Rapid Implementation Program (RIP) to Improve Operational Management and Efficiencies in Irrigation Districts

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Abstract. *The Rapid Intervention Program (RIP) was developed over a ten year period by the Texas Agricultural Extension Service, and is a structured and systematic approach for analyzing the distribution network and on-farm irrigation of irrigation schemes, and developing recommendations on improved management strategies. We applied the RIP in several irrigation districts in US and oversea, and to an irrigation division of the Lower Colorado River Authority in Texas.*

RIP is designed as a low-cost, user-friendly and versatile approach that takes advantage of the knowledge and experience of the scheme operators and managers, and involves the combination in one single tool of several rating forms that were developed and applied in Texas. A key component is the training of operators, so that they could implement and transfer the RIP to other irrigation schemes. In this paper we will present the RIP components, the procedure of applying and adapting it to different districts, and some of the main results.

Keywords. Irrigation District, Water Management, Water Supply, Seepage, Irrigation Scheduling, GIS

INTRODUCTION

Irrigation schemes (or irrigation districts) throughout the world are faced with huge challenges as government support for maintenance and modernizations have been reduced. Many irrigation schemes are self-funded through a fee collection that typically is insufficient to cover operating expenses alone. In addition, many irrigation schemes are facing increases in water competition and decreases in water supplies, and often aging and inefficient water distribution systems.

The Rapid Intervention Program (RIP) was developed over a ten year period by the Texas A&M Extension Service, under the direction of Guy Fipps (Bonaiti and Fipps, 2012, Bonaiti and Fipps, 2013a). RIP is a structured and systematic approach for analyzing the distribution network and on-farm irrigation of irrigation schemes, and developing recommendations on improved management strategies. RIP is designed as a low-cost, user-friendly and versatile approach that takes advantage of the knowledge and experience of the scheme operators and managers.

Components include:

- Inventory of basic data needed to estimate water supply, flows and on-farm irrigation needs.
- Distribution Network Hydraulic Head Survey and Analysis Tool.
- Distribution Network Condition Rating Tool.
- On-farm Head Survey and Analysis Tool.
- Spreadsheets for storage and analysis of data.
- GIS map of the command area.
- Training curriculums for persons implementing the RIP in flow measurement, canal management and basic concepts of surface irrigation.

A key component of the RIP is the training of collaborators so that they can implement and transfer the RIP to other irrigation schemes. Training is provided also on basic concepts of flow measurement and canal management, and on Excel and ArcGIS for Desktop software. All material is collected into a RIP Manual, to serve as both a training program and a reference guide to all the steps required in order to successfully apply the RIP.

The objectives of this paper is to describe how we designed a RIP procedure for irrigation schemes in Iraq, and the main components of the RIP manual which is designed to help trained operators to apply it successfully. For this study we selected irrigation schemes which are representative of the conditions in the Center and South of Iraq.

In this paper we also present results of a study conducted in the Gulf Coast Irrigation Division of the Lower Colorado River Authority (LCRA) in Texas, where we further developed the RIP with an emphasis on the prioritization of canals for lining (Bonaiti and Fipps, 2013b).

RIP MANUAL AND GENERAL PROCEDURE

The RIP manual (Manual) is organized to serve as both a training program and a reference guide to all the steps required in order to successfully apply the RIP. Each of the four major RIP components is discussed in the Manual along with comments and/or observations that the users may find useful. The Manual also includes Appendices which provide:

- A copy of all forms in English and Arabic.
- The suggested training curriculum for the specialized skills needed related to GIS mapping, use of spreadsheets and flow measurement.
- Examples of case studies of the application of the RIP to irrigation schemes in Iraq.

The Survey and Data Collection Tools were applied according to the following general steps:

1. Map the irrigation scheme with GIS. A map with details on canals and irrigated areas is a critical part of the RIP and is used to help organize and analyze the data collected. Usually, any existing maps are used along with recent aerial photographs to create the GIS. The GIS serves as a reference when discussing the data collection forms with the operators.

2. Completion of all forms. Typically, this is done in three stages:

    a. First in the office with assistance of the interviewers using the GIS as a reference, based on the operators' knowledge.

    b. Then the operators are instructed to go to the field and verify the information.

    c. The interviewers meet with the operators to verify all information.

3. Flow measurements. Actual flow rates required for all canal categories and at the on-farm turnout. Calculated flows based on the original design specifications are not useful for this purpose.

4. Enter data into RIP spreadsheets (Excel) and link to GIS as appropriate.

5. Analysis and Recommendations. The exact types of analyses that are done will vary from irrigation project to irrigation project due to their differences; thus, some of the spreadsheets and procedures will need to be modified depending on the specific conditions and objectives.

RIP assumes that the persons implementing the program have already had training and basic skills on use of GIS and Excel. However, implementers will need training to review basic concepts, and on how to apply these tools to the RIP. For example, Excel training covers how to use the RIP spreadsheets which are included on the Manual.

Persons who will conduct the flow measurements will need at least some understanding of open channel flow principle. Ideally, they will also have had experience with field instrumentation. Training is usually required on use of portable velocity meters. Even with experienced persons, training will help speeding up the field work and improve accuracy of measurement. Furthermore, speed up of measurement is particularly important when the water level in the canal fluctuates. Other devices, such as portable acoustic meters and flumes may also be used, but are not included in this manual.

SURVEYS

Distribution Network Hydraulic Head Survey and Analysis Tool (Head Survey)

The purpose of the Head Survey is the identification of areas and canals that currently have continuous or intermittent water supply problems, and the identification of the potential causes of these problems. The tools utilized for this survey are Head Survey Rating Forms, and Head Survey Spreadsheets. The Head Survey includes two sections, Head Problem and Drainage Problem.

We applied the survey as follows:

1. Obtain map (scale 1:25,000 or larger) of the distribution network and irrigated areas, making sure to identify for each canal the corresponding irrigated areas.

2. Working with the operators, complete survey forms for canals and command areas, and modify forms as needed:
    a. Train collaborators on how to rate canals and irrigated areas.
    b. Make changes in rating criteria and scale as needed.
    c. Identify canals and irrigated areas to be rated, and assign rating ID.
    d. Jointly complete survey.
3. Encourage operators to conduct ground truth.
4. Enter data into spreadsheet:
    a. Train collaborators on data entry (Excel spreadsheets).
    b. Enter data.
5. Analyze data and create maps showing results:
    a. Perform data quality control.
    b. Link data to GIS.
    c. Carry out additional analysis as needed.
    d. Review results with operators.
6. Create reports to include the following:
    a. Tables of results.
    b. GIS maps with results of rating for canals and irrigated areas.

Comments are included in the manual in order to help the user to avoid common mistakes and/or to plan future improvements. For example, with this rating it can happen that the same canal is rated differently when it serves areas that are rated differently. As two records for the same canal ID cannot be joined to the canal shape file but only related, these results cannot be displayed on map but only on tables.

An example of results of the Head Problem Survey application is reported below. Codes are entered in the forms, each of them representing a complete answer. Columns A1, A2, B and C in Table 1 represent the questions “Frequency of head problem during peak period”, “Frequency of head problem during non-peak period”, “Cause of head problem”, and “Severity of head problem” respectively. Figures 1 and 2 show the case of question A1, for which there are four possible answers: Never (0), Sometimes (1), Often (2), Always (3). Figure 3 shows the case of question C, for which there are three possible answers: Minor (0), Moderate (1), Major (2).

Table 1. Example of Head survey data summary in the Iraq case study ("n.d." for canals and command areas with no head problems)

HEAD PROBLEM						
Area_ID	Canal_ID	A1	A2	B	C	Notes
B-0/R	B-0/R	n.d.	n.d.	n.d.	n.d.	
B-0_I	B-0_I	n.d.	n.d.	n.d.	n.d.	
B-0_II	B-0_II	3	3	1, 2, 3d	1	
B-1	B-1	n.d.	n.d.	n.d.	n.d.	
B-2_I	B-2_I	n.d.	n.d.	n.d.	n.d.	
B-2_II	B-2_II	3	0	1, 2, 3d	0	
B-2_III	B-2_III	2	1	1, 2, 3d	1	
B-3	B-3	n.d.	n.d.	n.d.	n.d.	
B-4	B-4	n.d.	n.d.	n.d.	n.d.	
C-1_I	C-1_I	n.d.	n.d.	n.d.	n.d.	
C-1_II	C-1_II	3	2	3e, 3f	2	
C-3_I	C-3_I	n.d.	n.d.	n.d.	n.d.	
C-3_II	C-3_II	3	3	3e, 3f	1	
C-5_I	C-5_I	n.d.	n.d.	n.d.	n.d.	
C-5_II	C-5_II	3	2	3e, 3f	1	
BC-3	BC-3	n.d.	n.d.	n.d.	n.d.	
BC-4	BC-4	n.d.	n.d.	n.d.	n.d.	
BC-5	BC-5	n.d.	n.d.	n.d.	n.d.	
BC-6	BC-6	n.d.	n.d.	n.d.	n.d.	
BC-7_I	BC-7_I	n.d.	n.d.	n.d.	n.d.	
BC-7_II	BC-7_II	1	0	3d, 3f	0	
BC-8	BC-8	n.d.	n.d.	n.d.	n.d.	
BC-9	BC-9	n.d.	n.d.	n.d.	n.d.	
BC-9A	BC-9A	n.d.	n.d.	n.d.	n.d.	
BC-11	BC-11	n.d.	n.d.	n.d.	n.d.	
BC-12	BC-12	n.d.	n.d.	n.d.	n.d.	
BC-10_II	BC-10_II	3	3	3b, 3c, 3d, 3f	2	
BC-10_I	BC-10_II	n.d.	n.d.	n.d.	n.d.	
BC-10/13	BC-10/13	3	3	3c, 3d, 3f	2	
BC-19	BC-19	n.d.	n.d.	n.d.	n.d.	
BC-20/1	BC-20/1	n.d.	n.d.	n.d.	n.d.	
BC-20/2	BC-20/2	3	3	3b, 3d, 3f	0	
BC-20/2/2	BC-20/2/2	3	3	3b, 3d, 3f	0	
BC-18	BC-18	3	3	3b, 3d, 3f	0	

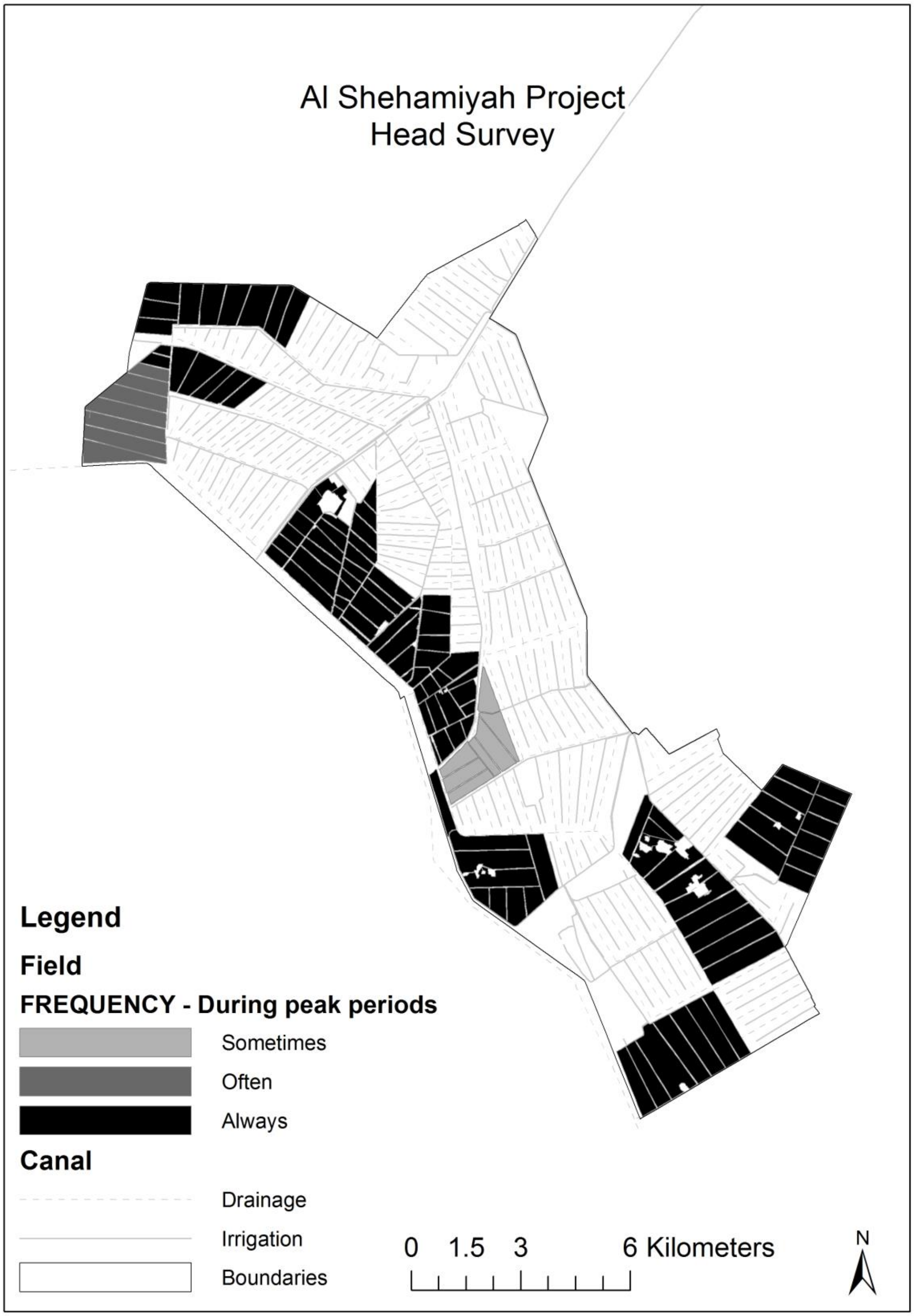

Figure 1. Example result for the Head Survey in the Iraq case study: Frequency during peak periods (Irrigated area)

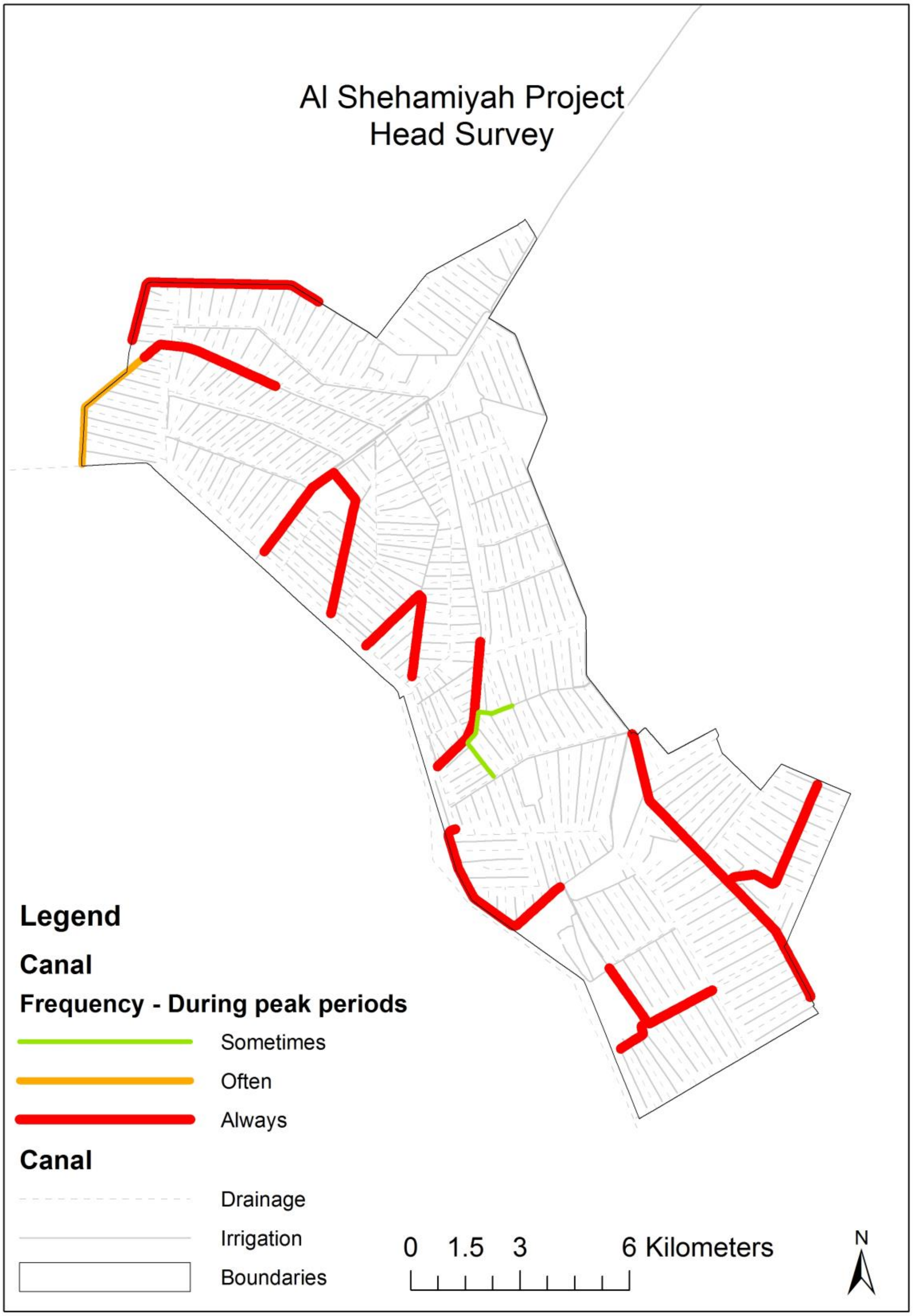

Figure 2. Example result for the Head Survey in the Iraq case study: Frequency during peak periods (Network)

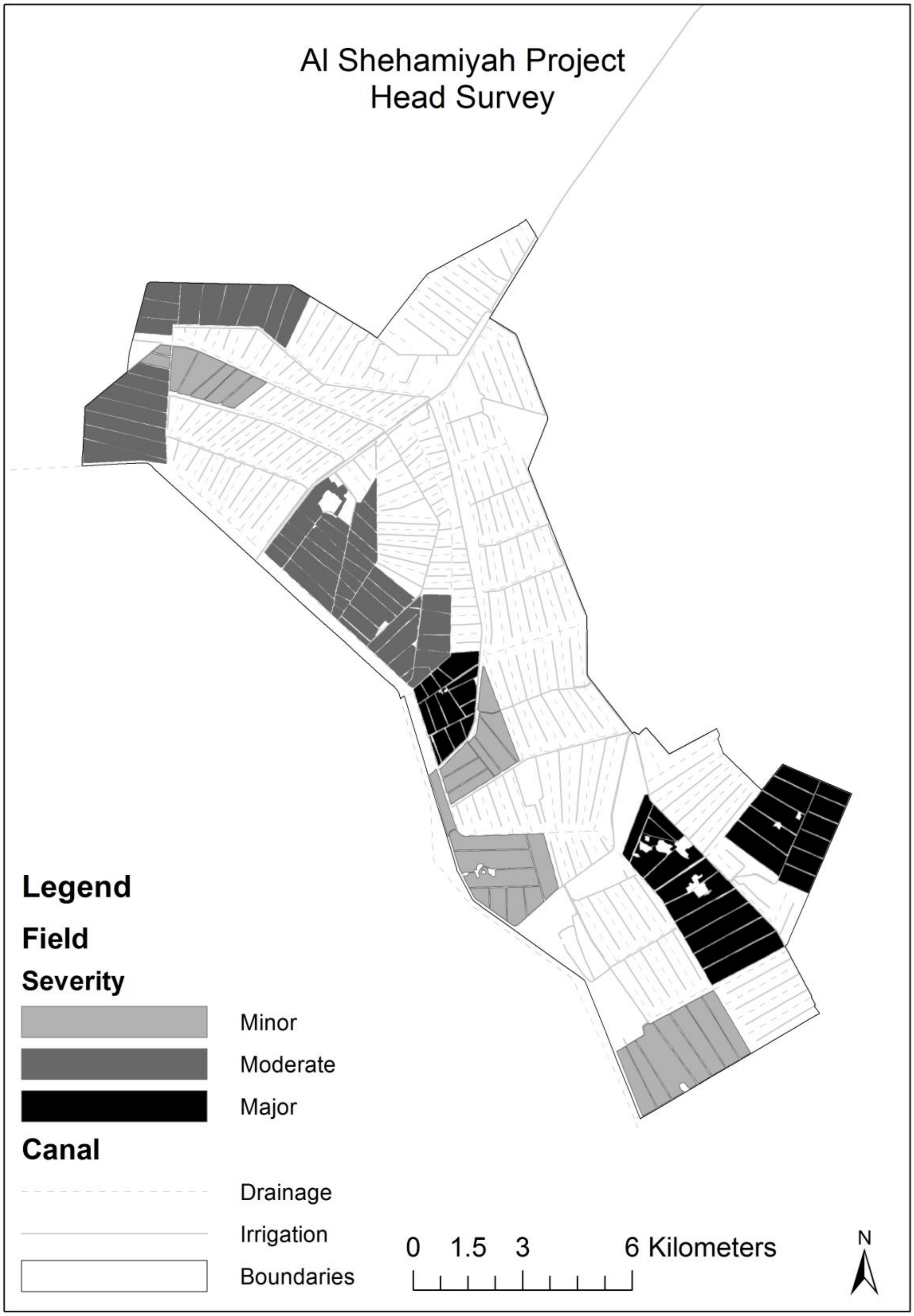

Figure 3. Example result for the Head Survey in the Iraq case study: Severity of head problem (Irrigated area)

Distribution Network Condition Rating Tool (Canal and Gate Evaluation)

The purpose of the Canal and Gate Evaluation is to assess general condition of the irrigation distribution network through a visual rating system to identify segments which need rehabilitation. The tools utilized for this survey are Distribution Network Condition Rating Form/Survey, and Excel Spreadsheet. The Canal and Gate Evaluation includes three sections, General Description, Questions to the Canal Riders, and Field Rating Forms (Concrete Canal, Earthen Canal, Gates).

As for the Head Survey, the Manual reports a suggested procedure and additional comments. For example we recommend to identify segments to be rated using existing hydraulic structures (such as diversion gates, control gates, bridges), and to make sure that segments are fairly homogeneous. For example, a segment will be split in more segments if during the field survey it results having a not homogeneous rating. An example of results of the application of the Concrete Canal Evaluation is reported in Table 2 and Figure 4. In figure we show the rating for the general conditions, i.e. column 10 in the table (0 = Excellent, 1 = Good, 2 = Fair, 3 = Poor, 4 = Serious Problems).

On-farm Head Survey and Analysis Tool (On-Farm Survey)

The purpose of the On-Farm Survey is to collect information needed to determine if the current flow at the farm turn-out is sufficient to allow for efficient on-farm irrigation. The tools utilized for this survey are On-Farm Survey Rating Form, and On-Farm Survey Spreadsheet.

As for the previous tools, the Manual reports a suggested procedure and additional comments. For example we recommend that answers should refer to a typical field in the scheduling unit, and during peak irrigation month. An example of results of the application of the On-Farm Survey is reported in Figure 5. Once again, forms are filled using codes.

An On-farm water delivery schedule calculation procedure is also available in the Manual. Additional data are needed to complete this calculation, which can be collected using recommended forms and procedures reported in the Manual

Table 2. Concrete Canal Evaluation data summary in the Iraq case study, for Main Canal (MC) and Branch Canal (BC). Column 10 is the rating for the general conditions (0 = Excellent, 1 = Good, 2 = Fair, 3 = Poor, 4 = Serious Problems)

QUESTION																							
GENERAL					CANAL RIDER				FIELD														
1_ID	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19a	19b	20	21	22a	22b
MC_0_4	0	4	0	1	1982	0	1	1A	2	2	1	0	2	1	0	0	2	1	2	3	1	1	10
MC_4_10.5	4	10.5	0	0	1982	0	1	1A	2	2	1	0	2	0	0	0	1	1	1	2	0	0	8
MC_10.5_13.5	10.5	13.5	0	0	1982	0	1	1A	2	2	1	0	2	1	0	0	1	1	1	3	1	1	8
MC_13.5_15	13.5	15	0	0	1982	0	1	1A	2	2	1	0	2	1	0	0	1	2	2	3	1	1	4
MC_15_16	15	16	0	0	1982	0	1	1A	2	2	1	0	2	1	1	0	1	1	2	3	1	1	3
MC_16_17.5	16	17.5	0	0	1982	0	1	1A	2	2	1	0	2	0	0	0	1	2	1	3	1	1	2
MC_17.5_19.6	17.5	19.6	0	0	1982	0	1	1A	2	1	1	0	2	0	0	0	1	2	2	3	1	1	4
BC_0_3	0	3	0	0	1982	0	1	1A	2	2	0	0	2	0	0	0	1	1	1	2	1	1	9
BC_3_5.4	3	5.4	0	0	1982	0	1	1A	3	2	1	0	2	0	0	0	1	1	2	2	1	1	15
BC_5.4_6.3	5.4	6.3	0	0	1982	0	1	1A	1	1	0	0	2	0	0	0	1	1	2	2	1	0	1
BC_6.3_6.9	6.3	6.9	0	0	1982	0	1	1A	1	1	0	0	2	0	0	0	1	1	1	2	0	0	0
BC_6.9_11.1	6.9	11.1	0	0	1982	0	1	1A	1	1	0	0	2	0	0	0	1	1	1	2	0	0	6
BC_11.1_12	11.1	12	0	0	1982	0	1	1A	1	1	0	0	2	0	0	0	1	1	1	2	0	0	0
BC_12_12.3	12	12.3	0	0	1982	0	1	1A	3	3	1	0	2	1	0	0	2	2	2	2	1	1	1

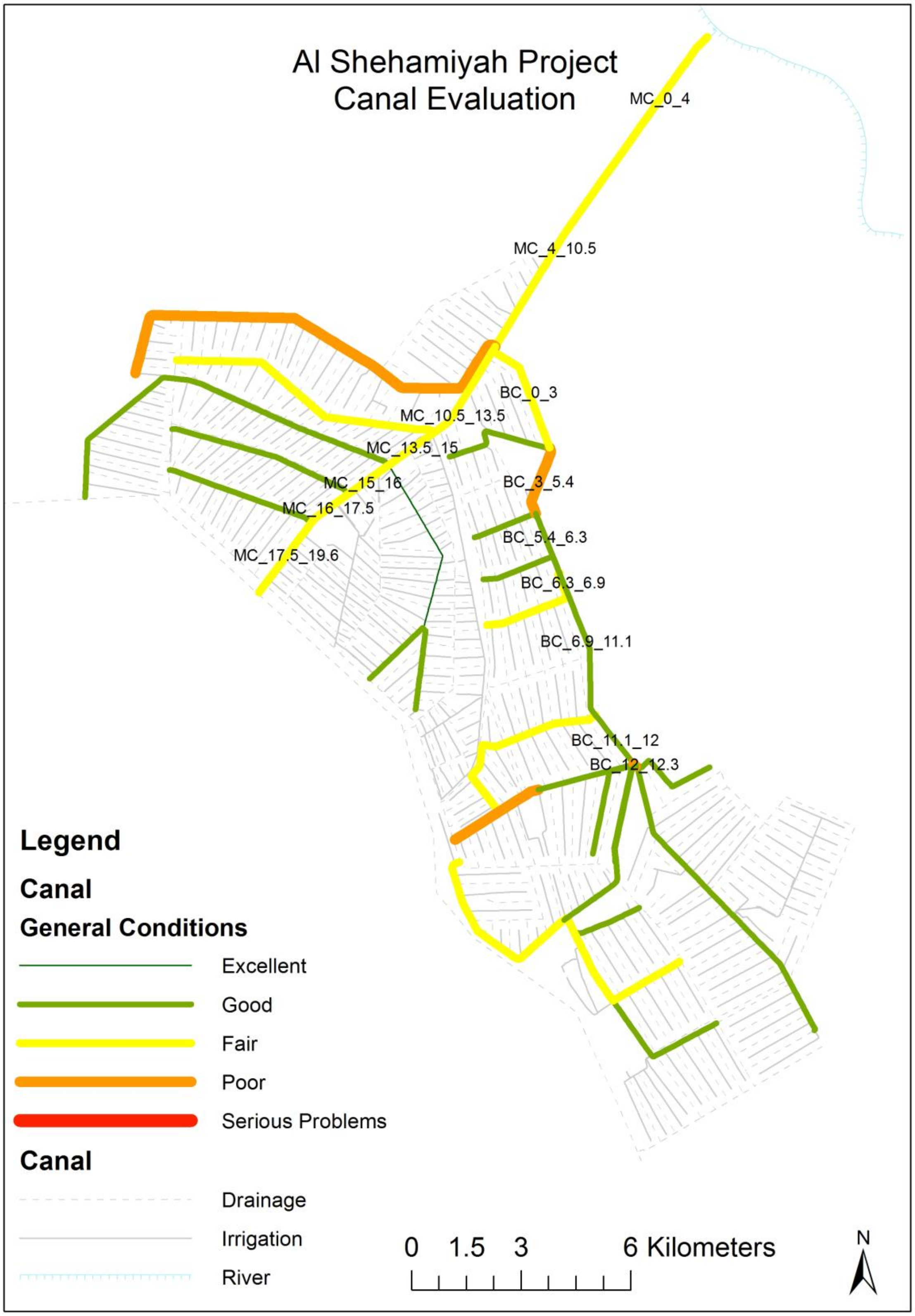

Figure 4. Example result for general conditions in the Canal evaluation (concrete canal) in the Iraq case study. Rating IDs are shown for the Main Canal and the Branch Canal

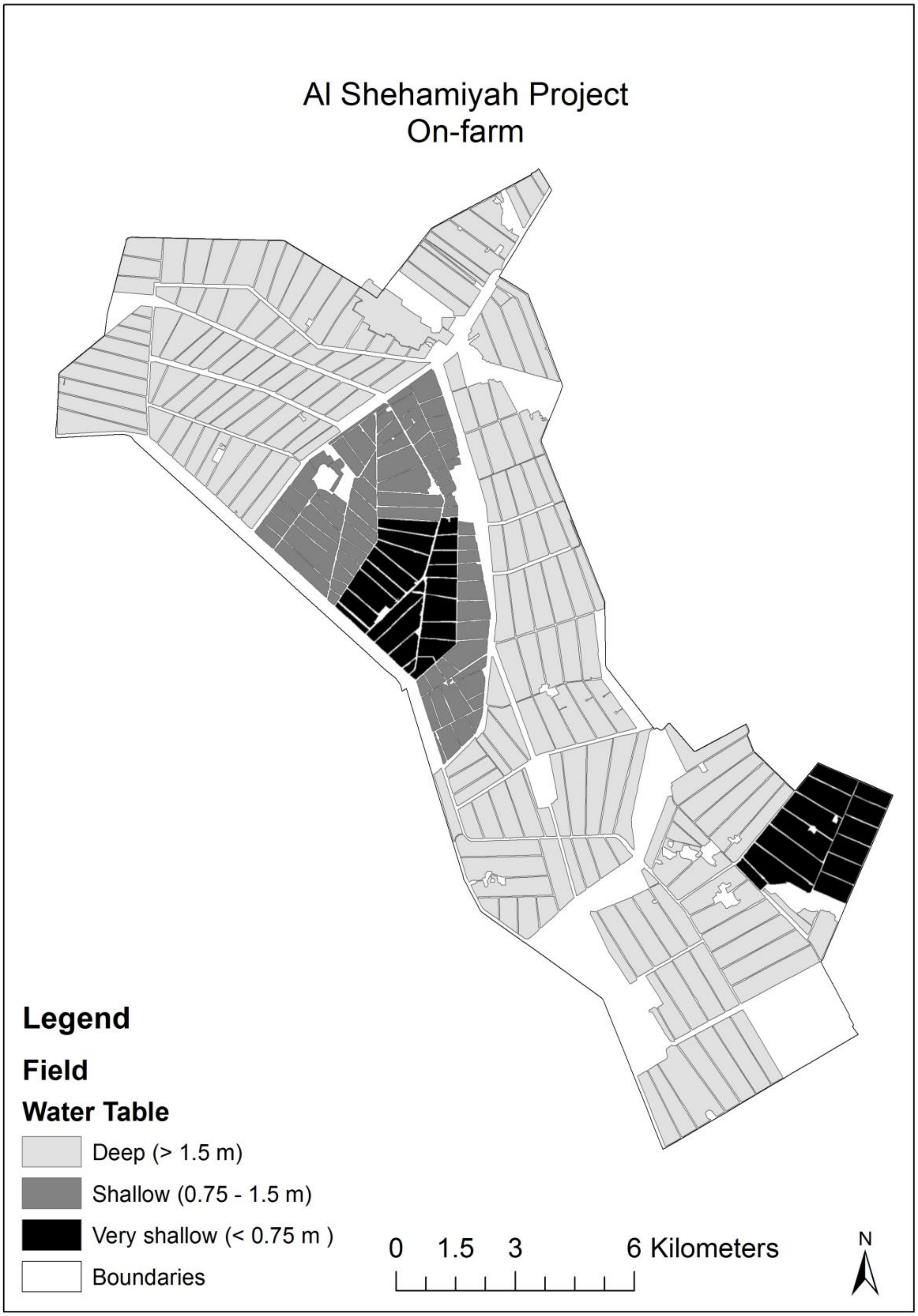

Figure 5. Example result for On farm survey in the Iraq case study: Water Table depth

GIS MAPPING

There is no GIS for irrigation schemes in Iraq. GIS is an essential component of the RIP, and we recommended a basic structure and a procedure to build it. Several comments are also included in the manual to guide the user, such as edit at a scale 1:5,000 or larger, use snap control when creating hydraulic network features, or draw canals features always in the direction of the flow.

PRIORITIZATION OF CANALS FOR LINING

In this study conducted in the Lower Colorado River Authority (LCRA) in Texas, we adopted the general procedure suggested in the RIP and conducted several surveys with LCRA personnel. We then updated and verified the methodology based upon field reconnaissance and GIS analysis. A 3-point ranking scale was used as an indication of the seriousness of expected seepage losses based on the following factors:

- Canal use frequency.
- Severity and cause of seepage.
- Visual indicators of seepage.
- Soil maps analysis.

Where:

- 1 = Highest priority, when at least two factors have maximum rating (ex. daily frequency, high seepage severity, serious visual problems).
- 2 = Priority level 2, when at least one of the factors have maximum rating, and canal is used at least yearly.
- 3 = Priority level 3, all other identified seepage locations where seepage is likely occurring.

Figure 6 gives the grouping of canals by priority for detailed seepage lost analysis: Nine (9) segments have priority level 1 (highest), for a total of 10 miles; Five (5) segments have priority level 2, for a total of 4.2 miles; and Ten (10) segments have priority level 3, for a total of 9 miles.

Five (5) segments, for a total of 4.1 miles, have been classified as likely having non-seepage losses, and mostly due to capacity and overflow problems. Some visual indicators of seepage losses are shown in Figures 7 and 8. Quantification of water savings from the lining of these canals requires further detailed analysis, such as soil detailed analysis (i.e. texture, infiltration, hydraulic conductivity) and flow measurements.

We found also non-seepage/leakage related problems. It is difficult to deliver water to about 7,000 acres of irrigated land due to land elevation problems, siltation at the farm turnout, and ruts made in canal embankments by cattle, and damage caused by cattle is widespread (Fig. 9 and 10).

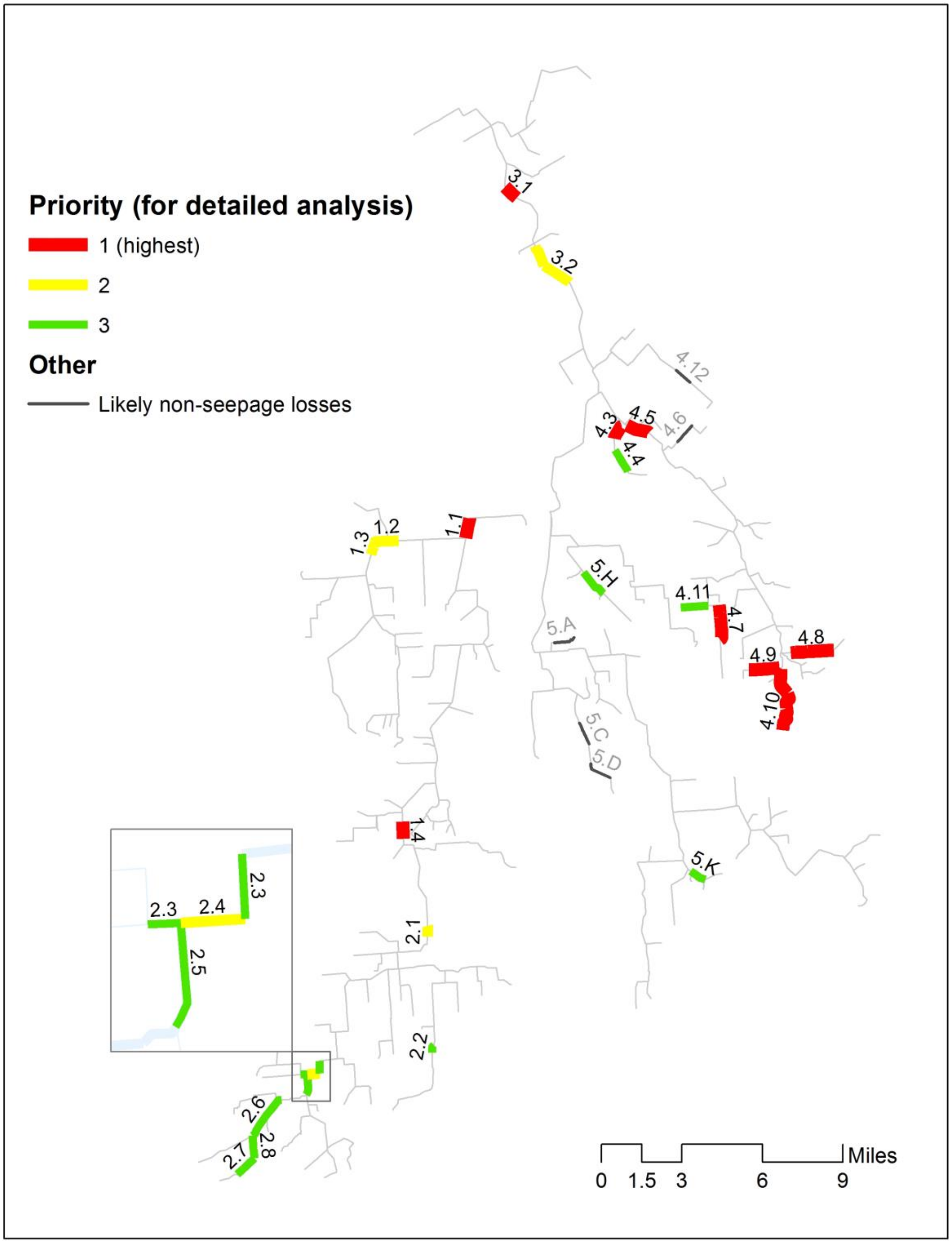

Figure 6. Rating of canal segments based on highest priority for detailed analysis in the Texas case study. Also shown are segments that likely have non-seepage water losses (such as due to overflow)

Figure 7. Seepage observed in canal embankment due to pocket gophers (4S7, top), and a crayfish burrow (4S5, bottom) in the Texas case study. Arrows identify the point of seepage

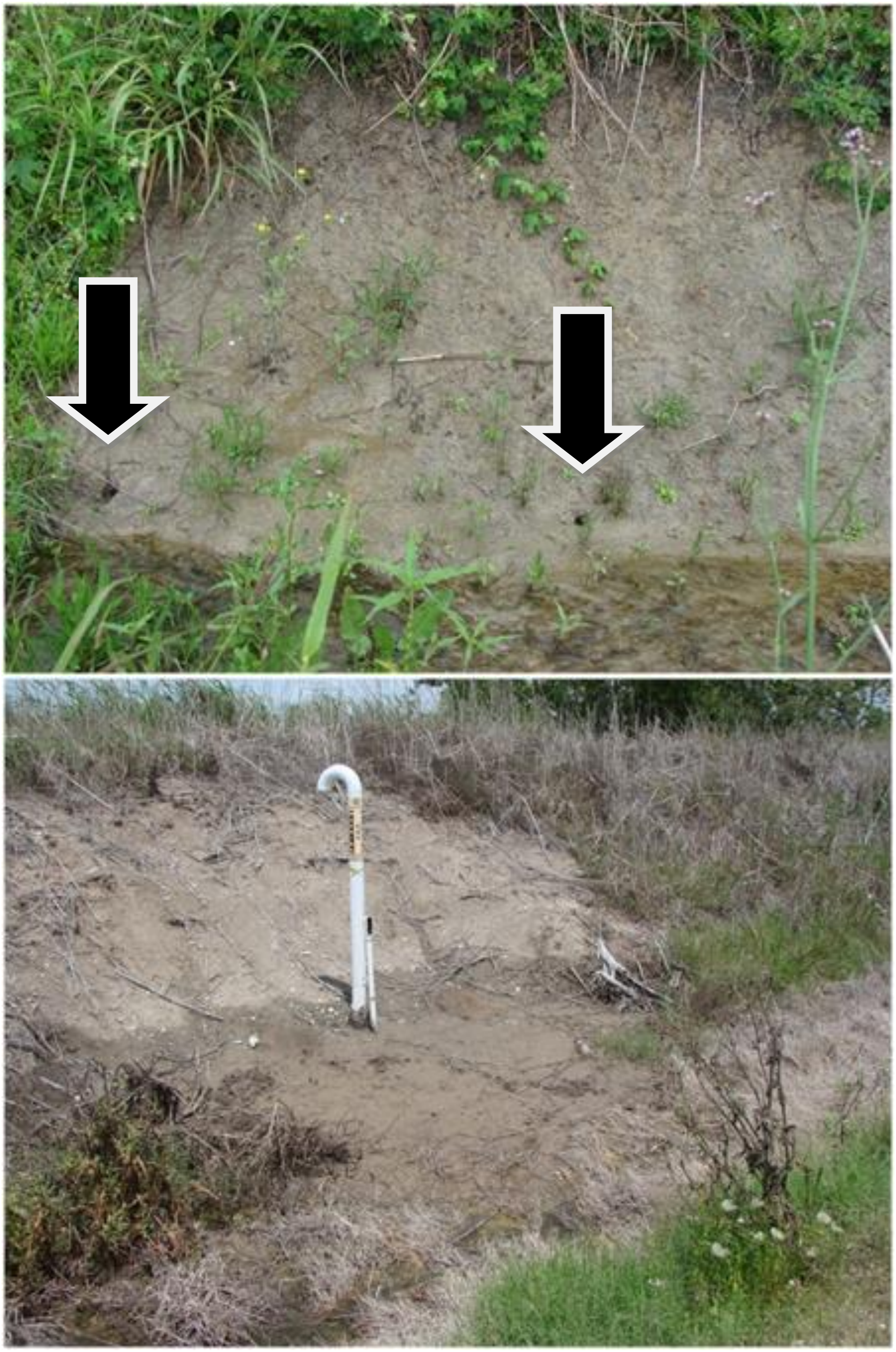

Figure 8. Seepage observed in canal embankment due to crayfish burrows (1S4, top), and pipe crossing (4S5, bottom) in the Texas case study. Arrows identify the point of seepage/leaks

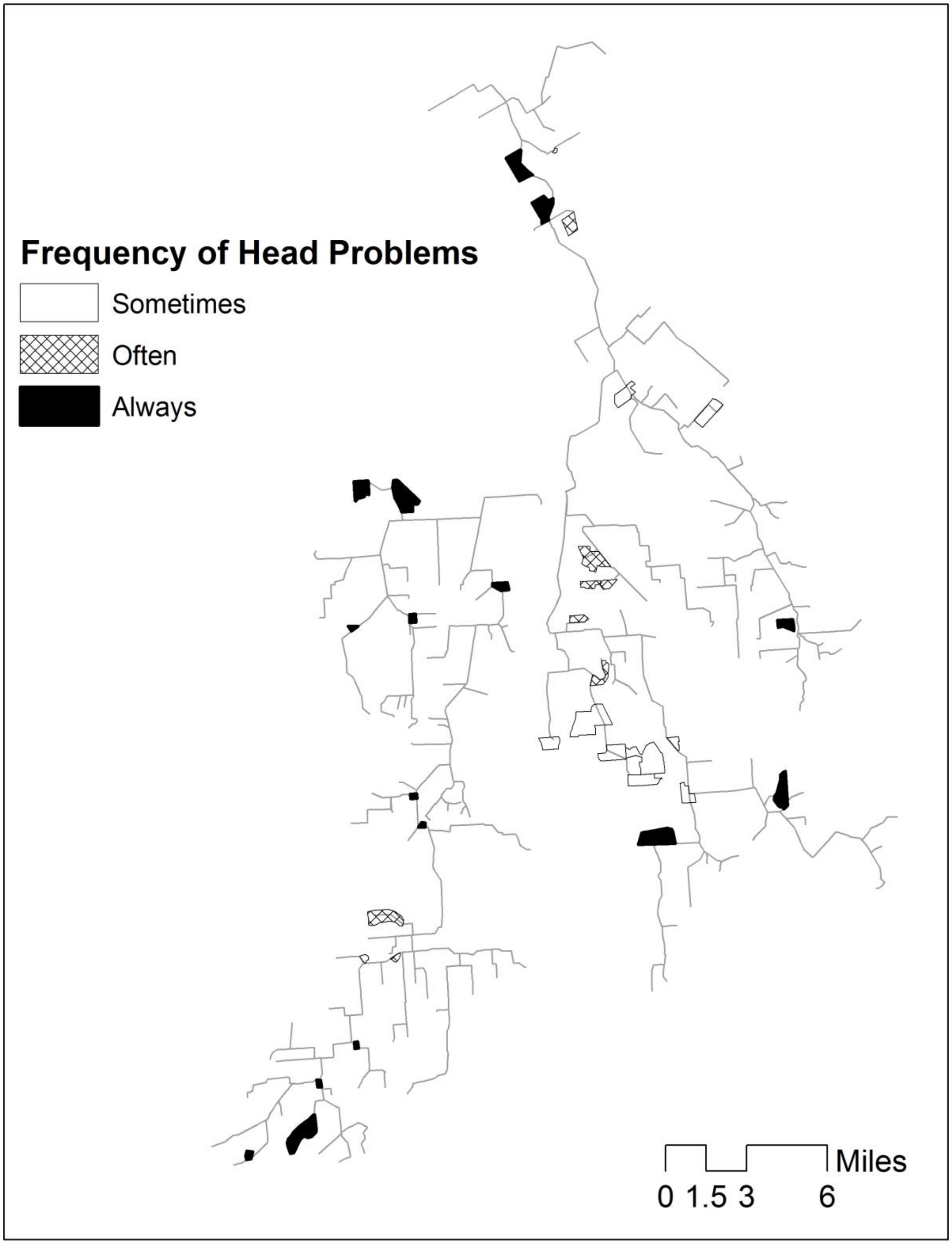

Figure 9. Frequency of Head problems in the Texas case study

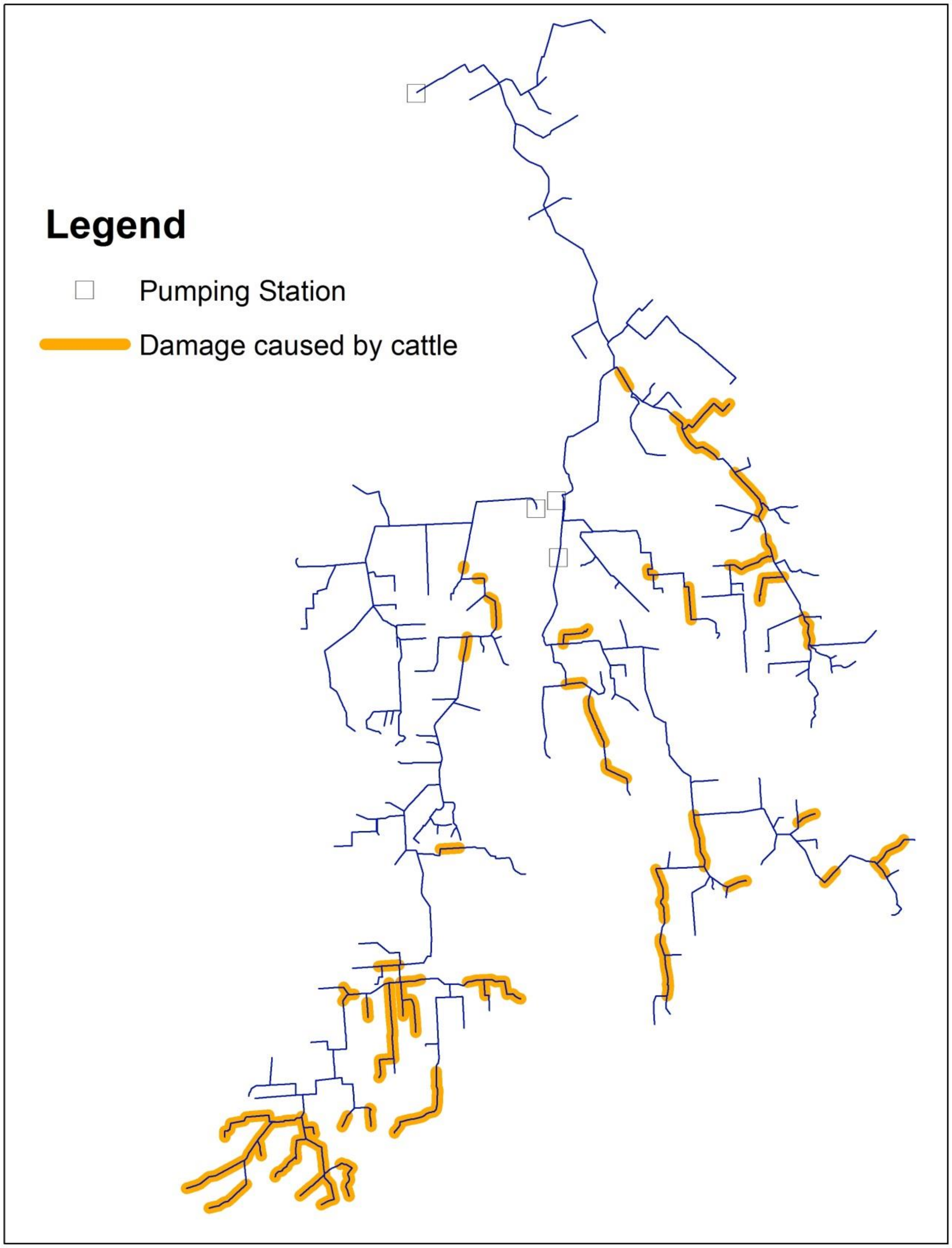

Figure 10. Canal segments damage by cattle in the Texas case study

CONCLUSIONS

The application of the RIP to the Iraq irrigation schemes allowed identifying priorities to be addressed to improve water delivery efficiency. It also provided an organized structure of data that can be further developed in more complex analysis.

All data in the RIP is interconnected and easily modifiable by a trained person, and results can be automatically updated with new data. This is the case of water delivery scheduling, which can be recalculated when detailed flow rate measurements or other field data becomes available.

By applying the RIP to the Gulf Coast Irrigation Division of the Lower Colorado River Authority (LCRA) in Texas, we identified 27.4 miles of canals that are likely to have significant seepage losses and/or leaks. These canals were ranked by priority for further analysis. We also identified non-seepage conditions and problems. Head problems resulting in insufficient flow were found that affects about 7,000 acres of irrigated land. Cattle damage is widespread in the South West and South East Sections of the Division.

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