the 1D river channel description. Minimum specifications for the modelling software are provided in Annex 1. For forecasting purposes the Consultant may select to run the combined 1D-2D model in real time if sufficiently fast simulations are possible, or alternatively prepare a “library” of flood maps corresponding to a range of river levels or discharges which can be linked to the observed or forecasted water level at the proposed Jalal-Abad water level gauge. In the latter case the 2D area is represented in a simplified way in the 1D model. The Consultant shall state the preferred approach and describe the methodology.

Regardless of which forecasting model approach is used, a 1D-2D coupled hydrodynamic model is required to allow for the generation of flood inundation depths and extents in Suzak. The 1D model extent covers the lower 60km of the Kugart River. Cross section surveys will be executed under a separate contract and provided to the Consultant. See Section. 2.3.1.1 for further details. The surveyed river cross sections may need to be extrapolated and merged with a suitable global DEM (eg MERIT, ALOS) where flood extents could extend beyond the survey. The lower river reaches incorporate a series of river diversions, bridges and river training structures including revetment, levees and groynes which must be appropriately accounted for in the model. Information on existing and on-going river training works is available with MES in Jalal-Abad.

The 2D component is limited to an approximate 40km^2 area downstream of Jalal-Abad. A detailed topographical survey will be available for this area, see Section 2.3.1.3 for details. The 1D and 2D components in this area shall be linked based on the thresholds for channel overtopping (bank or levee crest levels) while other surface features which may affect overland flow paths (such as raised roads, levees or irrigation canal banks) shall be represented in the 2D domain via suitable means (eg break lines or longitudinal weir structures). The surface roughness component for the 2D domain may be derived from satellite imagery.

Calibration of the 1D model is only possible at the Mikhailovka gauge where long term records of water level and discharge are available. A number of suitable recent flood should be selected to assess the model performance at this station and derive the suitable performance measures (NSE and RMSE).

2.2.3 Flood hazard maps

The calibrated 1D-2D model shall be used to generate flood hazard maps for Suzak for a range of Annual Exceedance Probabilities (AEP) to support MES and the local authorities in identifying high risk areas. The AEP’s include 50%, 20%, 10%, 5%, 2%, 1%, 0.4%, 0.2 % with the flood hazard maps indicating maximum flood extents, depths, velocities and hazard (velocity-depth combination). In the case that pre-computed flood maps are used in the real time forecast system (ie instead of running the 1D-2D model) additional scenarios may be required to cover the full range of potential river levels in sufficient resolution. The maps shall be overlaid on satellite imagery and shall identify the locations of relevant vulnerable buildings and infrastructure including schools, medical facilities, police and emergency services, electrical and water supplies etc.

2.2.4 Software

Three major software components are required to implement the FFEWS. These are the hydrological model, hydrodynamic model and flood forecasting platform. The software shall be provided by the Consultant and installed on the specified KyrgyzHydromet server. For the proposed system it is essential that only mature products (more than 10 years since initial release and with continuing updates) are considered. Those with strong user communities are advantageous to support the adoption of the end system by KyrgyzHydromet. Annex 1 lists the minimum specifications for each of the software products needed for the FFEWS. The Consultant shall indicate any initial or on-going license costs for each of the three software products and include these costs in their proposal. For licenses based on an annual subscription, the costs for the licenses for the duration of the project and the 2 years following its completion should be included in cost schedule. KyrgyzHydromet shall be specified as the end user of any necessary software licenses.

2.2.5 Flood forecast system installation, commissioning and acceptance

The developed hydrological and hydrodynamic models shall be integrated into a suitable and configurable software platform. The platform will allow for the automated production of flood forecast information including the following tasks:

- Import real time rainfall and temperature observations from KyrgyzHydromet server, undertake automatic data quality checks and store the data in the forecast system database
- Import real time water level observations, (optionally converts these to discharge via defined rating curves) and stores these data in the database
- Import and display gridded precipitation data from global data sources (eg IMERG) and local WRF forecasts
- Compute Mean Areal Precipitation (MAP) timeseries by gauge weighting of the observed data and by spatial averaging of the gridded data. Similar for temperature (MAT)
- Merge hindcast and forecast MAP and MAT timeseries and prepare in a suitable format for the models
- Execute the hydrological and hydrodynamic models, and assimilate observed data to one or both of these models
- Import the model results to the database, process and display forecasts of flood levels along the Kugart River and inundation extents in Suzak
- Analyze the results for any threshold exceedance and generate warning messages via email and SMS
- Provide an Application Programming Interface (API) for wider dissemination to web pages or mobile platforms

Minimum specifications for the forecast platform software are provided in Annex 1.

Notes:

i. In the case that the real time observation network is not available a secondary data source for observations is required. These should be derived from a suitable remotely sensed data source (eg IMERG, GPM, GSMaP))

ii. As noted previously, the forecast of flood inundation in Suzak may be computed by running the 1D-2D model in real time or alternatively by utilizing a pre-calculated library of flood extents.

iii. Data assimilation is considered to be an essential component of the forecast system in order to improve forecast accuracy. Observed discharges may be used to update the hydrological model and/or observed water levels similarly applied to the hydrodynamic model.

The Consultant shall describe the planned approaches to the above 3 requirements in the proposal.

The forecast platform software shall be installed (with the forecast models and software) on a designated virtual server at KyrgyzHydromet in Bishkek. The Consultant shall specify the hardware, operating system and other requirements for the complete system operation (models and platform) in their proposal.

The Consultant is expected to oversee the successful commissioning of the FFEWS and demonstrate in a site acceptance test (SAT) the full automation of the flood forecast workflow as described above.

2.2.6 Capacity building and maintenance support

An important component of the FFEWs establishment at KyrgyzHydromet will be acquiring and developing the necessary human resources needed to ensure the system is sustainable into the future. KyrgyzHydromet have existing skills in data management and processing, hydrology and IT (databases and programming) but lack skills in hydrological and hydrodynamic modelling and flood forecasting. Therefore a combination of new staff and existing staff will need to be trained and upskilled in modelling and forecasting including system operation and maintenance.

Hydrological and hydrodynamic modelling software training courses shall cover the model building process including data processing, model calibration and the assessment of model outputs. Training in the forecast platform should upskill KyrgyzHydromet operators to allow them to monitor the system and interpret the outputs, modify the system to accommodate the addition of new gauges, or other input data and to incorporate updates to the underlying models. Ideally KyrgyzHydromet staff should be involved in the model development and calibration and forecast system setup so that formal training courses can be reinforced by on-the-job training. The Consultant shall outline the approach to capacity building indicating the details and duration of training sources in their proposal.

Following the SAT and capacity building an approximate 24 month period of remote support shall commence. During this period the Consultant shall support the KyrgyzHydromet operators in monitoring the system operation and to troubleshoot any issues. The Consultant shall also assist the operators in assessing the system and model forecast performance and advise on any adjustments.

2.2.7 Consultant qualifications and experience

The Consultant Firm is expected to have at least 10 years of working experience in the flood forecasting and flood hazard mapping sector, including working with National Hydrometeorological Service organizations both in developed and developing countries including providing the relevant capacity development needs. Experience in flood forecasting and hazard mapping in mountainous countries will be an advantage.The Consultant should provide CV’s for a list of qualified and experienced specialist staff available for the execution of the works as required. The specialist personnel for this assignment is expected to include a mix of international and national experts. The suggested team composition, minimum experience and duties are shown below in Table 2.

Table 2: Suggested Consultant’s team composition and minimum required experience

No	Position (National / International)	Duties	Minimum Relevant Experience	Qualification	Estimated person-months
1	Team Leader / Lead Hydrologist (International)	Responsible for delivery of overall project, managing resources in terms of time and budget, quality assurance, client liaison. Preparation of progress and final reports. Supervision of the National Hydrologist tasks and ensuring quality of the developed model.	10 years project management experience in flood forecasting, flood risk management or water resources projects with significant hydrological and hydrodynamic modelling components.	MSc in environmental or water resources engineering or earth sciences	6
3	Hydrodynamic model specialist (International)	Collection, processing and quality checks of relevant topographical and hydrometeorological data. Preparing survey data for model input, development, calibration and validation of the 1D and 2D components of the hydrodynamic model. And reporting including model performance metrics. Preparation of model for real time operation	10 years in 1D and 2D hydrodynamic model development and application including flood hazard and risk mapping	MSc In civil, environmental or water resources engineering	3
4	Forecast platform / database specialist (International)	Establishment of the forecasting platform, establish database, configuration of real time and forecast data stream, hydrological and hydrodynamic models and data assimilation. Configuration of automated data processing and modelling tasks and generation of system outputs (warnings and reports)	10 years experience in flood forecast platform implementation	MSc in engineering, computer science or other relevant discipline	1.5
6	Engiineer Hydrologist (National)	Assisting in data preparation and processing including digitization and management of hydrometeorological data assisting the Team Leader	5 years experience in hydrometeorology	BSc in civil, environmental or water resources engineering	4
5	GIS specialist (National)	Collection, processing and quality checking of relevant spatial data need to support the modelling activities, Preparation and management of a project GIS database and preparation of preparation of topographical data and required mapping outputs.	10 years in GIS	BSc in earth sciences, computer science or other relevant discipline	42

2.3 Goods and services

2.3.1 Topographic surveys

As noted above, the topographic surveys will be procured via a separate contract to the Consulting services. The following basic information on the location and specification for the of the proposed river cross section and LiDAR surveys will be valid for any mode of procurement (through a national survey company or MES).

2.3.1.1 River cross sections

River cross section surveys are required at the locations shown in Figure 3. The coordinates of these points are given in Annex 2 .A total of 70 cross sections are required.

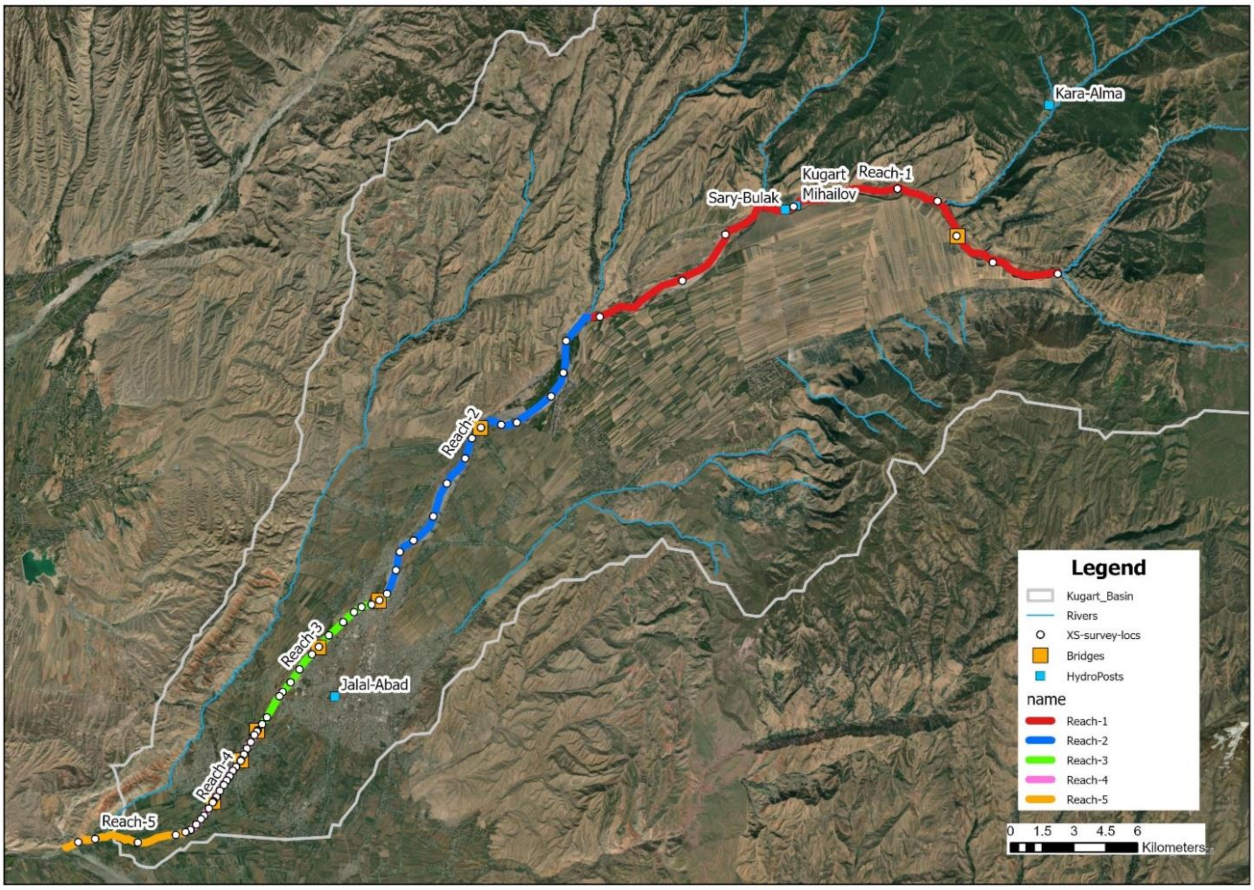

Figure 3: River cross section survey locations

The cross sections survey shall capture the main river channel (including below water area, the river banks, any riverside protection works (levees or flood walls) and extend 250m beyond the river bank or levee onto the floodplain. It is expected the survey can be carried out quickly using real-time kinematic (RTK) GPS equipment. Depending on the flow depths in the river the below-water profile in some locations may need to be surveyed by boat mounted echo-sounder or ADCP connected to RTK-GPS. The survey specifications are summarized in Table 3 and illustrated in Figure 4.

Table 3: Cross section survey summary specification

Item	Specification	Notes
Spatial reference and accuracy		
Map projection coordinate system	WGS 84 UTM Zone 44N	
Vertical reference	Baltic Sea level	
Vertical accuracy	0.20m	
Horizontal accuracy	0.50m	
	Channel survey	
Alignment	Perpendicular to dominant flow direction	Cross sections may be moved slightly if needed to meet this criterion
Maximum. spacing of points in river channel	25m	Survey points shall be closely spaced where vertical elevation is changing rapidly. At least 2 points shall be in the deepest part of the channel
Orientation	Survey from left to right – looking downstream	
Minimum number of points in the bed of the main river channel	5	
Minimum number of points at levees / flood walls	3 (crest level, land level river side, land level floodplain side)	The highest point of the levee / flood wall must be surveyed
Minimum and maximum distance of section line to bridges	Minimum 80m Maximum 120m	Preferred distance is 100m
	Floodplain survey	
Minimum extension from river bank	250m	Measured from top of river bank for levee/ flood wall
Maximum spacing of points	50m	Survey points shall be closely spaced where vertical elevation is changing rapidly.

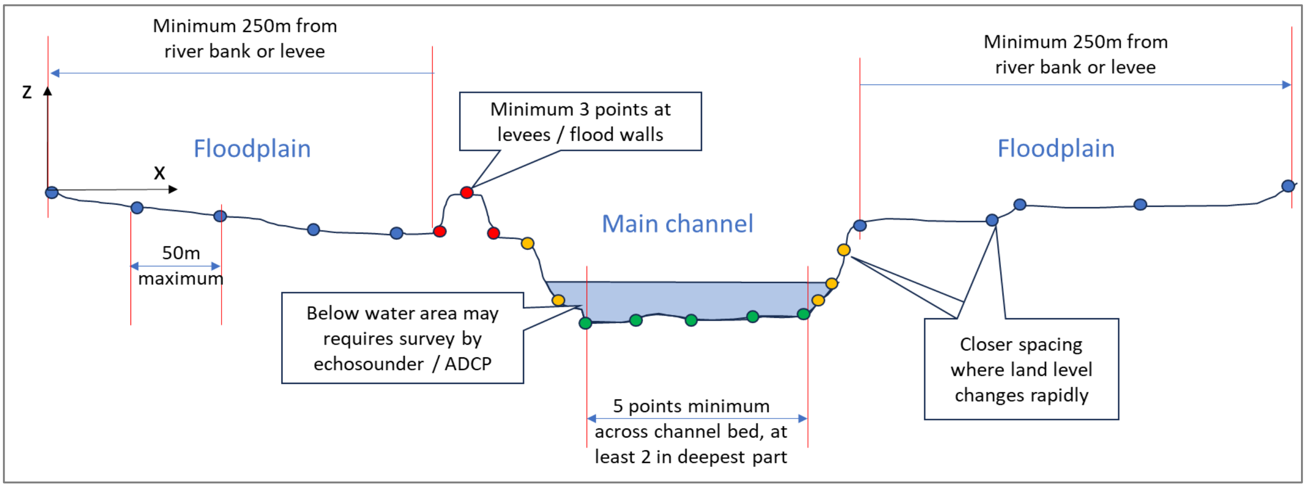

Figure 4: Illustration of river cross section survey requirements

The surveyor will submit the survey results as xyz values of each point (x and y in UTM 44N coordinates, z as the elevation to Baltic Sea datum). Photographs of the cross section including upstream and downstream views are also required and shall be submitted in suitable digital format and georeferenced.

The results of the topographical cross section survey shall be further processed and presented as a series x-z points in Excel table format, where x represents the lateral distance across the section (from left to right, looking downstream) and z is the vertical elevation (referenced to Baltic Sea level), see Figure 4.

2.3.1.2 Diversion structures and bridges

Surveys of the irrigation and new hydro diversion structures are required in case design or as-built drawings are not available. The diversion structure survey shall capture the sill level upstream and downstream of the structure, the gate widths and heights. The Bridge surveys shall capture the bridge soffit (structure underside) and deck level, and level of the safety railings, the number, location and size of any piers or supporting structures, and a cross section of the river at the upstream bridge face including the bridge abutments.

2.3.1.3 LiDAR survey

An airborne LiDAR survey is required on an approximate area of $40km^2$ over the Suzak settlement at the downstream end of the Kugart basin. The area to be surveyed is shown in Figure 5. The required vertical accuracy is 0.20m and horizontal accuracy is 0.50m. The surveyed data needs to be post processed to remove all buildings and generate a bare earth DEM (on a 3m x 3m grid or finer) .The specification for data acquisition and deliverables are given in Table 4 and Table 5 respectively.

Table 4: LiDAR survey acquisition specifications

Item	Specification
Map projection coordinate system	WGS 84 UTM Zone 44N
Vertical reference	Baltic Sea level
Vertical accuracy - 95% confidence- (1.96*$RMSE_Z$)	0.20m
Horizontal accuracy	0.50m
Nominal aggregate point density	>= 2 pulses/m^2
Pulse returns	Minimum 2
Swath overlap	15%
Max. difference between swaths	0.16m

Table 5: LiDAR deliverables specifications

Item	Content and Format	Notes
Point cloud – all returns	.LAS format of all point returns Tile size 1 x 1 km	Classified as first or second returns
Bare earth DEM	3m x 3m grid (or finer)-.TIFF or ESRI GRID format	Surface artefacts (buildings, vegetation) removed to represent average bare earth level in each grid cell)
Mission report and data validation	Report on flight mission including date, times and flight paths, survey control, accuracy and spatial distributions assessments	PDF, Excel

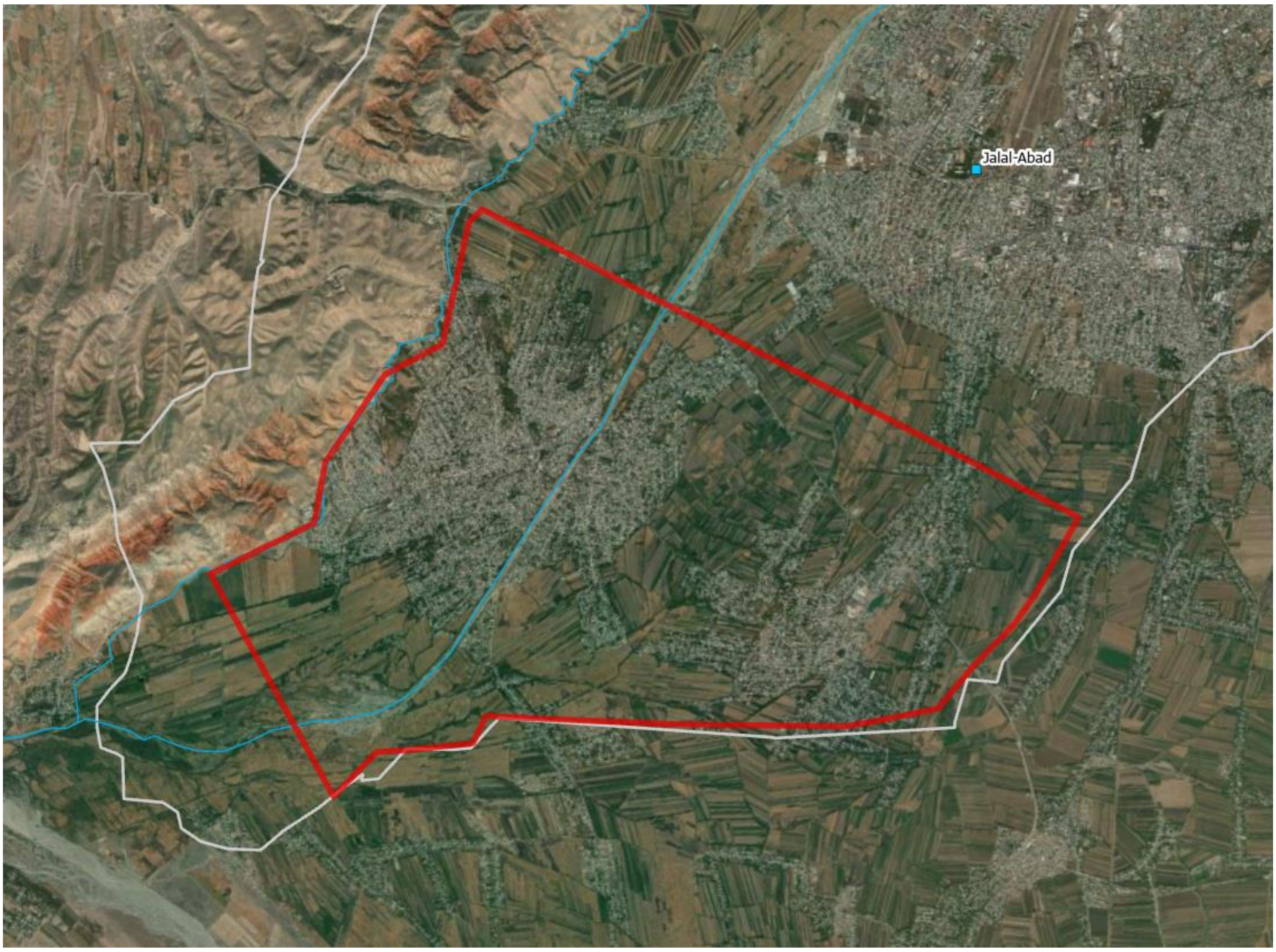

Figure 5: Extent of LiDAR survey

2.3.2 Note on Computer Hardware

A suitable server for installing and operating the FFEWS will be provided by KyrgyzHydromet from existing resources as a virtual server including the Windows Operating System. The specifications listed in Table 6 shall be confirmed by the Consultant as suitable for the proposed FFEWS. If additional computing resources are required these should be indicated in the Consultant's proposal together with envisaged access requirements. It is envisaged the server will be accessed via the internal network by remote desktop from the operator's own PC and therefore a monitor is not required.

Table 6: Tentative server specifications

Component	Requirement
Form	Rack
CPU's	16
Clock speed	3.6GHz or higher
RAM	32GB
Disk (Solid State SSD)	1TB
Operating System	Windows Server 2019 or 2022

2.4 Additional works

As part of the larger CCDRWR project (Loan 3746 / Grant 0634) new automatic meteorological and hydrometric station equipment will be installed in the Kugart Basin. As part of the ADB Consultant's investigation one additional water level radar has been proposed to be installed in Jalal-Abad. All of this equipment will be installed and commissioned under the CCDRWR project. The PIU will ensure that this work is included in the work plan of the main project and implemented in time.

3 Implementation outputs, schedule and arrangements

3.1 Technical outputs

The following technical outputs shall be produced by the Consultant as shown in Table 7:

Table 7: List of Technical outputs

Deliverable	Language	Format	Submission date of draft after contract signing
Report on the development, calibration and validation of the hydrological model	English and Russian	Soft Copy	2 months
Report on the development, calibration and validation of the hydrodynamic model	English and Russian	Soft Copy	4 months
Flood hazard mapping report	English and Russian	Soft Copy Hard copy (5)	5 months
Flood hazard maps and associated data	English and Russian	GIS files (ArcGIS compatible) Hard copy A0 (5)	5 months
Hydrological and hydrodynamic models for flood risk mapping	n/a	Digital (in model software)	5 months
Report on FFEWS system commissioning	English and Russian	Soft Copy	6 months
Training manuals (hydrological and hydrodynamic models, flood forecast platform)	English and Russian	Soft Copy Hard copy - Russian (5)	6 months
FFEWS User Manual	English and Russian	Soft Copy Hard copy - Russian (5)	6 months

3.2 Management reporting requirements

The consultant shall provide the following management reports as shown in Table .

Table 6: List of Management reports

Deliverable	Language	Format	Submission date of draft after contract signing
Inception Report	English and Russian	Soft Copy	1 month
Monthly progress reports	English and Russian	Soft Copy	2 months and monthly thereafter
Draft Final project summary report	English and Russian	Soft Copy	6 months
Final project summary report	English and Russian	Soft Copy Hard copy - Russian (5)	7 months

The Inception Report should contain the Consultant's work plan, assignment of functions for the Consultant's staff and include any changes or additions agreed during negotiations prior to signing of the Contract. This Report should also highlight any risks and issues which may negatively affect the project deadlines or effective execution of the works.

The final project summary report should (maximum 40 pages) should describe the main project activities and outcomes including a focus on the capacity of KyrgyzHydromet to continue to operate and maintain the Kugart FFEWS and the feasibility of extending this pilot to other river basins in the country.

3.3 Time schedule

The proposed time schedule is shown below in **Ошибка! Источник ссылки не найден.**. This envisages a 7-month initial implementation period up to system commissioning followed by a 24-month remote support and maintenance period.

The PIU procurement of the topographic surveys, in particular the river cross section surveys, are a critical element as these should ideally be undertaken during the low flow conditions in the autumn months. While the hydrological modelling is not dependent on these, the hydrodynamic modelling cannot start until these surveys are complete. Early PIU procurement of, or access to the computer server means that the forecast platform configuration can start once this is available and can be completed when the models are ready. The new water level radar should be installed along with other new automatic rainfall and water level stations before the flood forecast platform configuration commences.

No,	Activity	1	2	3	4	5	6	7	8-16
1	River cross section surveys (70 No.)								
2	Topographical (LiDAR) survey Suzart								
3	Hydrological model development and calibration								
4	Hydrodynamic model development and calibration								
5	Forecast platform establishment and FFEWS commissioning								
6	New automatic meteorologoical and hydrometric stations								
7	Capacity Building								
8	System maintenance support								

Figure 6: Project time schedule

3.4 Institutional arrangements

The primary implementing agency is the Program Implementation Unit (PIU) of the Climate Change and Disaster Resilient Water Resources (CCDRWR) sector project under the Ministry of Emergency Situations. The end user of the FFEWS is KyrgyzHydromet who will assume ownership of he system at the completion the project and assume responsibility for its operation and maintenance.

3.5 Facilities and support provided by the Client

The Ministry of Emergency Situations and KyrgyzHydromet will provide the following facilities and support to the Consultant:

- Office space for the Consultant team at KyrgyzHydromet in Bishkek

- Information on status of observation networks, measuring tools, communication and computing resources and data processing tools
- Relevant historical hydrometeorological data required for model calibration and validation (may require digitization)
- Topographical surveys as described in Section 2.3.1
- Information (design drawings and plans) of existing and on-going river training, protection and other infrastructure works on the Kugart River
- Support to identify vulnerable buildings and infrastructure in the Suzak flood mapping area
- Counterpart staff to receive the necessary training to maintain and operate the models and forecast system
- Suitable server (with operating system) for installing and running the forecast models and platform.
- IT support to facilitate access to the relevant real time observation database and WRF forecasts to feed into the forecast models, as well as assisting in installing and configuring the system hardware and software
- Meeting rooms and space for training of KyrgyzHydromet staff in Bishkek

ANNEX 1

Software Specifications

The table below lists the essential and desirable main features of the hydrological and hydrodynamic modelling software for the Kugart FFEWS system. Only mature products with more than 10 years development history since initial release and with continuing updates will be considered. Those with strong user communities will be considered an advantage to enhance the support and the adoption of the end system by KyrgyzHydromet.

Software specifications for modelling and forecast platform

Software Feature	Requirement
Hydrological model	
Operating system	Windows
Menu language	English, (Russian desirable)
User interface	Map based, with GIS import/export
Model basis	Conceptual
Parameter definition	Lumped or gridded
Simulation type	Continuous
Hotstart facility	Essential
Snow sub-routine	Essential (altitude variable preferred)
Automatic calibration	Essential
Time resolution	1min – 24 hours
Inputs	Precipitation, temperature, PET
Outputs	Sub-Basin discharge hydrograph
Hydrodynamic model	
Operating system	Windows
Menu language	English, (Russian desirable)
User interface	Map based, with GIS import/export
Model basis	Fully hydrodynamic with 1D-2D integration
1D structures (weirs, bridges, culverts)	Essential
2D structures (weirs, levees)	Desirable
Hotstart facility	Essential
Data Assimilation (DA)	Desirable in 1D hydrodynamic model (or ability to interface to external DA routines (eg OpenDA)
Inputs	Sub-basin inflows, downstream water level boundary
Outputs	Timeseries of water levels and flows in 1D, timeseries and maximums of water depth, water elevation current velocity and duration above threshold in 2D
Forecast Platform	
Operating System	Windows or Linux
Menu language	English, (Russian desirable)
User interface	Map based
Scalable (to other basins, additional users)	Essential

Software Feature	Requirement
Support for GIS, scalar, vector and gridded timeseries import and storage	Essential
Interface to hydrological and hydrodynamic models and support for Data Assimilation	Essential
Internal processing tools for data quality checks	Essential
Full automation of the complete forecasting train from data acquisition to forecast results analysis	Essential
Support for ensemble forecasting	Highly desirable
API for web development and/or separate web interface	Highly desirable

ANNEX 2

River cross section survey coordinates (WGS 84)

Ref	Reach	Note	Longitude degrees	Latitude degrees
1	Reach-1		73.35074931	41.13912374
2	Reach-1		73.31409105	41.14157762
3	Reach-1	Downstream bridge	73.29184552	41.15180703
4	Reach-1		73.28017932	41.16534524
5	Reach-1		73.25717842	41.16911318
6	Reach-1		73.22851611	41.16576853
7	Reach-1	Mikhailovka gauge	73.20018338	41.15764141
8	Reach-1		73.16360026	41.14314875
9	Reach-1		73.14187675	41.12205402
10	Reach-1	Upstream hydro regulator	73.12870816	41.11805746
11	Reach-1	Upstream hydro regulator	73.12028697	41.11219268
12	Reach-1	Upstream hydro regulator	73.10909098	41.10787717
13	Reach-1	Upstream hydro regulator	73.10229119	41.10535316
14	Reach-1		73.09779909	41.10366782
15	Reach-2		73.08019302	41.09229718
16	Reach-2		73.0802863	41.07873788
17	Reach-2		73.07467016	41.06831152
18	Reach-2		73.05681153	41.0559292
19	Reach-2		73.04832586	41.05434383
20	Reach-2	Upstream irrigation regulator	73.03890816	41.0539195
21	Reach-2	Upstream bridge	73.03711111	41.0523488
22	Reach-2		73.03262002	41.04757046
23	Reach-2		73.02997964	41.0387426
24	Reach-2		73.02101129	41.02754819
25	Reach-2		73.01508183	41.01306581
26	Reach-2		73.00535096	41.00212345
27	Reach-2		72.99844802	40.99680717
28	Reach-2		72.99715734	40.98900445
29	Reach-2		72.99346446	40.97869111
30	Reach-3	Upstream bridge	72.98955382	40.97570689
31	Reach-3		72.98529749	40.97355849
32	Reach-3		72.98000832	40.97207728
33	Reach-3		72.97600454	40.96964769
34	Reach-3		72.97056103	40.96497546
35	Reach-3		72.96324152	40.9588337
36	Reach-3	Upstream bridge	72.95830462	40.95359848

Ref	Reach	Note	Longitude degrees	Latitude degrees
37	Reach-3		72.95492283	40.95017273
38	Reach-3		72.94868812	40.9433345
39	Reach-3		72.94432195	40.93752482
40	Reach-3		72.94055937	40.93315084
41	Reach-3		72.93883771	40.9311876
42	Reach-3		72.93299987	40.92189679
43	Reach-3		72.93075373	40.91888099
44	Reach-3	Upstream bridge	72.92849013	40.91599912
45	Reach-4	Downstream bridge	72.92819458	40.91560103
46	Reach-4		72.92692507	40.91399286
47	Reach-4		72.9252538	40.91087635
48	Reach-4		72.92354654	40.90795074
49	Reach-4		72.92215106	40.90539534
50	Reach-4	Upstream bridge	72.92091094	40.90281366
51	Reach-4	Downstream bridge	72.92080056	40.90251426
52	Reach-4		72.9184409	40.89988109
53	Reach-4		72.91682887	40.89798438
54	Reach-4		72.91528155	40.89570182
55	Reach-4		72.91395861	40.89370282
56	Reach-4		72.91256461	40.8916601
57	Reach-4		72.910667	40.88898302
58	Reach-4		72.90902764	40.88636394
59	Reach-4	Upstream bridge	72.90772876	40.88444021
60	Reach-4	Downstream bridge	72.90745872	40.88398158
61	Reach-4		72.90554662	40.88128212
62	Reach-4		72.90336243	40.87804613
63	Reach-4		72.90173184	40.87644509
64	Reach-4		72.89940881	40.87387057
65	Reach-4		72.89636827	40.87143545
66	Reach-5		72.89386394	40.8702933
67	Reach-5		72.88859438	40.86878014
68	Reach-5		72.86789441	40.86406055
69	Reach-5		72.8440382	40.86391242
70	Reach-5		72.83476798	40.86194518