Implementation of the WFD in Sweden: Computer models for decision support

Report prepared for The Swedish Environmental Protection Agency
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Summary
The are two types of computer models that are important for watershed management. The first type are models for storage of information (data bases) that act as repositories for characterization of watersheds. Since the primary task of this type of model is information storage and access, there are advantages to using a standard model in a GIS format in all five water districts in Sweden. The second type of model supports watershed management decisions. These models may be linked directly to the first type of model or use data from this model for analytical purposes. These models are task specific. Each decision or scenario development requires a model which has been specifically developed to work with that particular decision or management problem. The output of these models are generally not compatible but rather can be considered to be ‘competitive’ models. Since models of this type are still at early stages of development, it would be an advantage to encourage the support of multiple models and not recommend a standard for all five water districts. The Water Framework Directive (WFD) timeline initially requires characterization of the district (2004) for which purpose the first type of model would appear to be adequate. The analytical requirements in the WFD do not need to be met until a later date (2009). This factor makes possible the parallel use of the second type of model for various decision support and scenario development in individual water districts over a several year period. This in turn may then be followed up with evaluation and comparison of these models and eventual recommendation of particular models for nationwide application based on experience with using these models.

Background
A working group set up by the European commission (WATECO) was charged with preparing a guidance document to adress the economic issues of the Water Framework Directive (WFD). The final document recommends the adoption of a three-step approach to implementation of the directive (WATECO, 2003):

Step 1: Characterization of Watersheds (by 2004)
- economic analysis of water uses
- project trends to 2015
- assess current level of cost recovery

Step 2: Identification of significant water management issues (by 2007)
- identify gaps in water status
  - no gap; estimate total costs of measures in place
  - gap; identify key pressures causing this gap

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Step 3: Assist with the identification of a cost effective programme of measures and economic impact of cost-recovery and incentive pricing (by 2009)

- no gap; assess cost recovery
- gap: identify potential measures, cost-effectiveness analysis, estimate total costs for proportionate measures, assess cost recovery

One of the important questions that should be addressed in following the three-step approach is whether there is an imperative that these steps be followed sequentially. This question becomes even more significant when considering decision support systems that may be used for working with management plans under the Directive, the subject of this report.

The report begins with a short characterization of different types of decision support systems and data base models including an analysis of the explicit and implicit requirements of models for computer support associated with implementation of the WFD. The next section looks at how the DPSIR model developed by the European Environmental Agency (EEA) can be used to analyze the need for different types of computer programs and tools for identifying, analyzing and storing information. The report concludes with a short description of generalized watershed models as well as agricultural sector models.

**Computer support for decision-making**

There are many types of computer support for decision-making. The two that are addressed in this report are a data base model for storing information and a DSS for working with data. In an idealized decision environment these types of program are compatible and complementary. An object oriented data base that is appropriate for information storage, for example in a GIS format, may also be used for the construction of scenarios based on the information stored in the data base. However, the structural requirements of the two types may differ.

An information data base does not have to be user friendly. It does need to be well defined so that information can be stored, retrieved and analyzed. DSS may be developed which retrieve information from the data base and use these pieces of information to estimate trends and develop prognoses or scenarios. This DSS does need to be user friendly and task oriented if it is to serve as a basis for local adaptation of information.

A fundamental difference inherent in the WFD as compared with formal response to other environmental issues is that in this case the resource (water) itself is assigned primacy. The assumption is that all human activities which utilize the resource or infringe on the quality of the resource should be identified and assigned costs associated with their impact on the resource. What this implies is that there is a normal state of the resource and that all deviations from this state are to be classified as impacts and in turn assigned economic value (cost recovery). However, the indicator values which define this normal state have not yet all been determined. For example, while hydrological balance may be a key indicator for defining the status of water in a river basin, a 'normal state' as indicated by the level of the water table is not defined. There seems to be an underlying belief that the relevant values for describing this state will be made more clear through the characterization of
watersheds which includes current status of the resource. Therefore there is a clear need for a data base system that stores information, a set of resource indicators, that may be used to describe the status of the resource at the river basin level.

There is also the need for characterization of the socio-economic forces which have an impact on the river basin as well as development of forecasting models which may include the use of scenarios for policy evaluation. Within the terminology of the WFD the concept of a baseline is also used sometimes to describe a business as usual scenario that may be used to evaluate other scenarios. The use of scenarios is perceived as a method for the development of river basin management plans. There needs to be a common starting point for development of the scenarios, the values of the indicators in the information data base. In addition there is a need for DSS which may be used to characterize changes in activities which in turn generate new scenarios. Since this means that the DSS are expected to be used in the development of management alternatives (the scenarios) then perhaps the appropriate place to start is with a description of the scenario development process.

Shoemaker (1995) describes the objective of scenario modeling as “to see the future broadly in terms of fundamental trends and uncertainties.” He goes on to recommend a 10-step process for developing scenarios (Figure 1). There are two facts which are noteworthy in Shoemakers’ 10-step process; the process is iterative and that quantitative evaluation is the last step before the actual scenarios are produced. The scenarios evolve through a conceptual process combined with information gathering to search for trends and identify uncertainties. DSS are based on trends and used to evaluate uncertainties.

**Figure 1. Shoemakers 10-step process for scenario development**

1. Define the scope
2. Identify the major stakeholders
3. Identify basic trends
4. Identify key uncertainties
5. Construct initial scenario themes
6. Check for consistency and plausibility
7. Develop learning scenarios
8. Identify research needs
9. Develop quantitative methods
10. Evolve toward decision scenarios

In conclusion it is perhaps useful to try to keep separate the need for an information storage system, the type of GIS model that will be used to characterize the watersheds, and the need for DSS which may be used to develop scenarios for management purposes. Keeping these two needs separate allows for parallel adoption and development and decreases modelling complexity. The expectation that a ‘meta-model’ can be developed that will both serve as a data base for river basin characterization and may be used to generate management scenarios places unrealistic demands on their realization and will slow down both processes.
Characterization of Watersheds and DPSIR model

<table>
<thead>
<tr>
<th>Figure 2. DPSIR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Driving forces of environmental change</strong> (e.g. industrial production)</td>
</tr>
<tr>
<td><strong>Pressures on the environment</strong> (e.g. discharges of waste water)</td>
</tr>
<tr>
<td><strong>State of the environment</strong> (e.g. water quality in rivers and lakes)</td>
</tr>
<tr>
<td><strong>Impacts on population, economy, ecosystems</strong> (e.g. water unsuitable for drinking)</td>
</tr>
<tr>
<td><strong>Response of the society</strong> (e.g. watershed protection)</td>
</tr>
</tbody>
</table>

The purpose of the DPSIR model is to structure the study and analysis of environmental problems. As noted above the WFD places the resource first and impacts after. However, the DPSIR structure can be adapted to follow the WFD implementation process rearranging the sequence of steps by starting with the state of the environment, following this up by looking at the pressures and the forces driving the process, evaluating the (economic) impacts and finally alternative responses that in turn affect the state of the environment and the start of a new analysis cycle. The first step is a combination of bio-physical (hydrolological, hydro-morphological and biological) characterization and identification of the economic (i.e. anthropogenic) activities in each river basin. This corresponds to the characterization of the basin in, for example, a GIS format as an object oriented data base. This should include not only the identification of the bio-physical status but also the activities in the river basin that have an impact on or are impacted by that status.

### Table 1

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Diversion and return</th>
<th>In situ use</th>
<th>Land use</th>
<th>Other sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Households</strong></td>
<td>-drinking water</td>
<td>-recreation</td>
<td>-housing</td>
<td>-transportation</td>
</tr>
<tr>
<td></td>
<td>-wastewater</td>
<td></td>
<td>-recreation</td>
<td></td>
</tr>
<tr>
<td><strong>Industry</strong></td>
<td>-production</td>
<td>-fishery</td>
<td>-plant</td>
<td>-transportation</td>
</tr>
<tr>
<td></td>
<td>-cooling</td>
<td>-transportation</td>
<td>-mining</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-wastewater</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>-hydropower</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Agriculture</strong></td>
<td>-production</td>
<td></td>
<td>-field crops</td>
<td>-transportation</td>
</tr>
<tr>
<td></td>
<td>-irrigation</td>
<td></td>
<td>-forestry</td>
<td></td>
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<tr>
<td></td>
<td>-livestock</td>
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</tbody>
</table>

The economic analysis of water uses explicitly calls for the valuation of activities (in the words of the WFD this includes water services, water uses and activities). However, the activities also can be categorized as falling under three different sectors; household, industry and agriculture. The total sum of these activities then represent the impact human activities place on water resources. In a previous report prepared for the Swedish EPA (Integrated appraisal for river basin management plans in Sweden, 2002-07-25), Marianne Löwgren identified data sources for use in watersheds (see Table 2 in the report) by category, sector, water use, indicator and source of information. Table 1 below is based on the classification by Löwgren but uses the three sectors suggested in the WFD guidance document (households, industry
and agriculture) in combination with the four categories used by Löwgren (water diversion and return, water use in situ, land use and other sources) to identify water uses, services and activities by sector.

As noted above, there is an informational storage need for indicators that represent each sector and category. For most of these combinations statistical information by sector is available in Sweden from SCB (see Löwgren, 2002-07-25) but needs to be adapted to river basin (sub-basin) boundaries. This may be possible using the rAps program currently under development (SCB/NUTEK). However, there is also a need to identify the resolution or scale that should be used for characterization purposes. This in turn will be determined not only by the bio-physical indicators chosen but also the socio-economic indicators. In addition, the use of DSS and scenario development place additional demands on information storage in the data base. An object oriented data base that could be presented in a GIS format would seem to fill all these purposes. As long as the information stored isn’t proprietary, the choice of platform or host for this purpose would not appear to be problematic with respect to limiting the choices for DSS to work with management planning. This is not true for the choice of DSS.

**Costs and cost recovery**
The WFD requires an ‘economic analysis of water uses’ and an assessment of the ‘current level of cost recovery’ by the year 2004 (Step 1 in the implementation process described above). Both of these tasks are related to the discussion of appropriate modeling choices. However, what is not clear is that what is really meant here is that the first phrase should specifically be interpreted theoretically while the emphasis in the second phrase emphasis should be on the word ‘current’. This is because at this stage all that can be done is to record current costs paid for water use and then theoretically analyze whether the activities being paid for are inclusive.

In Figure 3, a flow diagram is adapted from a report on the valuation of groundwater (Johansson et al, 2001). Even though the model was intended to illustrate the process of valuation of groundwater services, the flow is the same for surface water. What is particularly important here is that the first step requires the identification of ‘changes’ to water status (the ‘S’ in the DPSIR model) before valuation is possible. Step 2 in Figure 3 indicates that evaluation of the changes in water services must be performed before actual valuation can be started. In the terminology of the WFD this last step is ‘cost recovery’, are services paying for their use of the resource? Are users paying for the cost of resource recovery to the ‘unchanged’ status? These questions can only be answered after an assessment is made of the changes in quality/quantity and services provided. Which in turn requires that each change in management practice has to be uniquely identified and evaluated. This is where the use of decision support systems (DSS) comes in.
Complementary and competitive DSS
It may be helpful to think of two types of DSS. Those models which can be integrated (using some notion of common platform or data) where the modelled result provides a wide, non-conflicting output that may be evaluated and those models where the output is not consistent with output of other models. If the models are of the first type then several task-specific models can be used at the same time, in the same river basin and data can be exchanged between these independent (task-specific) models. The second type of model can also be used at the same time independently of each other but at some point in time a choice will need to be made over which model(s) will be used and which model(s) rejected.

Models which are competitive will in all likelihood develop rapidly because there is a strong incentive to demonstrate that the particular model is superior to its competitors and that it deserves to be the one chosen for a longer period of application. Therefore it may be advantageous to support the use of competitive models in different watersheds to encourage model development. This is particularly true when development of task-specific DSS are still not widely used. The water authorities in each district could compare the results of these competitive models and after a period of testing and evaluation (3-5 years?) recommend one of the models for nationwide use.

Task-specific DSS for sectoral categories
Each of the sectors identified in Table 1 is associated with a set of alternative management decisions. The availability of current models for computer support for decision-making needs to be evaluated for each of the sector categories. As described above there are two basic types of models for each of these categories; data base models for information storage and decision support systems. Löwgren (2002-07-25) identifies data sources which in turn may supply a GIS based system with information for models of the first type. The second type of model is more problematic because the specific decisions need to be modeled. For example from the first entry in the
lower left corner of Table 1 ‘production agriculture’, two economic models already exist for evaluating structural changes in the Swedish agricultural sector (CAPRI and SASM) in addition there are also farm level models available for evaluating changes in farm income on Scandinavian farms (LENNART, FASSET and ECECMOD). However, the limiting factor is the number of decision alternatives that may be evaluated using these models compared to the total number of decision alternatives that are of interest. For example, management alternatives to reduce the flows of phosphorus entering water from agricultural practices.

A provisional list of management options for reducing phosphorus loss from agriculture has been compiled in preparation for the 4th International Phosphorus Workshop (Wageningen, August 2004). The options are grouped under six headings:

A. reducing agricultural phosphorus input or increasing output
B. reducing soluble forms of phosphorus (leaching)
C. reducing mobilisation of particulate forms (erosion)
D. reducing phosphorus transport within field
E. reducing phosphorus transport in surface water
F. abating ecological consequences of eutrophication in surface water

Under heading A there are 10 individual management options described, under B. 19 options, under C. 23 options, under D. 13 options, under E. 10 options and finally under F. 6 options. This is a total of 81 options that need to be individually evaluated as management alternatives in a decision support system. The number of options is further complicated because these are just the measures themselves, methods (policies) for the implementation of these options need to be evaluated as well. These options are often combined in one or more policies and in addition, the implementation of a policy or management alternative will affect the outcome of other policies and management alternatives.

The farm decision support systems described above are considerably more limited in the number of nitrogen management alternatives which they may be used to evaluate (LENNART one policy option, FASSET three policy options and ECECMOD five policy options). Decision support models are not ‘black boxes’, they are constructed to evaluate a particular decision/policy or set of decisions/policies and to compare results. What this means is that they may only be used to evaluate questions that they are programmed to work with and each time a new question (management option/policy) is studied the model must be programmed to work with this question. These types of models are based on the questions they are designed to work with.

The partial list of individual models below represents both types of models, information data storage and decision support. The easiest way to differentiate between these types of model is whether or not the outputs are designed to be comparative or informational. It is difficult to identify which of the models are complementary and which are competitive. In part due to the fact that they may be partially complementary currently or may be made complementary with additional effort. Several of the models were suggestions from Oskar Larsson at the Swedish Environmental Protection Agency while the author included others. Any models which readers believe should have been listed below, were not omitted as a result of not being applicable but only as an oversight. The list is not construed to be comprehensive but rather is illustrative of the characteristics of some models that are currently in various stages of development. Aspects addressed in the description of the
models without regard to particular order are: model inputs, outputs, assumptions, shortcomings, principles, scale and type.

Generalized watershed models

WEAP (Water Evaluation and Planning System; GIS-based information storage system, water balance accounting, may be used as a platform for model-building. This model can be linked to DSS through spread sheets or through incorporation of assumptions, variables and relationships into the data base. The output is presented in a GIS format or as graphs and tables. What the model offers is a generic format for working with management options at any scale (sub-watershed to watershed). Because all the relationships must be defined and entered in the model or linked to the model, both natural science and economic variables may be incorporated. The model is available through licensing from the Stockholm Environmental Institute. More information at <www.sei.se>.

Watshman (Watershed Management System)\(^1\): Data base with some algorithms and data incorporated for calculating the effect of management options in Swedish watersheds. The program is designed for the management of nitrogen and phosphorus loading to surface water from point and diffuse sources. Economic variables are not included but may be combined with model outputs. The results may be imported to other watershed information systems, GIS-format for the model is under development. For more information see www.ivl.se/affar/miljo_it.

TRK (Transport — Retention — Källfördelning)\(^1\): Data-base describing Swedish land use (diffuse source) and point sources for nitrogen and phosphorus loading to surface water. The model was developed for reporting purposes and incorporates several process based natural science sub-models for calculating water balance and leaching coefficients. The model does not include economic variables but these may be combined with model outputs. The model uses submodels as inputs (HBV, HBV-N, SOILNDB, and coefficients for calculating phosphorus losses from agricultural production and nitrogen and phosphorus losses from forest and other land uses). For more information see <http://www-nrciws.slu.se/TRK/index.html>.

HBV-Np\(^1\): Developed for calculating nitrogen and phosphorus transport in a watershed. The model may be used for the development and analysis of scenarios and evaluation of recovery programs. The economic evaluation is based on cost estimates. The costs are not spatially site-specific generated but averages applied to a particular practice. However, it would be possible to import other types of socio-economic variables. The model is already based on a GIS platform which may be imported to other data bases or serve as a host for other data bases. For more information see www.smhi.se/sqn0106/if/hydrologi/hbv_np.htm.

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\(1\) For a comparison and evaluation of these models see the report “Påverkansbedömning för ytvatten enligt EG’s Ramdirektiv för vatten – tillgängliga metoder, verktyg och modeller samt utvecklingsmöjligheter för SMED&SLU” Slutrapport 2004-02-24. In Swedish. Author contact: Jessica Zakrisson (IVL), jessica.zakrisson@ivl.se
Fyrisåmodellen: Model developed for calculating nitrogen and phosphorus loading in Swedish watersheds. Individual watershed data must be entered (land use etc) for each area. The model does not include economic variables but these may be combined with model outputs. The model uses soil type and crop types, indexes for calculating leaching, lake area, atmospheric deposition of N, point source releases of N and P, individual septic leaching for N, time series for N concentration and transport in streams and hydrological flows. For more information contact: Mats Wallin, SLU, Institute for Environmental Analysis, mats.wallin@ma.slu.se.

rAps: Developed by Statistics Sweden (SCB) and the Swedish Business Development Agency (NUTEK) to work with Statistics Sweden's data base on a regional level (city, county or region). The model currently under development is designed to be used as a forecasting tool for regional development issues. The presentation of the statistical material (socio-economic variables) at a regional level makes this program interesting for use at a watershed level for tracking socio-economic statistics and including these in the development of management scenarios. The current program is a data base that may be accessed for use with Excel software. There has been discussion of resenting the statistical information in a GIS format as well. While the model currently works with politically defined regions it could be adapted to a region defined as a water district. Access to the data held by Statistics Sweden makes this a strong model for use as a data base model for water districts. However, the information in the data base is disaggregated from national and regional statistics and therefore is difficult to adapt to a very high spatial scale i.e. a site specific geographical location in the watershed. Since the information is both historical and currently updated it is of great use for working with scenario development. In addition, the material in the data base would be easy to export to other models. For more information see http://www.scb.se/templates/Standard24442.asp.

IWR-PLAN: Developed by the US Army Corps of Engineers to assist with the formulation and management of alternative watershed plans. Specifically designed for construction and evaluation of management scenarios. For more information see www.pmcl.com/iwrplan/.

Agricultural sector models
SASM (Swedish Agricultural Sector Model): A multi-regional, spatial equilibrium sector model designed to simulate the impacts on the agricultural sector of changes in markets, technology and policy. The output of the model is estimates of prices and quantities of inputs, farm products and processed products. The model uses a linear programming method to estimate the impact on the farm sector in general and on representative farm types in particular through the use of generalized farm production functions. The model does not include environmental variables but changes in natural science variables may be combined with the output of the model to evaluate the cost.

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1 For a comparison and evaluation of these models see the report "Påverkansbedömning för ytvatten enligt EG’s Ramdirektiv för vatten – tillgängliga metoder, verktyg och modeller samt utvecklingsmöjligheter för SMED&SLU” Slutrapport 2004-02-24. In Swedish. Author contact: Jessica Zakrisson (IVL), jessica.zakrisson@ivl.se
of management changes. For more information contact Lars Jonasson, LRF Konsult (model developer) at lars.jonasson@lantek-li.k.se.

CAPRI (Common Agricultural Policy Regionalised Impact Analysis): An economic simulation system developed by a network of European research institutes. Coincists of a disaggregated reional data base and an economic simulation model. Input to the model are primarily statistics from Eurostat that are assigned to agricultural production sectors in each region. The economic simulation combines expert input with the data base to develop outcomes based on market adjustment to prices and regulation. The purpose of the model is to study how the agricultural sector adapts to new information, inparticular adjustments to the CAP (Common Agricultural Policy) of the EU. The model has been used in several Swedish studies by the Swedish Institute for Food and Agricultural Economics (SLI). For more information see the following report from SLI which describes the model in more detail.
http://www.sli.lu.se/pdf/SLI_puMK4laktion20000401.pdf

LENNART: A dynamic DSS for evaluating the cost of implementing specific ‘best management practices’ on individual fields/farms. The model combines economic and natural science variables using input entered by the user. The user enters site specific characteristics and subjective evaluation of costs to calculate the income effect of participating in BMP programs. At this time a prototype model is available for estimating the cost and nitrogen leaching reduction of growing catch crops. The model currently only includes data for specific soil types and crop rotations in an area of southern Sweden. For more information contact Dennis Collentine, University of Gävle (one of the model developers) at dce@hig.se or see the prototype at http://neptunus.md.slu.se/NASTRA/BAK/index.html.

FASSET: Developed by a group of researchers from three Danish institutes. The model uses linear programming to analyze the impact on farm income and the environment to new agricultural policies. The model has been used to assess the development on four case farms of three policy scenarios. The output are changes in farm income and changes in N-leaching. An article describing an application of the model may be seen at http://www.sjfi.dk/Publikationer/Andre-artikler/Agrsystems.pdf.

ECECMOD: a Norwegian interdisciplinary research team developed this model to analyse environmental problems related to mineral emissions from agriculture. The scale of the model is the sub-watershed. The analyses are driven by a set of input data defining farm structures, soil and weather conditions in the actual watershed. The economic model uses linear programming to optimize the adjustment to new policies at the farm level. Type farms are developed to represent the farms in the watershed and a process model (SOIL-NO) is used to estimate the effect of policies on nitrogen leaching from the watershed. For more information contact Per Kristian Rorstad, Agricultural University of Norway (one of the model developers) at per.rorstad@ios.nh.no.

PRduct (Pollution Reduction Impact Comparison Tool): This is a software program for the evaluation of alternative agricultural and non-agricultural pollution reduction strategies at the watershed level. The tool was designed as a DSS to be used with the
AVGWLF watershed modelling system (http://www.avgwlf.psu.edu/overview.htm). The AVGWLF is an information storage system in a GIS format developed by a group at Pennsylvania State University with support from the Pennsylvania Department of Environmental Protection to simulate runoff, sediment, and nutrient (N and P) loadings from a watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model which uses daily time steps for weather data and water balance calculations. The PRedICT model allows the user to create management scenarios. Inputs may be compiled manually but if associated with the AVGWLF system can be imported directly. It is possible to compare six agricultural management systems with the model where practices and costs are assigned to load use in the watershed. In addition it is possible to include three urban management alternatives. The model is based on average loading and cost coefficients. The outputs of the model are estimated load reductions and costs for the reductions. For more information see http://www.avgwlf.psu.edu/predict.htm or contact Barry Evans, Pennsylvania State University, (one of the model developers) at bmel@psu.edu.

Conclusions
Implementation of the WFD with respect to economic analysis is composed of two parts; characterization of the watershed including current recovery costs and evaluation the cost efficiency of alternative management plans. Computer support for the first part should be in the form of information storage (a data base). An appropriate platform for this purpose is a GIS format as this allows for access to the data base for input from different sources of information as well as provides input for task specific DSS, the second part of the implementation program. There are numerous advantages to agreeing on a standard information storage model that can be used in all five water districts in Sweden. Since the hydrological and other natural science relationships are more complex and site specific than the socio-economic parameters the choice for this standard is best left up to consultation with institutes and experts within this area.

With respect to the socio-economic information the system being developed by SCB and NUTEK (rAPs) seems to have advantages as an information storage system. The model is built on statistics already gathered by SCB. The model regionalizes these statistics. Adjusting the regions to correspond to the boundaries of the water districts and organizing the information in a GIS format for incorporation into a comprehensive watershed characterization program are areas that still need to be developed.

The second type of model, task specific DSS, are due to their function highly individualized. There are not ‘black box’ types of models. The decision support needs to be a part of model development. Each specific decision being evaluated must be programmed into the model. This is true for scenario development as well. These types of models can only process the information that they are programmed to work with. The ‘proposed change in management practice’ described in Figure 3 is the starting point for valuation of the change. The management practice needs to be quantifiably related to water quantity/quality and in turn these changes need to be quantifiable related to water services provided before analysis of economic efficiency or cost recovery is possible. Since models of this type are designed to work with
specific questions/decisions the development of these types of models is possible only
after the management alternatives have been formulated at the watershed district
level. One of the principles of the WFD is that local management of water resources
will result in different priorities in the individual districts. Consequently, it is
important that DSS are developed/adapted to local management issues. DSS model
development and support is appropriate at the water district level. If all five of the
water districts in Sweden follow this approach and develop independent management
strategies that rely on task specific DSS this will act as a catalyst and spur model
development. Sharing information between districts will in the long run establish
certain DSS as standard applications. Conversely, choosing national standards for
DSS at an early stage will diminish the development of DSS and management plans
adapted to local priorities.

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