Inyo/Los Angeles Cooperative Effort to Develop Revisions to the Green Book

Workplan IA. - Develop New or Improved Operational Trigger Mechanisms for Pumping Wells

November 1, 2007

Developed by Staff from Inyo County Water Department and
Los Angeles Department of Water and Power

Problem Statement

The primary provision to manage pumping under the Water Agreement is commonly referred to as the On/Off procedure. Section V of the Water Agreement directs the Technical Group to prepare monthly projections of the "water balance" to inform pumping well "turn-on" and "turn-off" provisions. The decision mechanism governing management of individual wells and the prescribed monitoring and data analysis procedures are presented in the Green Book in Section I.B, and Sections III.B, C, D, F, and G. These sections are lengthy and will not be reviewed here. In addition to the soil water balance triggering mechanism, other provisions of the Water Agreement and other guidance documents (e.g. court decrees) direct operation of certain wells. These topics will be considered in the development of revised procedures described in this workplan.

The On/Off procedures have conceptual deficiencies as well as methods and provisions that interfere with the practical implementation of the Green Book and associated management of groundwater pumping.

To remedy the deficiencies, Inyo and LADWP need to improve current methods or develop new methods for monitoring and data analysis as well as the decision mechanism that will be used by the Technical Group to better determine the amount and distribution of groundwater pumping while protecting Owens Valley vegetation. The new procedure should meet the goals of the Water Agreement, *"to avoid certain described decreases and changes in vegetation and to cause no significant effect on the environment which cannot be acceptably mitigated while providing a reliable supply of water for export to Los Angeles and for use in Inyo County."*: Furthermore, the new procedure ideally should:

1. be capable of predicting impacts to vegetation
2. be conceptually straightforward and consistent with the hydroecology of Owens Valley vegetation
3. provide a quantitative pumping recommendation
4. be amenable to modeling for simulation of multiple pumping scenarios from which an optimum scenario can be determined

5. account for sources of measurement and prediction (if relevant) error
6. be designed to minimize the impact of necessary but poorly quantified or estimated parameters on the pumping recommendation
7. correspond with the annual time step of LADWP's pumping plan
8. rely on generally accepted monitoring and analysis methods that can be effectively implemented given the extent of the area to be managed
9. determine the locations and scale of monitoring that is appropriate for efficient wellfield management

Background

Staff from Inyo and LADWP conducted a series of meetings in 2006-07 to develop the procedures to be used in a cooperative effort to revise the Green Book and to identify issues that need to be addressed. The Inyo/Los Angeles Standing Committee received an update on the process at its meeting on February 12, 2007. The project managers for each agency agreed in April 2007 to begin work on item I.A, Development of New or Improved Operational Triggering Mechanisms for Pumping Wells.

A working group comprised of staff and consultants from Inyo and LADWP was formed in May to begin the process of developing a new triggering mechanism to manage pumping. The purpose for the working group was discussed at the Technical Group meeting on May 4, 2007. In recent years, Inyo County and LADWP have individually tasked staff and consultants to conduct research and develop procedures to replace or improve the Green Book methods, but there has been limited interaction between the scientists at both organizations. The working group agreed to conduct a series of meetings to share work to date and to select an approach to possibly replace the current triggering mechanism. The approach selected entails setting pumping amounts and distribution to accomplish vegetation management through linkage of vegetation to water table drawdown and recovery at specific points where model predictions of depth to water and vegetation are possible. The working group evaluated the technology necessary to implement the approach and agreed to test the feasibility of utilizing existing empirical models to manage the vegetation/water table relationships for two wellfields, Taboose-Aberdeen and Big Pine. Several technical obstacles for this approach to be viable also were identified. The working group prepared the workplan presented below to complete additional research to address apparent technical obstacles and identified parameters and topics for work groups to address.

Workplan

Plans for five individual tasks to develop and test the approaches were prepared by the working group. A synopsis of the plans is provided below followed by more detailed task plans. It is anticipated that one or more working groups will be assembled to work on individual tasks. Task leaders will be responsible for implementation of delineated Task Plans. Tasks may be modified as investigations move forward if additional questions or issues arise. The schedule may be revised by the project managers to accommodate staff participation on these and other working groups.

Synopsis of the task plans

Task IA-1: Preliminary Procedures for Prediction of Depth to Water (DTW) – Big Pine and Taboose/Aberdeen Test Cases

- Build data tables including all variables
- Develop models
- Radius of influence and exempt wells analysis
- Method to solve for pumping for specific wells or entire wellfield
- Error analysis of models
- Sensitivity analysis of management parameters (DTW target and drawdown/recovery cycle length)

Task IA-2. ~~Preliminary~~ Evaluation of DTW and Vegetation Cover Relationships – Big Pine and Taboose/Aberdeen Test Cases

- DTW/cover relationships models to help set DTW targets and address the effect of management model on local scale vegetation cover
- Add vegetation to the data tables
- Develop models
- Error analysis
- Combine with hydrologic models and simulate scenarios from the sensitivity analysis in Task IA-1

Task IA-3. – Evaluation of Groundwater Management Model Parameters Including Vegetation Targets, Recovery Periods, and Scale of Parameters

- Prepare and evaluate various alternative rationales to set numerical vegetation cover/DTW targets and length of drawdown-recovery cycle

Task IA-4. - Improvement to Existing Numerical Models to Augment Regression Methods – Big Pine and Taboose/Aberdeen Wellfields

- Long term enhancement of physically-based models to complement or replace empirical models

Task IA-5. Application of Selected Methods to Other Wellfields

- Apply and tailor methods to other wellfields

During the course of developing this workplan, the group determined that item I.B of the original outline, the Re-evaluation of Wells Exempt from the On/Off Mechanism, needed to be completed as part of Task IA. As part of another workplan a group will need to be tasked to develop or revise monitoring procedures to provide information to adapt and adjust management methods including the models used for planning, management model parameters (e.g. depth to water targets), and monitoring methods. Another work plan will be necessary to develop and improve methods to monitor vegetation for compliance with the goals of the Water Agreement. These two tasks are part of item II.A of the

original outline and if staff availability allows can proceed concurrently with later scheduled tasks in this workplan.

Task IA-1: Preliminary Procedures for Prediction of Depth to Water (DTW) – Big Pine and Taboose/Aberdeen Test Cases

Purpose

The task is to develop the models that could be used to determine the relationship between groundwater pumping and depth to groundwater (DTW). As part of this work, the radius of influence of individual production wells and exempt wells will be evaluated. This investigation of methods will primarily use existing regression and other point-scale tools for prediction of DTW. The radius of influence analysis and exempt well analysis will rely on existing numerical groundwater models and will be used to assist selection and revision of the regression models.

Description

This method is anticipated to be site or wellfield-specific. The Big Pine and Taboose/Aberdeen wellfields were selected as test cases to develop models and techniques described below because both ecological and groundwater numerical models have already been developed, and preliminary testing of regression models has been conducted. This task will evaluate the feasibility of applying existing regression and empirical models for determining pumping amounts annually based on prescribed water table fluctuations including DTW targets and recovery times. For this study, preliminary DTW targets will be used by this working group, but these will be modified in the future using results developed during the conduct of Task IA-2 and eventually Task IA-3.

This workplan is designed to develop an initial technique that can be utilized relatively quickly. If successful, the method can be deployed to other wellfields. Other tasks are anticipated to be conducted concurrently to improve or modify these initial methods.

The general approach will involve:

- Evaluation of the radius of influence of production wells individually, including exempt wells, according to their uses
- Selecting best relationships between runoff, pumping and DTW
- Creating a set of models that could be used to plan pumping based on assumed DTW targets (determination of targets is not a part of this workplan)
- Simulate one to multi-year drawdown and recovery cycles for selected scenarios

Method

The method will consist of eight subtasks, as follows:

SUBTASKS

1. The hydrostratigraphy and structural geology of the Owens Valley is known to be relatively complex. This, combined with the fact that many production wells are

perforated in confined or semi-confined aquifers means that the pattern of drawdown produced at the surface by any one well is irregular and site-specific, and generalized analytical drawdown solutions are of limited value.

The MODFLOW tools already developed for the Big Pine and Taboose/Aberdeen wellfields provide a readily-available means to provide an areal evaluation of drawdown produced by any one well (drawdown contours). This data is anticipated to be of significant value not only in evaluation of which production wells should be linked to a particular monitoring site, but to augment and test existing regression tools. Because of the principle of superposition, once the drawdown pattern of any one well is known, the drawdown pattern from any combination of wells can be estimated by superposition of the cones of depression of the wells in question, including exempt wells.

This task will be performed by selection of a standard and representative steady-state condition for the wellfield using MODFLOW, and sequentially evaluating the drawdown produced by each production well in turn. The cumulate drawdown of exempt wells will also be determined. This data will be stored in grid format so that it can be used readily by GIS or other mapping tools to estimate drawdown from any combination of wells by addition. For this purpose the drawdown after one year of pumping will be used to match regression tools described in Subtask 4 below.

2. Select candidate sites for evaluation utilizing radius of influence for each pumping well.

3. Build data tables including all variables (April DTW or elevation, runoff, pumping,) and calculation spreadsheets, including rationale for selected values. The purpose of this subtask is to produce a common, well documented set of data and models. Results from Subtask 1 will be used to associate indicator wells with production wells.

4. Select the best DTW regression tools to be used at each monitoring site (indicator wells and/or permanent monitoring sites)
    a) Inspect regression diagnostics
    b) Compare predicted hydrographs with actual hydrographs
    c) Analyze linkages between pumping wells and DTW at individual sites to develop a set of regression models that provide a single pumping value for specific wells, group of wells, or the entire wellfield.

5. Develop methods to account for model and parameter uncertainty. Determine if an acceptable level of prediction accuracy can be obtained for the models selected.

6. Conduct sensitivity analysis of pumping and DTW to management parameters (e.g., DTW targets, recovery periods), to assess the sensitivity of the models to these parameters on expected long term DTW and pumping.

7. Identify data gaps and recommend methods to fill them

8. Prepare documentation and provide recommendations regarding use of the models.

Deliverables

The deliverables associated with this task will consist of:

1. Intermediate deliverables consisting of brief memorandum or verbal status/issues reports to the larger cooperative working group and project managers.
2. Final report (Subtask 8) that includes documentation of radius of influence and exempt well evaluation, selected regression tools, rationale for selection, results of the sensitivity analysis, identification of data gaps, and recommendations for implementation of the method.

Anticipated Resources

This work will not require specialized tools or equipment, but will require access to hydrologic data currently housed at LADWP and ICWD. Software necessary to complete this work is available at both agencies.

Schedule

Twelve (12) months total, assuming adequate resources are available to complete the task.

Personnel

The Task Leader for LADWP is Saeed Jorat and Bob Harrington for Inyo County Water Department. Other staff may be assigned as needed. It is anticipated that the services of the MWH Owens Valley project team may be required.

Budget

The budget for this task will involve staff time. No outside costs are required.

Task IA- 2 –Preliminary Evaluation of Relationships between Vegetation Cover and DTW and Precipitation – Big Pine and Taboose/Aberdeen Test Cases

Purpose

The task is to develop methods for predicting vegetation cover for various DTW and precipitation scenarios. This investigation of methods for predicting vegetation cover will primarily use existing regression, empirical and/or other point-scale models.

Description

This preliminary method is anticipated to be site specific. The Big Pine and Taboose/Aberdeen wellfields were selected as test cases because both ecological and groundwater numerical models have already been developed, and preliminary testing of regression models has been conducted. This project will evaluate the feasibility of applying existing regression and empirical models for predicting vegetation cover as a function of DTW and precipitation.

This task is anticipated to be initiated immediately after selection of monitoring locations with Task IA-1. Other tasks are anticipated to be conducted concurrently to fill data gaps and to improve or refine the models and parameters completed in Tasks IA-1 and 2.

The general approach will involve:

- Selecting the best relationships between DTW, precipitation, and other factors and vegetation cover.
- In coordination with Task IA-1, create a set of models that can be used to analyze pumping based on a range or point-specific vegetation targets (determination of final targets is not a part of this work).
- Revise simulation of multi-year pumping cycles for selected scenarios completed Task IA-1, if necessary.

Method

The method will consist of seven subtasks, as follows:

SUBTASKS

1. Select the best vegetation cover regression or empirical tools to be used at each location identified in Task IA-1. If necessary, modify the vegetation tools to match the time periods and DTW variables identified in Task IA-1.
2. Expand data tables developed in Task IA-1 to include vegetation cover relationships. The purpose of this subtask is to produce a common, documented data set and models.
3. Develop methods to account for model and parameter uncertainty. Determine if an acceptable level of accuracy can be obtained.

4. Combine the tools developed in Task IA-1 with the tools selected in Subtask 1.
5. Input the results of the sensitivity analysis of the hydrologic models into models developed/selected as part of this task to assess the expected vegetation conditions for the range of model parameters. This information will be essential to inform the effort described in Task IA-3. If necessary, conduct additional simulations using the combined models from Task IA-1 and IA-2 to evaluate the combined models. (Selection of final set of recommended targets is not a part of this Task.)
6. Identify data gaps and recommend methods to fill them. Identify methods for periodic updating and improvement of the method.
7. Prepare documentation and provide recommendations regarding use of the tools.

Deliverables

The deliverables associated with this Task will consist of:

1. Intermediate deliverables consisting of memorandum or verbal status/issues reports to the larger cooperative working group and project managers.
2. Final report (Subtask 7) that includes documentation of selected regression or empirical tools, rationale for selection, identification of data gaps, results of scenario testing, and recommendations for implementation and continuous improvement of the method.

Anticipated Resources

This work will not require specialized tools or equipment, but will require access to vegetation data currently housed by both LADWP and ICWD. It is anticipated that the resources of MWH Americas, Inc. will be required.

Schedule

Twelve months total, assuming that adequate resources are available to complete the work. The beginning of this task is dependent on selection of monitoring locations in Task IA-1. In addition, this working group will need the final selected DTW models from Task IA-1 at least one month before completion of the task.

Personnel

The task leader for LADWP is Paula Hubbard and Sally Manning for Inyo County Water Department. Other staff may be assigned as necessary. It is anticipated that the services of the MWH Owens Valley project team will be required.

Budget

The budget for this task will involve staff time. No outside costs are required.

Task IA-3 – Evaluation of Groundwater Management Model Parameters Including Vegetation/DTW Targets, Recovery Periods, and Scale of Parameters

Purpose

It is anticipated that the amount of pumping allowed in any time period and resulting vegetation conditions using the models and techniques developed in Tasks IA-1 and IA-2 will be sensitive to the point-scale DTW targets and vegetation/DTW relationships employed. Therefore, the determination of vegetation targets is a required aspect of a pumping management scheme. The purpose of this Task is to evaluate various rationales that could be used to set numerical vegetation targets and recovery periods for use of the models developed under Tasks IA-1 and IA-2.

Description

There are a variety of methods that could be used to set vegetation targets and recovery periods, including but not limited to:

- Use of a static target based on 1984-87 baseline values
- Use of a multi-year average related to 1984-87 baseline
- Target values which incorporate 1984-87 baseline values and valley-wide changes such as those due to succession or climate change
- Target values not related to 1984-87 baseline values, but related instead to other value-based or ecological criteria

Method

The working group will develop at least three different alternatives for setting vegetation targets, scale of compliance, and recovery periods, all of which can meet the goals of the LTWA. Initially, these targets will be limited to the point-scale monitoring locations identified in Tasks IA-1 and IA-2. Questions of spatial arrangement and locations should also be addressed.

The Working Group will not be tasked with selection of a single recommended set of targets. Rather, the group will be responsible for identifying possible alternatives, or frameworks for setting targets that will be considered by the Technical Group and Standing Committee.

Deliverables

The deliverable for this Task will be a technical memorandum that includes the following:

- A list of alternative methods for setting point-scale vegetation targets for the locations identified in Task IA-1.

- An evaluation of how these methods could be evaluated at a wellfield or larger scale.
- A description of key areas of potential controversy identified by the group

Anticipated Resources

No special equipment or tools will be required to complete this Task.

Schedule

This work is expected to take approximately six (6) months, assuming adequate resources are available. In consideration of the importance of this work, it should begin immediately. The initiation of this work is not dependent on data developed in previous Tasks.

Personnel

The task leader for LADWP is Milad Taghavi and Aaron Steinwand for Inyo County Water Department. Other staff may be assigned as necessary. It is anticipated that the services of the MWH Owens Valley project team will be required.

Budget
The budget for this task will involve staff time. No outside costs are required.

Task IA-4 - Improvement to Existing Numerical Models to Augment Regression Methods – Big Pine and Taboose/Aberdeen Wellfields

Problem Statement

Wellfield scale groundwater and ecological models exist for both the Big Pine (BP) and Taboose/Aberdeen (TA) wellfields. It is anticipated that these tools can be useful in filling in data gaps where regression or empirical relationships do not exist. In addition, there is a need to test the usefulness of modeling tools as a management method, because in other wellfield locations, regression and empirical relationships may not yet be available. If the empirical methods developed in Tasks 1A-1, 2, and 3 prove to be effective for management, there will remain a need to be able to assess the effects on the environment at larger spatial scales.

Description

This task will incorporate the following general activities:

- Provide for knowledge transfer of existing numerical modeling tools (both MODFLOW and EDYS) to ICWD personnel. It is anticipated that more effort will be needed for knowledge transfer for EDYS in comparison to MODFLOW.
- Improve models for the BP and TA by incorporating new methods used in the Bishop wellfield model, and improvements suggested by ICWD after review of the models.
- Develop local-scale EDYS models to test and compare regression and/or empirical methods and existing vegetation data, and to expand prediction methods to locations where data is not sufficient to develop regression and/or empirical methods.

Method

SUBTASKS

1. MWH and LADWP have been developing wellfield-scale MODFLOW and EDYS models for both the BP and TA wellfields for the last several years. These tools provide significant capability for development of future management methods. However, ICWD personnel have not had the opportunity to participate in the development or testing of these models. The primary purpose of this task is to provide time and materials for ICWD personnel to review the work to date and to familiarize themselves with these models. After this work has been reviewed, ICWD will have the opportunity to provide opinions as to the usefulness of these tools in continuing cooperative work. If these tools are deemed of value by ICWD in continuing cooperative work, ICWD would provide recommendations and comments as to how these tools can be modified or improved (Subtask 2), based on their expertise and experience in the Owens Valley.

The knowledge transfer will be initiated by the conduct of a workshop in which the rationales, methods, and results of previous modeling efforts are presented and discussed.

2. Improvement of existing Big Pine and Taboose Aberdeen models by incorporating any agreed upon revisions or modifications identified by ICWD or LADWP after review of the models described in Subtask 1.

3. EDYS is a complex deterministic model that can be used in variety of levels of spatial detail. The model has a variety of variables that control movement of water and changes in vegetation biomass and plant community types on a wellfield scale. This subtask involves development of local-scale EDYS models (surrounding the permanent monitoring sites) in the Big Pine and Taboose/Aberdeen wellfields that can be directly compared to the vegetation data produced historically at the permanent monitoring sites.

   Simplified local-scale EDYS models will be developed at each of the permanent monitoring sites in the Big Pine and Taboose/Aberdeen wellfields, and the output will be compared to the historical permanent monitoring site data. Thus, these local scale models will serve the following purposes:

   - To provide additional means for knowledge transfer to ICWD regarding the use of EDYS in the Owens Valley.
   - To provide a means to "validate" the EDYS model where historical data is available.
   - Pending validation and acceptance by the working group, to provide a tool for prediction of changes in vegetation as a function of changing groundwater levels in areas where historical data does not exist (in combination with other tools such as regression equations or MODFLOW output).

Deliverables

The deliverable for this report is a draft and final report that describes updates and improvements to the each of the models.

Anticipated Resources

The conduct of this task will require the use of the MODFLOW/EDYS models previously developed and associated software.

Schedule

This task is anticipated to take approximately 30 months assuming adequate resources are available. Individual subtasks may be completed between, and during the conduct of other tasks.

Personnel

The task leader for LADWP is Saeed Jorat and Bob Harrington & Aaron Steinwand for Inyo County Water Department. Other staff may be assigned as necessary. It is anticipated that the services of the MWH Owens Valley project team will be required.

Budget

The budget for this task will involve staff time. No outside costs are required.

Task IA-5 - Application of Selected Groundwater Management Methods to Other Wellfields

Purpose

Tasks IA-1, IA-2, and IA-3 will result in recommended groundwater management methods applicable to the Big Pine and Taboose/Aberdeen wellfields. The purpose of this Task is to determine how these methods (if successful) can be applied at the remaining Owens Valley wellfields.

Description

The exact methods to be used by this work group will be determined after the completion of Tasks IA-1 through IA-3, and it is likely that the methods developed in those Tasks will require modification to account for specific conditions in each wellfield. The Laws wellfield requires consideration of McNally canal operations, a relatively large amount of groundwater pumped for irrigation, and water supply for Enhancement/Mitigation projects. The Bishop Cone wellfield has not had On/Off management implemented because it has been assumed that groundwater pumping restrictions of the Hillside Decree would sufficiently limit pumping, so wells on the Bishop Cone are currently not linked to monitoring sites. Pumping management in the Thibaut-Sawmill wellfield will need to consider the probability that pumping in the Taboose-Aberdeen and Independence-Oak wellfields affects the water table in Thibaut-Sawmill. The Independence-Oak and Symmes-Shepherd wellfields also are subject to interference from adjacent wellfields. The Bair-Georges wellfield requires consideration of impacts to Reinhackle Spring. The Lone Pine wellfield has no existing indicator well models, and a new production well that has not yet been activated. In undeveloped areas such as Owens Lake or Rose Valley, tools that rely on statistical analysis of historical records of pumping and groundwater fluctuations will be unavailable

Method

The working group will apply general lessons learned from the Big Pine and Taboose/Aberdeen wellfields and adjust the models and techniques developed to accommodate site-specific conditions for all other wellfields. It is recognized that individual wellfields have site-specific considerations that may prevent direct transfer of methods from one wellfield to another. It is anticipated that site specific conditions may vary from wellfield to wellfield. For example, Lone Pine Wellfield does not have any vegetation monitoring site at this time. Vegetation monitoring sites have to be located as part of developing a groundwater management method for this wellfield; and groundwater pumping in Bishop Wellfield is currently managed according the terms of Hillside Decree.

Deliverables

The primary deliverable of this Task is the development of operational models for other wellfields similar to those developed under Tasks IA-1 and Task IA-2.

Anticipated Resources

This work will require access to hydrologic and vegetation data currently housed at LADWP and ICWD. Software necessary to complete this work is available at both agencies. The conduct of this task will require the use of the MODFLOW/EDYS models and associated software. It is anticipated that the resources of MWH Americas, Inc. will be required.

Schedule

One and a half years, assuming adequate resources are available.

Personnel

The task leader for LADWP is Saeed Jorat and Bob Harrington for Inyo County Water Department. Other staff may be assigned as necessary. It is anticipated that the services of the MWH Owens Valley project team will be required.

Budget

The budget for this task will involve staff time. No outside costs are required.

Approval for Release:

01/08/07
Project Manager, ICWD / Date

11/1/07
Project Manager, LADWP / Date