PROPOSED MINIMUM WATER LEVEL CRITERIA FOR THE LOWER WEST COAST AQUIFER SYSTEM WITHIN THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT

South Florida Water Management District

Water Supply Division

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INTRODUCTION

This report documents the methods and technical criteria used by staff of the South Florida Water Management District (SFWMD or District) to develop minimum aquifer levels (MALs) for the Lower West Coast (LWC) aquifers. These MALs are being developed pursuant to the requirements contained within the "Florida Water Resources Act", and specifically, Sections 373.042 and 373.0421, F.S., as part of a comprehensive water resources management approach geared towards assuring the sustainability of the water resources. The proposed MALs are not a “stand alone” resource protection tool; but should be considered in conjunction with all other resource protection responsibilities granted to the water management districts by law. This includes consumptive use permitting, water shortage management, and water reservations. A model framework identifying the relationship between these tools is discussed in this document and was used in developing the MALs. In addition, the District has completed the Lower West Coast Water Supply Plan (LWCWSP) pursuant to Chapter 373.0361 F.S., which identifies potential future supplies and demands and provides recommendations for water resource development projects to provide for reasonable demands of humans and the environment over the next twenty years. The LWCWSP also includes a recommendation for the establishment of the minimum aquifer levels and outlines a prevention strategy pursuant to the requirements of law.

Establishing *minimum* levels alone will not be sufficient to maintain a sustainable resource or protect it from significant harm during the broad range of water conditions, which occurs in South Florida. The necessary hydrologic/hydrogeologic regime for sustainability of the LWC aquifer system must be defined and implemented through the use of other water resource protection tools including planning and regulatory efforts that will be implemented over time to expand and protect water supply and distribution. The proposed minimum levels for the LWC aquifers will be used by the District, and other agencies, as regional indicators that significant harm to the resource may be imminent unless management actions are taken. In such cases, a regional response would occur, such as mandatory water restrictions and/or shifting to alternative supplies. Development of minimum level criteria for the aquifer system as a means to protect the aquifers from significant harm should not change the application of existing drought management methods and criteria that affect operation of individual wellfields.

This document represents a formal step in the process to establish a MAL for LWC aquifers. This report includes 1) a description of the framework for determining MFLs based on the best available information (this approach may be applied to other surface and ground waters within the District) and 2) development of a technical methodology and basis for establishing MALs for LWC aquifers. Other steps in the formal MAL establishment process include 1) an independent scientific peer review of this document pursuant to Section 373.042, F.S., 2) rule drafting, 3) governing board policy review and approval and 4) final rulemaking. All of these steps are conducted under the review and participation of the public through noticed public meetings.

Implementation of the MALs is achieved after the rule becomes effective and includes execution of the prevention strategy through fulfilling the recommendations contained in this report including application of the District's water shortage rules as conditions warrant.

The first chapter of this report provides the legal and policy basis for establishing a minimum flow or level. Chapter 2 describes the geographic setting, the water resources at risk, and functions that these resources serve and that need to be protected. Chapter 3 documents the methods and data that were used to establish significant harm criteria for the different areas, resources and functions. Chapter 4 describes the specific hydrologic criteria, with frequency, duration, and depth components, that were developed to indicate the point at which significant harm occurs. Chapter 4 also includes an analysis of the proposed minimum aquifer levels to determine if the criteria is or will be exceeded in the future. Based on this analysis, a recovery or prevention plan will be outlined that will protect the aquifers from exceedances of the criteria. Conclusions and recommendations are presented in Chapter 5. A list of selected references is included at the end of the report. Copies of these documents were made available to the scientific peer review panel.

LIST OF ABBREVIATIONS AND ACRONYMS

BOR	Basis of Review
CUP	Consumptive Use Permit
District	South Florida Water Management District
ET	evapotranspiration
F.A.C.	Florida Administrative Code
FAS	Floridan Aquifer System
F.S.	Florida Statutes
IAS	Intermediate Aquifer System
LEC	Lower East Coast
LOC	Level of Certainty
LWC	Lower West Coast
LWCWSP	Lower West Coast Water Supply Plan
MALs	Minimum Aquifer Levels
MDL	Maximum Development Level
MFLs	Minimum Flows and Levels
NGVD	National Geodetic Vertical Datum
SAS	Surficial Aquifer System
SFWMD	South Florida Water Management District
SWFS	Southwest Florida Study
SWFWMD	Southwest Florida Water Management District
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

CHAPTER 1

Basis for the Establishment of Minimum Flows and Levels

This chapter provides an overview of the legislation that authorizes the water management district to establish minimum flows and levels. It also provides for the factors and considerations that need to be addressed in the process of establishment. An outline of South Florida Water Management District's policies on water resource protection authorities are also included to allow the reader to understand the role MFLs play with respect to the holistic approach to achieving sustainability used by this District.

I. Legal and Policy Bases for Establishment of Minimum Flows and Level

Florida law requires the water management districts to establish MFLs for surface waters and aquifers within their jurisdiction [Section 373.042(1), F.S.]. The minimum flow is defined as the "...limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." The minimum level is defined as the "limit at which further withdrawals would be significantly harmful to the water resources of the area." [Section 373.042(1)(a)-(b), F.S.]. The statute further directs the water management districts to use the best available information in establishing a MFL level. Each water management district must also consider, and at its discretion may provide for, the protection of non-consumptive uses in the establishment of MFLs. In addition, a baseline condition for the protected resource functions must be identified through consideration of changes and structural alterations in the hydrologic system.

Each surface water body or aquifer serves an array of water resource functions. These functions must be considered when establishing a MFL as a basis for defining significant harm. The term "water resource" is used throughout Chapter 373. Water resource functions protected under Chapter 373 are broad, as illustrated in Section 373.016, F.S., and include flood control, water quality protection, water supply and storage, fish and wildlife protection, navigation, and recreation.

The State Water Resource Implementation Rule, Section 62-40.405, F.A.C, outlines specific factors to consider when establishing MFLs including protection of water resource natural seasonal changes in water flows or levels, environmental values associated with aquatic and wetland ecology, and water levels in aquifer systems. Other specific considerations include:

- Fish and wildlife habitat and the passage of fish
- Maintenance of freshwater storage and supply
- Water quality
- Estuarine resources
- Transfer of detrital material
- Filtration and absorption of nutrients and pollutants

- Sediment loads
- Recreation in and on the water
- Navigation
- Aesthetic and scenic attributes

This policy determination as to which resource functions to consider in establishing MFLs is within the Governing Board's purview. This analysis requires a comprehensive look at sustainability of the resource itself as well as its role in sustaining overall regional water resources. Chapter 3 of this MFL document provides a detailed description of the relevant water resource functions of the LWC Aquifer System.

Once the water resource functions to be protected by a specific minimum flow or level have been identified, the baseline resource conditions for assessing significant harm must be identified. Considerations for making this determination are set forth in Section 373.0421(1)(a), F.S., which requires the water management districts, when setting a MFL, to consider changes and structural alterations that have occurred to a water resource. Likewise, Section 373.0421(1)(b), F.S., recognizes that certain water bodies no longer serve their historical function and that recovery of these water bodies to historical conditions may not be feasible. These provisions are discussed in Chapter 3, to examine their applicability to the minimum levels that are proposed for the LWC aquifers.

II. What level of protection is provided by the MFL standard of *significant harm*?

The overall purpose of Chapter 373 is to ensure the sustainability of water resources of the state (Section 373.016, F.S.) To carry out this responsibility, Chapter 373 provides the District with several tools with varying levels of resource protection standards. MFLs play one part in this framework. Determination of the role of MFLs and the protection that they offer, versus other water resource tools available to the District, is discussed below.

Each water resource protection standard must fit into a statutory niche to achieve this overall goal. Pursuant to Parts II and IV of Chapter 373, surface water management and consumptive use permitting regulatory programs must prevent **harm** to the water resource. Water shortage statutes dictate that permitted water supplies must be restricted from use to prevent **serious harm** to the water resources. Other resource protection tools include reservation of water for fish and wildlife, or health and safety (Section 373.223(3)), and aquifer zoning to prevent undesirable uses of the ground water (Section 373.036). By contrast, MFLs are set at the point at which **significant harm** to the water resources, or ecology, would occur. The levels of harm cited above, harm, significant harm, and serious harm, are relative resource protection terms, each playing a role in the ultimate goal of achieving a sustainable water resource.

The conceptual relationship among the terms harm, significant harm, and serious harm proposed by the District is shown in **Figure 1**.

The general narrative definition of significant harm proposed by the District (SFWMD 2000) for the water resources of an area is as follows:

> **Significant harm** *is defined as a loss of specific water resource functions that take multiple years to recover, which result from a change in surface water or ground water hydrology.*

The resource protection criteria used for Consumptive Use Permitting (CUP) are based on the level of impact that is considered harmful to the water resource. These criteria are applied, to various resource functions, to establish the range of hydrologic change that can occur without harm. The hydrological criteria include level, duration, and frequency components and are used to define the amount of water that can be allocated from the resource. Saltwater intrusion, wetland drawdown, aquifer mining, and pollution prevention criteria in Chapter 40E-2, F.A.C., all together define the harm standard for purposes of consumptive use allocation.

These harm criteria may be applied using climate conditions that represent an assumed level of certainty. The level of certainty used in the Lower West Coast, Lower East Coast, and Upper East Coast Regional Water Supply Plans is a 1-in-10 year drought frequency, as defined in the District's permitting rules. In addition, the 1-in-10 year drought level of certainty is the water supply planning goal that was established in (Section 373.0361, F.S.). The standard for harm, as used in the CUP process, is considered to be the point at which adverse impacts to water resources cannot be restored within a period of one to two years of average rainfall conditions. These short-term adverse impacts are addressed for the CUP program, which calculates allocations to meet demands for use during relatively mild, dry season conditions, defined as the 1-in-10 year drought event. See the discussion regarding other resource protection tools associated with CUP in Chapter 4.

Pursuant to Section 373.246, F.S., water shortage declarations are designed to prevent serious harm from occurring to water resources. Serious harm, the ultimate harm to the water resources that was contemplated under Chapter 373, F.S., can be interpreted as long-term, irreversible, or permanent impacts. Declaration of water shortages is the tool used by the Governing Board to prevent serious harm. When drought conditions exist, water users, typically for irrigation or outside use, increase the amount of withdrawals to supplement water not provided by rainfall. In general, the more severe the drought, the more supplemental water is needed, This feature, combined with the lack of recharge from rainfall, result in the need for progressively restrictive cutbacks until normal rainfall and water levels return.

The District has implemented its water shortage authority by restricting consumptive uses based on the concept of shared adversity between users and the water resources (Chapter 40E-21, F.A.C.). Under this program, different levels or phases of water shortage restrictions are imposed relative to the severity of drought conditions. The four phases of the current water shortage restrictions are based on the relative levels of risk posed to resource conditions leading up to the serious harm impacts. Under the SFWMD's program, Phase I and II water shortages are primarily designed to prevent harm, such as localized, but recoverable, damage to wetlands or short-term inability to maintain water levels needed for restoration. Actions that may be taken include reducing water use through conservation techniques and minor use restrictions, such as car washing and lawn watering. Phases III and IV, however, require use cutbacks that are associated with some level of economic impact to the users, such as agricultural irrigation restriction.

III. MFL Recovery and Prevention Strategy

Upon establishment of the MFL through rulemaking, it is implemented through a multifaceted recovery or prevention strategy, developed pursuant to Section 373.0421(2), F.S. A minimum aquifer level prevention strategy was developed for the LWC Aquifer System in the Lower East Coast Regional Water Supply Plan (approved May 2000) and the Lower West Coast Regional Water Supply Plan (approved April 2000), and will be implemented following establishment of the MFL.

Section 373.0421(2), F.S., provides that if it is determined that water flows or levels will fall below an established MFL within the next 20 years or is presently below the MFL, the water management district must develop and implement a recovery or prevention strategy. The twenty-year period should coincide with the regional water supply plan horizon for the subject area and the strategy is to be developed in concert with that planning process.

The goal of the recovery and prevention strategy is to continue to provide sufficient water supplies for all existing and projected reasonable-beneficial demands, while taking actions to achieve the MFL criteria. If the existing level is below the MFL, recovery to the MFL must be achieved "as soon as practicable." Many different factors will influence the water management district's capability to implement the proposed actions in a timely manner, including funding availability, detail design development, permittability of regulated actions, land acquisition, and implementation of updated permitting rules.

Depending on the existing and projected flows or levels, from a regulatory standpoint, either water shortage triggers, interim consumptive use permit criteria, or both, may be recommended in the recovery and prevention strategy. The approach varies depending on whether the MFL is currently exceeded or not, and depending on the cause of the MFL exceedances, e.g., consumptive use withdrawals, poor surface water conveyance facilities or operations, over drainage, or a combination of the above.

Incremental measures to achieve the MFL must be included in the recovery and prevention strategy, including a timetable for a provision of water supplies necessary to meet reasonable beneficial uses. Such measures include development of additional water supplies and conservation and other efficiency measures. These measures must make water available "concurrent with to the extent practical, and to offset, reductions in permitted withdrawals, consistent with …[Chapter 373]." The determination of what is "practical" in identifying measures to concurrently replace water supplies will likely be made through consideration of economic and technical feasibility of potential options. Additional information about the specific prevention strategy recommended for the LWC Aquifer System is provided in Chapter 4.

IV. Process Steps and Activities

The process for establishing a minimum aquifer level for the LWC aquifers can be summarized as follows:

1. Through the development of the Lower West Coast Regional Water Supply Plan, the Lower East Coast Regional Water Supply Plan and concurrent staff research and analysis a methodology and technical basis for establishment of the MAL was developed.
2. Further public consideration of a technical basis and methodology for establishing the MAL and review of the first draft of the rule was conducted during rule development workshops in August 2000.
3. A scientific peer review of the MAL document will be conducted during September 2000 to verify the technical criteria pursuant to Section 373.0421(2), F.S.
4. In October 2000 revisions to the MAL document recommended by the panel, as appropriate, will be incorporated into the criteria.
5. A final rule draft will be presented to the Governing Board for review and public comment. Staff will seek authorization to publish the rule draft in the Florida Administrative Weekly in December 2000.
6. Barring receipt of a petition for a rule challenge, the Governing Board will consider adoption of the final rule. Should a petition be received, an expedited administrative hearing will be conducted to resolve issues with the proposed rule draft.

CHAPTER 2

Ground Water Resources within the Lower West Coast Planning Area

The hydrogeology of South Florida is diverse. It includes aquifers which are confined (in which ground water is under greater than atmospheric pressure and isolated from vertical recharge), semi-confined (having some vertical recharge), and unconfined (ground water is at atmospheric pressure and water levels correspond to the Water Table). Within an individual aquifer, hydraulic properties and water quality may vary both vertically and horizontally. Because of this diversity, ground water supply potential varies greatly from one place to another. This chapter contains a generalized description of the groundwater resources of the study area and presents information relevant to the establishment of minimum aquifer levels. For a more detailed description of the hydrogeology of the area, along with addition data, the reader is directed to the references included in the end of this report.

The three major aquifer systems: the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS) and the Floridan Aquifer System (FAS) are described on Figure 2 and 3. The generalized aquifer characteristics summarized by county are included on Tables 1 through 5. Maps showing the structure top elevation, hydraulic conductivity/transmissivity, are included on Figures 4 through 10.

I. Surficial Aquifer System

The SAS may be divided into two aquifers, the Water Table and Lower Tamiami, which are separated by leaky confining beds over much of the area. In northern Lee County, where the confining beds are absent or insignificant, the Lower Tamiami is not a separate aquifer but part of the unconfined Water Table aquifer. The thickness of the SAS ranges from more than 200 feet in central and southern Collier County to less than 20 feet along the Caloosahatchee River in eastern Lee and Hendry counties.

The Water Table aquifer includes all sediments from land surface to the top of the Tamiami confining beds. Within Lee County, four major public water supply wellfields, all located in areas where the confining beds are absent, pump water from the Water Table aquifer. These are Lee County Utilities (Corkscrew Wellfield and Green Meadows Wellfield), Gulf Utilities, and the city of Fort Myers. The aquifer also furnishes irrigation water for many uses, including vegetables, nurseries, and landscape irrigation. In Hendry County, the Water Table aquifer is generally used only where no suitable alternative is available, though it may yield copious quantities of water in isolated areas. It produces good quality water, except in areas near LaBelle and parts of the coast, that have high concentrations of chlorides and dissolved solids, and isolated areas with high iron concentrations.

The Lower Tamiami aquifer is the most prolific aquifer in southeast Hendry and all of Collier counties. The Lower Tamiami aquifer supplies drinking water to Bonita Springs**,** Collier County, City of Naples, Immokalee utilities as well as meeting the demands of most landscape, recreational and agricultural irrigation wells. Salt water occurs within the aquifer along the Lee and Collier coastlines. As a result, consumptive use withdrawals have been carefully managed and the interface has remained stable for more than 15 years. Remnant brackish depositional water occurs within the aquifer in localized areas where 1) groundwater flow divides occur that resist flushing and 2) in low permeable basal sediments that also resist freshwater flushing.

II. Intermediate Aquifer System

The IAS consists of five zones of alternating confining and producing units which are further described in other District publications (Knapp et al., 1984, and Smith and Adams, 1988;). The two producing zones, which comprise the IAS, include the Sandstone and Mid-Hawthorn aquifers.

The Sandstone aquifer has variable thickness. It averages over 100 feet near Immokalee and portions of central Lee County, but pinches out to the south around Alligator Alley, to the northwest in Cape Coral, and to the east in the middle of Hendry County. The productivity of the Sandstone aquifer is highly variable. It provides all of the water withdrawn by the Lehigh Acres Public Water Supply Wellfield and a portion of that withdrawn by the Lee County Corkscrew and Green Meadows wellfields. In western Hendry County, where the Lower Tamiami aquifer is absent, it is an important source of water for agricultural irrigation, but is utilized near capacity in support of large scale agricultural operations. This high degree of utilization manifests itself during droughts when domestic centrifugal wells loss service due to low water levels. The Sandstone has no source of saline water and receives recharge as vertical seepage from overlying aquifers.

Although present throughout the LWC Planning Area, the Mid-Hawthorn Aquifer is consistently low yielding and characterized with low storativity and low leakance. Its thickness is variable and relatively thin (it rarely exceeds 80 feet). This variability, combined with the presence of interbedded low permeability layers, results in low productivity of the aquifer. Water quality in central Lee County, the structural high for the aquifer, is excellent. As a result, the aquifer is used extensively here for domestic potable and irrigation use. Due to the low yield and high use, the potentiomentric surface of the Mid-Hawthorn has declined as much as eighty feet over the last thirty years without measurable changes in water quality. Where the aquifer dips to the south and west, salinity levels increase (chloride concentrations of 300 to 600 mg/l). Despite the higher salinity levels, the aquifer is continuing to experience increasing demands in southern coastal Lee County where the other shallow fresh water aquifers are not permitable due to saltwater constraints. As a result, groundwater levels within the Mid-Hawthorn aquifer in Lee County are approaching the top of the aquifer in some localized areas.

The Mid-Hawthorn aquifer formerly provided water for the city of Cape Coral and the Greater Pine Island water utilities. However, its limited water-producing characteristics made

it an unreliable source. Both utilities have been forced to develop other sources. It is also used for domestic self-supply in those areas of Cape Coral not served by city water and for small water utilities north of the Caloosahatchee River. Elsewhere the aquifer is used only occasionally for agricultural irrigation.

III. Floridan Aquifer System

The FAS, which underlies all of Florida and portions of southern Georgia and Alabama, contains several distinct producing zones which are described by Wedderburn et al., 1982. Although it is the principal source of water in Central Florida, the FAS yields only non-potable water throughout most of the LWC Planning Area. The quality of water in the FAS deteriorates southward, increasing in hardness and salinity. Salinity also increases with depth, making the deeper producing zones less suitable for development than those near the top of the system.

Developments in desalination technology have made treatment of water from the upper portion of the FAS feasible where chloride concentrations are not prohibitively high. The most productive zones are the lower Hawthorn and Suwannee aquifers. Currently, several utilities including the city of Cape Coral, Greater Pine Island, Collier County, Marco Island Utilities, and Island Water Association (Sanibel), obtain water from the lower Hawthorn or Suwannee aquifers. Elsewhere, the aquifers supply only a few agricultural irrigation wells. Improvements in desalination treatment technology will make development of these aquifers increasingly feasible; continuing increases in the demand for water in the LWC Planning Area, moreover, will make it necessary. Portions of the producing zones may also have potential for use in ASR projects.

In the deeper producing zones of the FAS, there are areas of extremely high transmissivity, known as "boulder zones." Although they are not used as supply sources within the LWC Planning Area due to the high salinity and mineral content, these formations may serve other purposes. Some areas of the boulder zones have been used as disposal areas for treated wastewater effluent or residual brines from the desalination process.

IV. Surface Water/Ground Water Relationships

In the preceding sections, surface water and ground water resources have been addressed as separate entities. In many ways, however, they are highly interdependent. The construction and operation of surface water management systems affect the quantity and distribution of recharge to the SAS. Surface water management systems within the LWC Planning Area function primarily as aquifer drains, since the ground water levels generally exceed the surface water elevations within the LWC Planning Area. The Caloosahatchee River and the Gulf of Mexico act as regional ground water discharge points (Wedderburn et al., 1982). Ground water seepage represents significant inflows to the Caloosahatchee, Orange, Imperial, and Estero rivers as well as base flows to wetland and slough systems. During the wet season, some recharge to the SAS may occur from drainage canals, small lakes such as Lake Trafford and low lying areas where stormwater levels may temporarily exceed local ground water levels (Knapp, 1984; Smith and Adams, 1988). Surface water management systems also impact

aquifer recharge by diverting rainfall from an area before it has time to percolate down to the Water Table. Once diverted, this water may contribute to aquifer recharge elsewhere in the system, supply a downstream consumptive use, or it may be lost to evapotranspiration (ET) or discharged to tide.

Recharge to the Water Table is provided by percolation of rainfall. The vertical movement of ground water from the Water Table in turn provides recharge to the underlying Lower Tamiami and Sandstone aquifers. This is represented on a large scale by similarities between regional potentiometric maps of the three aquifers during the 1970s and early 1980s (Wedderburn et. al., 1982). The evidence of vertical recharge is also demonstrated on a local scale where clustered monitor wells show a downward gradient across the three aquifers. However, this vertical connection is not very great (except when confining beds are absent) as evidenced by more recent water level data between layers. During the early 1980s, the water level differences between the Water Table aquifer and the Sandstone aquifer in central Lee County were approximately five feet at any given time. However, as consumptive uses of the Sandstone began to appear and increased the differences between the two aquifers grew in magnitude (to over twenty feet at times) and also showed time lags between hydrologic events. This suggests that significant confinement exist between the units, which provide buffering from withdrawals within the semi-confined aquifers.

The Sandstone Aquifer comes into direct contact with the SAS northeast of Immokalee (Smith and Adams, 1988), In those areas the Sandstone aquifer responds almost immediately to rain events, but the aquifer is receiving the water through the SAS and it does not have direct contact with surface water systems. The remainder of the IAS is not hydraulically connected to surface water.

The potentiometric surface of the Mid-Hawthorn aquifer shows that this unit is recharged by the underlying FAS. This is supported by pre-development water level data that showed the Mid-Hawthorn free flowed at land surface (an upward gradient). This recharge pattern is also supported by the characteristic of the water quality. Water from both the FAS and the Mid-Hawthorn are sodium chloride waters while water from the shallower semi-confined aquifers are calcium bicarbonate type waters (Knapp et. al. 1984).

The FAS is not hydraulically connected to surface water within the LWC Planning Area. Recharge to the system occurs as lateral movement from the recharge area in central Florida. As a result of this very slow process, the depositional waters have not yet been flushed from the system and the waters are salty. Because the flow rates are so low, the water quality is generally stratified with higher levels of salinity occurring with depth. When using the FAS water for irrigation, it is usually diluted with surface water to achieve an acceptable quality for use. Consequently, surface water availability for dilution purposes can be a limiting factor on the use of FAS water. However, because the system is hydraulically isolated from the surface, the FAS is drought proof and won't cause wetland impacts. This factor, combined with improvements in the desalting technology and the hundreds of feet of available brackish water, has made the FAS an attractive source for public water supply and aquifer storage and recovery systems.

Table 1: Ground Water Systems in Charlotte County

Aquifer System	Aquifer Unit	Thickness (Feet)	Water Resource Potential
Surficial Aquifer System	surficial Aquifer	0-70	Aquifer productivity is variable. Most wells yield less than 50 gpm, but can range as high as 600-700 gpm in wells tapping the Caloosahatchee marl in southeastern Charlotte County.
Intermediate Aquifer System	Sandstone Aquifer/ Mid- Hawthorn Aquifer	70-260	Low yield, fresh water. Important source for domestic and irrigation wells in southeastern Charlotte County.
Florida Aquifer System	Lower Hawthorn Aquifer/ Upper Tampa Aquifer	150-300	Widely used for irrigation, but requires desalination treatment for potable use. Most productive zones lies
	Suwannee Aquifer	200-300	Most productive aquifer in Charlotte County, but water requires desalination treatment for potable uses. Water quality deteriorates from east to west and with depth.
	Ocala Group	200-300	

Table 2: Ground Water Systems in Collier County

Aquifer System	Aquifer Unit	Thickness (Feet)	Water Resource Potential
Surficial Aquifer System	Water Table Aquifer	20-100	The Water Table and the Lower Tamiami aquifers are the most productive sources in the County. Excellent quality water except for isolated areas with high iron content. Potential for saltwater intrusion in coastal areas. In areas where the confining zone is absent, there is direct hydraulic connection of the Lower Tamiami and the Water Table Aquifer.
	Lower Tamiami Aquifer	40-180	
Intermediate Aquifer System	Sandstone Aquifer	0-110	Yields large amounts of fresh water in the northern portion of the county but is absent south of Alligator Alley. Suitable for mostly agricultural uses.
	Mid-Hawthorn Aquifer	60-120	Aquifer is low yielding and produces poor quality water. Suitable only for small irrigation uses.
Florida Aquifer System	Lower Hawthorn/ Suwannee Aquifer	100-300	Capable of high yields but requires desalination treatment. Used in Aquifer Storage Recovery projects and for potable supply (desal).

Table 3: Ground Water Systems in Glades County

Aquifer System	Aquifer Unit	Thickness (Feet)	Water Resource Potential
Surficial Aquifer System	surficial Aquifer	20-100	Low yield in most areas for private domestic supply, but water quality is poor near Lake Okeechobee.
Intermediate Aquifer System	Sandstone Aquifer/ Mid- Hawthorn Aquifer	90-230	Adequate in most areas for private domestic supply and too small to moderate irrigation.
Florida Aquifer System	Lower Hawthorn Aquifer/ Suwannee Aquifer	500-1,400	Aquifer is under flowing artesian conditions throughout Glades County. The aquifer is highly productive. Productivity generally increases with depth: however, chloride, TDS, and sulfate concentrations increase with depth throughout the county. Aquifer is unsuitable for irrigation in southern Glades County.

Table 4: Ground Water Systems in Hendry County

Aquifer System	Aquifer Unit	Thickness (Feet)	Water Resource Potential
Surficial Aquifer System	Water Table Aquifer	0-100	Productivity varies widely. High iron content and color. Used for agricultural irrigation in SE County
	Lower Tamiami Aquifer	0-135	Most productive aquifer in Hendry County. Heavily used in the southeast county area. Thin or nonexistent in the northern and western portions of the county.
Intermediate Aquifer System	Sandstone Aquifer	0-120	Occurs in western Hendry County. High quality but moderate yield. Heavily used in this area resulting in significant reductions in potentiometric head.
	Mid-Hawthorn Aquifer	Insufficient Data	Limited occurrence in Hendry County. Very low productivity; moderate to high salinity, water quality most suitable for most small irrigation uses.
Florida Aquifer System	Lower Hawthorn/ Suwannee Aquifer	No Data	Little is known about the Floridan in Hendry County. It is believed to be capable of producing large volumes of saline water through flowing wells. Water is suitable for irrigation with blending.

Table 5: Ground Water Systems in Lee County.

Aquifer System	**Aquifer Unit**	**Thickness (Feet)**	**Water Resource Potential**
Surficial Aquifer System	Water Table Aquifer	20-80	Yields moderate amounts of high quality water. Susceptible to saltwater intrusion nears the coast although yield along the coast is low.
Intermediate Aquifer System	Lower Tamiami Aquifer	0-140	Absent from northern Lee County. Where present, yields moderate to large amounts of high quality water. Contains saltwater along SW Lee County coastline where no new demands are being permitted from this source.
	Sandstone Aquifer	0-110	Used extensively for agriculture and potable supply in east central Lee County. Moderate yield with high quality water, low leakancce. Large scale drawdowns exist.
Florida Aquifer System	Mid-Hawthorn Aquifer	40-120	Yields small quantities of good quality water in Cape Coral and central Lee County. Low yield storativity and leakance. Used extensive for domestic self supply and minor irrigation. Drawdowns exceed 80 feet.
	Lower Hawthorn/ Suwannee Aquifer	150-300	Capable of high yields but requires desalination treatment. Well suited for Aquifer Storage and Recovery systems and public water supply via desalinization.

CHAPTER 3

ANALYSIS OF SIGNIFICANT HARM FACTORS

This chapter contains information used by staff to formulate recommendations for minimum aquifer level for aquifers in the Lower West Coast planning area. It consists of a summary of technical information that was considered within the statutory guidelines provided the districts in the establishment of minimum levels. More detailed and extensive data on the aquifer characteristics and use are available in the selected references included at the end of this report.

I. Consideration/Exclusions

As discussed in Chapter 1, when establishing minimum flows and levels, the Governing Board shall consider changes and structural alterations to watersheds, surface waters and aquifers and the effects such changes have on the hydrology of the affected water body. In addition, the legislature also recognizes that certain water bodies serve their historical hydrologic functions and that setting an MFL based on its historical condition may not be appropriate.

Staff has evaluated existing data to identify any long-term changes to the aquifers that should be considered in the establishment of minimum levels. Review of historic data reveals that the principle changes in the LWC aquifers have been reductions in water levels/potentiometric head. In some localized areas there have also been changes in groundwater quality.

Figures 11 through 14 consist of a series of hydrographs showing changes to the water levels over time. Monitor wells, which show the greatest reductions in water levels, are located adjacent to large production wells and in confined aquifers with low transmissivities, storativity, and leakance. Water levels within the Mid-Hawthorn aquifer in central Lee County have dropped approximately 60 to 80 feet below estimated pre-development levels. The pre-development levels for this aquifer were about 10 to 20 feet NGVD (or approximately 5 to 10 feet above land surface) in western Lee County. However, beginning in the early 1970s, the potentiometric head began to decline in response to increase use of the aquifer by public water supply wellfields and increasing numbers of domestic wells. Figure 11, of monitor well L-581 located in Cape Coral, shows how these declines have continued over the past twenty-five years.

Declines on over 30 feet below pre-development levels occur locally in the Floridan aquifer system near the public water supply wellfields of Cape Coral (Figure 12). The declines in the FAS are more recent, triggered by the shift to this source by Cape Coral, Greater Pine Island and Sanibel Island during the last 25 years. This aquifer system is well confined, with low storage and leakance which causes the large drawdowns under moderate pumpage.

The potentiometric levels within portions of the Sandstone aquifer have also declined as much as 30 feet seasonally in the agricultural areas of western Hendry and eastern Lee counties. Water level changes of 15 feet or less occur in the Lower Tamiami aquifer near the major

wellfield in Collier County. The main difference between the water level changes observed in the FAS/Mid-Hawthorn aquifer and the Sandstone/Lower Tamiami aquifers is that the water levels recover to near pre-development levels in the shallower aquifers during the wet season. This is attributed to several factors including a higher hydraulic connection between these aquifers and the Water Table and the seasonality of the agricultural demands that utilize these two aquifers.

There are no long-term declines in the Water Table aquifer. This is attributed to the limitations on yield and water quality (color and iron), the consumptive use permit constraints on impacts to wetland and saltwater intrusion, the unconfined nature of the aquifer, high annual rainfall and flat, low lying topography.

Water quality changes are much more localized and variable. The long term changes to water quality reflect both declines and improvements. Principal changes to the Water Table aquifer have been related to point source contaminants associated with land use such as gas stations, and industrial sites. Monitor data collected along the coast show no signs of long-term saline intrusion although chloride levels do fluctuate seasonally. Water quality data for the semi-confined aquifer show some instances of localized saline water changes associated with water use. In many cases, the water quality has actually improved due to the cementing in of old abandoned free flowing wells originally constructed into the FAS. These well were drilled in the 1940s for agriculture and were short cased. The short casing allowed the high-pressure water to invade the shallow freshwater aquifers. During the 1980s, the District and local governments located and cemented-in over 250, six-to-ten inch diameter wells stopping the uncontrolled flow of approximately 400 million gallons per day of saline water.

In other areas, salinity has increased due to pumping. These cases occur in the FAS wellfields, which de-salt the deep saline waters. In a few of the production wells, dissolved chloride levels increased as a function of upconing of deeper saline water caused by the lowering of head pressure at the production wells. District consumptive use permit rules allow for controlled degradation of a saline source of supply as long as the use remains sustainable and no harmful impacts occur to other legal users.

No other data was found relating to other changes in time-invariant aquifer characteristics such as permeability, storage etc. No data was found pertaining to structural alterations to the aquifers

Based on these factors, staff has concluded the following:

1) No structural alterations have occurred to the subject aquifers on a scale to be considered in the establishment of MFL's

2) The changes to the aquifers (ground water levels and quality) as related to pre-development conditions are attributed to consumptive use withdrawals, which have not resulted in impacts to the aquifer function as a water supply source. These changes are, therefore, considered to be acceptable under Section 373.0421(1)(a), F.S.

3) The aquifers are found to continue to provide their historic hydrologic function and therefore no exclusions are proposed for the subject aquifers.

II. Water Resource Functions of LWC Aquifers

Chapter 62-40.405 F.A.C. identifies several environmental values associated with coastal, estuarine, aquatic and wetland systems that shall be given consideration when adopting MFLs. The following summarizes the staff's evaluation regarding applicability of these functions.

Water Resource Function	Evaluated for MFL
Fish and wildlife habitat and the passage of fish	Yes for Water Table aquifer
Maintenance of freshwater storage and supply	Yes
Water quality	Yes
Estuarine resources	Yes for Water Table aquifer
Transfer of detrital material	Not Applicable for Aquifers
Filtration and absorption of nutrients and pollutants	Not Applicable for Aquifers
Sediment loads	Not Applicable for Aquifers
Recreation in and on the water	Not Applicable for Aquifers
Navigation	Not Applicable for Aquifers
Aesthetic and scenic attributes	Not Applicable for Aquifers
Recreation in or on the water, fish and wildlife habitats	Not Applicable to LWC aquifers

With regard to the aquifers in the Lower West Coast planning area, only the Water Table aquifer has hydrologic connections to surface water features. Two of these values, fresh water storage/supply and water quality, are functions that are applicable to the Water Table and semi-confined aquifers in the area. In addition, staff considered the function of structural support/subsidence in developing the MALs for the aquifers. What follows is an evaluation of the functions of each aquifer and an analysis of available data related to these functions.

III. Evaluation of Significant Harm

Water Table Aquifer: The principal functions associated with the Water Table aquifer includes base flow to streams, creeks and rivers etc., water supply to wetland systems, water supply to man and structural support. Lowering the water levels within the aquifer potentially affects all of these functions.

The relationship between groundwater levels, seasonal variation of rainfall and resulting hydrologic responses of isolated wetlands in Lee County is presented in a study by Shaw and Huffman, 2000. This study also looks at the aspects of consumptive use withdrawals on wetland hydrology as well. The report clearly shows that the potential for harmful impacts to wetlands exists should CUP withdrawals go unmanaged.

In studies conducted in the Southwest Florida Water Management District (SWFWMD), documentation of the destruction of wetland habitats including loss of hydropattern, loss of organic soils, falling mature cypress trees, etc. is attributed to excessive Water Table drawdowns from nearby wellfields. Shaw studied these impacts and proposed an impact characterization system based on the degree of hydrologic alteration. The impacts range from no harm to significant and serious harm. His observations suggested that while lowered groundwater levels impact isolated wetlands, the more severe impacts occur when the lowered levels are sustained for multiple years. Along this line, Shaw identifies that changes to surface water features, such as a road which transects wetland, housing developments which encroach into wetlands and drainage features, have had far more impacts to wetland hydrology than consumptive uses.

Isolated wetlands appear resilient to seasonal declines in water levels greater than five feet below land surface for several months provided normal rainfall patterns return in the wet season and ground water levels recover to normal pool. Water uses, which prevent this wet season groundwater level rebound, will harm these systems.

The SWFWMD has adopted MFLs for isolated lakes and wetland systems based on a statistical analysis of three categories of wetlands: non-impacted, impacted and significantly impacted. An extensive network of monitored wetlands facilitated the methodology used by SWFWMD. Such a monitor network did not exist in the SFWMD until recently when the agency has funded a wetland monitor program in the amount of approximately $2.5 million. This monitor program is beginning its fourth year of development with approximately three additional years of data collection anticipated. At this time, staff is of the opinion that further data collection and analysis is needed to better define the hydrologic deficits that would result in significant harm to isolated wetlands.

In a similar situation, very little data exists with regard to groundwater base flows to rivers, streams, creeks and sloughs within the study area. At this time, the Caloosahatchee River downstream of S-79, is the only surface water body on the District's MFL priority water body list. There are several other rivers, creeks and sloughs within the study area where the relationship between groundwater and surface water flows and levels should be evaluated. These water bodies include the Imperial, Estero and the Orange rivers, the Fakahatchee Canal, and the Six Mile Cypress Slough. These water bodies, and others, are included in the scope of the study for the Southwest Florida Feasibility Study. This study is a joint venture between the United States Army Core of Engineers and the District. It is anticipated to be completed in three years and will focus on the ecological functions and hydrologic needs of southwest Florida.

Data resulting from this study may be used to define MFLs for the above-mentioned surface water bodies. In the mean time, the impact of withdrawals from the Water Table aquifer was evaluated within a half-mile radius of each of these water bodies and is summarized in Figure 15 and Table 6.

Considering the relatively low demands on the Water Table, the distance from the surface water body, and the low permeability of the aquifer, it is not anticipated that consumptive use

withdrawal will result in significant harm to these water bodies prior to the completion of the Southwest Florida Feasibility Study.

Water supply for man's use is another major function of the Water Table aquifer. Utilization of the Water Table aquifer by county is summarized in Tables 7 and 8 below. The Water Table is the source of supply for public drinking water, agriculture, landscape irrigation and commercial and industrial uses. The reliable yield of water from this aquifer provides a significant role in the economy of the region.

Table 7: Allocation of Water by Source in Million Gallons per year (as of August 2000)

Aquifers	**Lee**	**Collier**	**Hendry**	**Charlotte**	**Glades**
Surface Water	56235	43861	37966		14654
Water Table	36381	43182	7087	792	2157
Lower Tamiami	5521	53505	14256		
Sandstone	7450	7144	2980		644
Mid-Hawthorn	6023		696		2104
Floridan	22489	7774		718	

The reliable yield of the Water Table aquifer is provided through the consumptive use permit criteria. The use of the Water Table aquifer for water supply could be significantly harmed by large-scale water quality degradation (pollution and saltwater intrusion) or over-development. The District restricts permit withdrawals in order to prevent harmful movement of saltwater and point source pollution under moderate drought conditions. The Water Table aquifer is generally well protected from coastal saltwater intrusion because of the low yield of the aquifer along the coastal margin. With the exception of southern Collier County, the hydraulic conductivity of the Water Table generally less than 500 feet/day and the thickness of the aquifer is generally 40 feet or less. Further, the Water Table aquifer contains moderate levels of iron. These factors, combined with the general availability of better yielding freshwater aquifers at shallow depths, have limited the use of the Water Table aquifer near the coast. Point source contamination is limited in distribution and magnitude related to the land use of the LWC. Based on future land use plans (LWCWSP 2000) the prospect of establishing MFLs to limit groundwater contamination is not necessary.

Consideration was given to establishing significant harm based on over-development of an unconfined aquifer in the LWCWSP. Concerns were that if other water resource constraints of the water use permit program were not applicable (e.g. no wetlands, saltwater, other users, pollution etc nearby) how low could the aquifer be drawndown without losing the ability to provide water. Since the Water Table aquifer is relatively thin throughout most of its extent, it

is possible that large withdrawals or cumulative withdrawals could dewater the aquifer to a point where the drawdown characteristics reflect a confined aquifer. At some point past 50% of the saturated thickness of an unconfined aquifer, the reduction in storage causes the aquifer to cease performing like an unconfined aquifer as described by the Boulton equation, and instead exhibits drawdown characteristics of a confined aquifer with low storativity. As a result, the aquifer yield rapidly diminishes as the saturated thickness declines rendering well yields unusable. However it is also recognized that these impacts would be most severe at the well head and therefore self-limiting.

At this time, staff has not encountered these types of impacts. This is most likely due to the restrictions on the use imposed by the CUP rules. Staff is unaware of any steadfast criteria related to this type of dewatering to base a minimum aquifer level on. The District is proposing new CUP rules that will require an applicant to evaluate the possibility of this type of dewatering phenomenon when the projected maximum demands result in a drawdown of one half the pre-development thickness of the aquifer. Based on the results of such an evaluation, an alternative source of supply may be required by the permit to serve the water need during drought.

The last function that was considered for the Water Table aquifer is structural support of the substrate. The Water Table aquifer consists of basically two lithologic facies; a loosely to unconsolidated clastic sequence and a moderate to well indurated carbonate sequence. The District complied existing information on the potential for subsidence and prepared a paper for peer review (Appendix 1). The results of this preliminary study suggest that a low but real potential exist for aquifer compaction or subsidence. However, due to the lithologic framework of southwest Florida, the magnitude of the drawdown necessary to potentially cause such an impact would be larger than what exists today and on the order of 75% of the thickness of the aquifer. However, all peer reviewers agreed that additional study was necessary to better define the risks and drawdown criteria.

Summary/Recommendation:

1) With regard to the function of wetlands base flow, staff concludes that there is insufficient data available to identify the degree of hydrologic change that would produce significant harm to isolated wetland. It is recommended that the district continue to fund the on going wetland hydrologic study through its conclusion in three years and evaluate the findings through the nest LWCWSP revision process scheduled for 2005.

2) With regard to the function of baseflow to river, stream, creek, and sloughs, staff concludes that there is insufficient data available to identify the degree of hydrologic change that would produce significant harm to these water bodies. It is recommended that the specific studies needed to quantify the relationship between the Water Table aquifer at these surface water bodies be included in the scope of the South West Feasibility Study to be conducted during the nest three years. The results of the South West Feasibility Study will then be evaluated through the LWCWSP process scheduled for 2005.

3) With regard to the water supply function, staff concluded that the CUP permit criteria are sufficiently restrictive to assure sustainable yield of the aquifer and prevent harmful water

quality degradation. It is recommended that the district establish rules to require applicants with proposed drawdown of one half the pre-development saturated thickness, to evaluate the potential for dewatering the aquifer and propose alternative supplies during drought.

4) With regard to the function of structural support of the substrate, Staff concludes that there is insufficient data available to identify the degree of hydrologic charge that would produce significantly harmful subsidence. It is recommended that staff budget and construct specialized monitor station to measure subsidence at select stations and evaluate the results through the next LWCWSP revision process scheduled for 2005.

As a result of the lack of technical data to determine significant harmful hydrologic variation to natural system and considering the on going research projects underway and the protection afforded by the District CUP program, it is recommended that an MFL for the Water Table aquifer be delayed until the research has been completed.

Lower Tamiami, Sandstone and Mid-Hawthorn aquifers: The two water resource functions associated with all three of the semi-confined aquifers are 1) water supply and 2) structural support to the overburden. Reduction in water levels could effect the water supply function of these aquifers through induced movement of saline water to an extent where the water quality in the aquifer is not usable for the use intended. As described in Chapter 2, there are limited sources of saline water within the Lower Tamiami aquifer (along the coast), Sandstone (no real source of saline water) and the Mid-Hawthorn. Further, the District's CUP rules and water shortage rules are geared towards regulating withdrawals that would cause saltwater migration (see CUP protection discussion below). Water quality data collected over the past twenty years show these regulations have been successful in limiting harmful movement of saltwater. Therefore, no changes or an additional protective criterion to regulate saltwater movement is recommended.

Another factor that could significantly harm the water supply function of these aquifers is if water levels drop to a point where the aquifer yield diminishes. A reduction in aquifer yield could result if water levels dropped to point where the clayey confining beds compacted to a degree where vertical recharge was restricted. Another condition that could result in a reduction of aquifer yield would be if the water level dropped below the top of a confined aquifer introducing air into the unit. This condition presents several problems including gas binding; dissolved mineral instability as a result of changed pH and pH, water quality changes and dewatering. Shifts in redox potential resulting from introducing air into the anaerobic semi-confined aquifers would effect several of the naturally occurring chemical species including iron, calcium carbonate, and sulfur compounds. Such changes could drive precipitation/solution reactions changing the water quality within the aquifer as well as the physical properties of the aquifer itself. These types of geochemical changes could occur rapidly so that exposures of only a few days could be significantly harmful.

Inherent with water level declines of this magnitude is the structural stability of the overburden. The lithostratigraphy of southwest Florida is layered limestones, clays/silts and sands. Decreases in hydrostatic pressure in confined aquifers result in increased grain to grain contact load on the sediments. The sediments compact in response to the added load and the land surface subsides. Chief controlling factors in the potential for subsidence are the number,

thickness, compressibility, and permeability, of the fine grained interbeds and confining beds, clay mineralogy, geochemistry of the pore fluids in aquifers and aquitards, initial porosity, previous loading history and cementation (Poland and Davis, 1969). The degree of compaction is related to the amount of time the water levels are depressed. However, once the compaction potential is achieved, whether fast or slow, further compaction won't occur unless additional drawdowns are imposed. This is relevant in the study area as groundwater levels are thought to have been much lower during the ice ages than in modern times. This is evidenced by the paleo-karst like features found in eastern Lee County.

Utilizing a method for estimating compaction set forth in Freeze and Cherry (1979), and estimated values for compressibility associated with the earth materials found in the LWC strata, staff estimated a limit for drawdowns at 75% of the distance between the average pre-development potentiometric head and the structural top of the aquifer. This guideline is being considered in the establishment of maximum developable levels for CUP allocation criteria. This proposed permitting criteria would limit drawdowns to levels above these compaction guidelines. Reductions in the potentiometric head below these guidelines would be considered increasingly harmful to the aquifer.

Summary/Recommendation: 1) Based on the information presented for the protection of the water supply and structural stability functions of the Lower Tamiami, Sandstone and Mid-Hawthorn aquifers, Staff recommends that significant harm would occur if water levels dropped to the top of the aquifer for any length of time. 2) It is recommended that the District conduct research to better quantify the potential for subsidence within the study area. This research should include the construction of specialized subsidence monitor wells in areas where the greatest potential drawdowns will occur and also conduct compaction testing on lithologic core samples. 3) The District should adopted new CUP criteria to define the maximum developable levels for each of these aquifers to prevent subsidence up and including a 1 in 10 drought condition. In addition, the District should modify its water shortage rules 40E-22 F.A.C. to define the maximum developable levels as criteria to be considered in the declaration of water shortage and the imposition of mandatory water use cutbacks.

CHAPTER 4
Proposed Minimum Aquifer Level Criteria for LWC Aquifers/Recovery Prevention Plan

I. Minimum Level Criteria

Significant harm is defined as a loss of specific water resource functions that take multiple years to recover, which results from a change in surface water or ground water hydrology. Based on the functions and information pertaining to the Lower West Coast aquifers provided, the following are the proposed minimum levels for the Lower West Coast aquifers.

Water Table Aquifer: As discussed in Chapter 3, the water resource functions considered for this aquifer include, 1) surface water base flow to rivers, streams, creeks and sloughs, 2) base flows to isolated wetlands, 3) water storage and supply and 4) structural support to the overburden. However, significant deficiencies in data quantifying the relationship between groundwater levels and surface water hydrology exist. Filling these gaps in information is needed in order to make a determination regarding what hydrologic deviation would constitute significant harm to major surface water bodies with the Lower West Coast Planning Area. Considering the ongoing status of research geared towards addressing these deficiencies, staff concludes that minimum levels for the Water Table aquifer should be postponed until best available information is available. Staff shall revisit the establishment of minimum aquifer levels for the Water Table aquifer upon the completion of 1) the isolated wetland study and 2) the Southwest Florida Feasibility Study. Both of these studies are anticipated to be completed in three years. At that time, minimum flows and levels for specific surface water bodies and the Water Table aquifer can be developed jointly through the Lower West Coast Water Supply Plan update process. In the mean time, the District shall use the consumptive use permit "no harm"
criteria and the water shortage authority to protect the surface water resources from over pumpage.

Lower Tamiami, Sandstone and Mid-Hawthorn aquifers: The two identified water resource functions served by these aquifers include 1) water supply and 2) structural support to overburden. Based on this, Staff considers that significant harm would occur to these aquifers if water levels within any non-pumping observation well penetrating the aquifer, dropped below the structure top of the aquifer. The top of the aquifer should be defined using the lithologic and hydrologic characteristics described in District groundwater reconnaissance reports referenced herein on a site by site basis.

Floridan Aquifer System: Like the semi-confined aquifers listed above, the two identified water resource functions served by the Floridan Aquifer System include 1) water supply and 2) structural support to overburden. However, based on the depth, the high yield and the saline nature of the aquifer system, the identified function water supply does not appear to be threatened by forecasted development in the next twenty years. Therefore no minimum aquifer levels are proposed for this system.

II. Recovery/Prevention Plans:

Pursuant to legislative directions, and utilizing the information provided in the Lower West Coast Water Supply Plan (SFWMD, 2000), the proposed minimum aquifer levels for the Lower Tamiami, Sandstone and Mid-Hawthorn aquifers were evaluated against existing and projected ground water level data to determine if the proposed minimum aquifer levels are being, or would be exceeded over the next 20 years. Based on the conclusions contained in the LWCWSP, staff concludes that the minimum levels are not and will not be exceeded over the next twenty years. Therefore a recovery plan, as discussed in Chapter 373.0421(2) F.S., is not needed. However in order for the presumption to hold true over the next twenty years, a prevention plan is proposed as follows.

1) The District should continue to issue water use permits using the no harm criteria contained in the permit rules at a 1 in 10 LOC.

2) The District should develop new rules that limit the cumulative reduction of the potentiometric head in the Lower Tamiami, Sandstone, and Mid-Hawthorn aquifers to a "maximum developable limit". This MDL should be established at a level above the top of the aquifer (approximately 40 feet above the top of the aquifer) sufficient to accommodate the aquifer compaction criteria and two phases of water shortage cutbacks. Once the MDL rule is established, no water uses permit applications would be authorized that cause a reduction in the potentiometric head below the MDL up to and including a 1 in 10 year drought condition (1 in to LOC).

3) The District shall continue to utilize its authority to implement water shortage restrictions during extreme drought condition and to avoid exceedances of the proposed MALs. The District should propose revisions to the water shortage criteria contained in rules 40E-22 that identify the levels within the semi-confined aquifers where staff would consider recommending Phase I and Phase II water shortage cutbacks.

4) The District shall work with local governments to evaluate the feasibility of alternative irrigation supplies along coastal Lee and Collier Counties consistent with recommendation no. 4.1 of the LWCWSP (SFWMD,2000). In addition, the District shall work with local governments to develop ordinances which require new developments to construct irrigation piping throughout the project and to prohibit the construction of new wells into aquifers where the MDL has been reached.

Additional Water Resource Protection Measures: Water Use Regulation

As discussed in Chapter 1, the minimum aquifer levels are only a part of the overall tools to protect the water resources. The following is a discussion of the consumptive use permitting (CUP) criteria applicable to aquifer protection to assist the reader better understand the other protections afforded the water resources. These resource protection tools will complement the recover and prevention strategy above.

The District's consumptive use permitting program contains criteria to prevent harm to the water resource under normal to moderate drought conditions. As a result of implementing this program, withdrawals of water covered by a water use permit normally shall not result in an exceedance of the MFL through the 1-in-10 drought level of certainty (LOC) provided in the water use permit. The exception to this statement may occur either during extreme droughts or if a permittee violates the conditions of their permit.

The technical and administrative criteria applicable to water use are included in the "Basis of Review (BOR) for Water Use Permit". In order to attain a permit, an applicant must meet all criteria contained in district rules. The permit will be constrained by the most restrictive criteria applicable to each particular project. The permit criteria includes constraints on the volume of water reasonably needed for the project, limitation on the impacts allowable to other existing legal users and constraints aimed at protecting the water resources of the state.

The following is a discussion of existing and proposed CUP water resource protection criteria that act to prevent harmful over development to the aquifer in the Lower West Coast Planning Area. These regulatory water resource criteria have been considered in the establishment of the proposed MFLs for the LWC aquifer system in that they are the first line of defense against significant harm. Significant harm will not result to the Lower West Coast aquifers when meeting these criteria. Indeed, since its inception, implementation of the District CUP program has prevented significant harm to the water resources. As a result, no actual case studies exist where significant harm occurred and where a cause and effect relationship could be derived from data in the field. Therefore, familiarity of the standards of protection afforded through a CUP is necessary to develop the standards for significant harm.

1) Saltwater Migration: Harmful saltwater movement into fresh water portions of an aquifer is prohibited by district rules. Saltwater movement occurs either laterally along a coastal freshwater/saltwater interface, or vertically as upconning. District rules 40E2-301(a) and Section 3.4 of the Basis of Review, address both of these conditions and provide criteria limiting the influence of the applicant's proposed drawdown in conjunction with all other permitted users near the saltwater interface. However, users of saline water from within a saline aquifer may cause limited increases in salinity provided the criteria in Section 3.4.1 of the Basis of Review are met. These criteria prevent declines in water quality to a degree that the source is no longer useful to the applicant or other existing legal users and prevent the use of the saline water to cause harmful saltwater intrusion into freshwater aquifers. Water quality monitoring requirements are placed on permits where saltwater occurs near the withdraw and limiting conditions of the permit require the permittee to moderate or cease pumpage as required to prevent saltwater intrusion related to their use.

2) Wetland Protection: Withdraw of water that result in harmful shortening to hydropatterns of wetlands are prohibited. Proposed revisions to the existing rule will provide additional detail on the types and magnitude of allowable drawdown under different types of wetlands and provide a more detailed description of what types of wetlands/surface water bodies are protected under the rules (e.g. a slough vs. a drainage canal). Historically, District issued consumptive use permits have limited cumulative groundwater drawdown in the Water Table aquifer to less than 1 ft at the edge of a wetland when pumping the maximum day allocation for 90 days without recharge to the aquifer. These guidelines, which were

implemented in the 1980's, were never spelled out into rules but have been applied as guidelines ever since. These criteria were evaluated by a independent scientific peer review panel in the 1993 and further evaluated under a lengthy wellfield/wetland research study. Both of these evaluations concluded that these guidelines were sufficient in preventing harm to wetlands. Permits issued with impacts near the 1 ft drawdown guideline contain limiting conditions requiring monitoring of the wetland, and are required to mitigate harmful impacts including moderating or ceasing pumpage should harm result from their withdrawals.

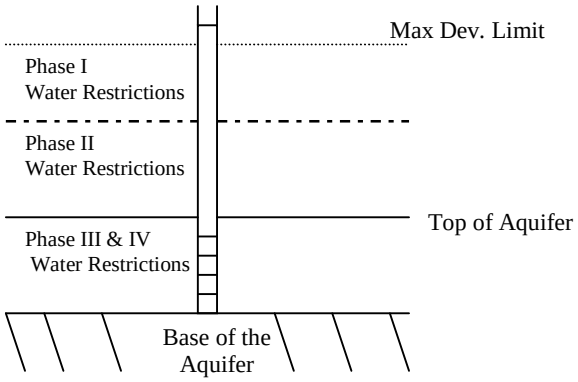
3) Pollution Protection: Withdrawals of water are not allowed to induce contaminants within an aquifer to move into uncontaminated areas of an aquifer (Section 3.5 Basis of Review). This requirement is met by restricting groundwater drawdowns resulting from the proposed use of water, at the area of contamination. However, District rules allow for the direct withdraw of contaminated water, provided the contaminated water will be remediate and the use will not expand the area of contamination.

4) Impacts to Land Use: Withdrawals of water that cause harmful impacts to adjacent land users are prohibited (Section 3.6 Basis of Review). Harmful impacts to land uses that are prohibited include sinkhole development, land subsidence, damage to crops through draining of seepage irrigation lands, and reductions in water levels within adjacent water bodies to the extent that their function is impaired (e.g. a surface water management impoundment which experiences erosion to the control structure caused by dewatering).

5) Interference with Existing Legal Users: District criteria requires a user to mitigate impacts to existing legal users whose withdraw capacity is impaired as a result of the new withdraw. Harmful interference to a use can occur as a reduction in well yield or change in water quality. Mitigation could be in the form of compensation for costs incurred and/or reduction of use.

6) Maximum Development Levels (MDL): If all other constraints on consumptive use withdrawals are met, how low should a well be allowed to dewater an aquifer? This question doesn't practically come up when dealing with the Water Table aquifer due to coastal saltwater intrusion and wetlands. However, in the Lower West Coast Planing Area, there are shallow semi-confined aquifers where this question is relevant. In order to prevent harmful dewatering of these aquifers, the District is proposing maximums developable level criteria for the Lower Tamiami, Sandstone and Mid-Hawthorn aquifers. The significant harm that these criteria are proposed to protect against is dewatering a semi-confined aquifer to a level below the structural top of the aquifer. To achieve this, drawdowns will be limited to a specific elevation above the top of the aquifer. The proposed height above the aquifer top, ranging between 20 to 40 ft, is based on observed seasonal variance in water levels for each aquifer during a 1 in 10 drought condition coupled with the amount of water level declines observed during past water shortage events. The concept is to limit CUP withdrawals to a level above the top of the aquifer in a manner to provide a buffer to protect against significant harm during drought events more severe than a 1 in 10 condition. Should water levels within the aquifer drop below the MDL, water shortage restrictions would be imposed. In this manner, the potential for

significant harm to the aquifer (dewatering below the structure top of aquifer) would be reduced and managed.



7) Water Shortage Restrictions: All District CUPs contain a limiting condition requiring the permittee reduce pumpage during a declared water shortage consistent with the provisions contained in rule 40E-21. The magnitude of the cutbacks are related to the efficiency of the use type and the severity of the drought.

CHAPTER 5
Conclusions and Recommendations

Based on the information contained in this report and the selected supporting references, staff concludes the following:

1) The principle functions of the Water Table Aquifer include: provision of base flows to surface water features; water supply; and structure support to overburden. There is insufficient information available pertaining to the relationship between groundwater base flows and the protection of surface water bodies particularly with regard to defining significant harm to these water bodies. It is concluded that the definition of significant harm to major rivers, streams, lakes, slough and wetland systems should be based on ongoing research currently being conducted in the Lower West Coast Planning Area. Defining a minimum level for the Water Table aquifer to protect surface water bodies using existing information would not be supported by sufficient data at this time.

2) The principle functions of the Lower Tamiami, Sandstone and Mid-Hawthorn aquifers are: water supply and structural support to the overburden. The ability of these aquifers to function as sustainable water supply sources would be significantly harmed if the potentiometric head of these semi-confined aquifers is lowered below the top of the aquifer. Such a reduction in head could result in a significant reduction of aquifer supply function. Harmful impacts identified with exceeding the minimum aquifer levels include: air entrapment in the aquifer, geochemical changes affecting water quality, potential reduction in porosity of the aquifer materials as a result of changes in dissolved ion stability, and potential reductions of inter-aquifer migration of recharge related to compaction of clayey confining beds. These harmful impacts would occur rapidly as the water levels dropped below the proposed MAL. Therefore the duration of such a water level exceedance should be minimal.

3) The potential for subsidence and impacts to the function of structural support to the overburden is considered to be low but real none the less. While there is limited data available for evaluating the magnitude of potential subsidence in the LWC aquifers, there is consensus among the scientists reviewing the available data, that there is a real potential for subsidence. Further, additional research is warranted to better quantify the degree of groundwater level drawdown that would be critical to the LWC aquifers. Based on existing information and methodologies evaluated, the guideline proposed of limiting drawdown to no more than 75% of the distance between the pre development potentiometric head and the top of the aquifer appears to represent a first order estimate of the maximum developable limit of drawdown. Reduction of groundwater levels below this guideline may be harmful with regard to compaction and subsidence.

4) The consumptive use permitting program has been effective in limiting the degree of groundwater drawdown to prevent harm to the water resources since its inception in the mid 1970's. However, groundwater levels have continued to decline and drop below pre-development levels in the Lower Tamiami, Sandstone, Mid-Hawthorn, and Floridan aquifer system. While these lower levels haven't resulted in harm to the aquifers, there are some

areas within the LWC where the maximum permitable limit of an aquifer has been or is close to being reached under the 1 in 10 drought LOC. No new uses are permitted when these conditions occur. As a result, the conditions which could produce a minimum aquifer level exceedance are: if a water user violates his water use permit; local governments allow exempt domestic wells to proliferate in these areas; and a drought more severe than 1 in 10 condition occurs.

5) Based on existing groundwater level data and the 20 year demand projections contained in the LWCWSP (SFWMD, 2000), it is concluded that the proposed minimum aquifer level criteria is not being exceeded, nor is it anticipated that the criteria would be exceeded in the next 20 years provided the proposed prevention plan (Chapter 4) is implemented.

6) The water supply function of the Floridan Aquifer System is not expected to be harmed by consumptive use over the next 20 years. The use of the Floridan Aquifer System is anticipated to be low due to the salinity/treatment costs associated with the supply.

Based on information compiled in this report and consistent with the conclusion above staff makes the following recommendation.

1) The District should adopt rules, pursuant to the authority provided in Chapter 373.042 F.S., that establish minimum aquifer levels for the Lower Tamiami, Sandstone and Mid-Hawthorn aquifer based on the significant harm definition contained herein. This rule shall define the minimum aquifer level as the structural top of the source aquifer as described in Chapter 4.

2) The District should continue the ongoing research into the effects of hydrologic variations on the functions of isolated wetlands as recommended in the governing board approved LWCWSP.

3) The District should continue its joint venture with the USACE in conducting the South West Florida Feasibility Study as recommended in the Governing Board approved LWCWSP and the LECWSP. A component of this study should include collection of data to quantify the relationship between groundwater and surface water flows and environmental function of the Orange, Estero, and Imperial rivers and the Six Mile Cypress Slough and Fakahatchee Canal.

4) The District should adopt CUP rules that establish maximum developable levels for the Lower Tamiami, Sandstone and Mid-Hawthorn aquifers. These rules would identify the lowest safe level of groundwater that could quality for a water use permit. Such levels shall be established above the proposed minimum levels recommended in this paper.

5) The District should implement all provisions of the minimum aquifer level prevention plan described in Chapter 4.

6) The District should fund the construction of specialized monitor wells to measure subsidence. These wells should be located in areas where the greatest groundwater drawdown occurs. The addition to construction of the test wells, the district should complete compaction tests on cores of the aquifer and confining materials as recommended by the peer review of the District subsidence paper.

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