Hydrometric Measurements
in both Quality and Accuracy

26~28th Nov., 2018

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1. Background

- In order to improve accuracy of the hydrological measurement, it is necessary to improve relevant techniques and use of adequate instrument and analysis method for specific flow conditions.
- Both of Application of advanced techniques and improvement of existing method(measurement, analysis and procedure, QC, data assessment) are equally important.
- The main objectives of action plan were to provide technical reports or guidance about three parts of hydrological observation techniques
  - **Automatic discharge measurement system**
    (IRDIMS, Integrated Real-time Discharge Measurement System)
  - **Sediment measurement by new techniques**
  - **Development of rating curve**

Providing guidelines for application of automatic discharge measurement system and development of new measuring technique

- Providing guidelines for application of IVM and operation of IRDIMS
  - Specific and detail guideline for all procedures from installation to operation of the measurement system using IVM

  → For standardization on use of IVM by systematic procedures(using S/W tools)

- Development of new measuring technique to be applied to the IVM and IRDIMS
  - Applicability analysis on new equipment such as surface velocimetry
  - Operation of test bed to analyze new technique

  → Technical report based on results of test bed for new application

2. Work Plan for 2017~2020

Improvement of sediment measuring techniques

- Development of method to estimate SSC using ADVM
  - Develop technique to estimate concentration of suspended sediment(SSC) through analysis on the variation of Signal Intensity (SI) of the ADVM with SSC using data from the IRDIMS stations

→ Technical report on applicability of new technique by field test

Improvement & development of systematic procedure for use of rating curve

- Providing specific guidelines for development of rating curve
- Development of software tools to calculate discharge(including post processing and data QC) and develop rating curves

→ Guidelines and software tools for all procedures to develop rating curve

2. Work Plan for 2017~2020

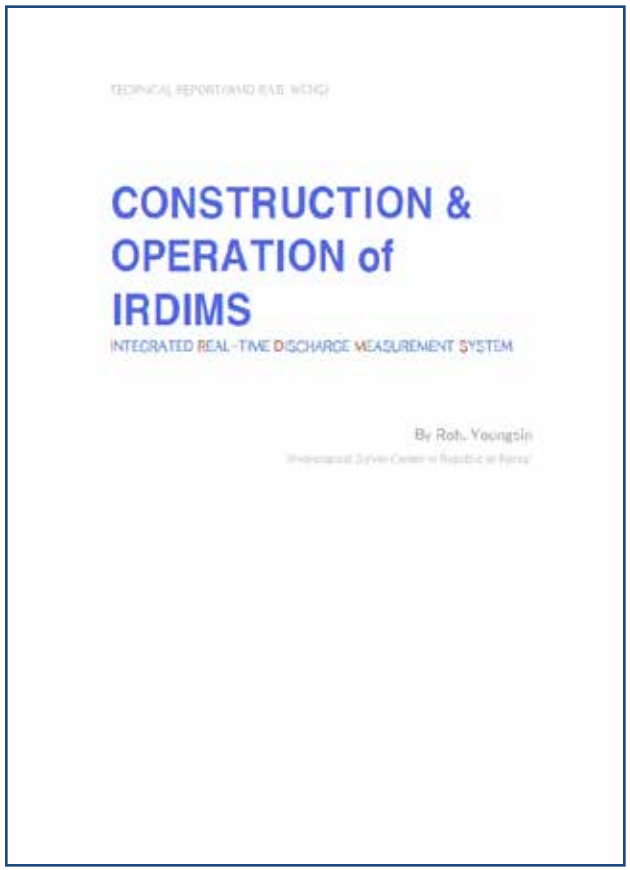
Deliverables	Activity	Outputs	Resources	Milestones	Linkages	Progress
1. Improvement in hydrometric measurements in both quality and accuracy	a) Providing guidelines for application of real-time measurement system and development of new measuring techniques • Providing guidelines for application of IVM and IRDIMS • Development of new measuring techniques to be applied to the IVM and IRDIMS	• Guidelines related to IRDIMS - Installation and operations - Maintenance - Development of index ratings • Technical report on new applications of IRDIMS - New application using surface velocimetry - Case studies using test bed	Republic of Korea (ROK)	• Guidelines by Dec 2020 • Construction of test bed by Dec 2017 • Technical Report by Dec 2019	CHy ROK	• Writing guideline of installation and discharge calculation • Operating test bed for surface velocity meter • Analyzing data to calculate discharge using surface velocity
	b) Improvement of sediment measuring techniques • Development method to estimate suspended sediment using ADVM	• Technical report on estimation of suspended sediment using ADVM	Republic of Korea (ROK)	• Technical report Dec 2020	CHy ROK	• Case study from existing sample data of IRDIMS station
	c) Improvement and development of systematic procedures for use of rating curve • Providing specific guidelines for development of rating curves (for all procedures) • Development of software tools to calculate discharge (including post processing and data QC) and develop rating curves	• Guidelines on development of rating curves (from field measurement to assessment of rating curves) • Software tools - Discharge calculation for all kinds of instruments - Development of rating curves	Republic of Korea(ROK)	• Guidelines Dec 2018~ Dec 2020 • Software tools Dec 2018~ Dec 2020	CHy ROK	• Korean Guidelines have been finished and are in translation to English • Development of Calpad and its manual is being writing

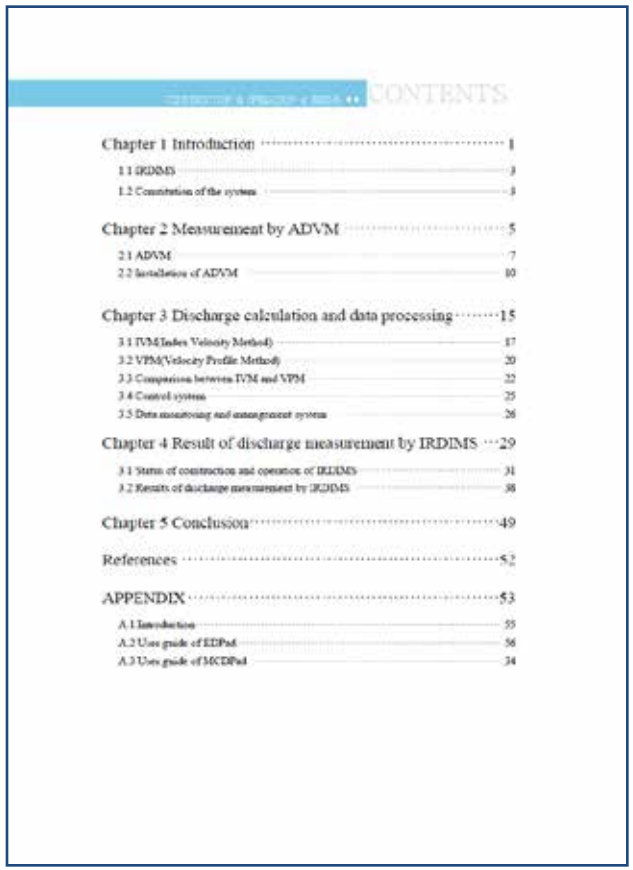
2. Work Plan for 2017~2020

Deliverables	Activity	Outputs	Resources	Milestones	Linkages	Progress
2. Global application of software tools and methods for measuring discharge	(a) Assessment of applicability of software tools • Request CHy to review and test software tools • Request RA II members to test software tools and report to WGHS Chairperson • Improvement of software by considering results of the testing	Software tools and methods for measuring discharge including backwater and tidal influence	• Republic of Korea (ROK) • CHy AWG • RA II Members	• Request test and review by Dec 2018 • Development of Ver 2.0 Dec 2019 • Development of Final ver. Dec 2020	CHy RA II	• (Development of Ver. 1.0 has been completed in 2016) • Upgrading to Ver. 2.0 (debugging problem of lower version)

Technical Report of Construction & operation of IRDIMS

- Introduction of IRDIMS, ADVM(Spec., installation)
- Discharge calculation (IVM, VPM)
- Case studies on various conditions(Tidal effect, backwater etc.)



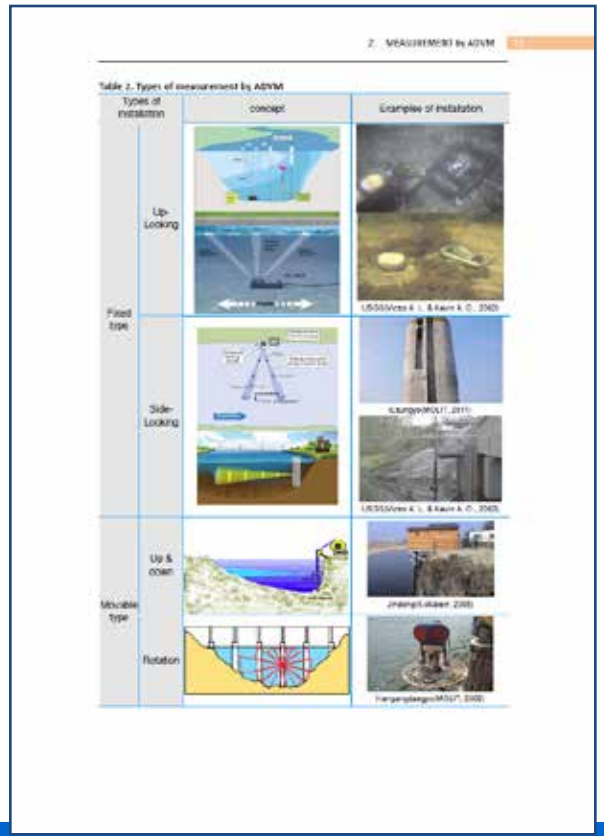


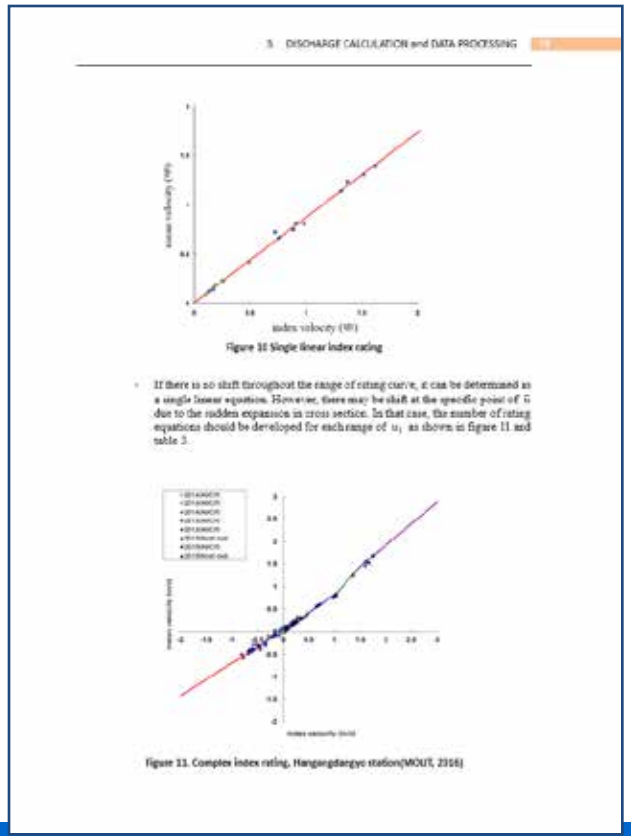
1. Introduction
2. Measurement by ADVM
3. Discharge calculation and data processing
4. Results of discharge measurement by IRDIMS
5. Conclusion

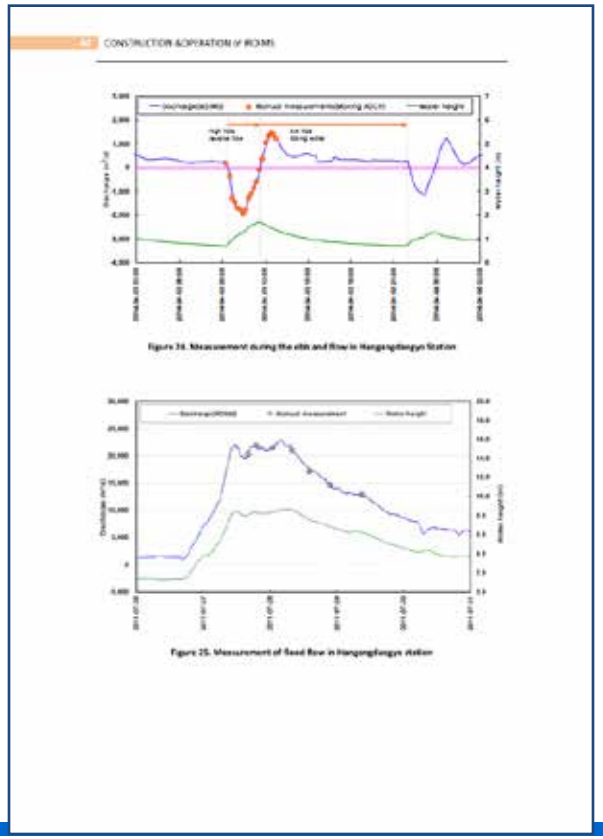
APPENDIX
- Introduction of softwares
- User guide of EDPad & MCDPad

Technical Report of Construction & operation of IRDIMS

- Introduction of IRDIMS
- ADVM(installation considering spec. and flow conditions etc.)
- Discharge calculation (basic theory of IVM, VPM and the procedure)
- Case studies on various conditions (Tidal effect, backwater etc.)

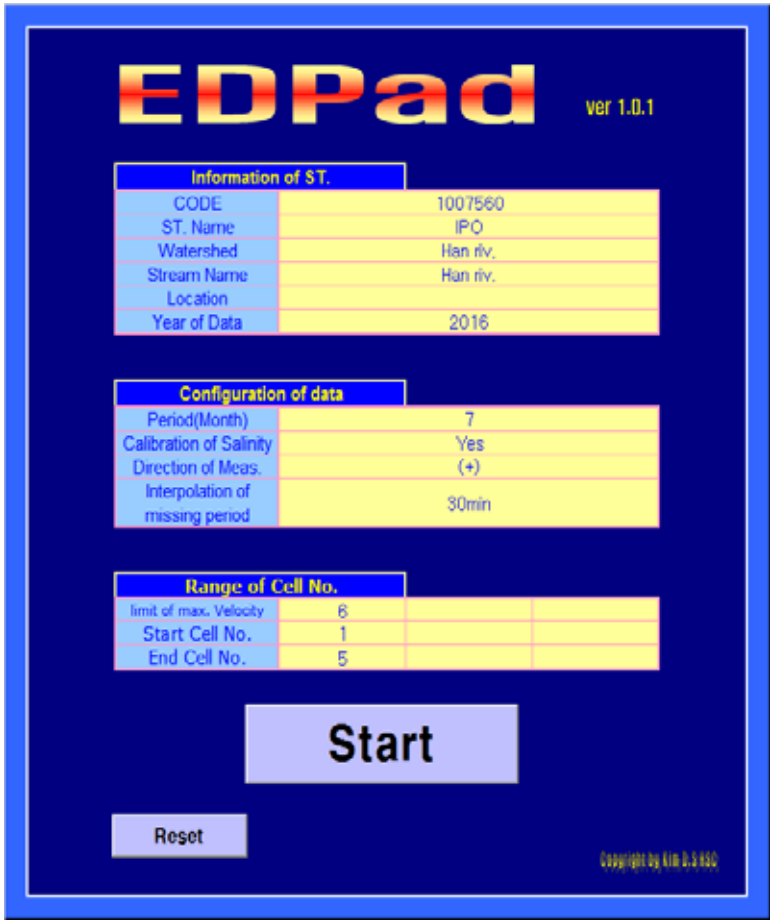


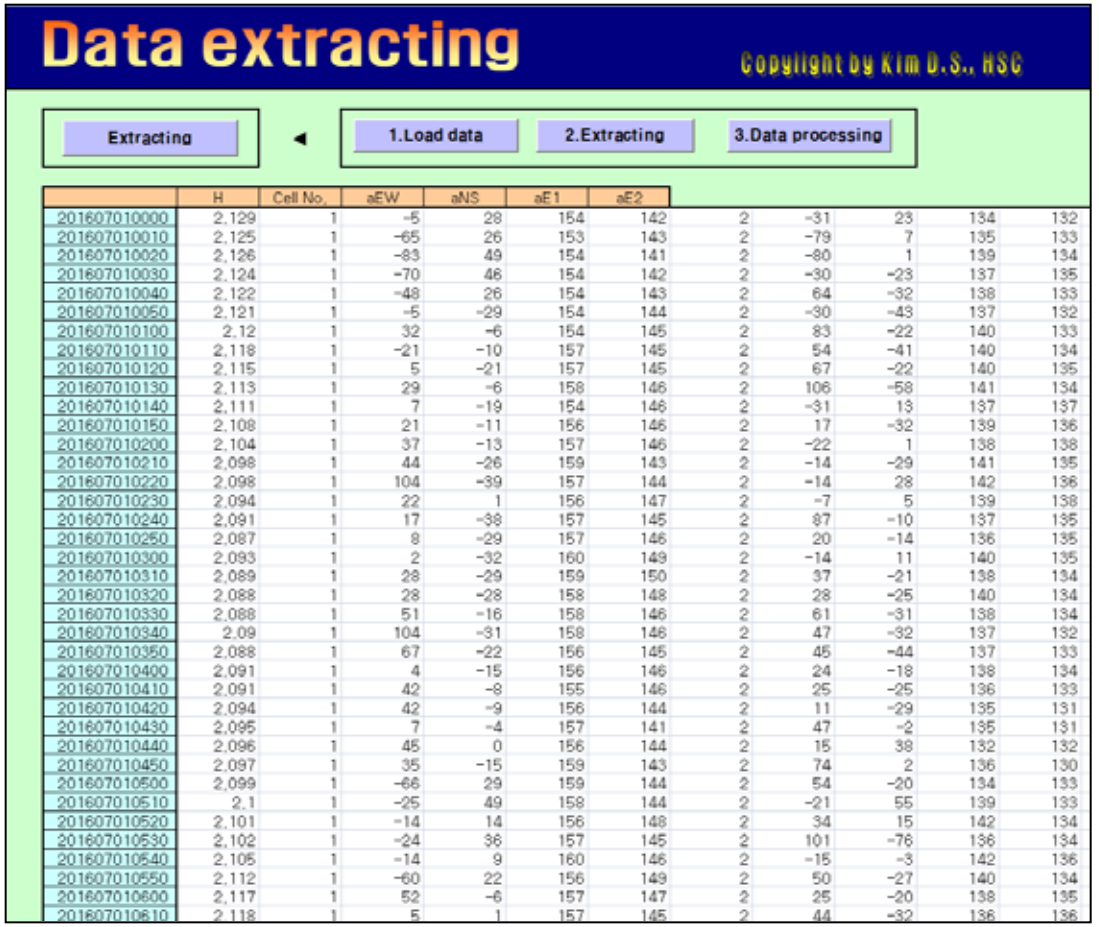




Software Tools to develop index rating for IRDIMS

- EDPad to data extracting from ADVM
- It is useful to data handling of index velocity measured by ADVM





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201607010020	2,126	1	-83	49	154	141	2	-80	1	139	134
201607010030	2,124	1	-70	46	154	142	2	-30	-23	137	135
201607010040	2,122	1	-48	26	154	143	2	64	-32	138	133
201607010050	2,121	1	-5	-29	154	144	2	-30	-43	137	132
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201607010330	2,088	1	51	-16	158	146	2	61	-31	138	134
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201607010410	2,091	1	42	-8	155	146	2	25	-25	136	133
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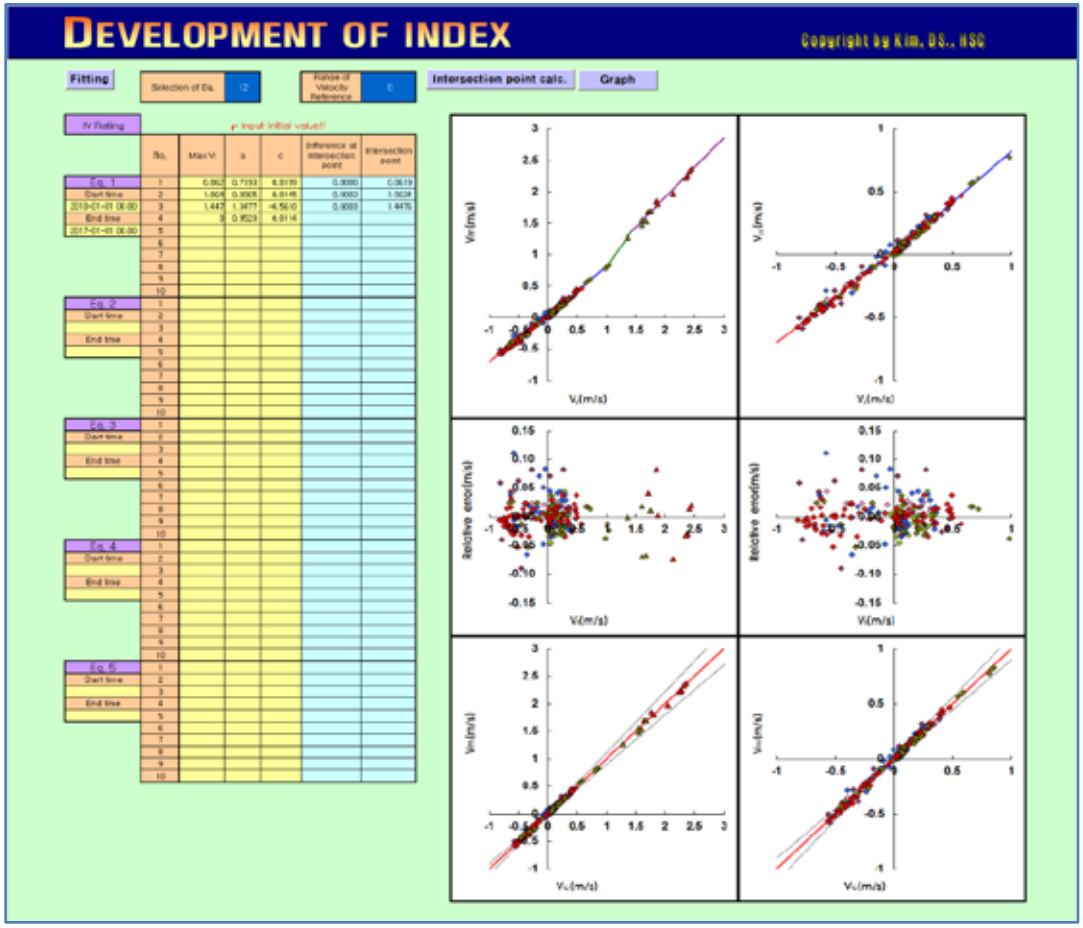
201607010530	2,102	1	-24	36	157	145	2	101	-76	136	134
201607010540	2,105	1	-14	9	160	146	2	-15	-3	142	136
201607010550	2,112	1	-60	22	156	149	2	50	-27	140	134
201607010600	2,117	1	52	-6	157	147	2	25	-20	138	135
201607010610	2,118	1	5	1	157	145	2	44	-32	136	136

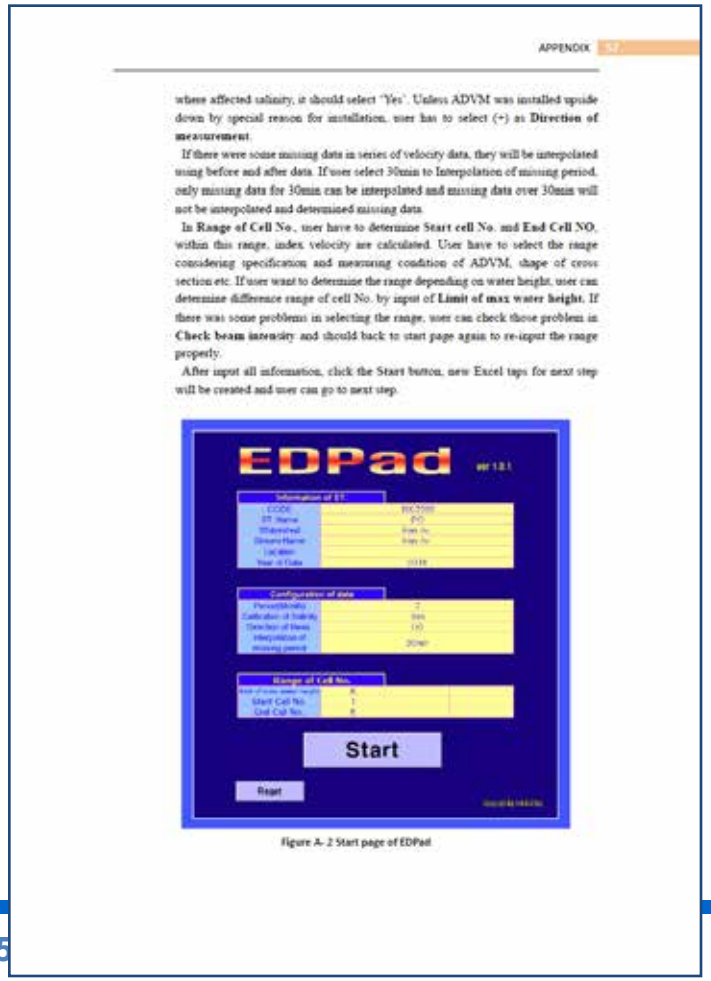
Software Tools to develop index rating for IRDIMS

- MCDPad to develop index rating
- Providing all procesures for developing index rating and discharge calculation



Software Tools to develop index rating for IRDIMS

- Userguide of software tools was included in Appendix of the technical report
- 2 software tools and source code will be provided
  (* source code will be provided to only user who request to use it for feedback)



APPENDIX

where affected salinity, it should select 'Yes'. Unless ADVM was installed upside down by special reason for installation, user has to select (+) as **Direction of measurement**.

If there were some missing data in series of velocity data, they will be interpolated using before and after data. If user select 30min to Interpolation of missing period, only missing data for 30min can be interpolated and missing data over 30min will not be interpolated and determined missing data.

In **Range of Cell No.**, user have to determine **Start cell No.** and **End Cell NO.** within this range, index velocity are calculated. User have to select the range considering specification and measuring condition of ADVM, shape of cross section etc. If user want to determine the range depending on water height, user can determine difference range of cell No. by input of **Limit of max water height.** If there was some problems in selecting the range, user can check those problem in **Check beam intensity** and should back to start page again to re-input the range properly.

After input all information, click the Start button, new Excel taps for next step will be created and user can go to next step.

Figure A- 2 Start page of EDPad

CONSTRUCTION &OPERATION of IRDIMS

Figure A- 8 Start page of MCDPad

(2) Input of manual measurement DB

This sheet of figure A-8 is to organize data set of manual measurements to get mean velocity. In HSC, all measured data are managed by this sheet called DBPad. All information of individual discharge measurement data are organized in this sheet, including code(DM No.), date and time, water height, width, area, mean velocity, discharge, measuring instrument, start & end time of measurement, water heights of start & end of measurement.

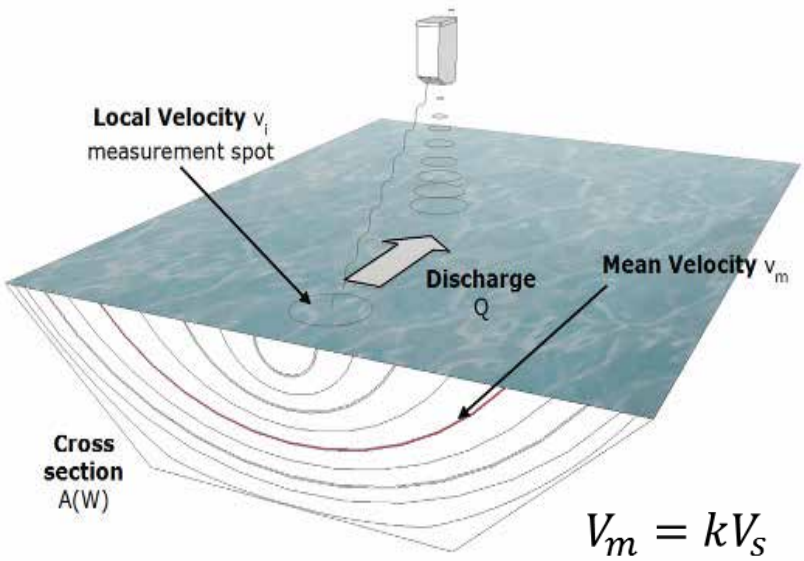
However, even though user does not have this type of data sheet, user can use MCDPad by input some information in the each cell of spreadsheet. To develop index rating through MCDPad, it is necessary to input water height, area, mean velocity, discharge, start & end time of measurement, water heights of start & end of measurement into each cell in the spreadsheet of DB.

Development of new measuring techniques to be applied to the IVM and IRDIMS

- Operating test-bed to surface velocity meter

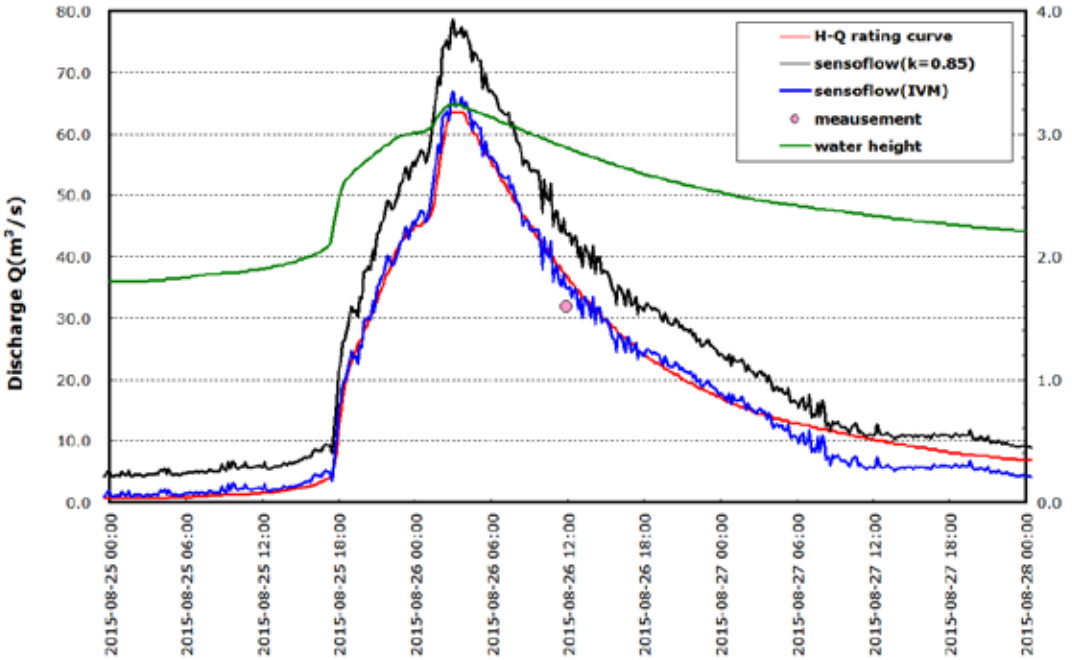
→ Surface velocity meter(Sensoflow) has been installed and being operated to analyze applicability to be used for IRDIMS

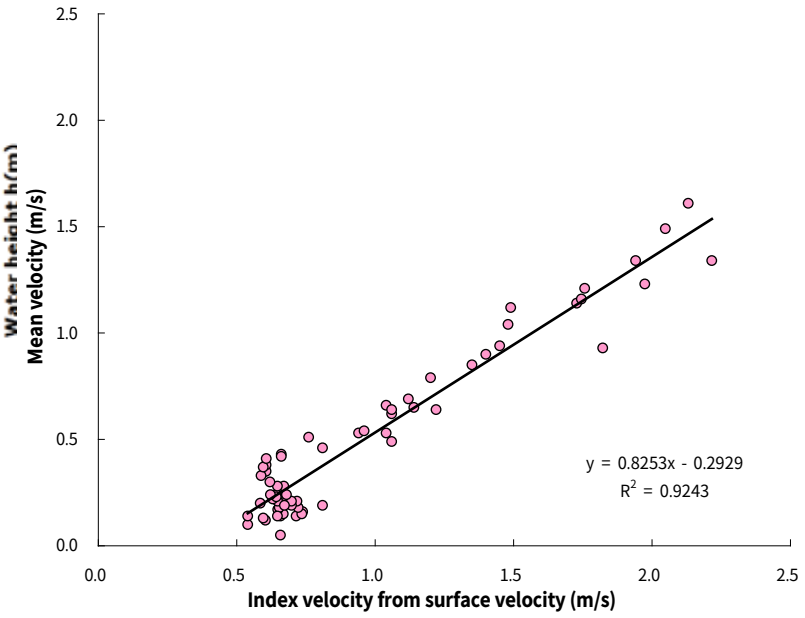
→ Applying k=0.85 and IVM to estimate mean velocity from surface velocity



Applicable analysis on use of surface velocity meter

- Operating test-bed to surface velocity meter
  - Result by applying IVM showed good agreement with H-Q rating curve, whereas method using k=0.85 resulted in over estimation
  - However, it showed some different for low flow condition





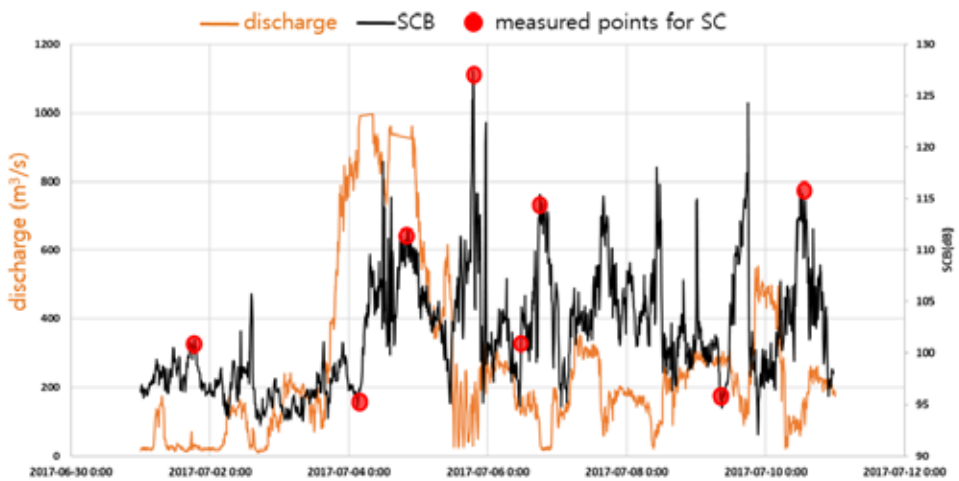
Improvement of sediment measuring technique

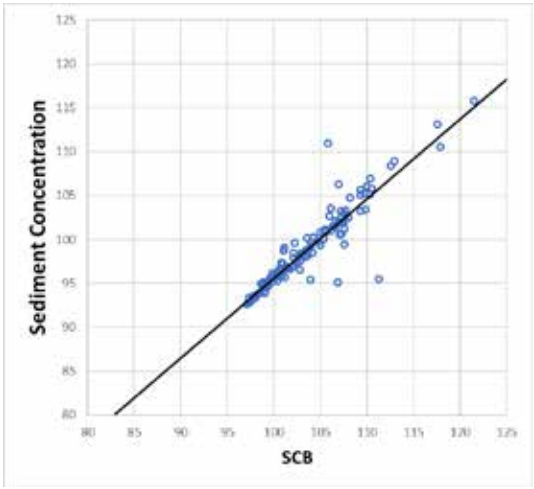
- Development of the method to estimate suspended sediment using ADVM

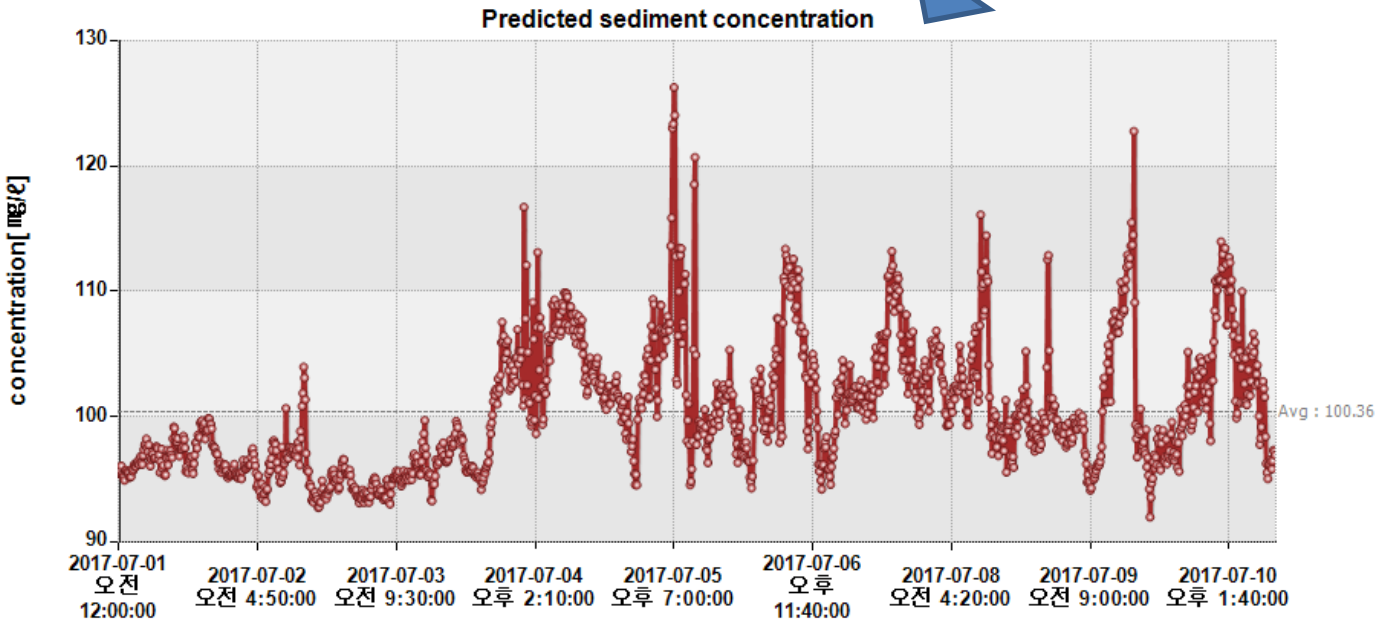
  - Development of technique to estimate suspend sediment using variation of SI of ADVM by SSC.
  - Comparison of SI of ADVM(fixed- and moving position) and SSC data sampled at the IRDIMS station

  → Development of method to estimate SSC using ADVM

3. ACTIVITIES and OUTCOMES





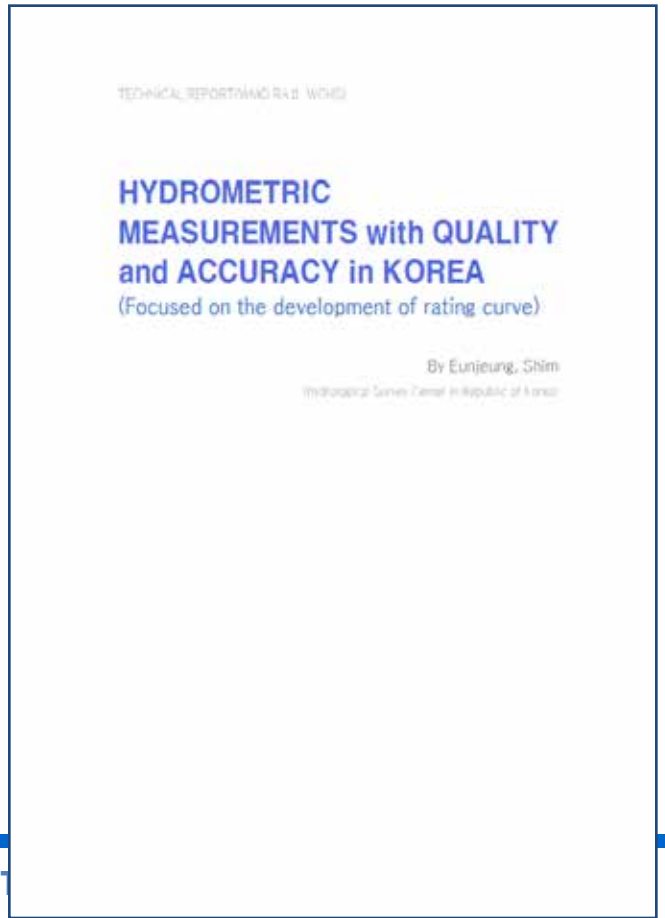


Improvement and development of systematic procedure for use of rating curv

- Providing specific guidelines on development of rating curve
  - Specific and detail guidelines classified by each procedure
    - ① discharge measurement (using current meter, ADV, ADCP, Float rod, surface velocimetry)
    - ② Maintenance and management of the measuring instrument
    - ③ Data processing and QC
    - ④ Development and assessment of rating curve for various conditions
- Development of software tools
  - to calculate discharge for each instrument
  - to develop rating curve

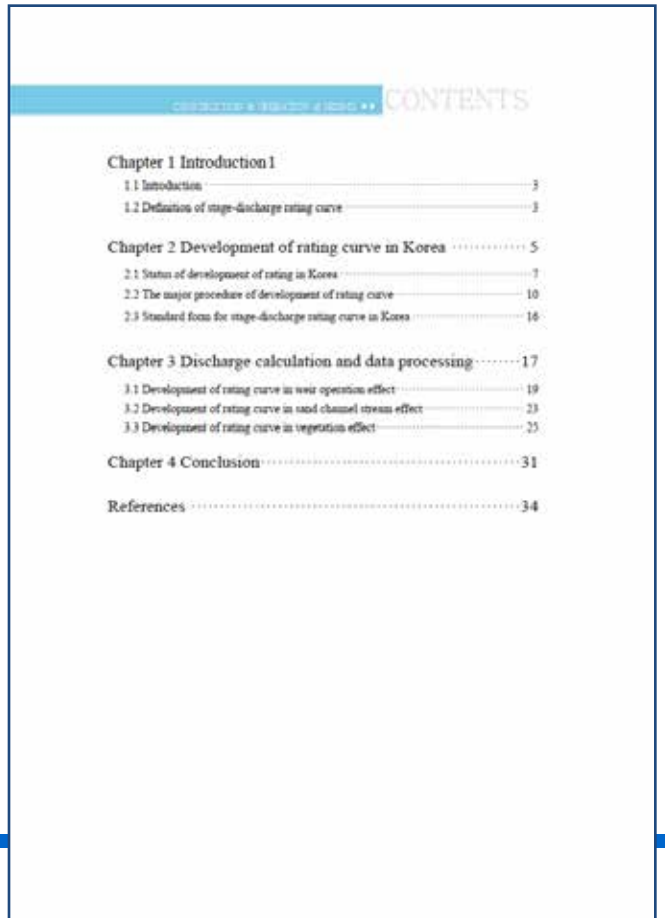
Technical Repot on Development of H-Q Rating Curve

- Introduction of the procedure on development of H-Q rating curve and software tools used in KIHS
- Case studies on various conditions (weir operation, vegetation growth, continuous bed change)


HYDROMETRIC MEASUREMENTS with QUALITY and ACCURACY in KOREA

(Focused on the development of rating curve)

By Eunjeung, Shim


CONTENTS

1. Introduction
2. Development of rating curve in Korea
3. Case analysis on development of rating curve with various field conditions
   - weir operation
   - vegetation growth
   - continuous bed change
4. Conclusion

Technical Repot on Development of H-Q Rating Curve

- Introduction of the procedure on development of H-Q rating curve and software tools used in KIHS
- Case studies on various conditions
  (weir operation, vegetation growth, continuous bed change)

Figure 15 Monitoring case of weir operation

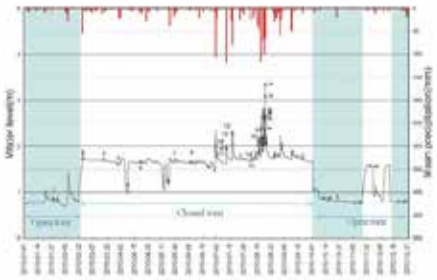


Figure 16 Time series of water level and distribution of measurement

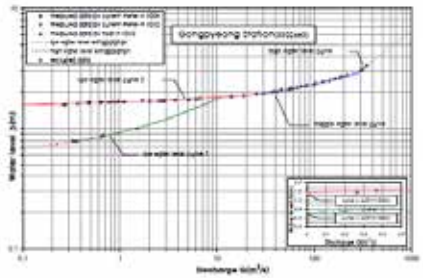


Figure 17 Case on development of rating curve by weir operation

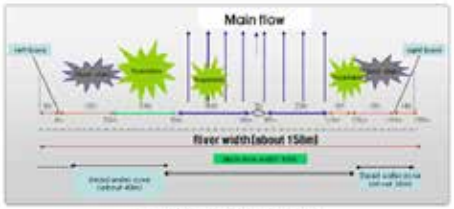


Figure 24 Sample of the site sketch

The shifts associated with vegetal growth are cyclic and therefore change with time. The growth increases as the growing season progresses and declines during the dormant season, but shifts may terminate abruptly if the vegetation is washed out by a stream rise. In analyzing shifts there is no substitute for experience with a given stream because the shift pattern can often be interpreted logically in more than one way. (USGS, 1982)

As vegetation grows and disappears seasonally, the rating curve shifts to the left (negative shift) according to the vegetation growth, and then the rating curve shifts again reaches to the right (positive shift), and return to the base rating without effect on vegetation.

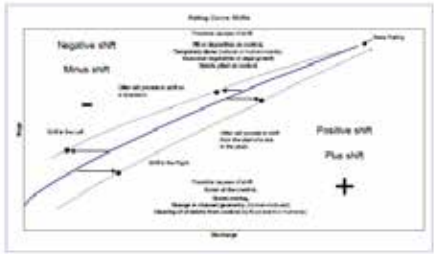


Figure 25 Stage discharge rating curve shift (USGS, 1982)

The figure below shown an example according to the monitoring of vegetation growth and development of shift rating curve by vegetation at Wicheon Mineong

Table 3 Rating curve Equation (Gongpyeong , 2010)

Station	Water levels	Rating Curve Eq	Note	
Gongpyeong	0.00 ft ~ 5.82	$Q = 7.467 \times (h - 0.200)^{1.841}$	0.7m below extrapolation	Weir opening
	5.82 ft ~ 12.30	$Q = 104.893 \times (h - 1.300)^{2.419}$		
	12.30 ft ~ 15.00	$Q = 104.893 \times (h - 1.300)^{2.419}$	1.00m below extrapolation	Weir closing
	15.00 ft ~ 19.00	$Q = 114.706 \times (h - 1.400)^{2.179}$	0.50m above extrapolation	10/01/01 00:00 ~ 11/01/01 00:00
	19.00 ft ~ 24.00	$Q = 56.873 \times (h - 0.000)^{2.519}$		

4.2 Development of rating curve in sand channel stream effect

In sand channel streams, stage-discharge relations are continually changing with time because of seepage erosion and sedimentation changes in the configuration of channel bed. So in this condition, monitoring of river bed changes before and after the flood is very important.

The most important thing is to get a picture that shows change in section and change in the flow of stream. On-site photography at the same location can improve the quality of monitoring.

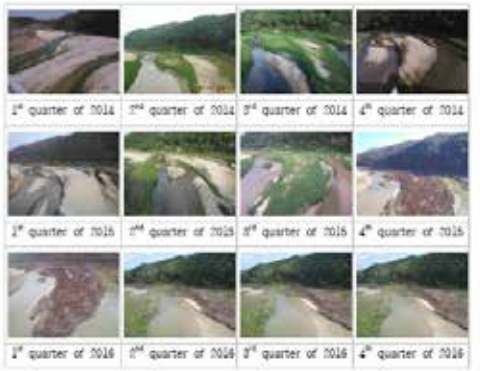


Figure 18 Field monitoring (Site photos) by period for 3 years

Software tool to calculate discharge(CalPad)

- Development of software tool to calculate discharge for all kinds of point velocitmetry (Price meter, ADV etc.) using midsection and meansection method

CalPAD 1.2.0 For Wading Discharge Measurements

KICT2003 Hwang Seok Hwan

Enter Site Information | Add Location | Delete Location | Cal. of Depth | Cal. of Discharge | Save Input Data | Re-Meas | New Meas | Help

Location	Distance (m)	Depth (m)	Time (hh:mm)	Gauge Height (m)	0.2D Depth (0.2D)	0.2D Correction Factor	0.2D Revolutions (counts) or Velocity	0.2D Exposure Time(sec)	0.6D Depth (0.6D)	0.6D Correction Factor	0.6D Revolutions (counts) or Velocity	0.6D Exposure Time(sec)	0.8D Depth (0.8D)	0.8D Correction Factor	0.8D Revolutions (counts) or Velocity	0.8D Exposure Time(sec)
LEW	♦ The program is protected by copyright law and international treaties. Reproduction and distribution of all or part of this program without permission is prohibited.															
1	0.00	0.00	16:38	0.617					0.09							
2	0.30	0.28							0.11	1.00	0.074	120.00				
3	0.70	0.34														
4	1.20	0.40														
5	1.70	0.37														
6	2.20	0.41														
7	2.70	0.45														
8	3.20	0.48														
9	3.70	0.45														
10	4.20	0.39														
11	4.70	0.35														
12	5.20	0.28														
13	5.70	0.27														
14	6.20	0.24														
15	6.70	0.22														
16	7.20	0.20														
17	7.70	0.19														
18	8.20	0.18														
19	8.70	0.20														
20	9.20	0.28														
21	9.70	0.37														
22	10.20	0.42														
23	10.70	0.50														
24	11.20	0.48														
25	11.70	0.52														
26	12.70	0.53														
27	13.70	0.46														

Measurement Summary

Date: 16-11-09 16:38 | Start-End: 16-11-09 16:38 ~ 17:29

Measurement	Gauge Height, H (m)	Width, W (m)	Area, A (m²)	Mean Velocity, V (m/sec)	Discharge, Q (m³/sec)	Type of Current Meter	No. Verticals (counts)	Discharge Ratio of Section(%) Max.	Min.	Ave.	Mean Depth (m)
1	0.62	31.70	11.20	0.07	0.78	owTrackerFlowTrack	38	5.98	0.00	2.78	0.35
2											
Average	0.62	31.70	11.20	0.07	0.78	owTrackerFlowTrack	38	5.98	0.00	2.78	0.35

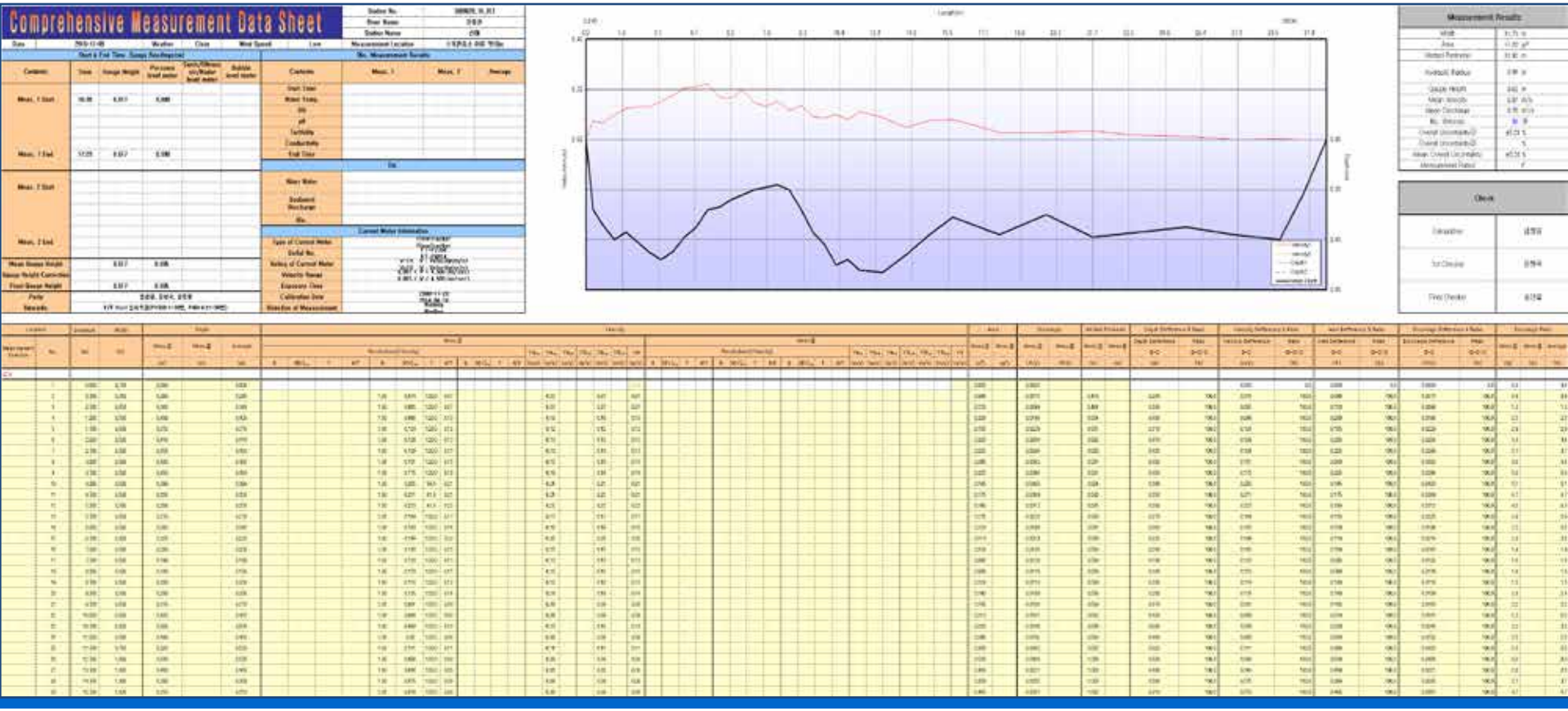
Measurement	Random Uncertainty (No. Verticals) X'm(%)	Individual Components of Systematic Uncertainty X''b(%)	X''d(%)	X''c(%)	X'Q Random(%)	X''Q Systematic(%)	X0 Overall(%)
1	1.0	0.3	0.3	0.5	2.55	0.61	5.24
2							
Average	1.0	0.3	0.3	0.5	2.55	0.61	5.24

Measurement	Individual Components of Random Uncertainty No. Verticals	Width	Depth	Exposure Time	No. points in a vertical	Current Meter Calibration	Sum
1	1.000	0.009	0.095	1.699	1.422	0.749	4.974
2							
Average	1.000	0.009	0.095	1.699	1.422	0.749	4.974

Measurement	Relative Ratio of Components in Random Uncertainty No. Verticals	Width	Depth	Exposure Time	No. points in a vertical	Current Meter Calibration	Sum(check)
1	0.154	0.000	0.001	0.446	0.312	0.087	1.000
2							
Average	0.154	0.000	0.001	0.446	0.312	0.087	1.000

Software tool to calculate discharge(CalPad)

- It provide functions not only to calculate discharge but also useful information to check whether data measured properly (velocity profile, uncertainty, max. ratio of subsections)
- It is available to use of digital field note with mobile equipment



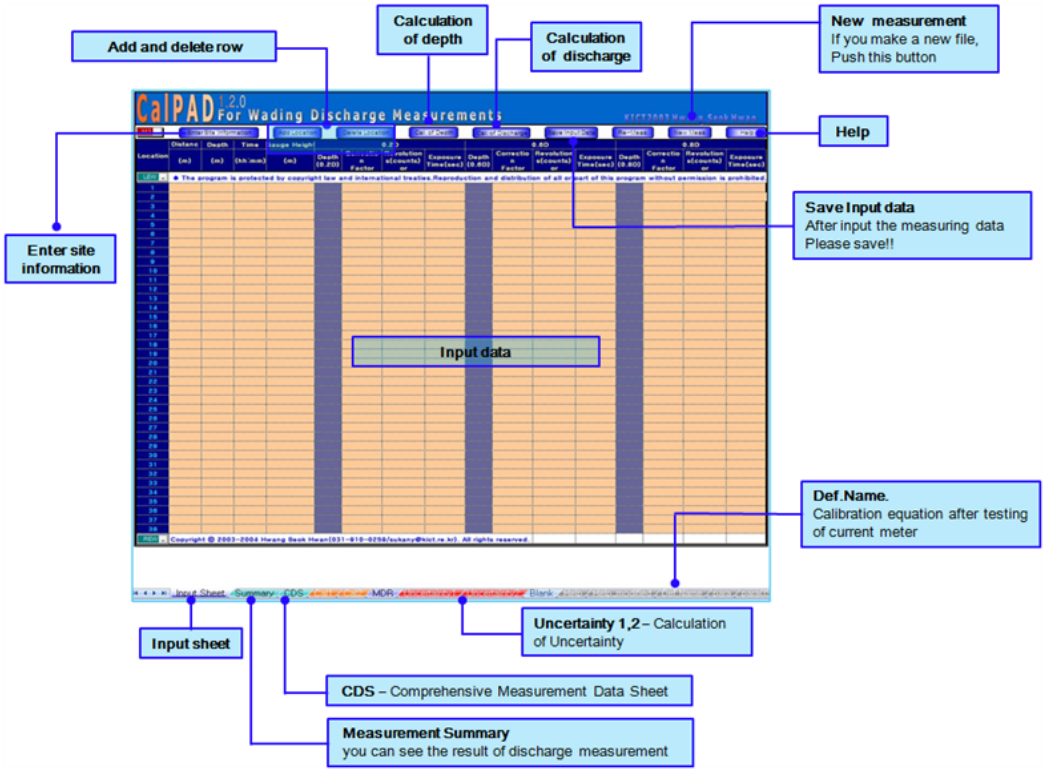
Software tool to calculate discharge(CalPad)

- CalPad and its quick guide have been ready for providing

◆ Standard Calculating Procedures

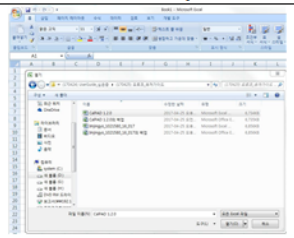
① Open CalPAD 1.2.0 file → ② Click New measurement → ③ Save File as → ④ Enter Site information → ⑤ Input Data → ⑥ Calculation of Discharge → ⑦ Result (Measurement Summary)

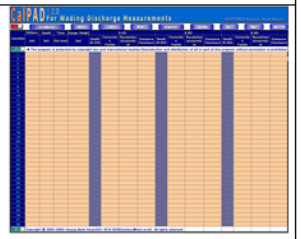
CalPAD 1.2.0 Sheet



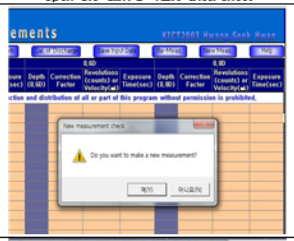
CalPAD 1.2.0 Calculating Procedures

① Open the CalPAD 1.2.0


Open the CalPAD 1.2.0 excel sheet

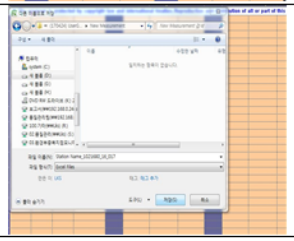

CalPAD 1.2.0 main Input sheet

② New Measurement



If you want to make a new measurement file,
Click the new measurement button
About the Question → Answer Yes

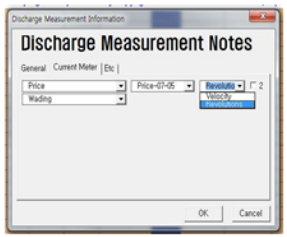
③ Save File as



Save File As
EX) Station Name_DM_Date_No
Imjingyo_1021580_16_017

You can specify folders and file names whatever you want

④ Input the station information



3. ACTIVITIES and OUTCOMES

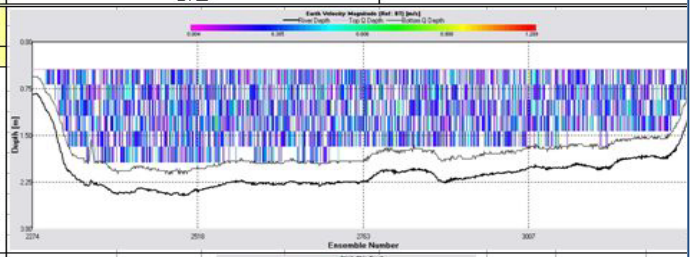
Software tool to calculate discharge(ADCP)

Discharge measurement results table (by ADCP)

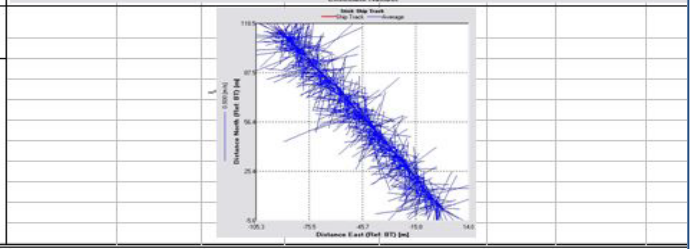
DM No.	0			측정일시	#VALUE!		
하천명	0	지점명	0	측정위치	0		
시작수위	0	종료수위	0	기준수위	0	날씨	흐림
측정자	o	시행방법	보트법	ADCP 주파수	1,200	ADCP 모델	Workhorse Ric Grande
측정모드	-	하상재료	모래, 실트	반복횟수	3	기기잠김	0.0
지점특성	양호함						
부정류	없음						

자기장 편각 0.0 °

단면형태 및 유속분포 (직접입력)



보트코스 (직접입력)



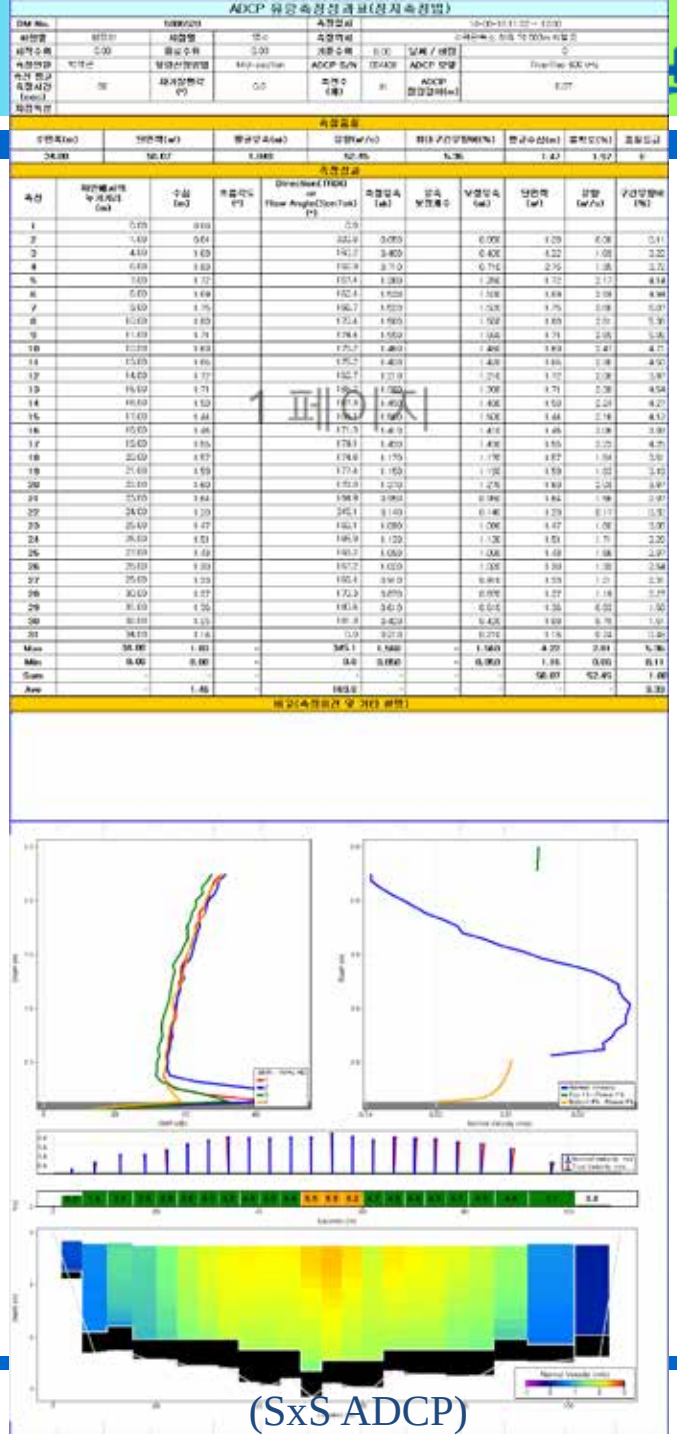
직선

측정성과

번호	진행방향	좌안폭	우안폭	코스상태 (직접입력)	유량(CMS)	오차%	결측율 (직접입력)	비고
T1								
T2								
M1						#VALUE!		
M2						#VALUE!		
M3						#VALUE!		
M4								

보고서양식 / DB입력 / 측정결과 / 자료 / 입력양식 / 원시자료

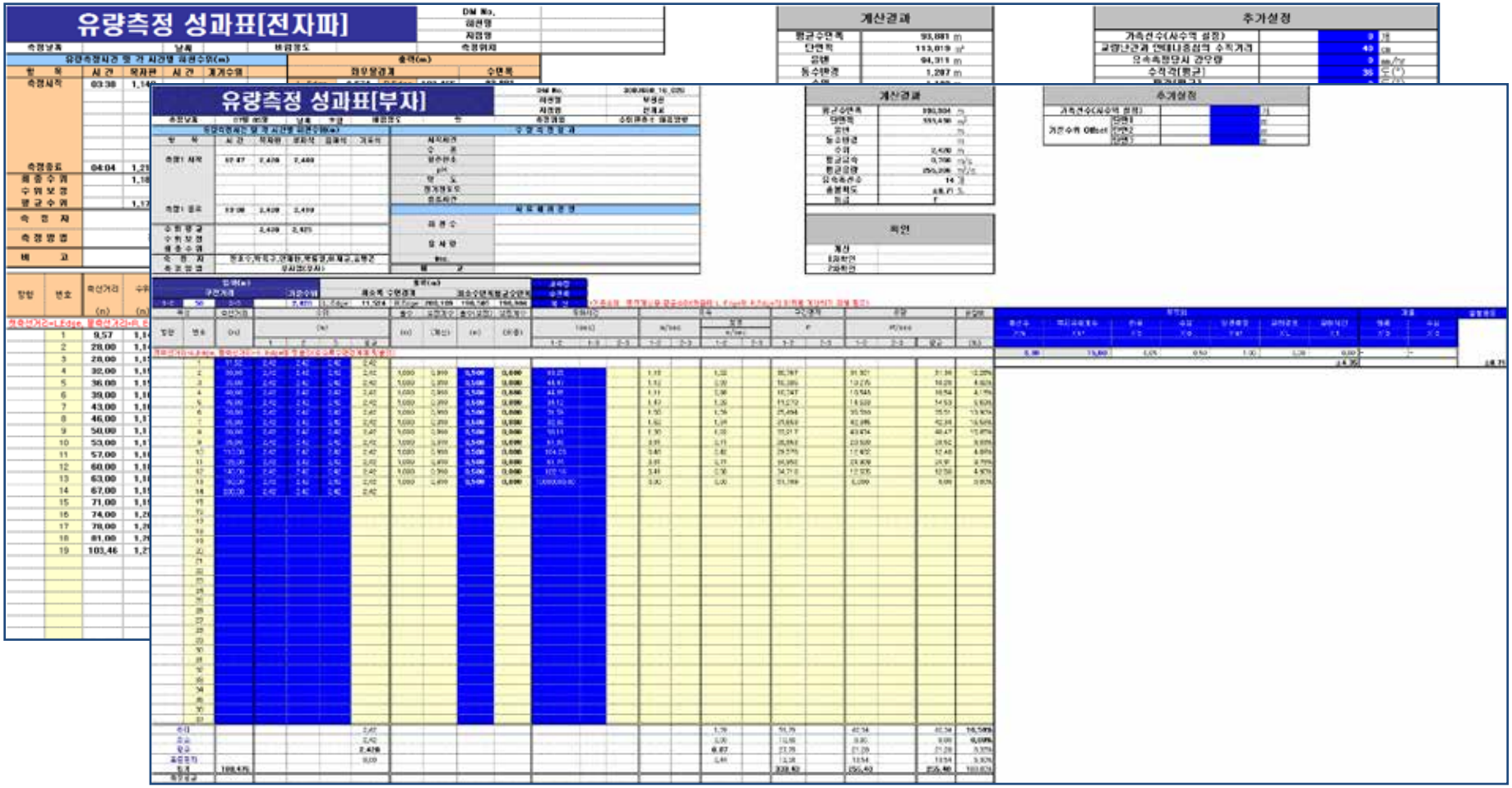
(moving ADCP)



(SxS ADCP)

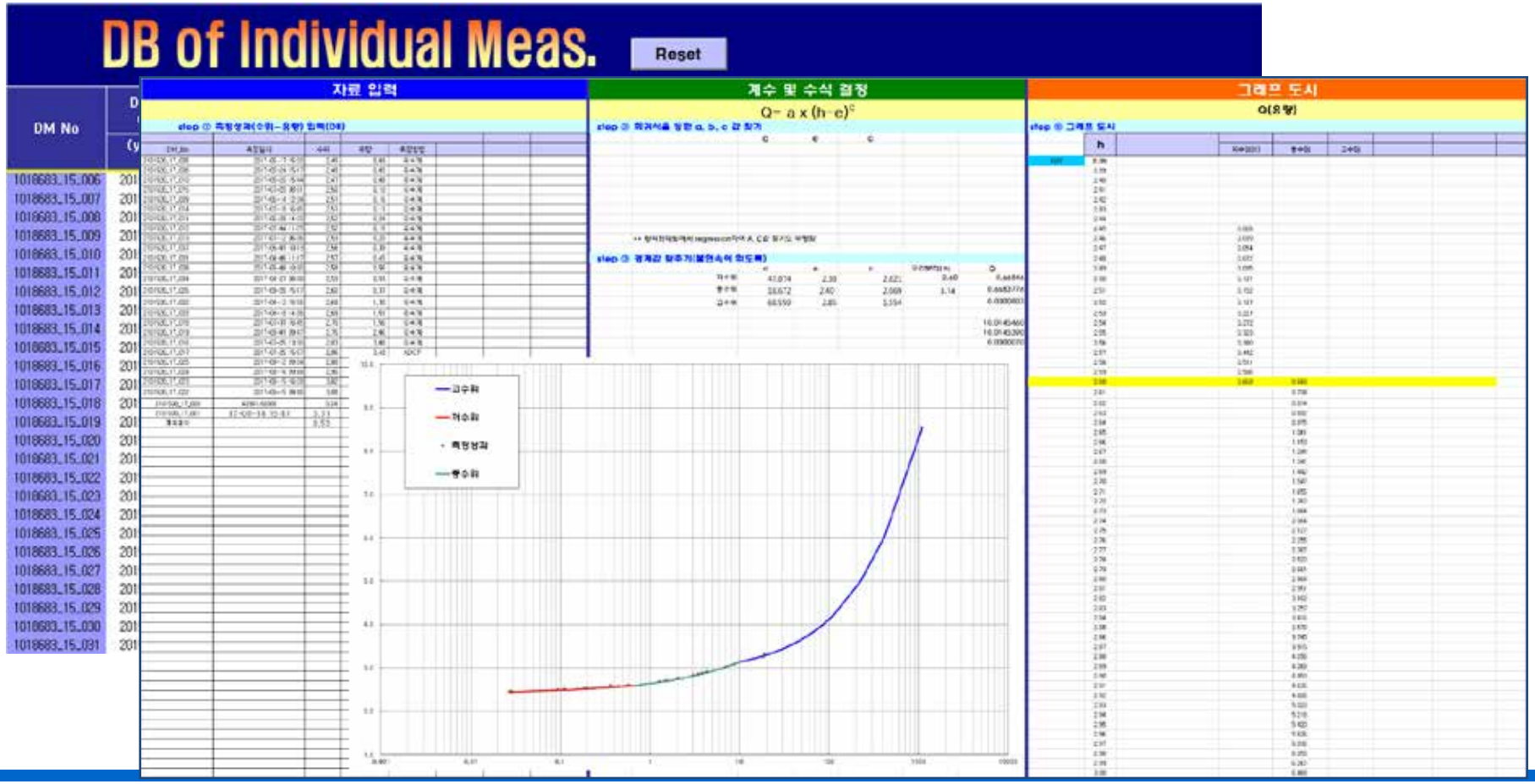
Software tool to calculate discharge(others)

- Surface velocity meter and float rod



Software tool to develop rating curve

- Data management for individual measurement data
- Development of H-Q rating curve



Thank You for Your Attention !