Development of a Reservoir System Operation Model for Water Sustainability in the
Yaqui River Basin

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Adil Mounir

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This thesis titled
Development of a Reservoir System Operation Model for Water Sustainability in the
Yaqui River Basin

by
ADIL MOUNIR

has been approved for
the Department of Civil Engineering
and the Russ College of Engineering and Technology by

Daniel Che
Assistant Professor of Civil Engineering

Dennis Irwin
Dean, Russ College of Engineering and Technology

ABSTRACT

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Development of a Reservoir System Operation Model for Water Sustainability in the Yaqui River Basin

Director of Thesis: Daniel Che

The Yaqui River Basin (YRB) is located in the semi-arid state of Sonora in northwest Mexico. This watershed flow is controlled by three reservoirs: Angostura, Novillo, and Oviachic. In order to assess and improve the management of the Yaqui reservoir system, a daily reservoir operation model was developed. This model is composed of a semi-distributed daily watershed simulation combined with an optimization model. The hydrologic simulation was developed using the Hydrologic Modeling System (HEC-HMS) developed by the US Army Corps of Engineers (USACE) Hydrologic Engineering Center. This simulation framework can estimate the water availability in different regions of the watershed. The HEC-HMS model was integrated to a nonlinear optimization model that estimates the water allocation in order to satisfy the competing water demands from different users according to water rights established in Mexico's National Water Law. The optimization model is developed using the General Algebraic Modeling System (GAMS). The communication between HEC-HMS and GAMS was completely automated via Python scripts for time efficiency reasons.

Different hydrological forcing (precipitation, temperature, and solar radiation) scenarios were applied to the HEC-HMS simulation: (1) a network of daily ground observations from Mexican water agencies during the historical period of 1990-2010, (2)

gridded fields from the North America Land Data Assimilation System (NLDAS) at 12 km resolution during the same simulation period, and (3) bias corrected NLDAS fields. The NLDAS forcing and bias corrected NLDAS performed better for Angostura and Novillo whereas ground observation datasets provided the best simulation for Oviachic. The simulated reservoir releases were compared to ideal releases at the three reservoirs to generate confidence in the simulation tools. It was concluded that authorized water allocation is unable to satisfy all users' demands. The simulated water allocation satisfied these demands; therefore the model could be used to assist local reservoir operators make decisions.

RESUME

Le bassin de la rivière Yaqui est situé dans l'état de Sonora au nord-ouest du Mexique. Ce bassin versant se trouve dans une région semi-aride et comprend 3 grands barrages; à savoir Angostura, Novillo et Oviachic. Dans cette étude, un modèle a été conçu pour l'optimisation de l'exploitation journalière des réservoirs du bassin versant Yaqui. L'objectif de ce modèle est d'évaluer la manière par laquelle ces barrages sont gérés. Ce modèle se compose d'une modélisation hydrologique journalière et semi-repartie et d'un modèle d'optimisation. La modélisation hydrologique a été faite à l'aide du système de modélisation hydrologique HEC-HMS développée par le « US Army Corps of Engineers (USACE) Hydrologic Engineering Center ». Cette structure de simulation est capable d'estimer la disponibilité des ressources en eau superficielle dans différentes régions du bassin versant. Le modèle HEC-HMS a été intégré à un modèle d'optimisation non linéaire capable d'attribuer l'eau nécessaire pour la satisfaction des différents besoins en eau selon les droits établis par la loi nationale Mexicaine. Le modèle d'optimisation a été développé à l'aide du programme General Algebraic Modeling System (GAMS). Ce dernier communique avec HEC-HMS de manière automatisée grâce à des scripts Python pour un meilleur rendement.

Différents scénarios de forçage atmosphérique (pluie, température et rayonnement solaire) ont été appliqués à la modélisation HEC-HMS: (1) un réseau d'observations journalières au sol obtenu grâce aux agences de l'eau mexicaines pendant la période historique 1990 jusqu'à 2010, (2) un champs de données ayant une résolution spatiale de 12 km généré par le North America Land Data Assimilation System (NLDAS) pendant la

même période historique, et (3) un champs de données obtenu en corrigeant le biais des données NLDAS. Les deuxièmes et troisièmes forçages produisent une meilleure modélisation hydrologique du bassin déterminé par le barrage Angostura et celui déterminé par Novillo tandis que les observations au sol ont donné lieu à la meilleure modélisation du bassin déterminé par le barrage Oviachic. L'attribution de l'eau aux différents utilisateurs des barrages simulée par le modèle a été comparée à la vraie attribution dans le but de valider le modèle. Il a été conclu que la réelle attribution de l'eau est incapable de satisfaire la demande en eau. L'attribution de l'eau simulée a pu satisfaire cette demande, ainsi, le modèle développé pourrait assister les managers dans la gestion des barrages.

DEDICATION

This work is dedicated to my loving parents Mustapha and Malika.

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CHAPTER 1 -INTRODUCTION

1.1 Optimal operation of water reservoirs

For years, humans have been building reservoirs to supply water for drinking and irrigation purposes. However, today's reservoirs often serve additional purposes such as generating hydro-electricity, preventing or reducing downstream flooding, and other recreational uses. In addition to the fact that one reservoir can serve multiple purposes, there can be several reservoirs in one basin. Therefore, managing the water resources provided by multiple reservoirs is a challenging task. It is also difficult to predict the volume of water inflowing to each reservoir because of its stochastic nature, which means that it cannot be predicted precisely. Another challenge that operators need to tackle is to satisfy the needs of every user sector. In order to manage multiple reservoirs, they used to rely on simplistic simulation models as well as their judgment. However, they can now be assisted by computer simulation models called Decision Support Systems (DSS), which are able to provide fast results despite the considerable amount of data incorporated. Additionally, DSS are designed to optimize the operation of reservoir systems with a reduced degree of approximations. Decision makers can specify objectives and constraints of their desired reservoirs when inputting information in the DSS. The DSS would then output tables and plots representing the optimized operation that satisfies the specified constraints (Labadie, 2004). DSS can be based on a wide variety of optimization methods depending on the application. These methods are mathematical approaches designed to compute a set of decision variable values that minimize or maximize an objective function subject to constraints. In the context of a river reservoir

operation, these methods find the optimal water allocation among different water use sectors. The most common methods are linear, nonlinear, dynamic, stochastic, heuristic programming and artificial neural networks. Apart from the optimization methods mentioned above, DSS would need to approximate the reservoir's water inflow via a hydrologic model that can use a stochastic approach, a physically based approach, or a conceptual approach. Each approach can be effective depending on the objective of the study and the degree of accuracy desired (Xu 2002).

1.2 Yaqui River Basin

The Yaqui River Basin (YRB) is located in northwest Mexico. The majority of the watershed lies in Sonora, which is a Mexican state. Other parts of the basin lie in the Mexican state Chihuahua, as well as the two American states of Arizona and New Mexico (Figure 1). The Yaqui watershed is the largest in the state of Sonora with a length of 5,397 km and an area of 72,000 km². This basin is located in the latitude range of 27° and 32° N and the longitude range of 107° and 111° W.

Figure 1: Location of the Yaqui River Basin and its reservoirs

The watershed is located in a semiarid to arid area. Precipitation is 527 mm/year on average, with the mean annual temperature being above 22°C. The basin experienced severe droughts in the years 1994 to 2004 (Figure 2).

Figure 2: Annual precipitations in the Yaqui River Basin

Three main dams were built in the YRB forming the Angostura, Novillo, and Oviachic reservoirs (Figure 1). Angostura is located in the northern region of the watershed and provides water for urban and industrial users, which are Pueblos Ribereños and a copper mining complex, respectively. The Novillo is the middle reservoir and was built by the Federal Electricity Commission (CFE) to generate additional electricity in the region. The Oviachic dam is located in the south and supplies water for urban and irrigation users. The urban users are cities located in the Yaqui valley whereas the Irrigation District No.041 is in charge of all agricultural activities. Although several crops are grown by farmers, wheat covers most of the planted area.

Crop pattern in the agricultural year 2009-2010 in the YRB

Figure 3: Crop pattern in the agricultural year 2009-2010 in the YRB
(Figure created by author using information obtained from the Irrigation District No.041)

The management of water resources in the YRB has been qualified as “poor [...] and uneven” (Narchi & Radonic, 2015, p.35). Several challenges face managers of the YRB. The first difficulty is estimating water availability in different regions in the watershed. Another difficulty is satisfying the competing demands from different user sectors. This task can be very challenging when daily decisions regarding water allocations have to be made.

1.3 Goal, objectives, and study approach

The objective of this research is to develop a methodology for determining reservoir release schedules in order to help tackle some of the challenges facing the operation of the three existing reservoirs in the YRB. The optimization model developed in this study can determine daily water allocations satisfying demands of different users in a sustainable manner. This requires daily precipitation, temperature, solar radiation, and evaporation rate data. It also requires a good estimation of the water inflowing to

every reservoir. It is for this reason that a hydrologic simulation was developed, which is used to provide hydrographs for the optimization model. The communication of information between the hydrologic simulation and the optimization model can be time efficient when it is completely automated, which is completed by using Python as a programming language. The objectives of the study can be summarized as the following:

- Develop a hydrologic simulation for the watershed capable of estimating volumes of water flowing into each reservoir
- Optimize operations of each reservoir using an optimization model
- Automate the integration of the hydrologic simulation and the optimization model using an open source programming language
- Assess/improve the operation policies followed by the managers of the Yaqui system

The objectives mentioned above were reached by achieving the following tasks:

- Collect historical atmospheric information and hydrographs flowing into the Yaqui system
- Correct the North American Land Data Assimilation System (NLDAS) bias
- Perform hydrological simulations using Hydrologic Modeling System (HEC-HMS) for three different forcing scenarios: (1) a network of daily ground observations from Mexican water agencies during the historical period of 1990-2010, (2) gridded fields from the North America Land

Data Assimilation System (NLDAS) at 12 km resolution during the same simulation period, and (3) bias corrected NLDAS fields

- Calibrate and validate hydrological simulations for the three types of forcing
- Collect reservoir operation constraints and historical reservoir releases in the Yaqui system
- Formulate the optimization problem using General Algebraic Modeling System (GAMS)
- Perform a manual global simulation using both hydrological simulation and optimization model
- Write Python scripts to automate the communication of all programs used in the overall model
- Analyze results and discuss model limitations and future work

1.4 Motivation

This study is motivated by the need to improve operation strategies implemented in the YRB. The goal is to develop a tool capable of helping managers of the Yaqui water resource in making decisions. However, this work is not limited to this study area. Although the approach is applied to the three existing reservoirs in the YRB, it is still valid for other watersheds. The newly developed method of linking a hydrologic simulation to an optimization model can benefit all projects related to reservoir system planning, management, and water allocation. The approach is able to save considerable time during the development and use of a reservoir operation model.

1.5 Organization of the thesis

This chapter has introduced some of the challenges of reservoir operation in general and the case of the YRB in particular. It also explained the objectives of this work and the research approach. Chapter 2 presents the YRB, its reservoir locations and characteristics, introduces the water crisis in the region, details the previous research conducted in the same study area, and explains the relevance of this work. Chapter 3 discusses existing literature related to reservoir operation optimization by explaining different advantages and limitations of each method and illustrates how these techniques were previously used. Chapter 4 describes the approach followed in this thesis in order to reach the objectives. It begins by describing the HEC-HMS hydrologic simulation and then describes the GAMS optimization model. The two programs HEC-HMS and GAMS are also introduced in this chapter. Chapter 5 presents the different data used in this model and explains the assumptions made. The data mentioned in this chapter are grouped as hydrologic data, atmospheric data, and economic data. The assumptions are grouped as industrial water allocations, urban water allocations, and reservoir operation assumptions. Chapter 6 consists of the application of the model and the results obtained from the hydrologic simulation, as well as the overall model. It also discusses and hypothesizes reasons explaining these results. Chapter 7 presents conclusions of this work and introduces some recommendations and future work. Chapter 8 discusses how this tool can be applied by water management authorities. It also considers how to generalize this process to other watersheds.

CHAPTER 2 - YAQUI RIVER BASIN

2.1 Basin location and characteristics

The Yaqui River Basin (YRB) is located in northwest Mexico. The Yaqui belongs mainly to the Mexican state of Sonora, but a small eastern part also lies in the Chihuahua state while its northern portion is part of the U.S state of Arizona (Figure 4). The Yaqui watershed is the largest in the Sonora state with a length of 5,397 km and an area of 72,000 km². This basin is located in the latitude range of 27° and 32° N and the longitude range of 107° and 111° W.

Figure 4: Location of the YRB

The climate in the YRB is semiarid to arid. The average rainfall is 527 mm/year and the mean annual temperature is above 22°C (INEGI, 1993). Severe droughts were observed during the years 1994 through 2004. In this period, the three water reservoirs in this basin emptied. Even though the rainfall in 2004 was considerable enough to refill the

reservoirs, unfortunately, dry conditions returned in 2005. This weather condition had a negative impact on the agriculture, which is significant in this region.

Figure 5: Photo of El Oviachic reservoir in the year 1992 and 2003
(Source: Matson, 2012)

The YRB is one of the most important agricultural regions in northwest Mexico due to its large land area allocated to this activity. The main crop within the basin is wheat, covering approximately 70% of the total planted area. Other important crops include maize, safflower, garbanzo beans, cotton, alfalfa, and fruits (Minjares, 2004). The Irrigation District No.041(Figure 6) has an irrigable land of 227,224 hectares.

The Mexican government is providing aid to the growers in this area. Hernandez, Mayer and Watkins (2011) explained that policies opened the agricultural market to international competition in the 1990s in order to help farmers sell more products. Hernandez, Mayer and Watkins (2011) also mentioned that local farmers became in charge of the Distrito de Riego del Rio Yaqui (DRRY). This Irrigation District is the organization controlling the water in the Yaqui valley. It holds rights to 2,903 million m³/yr of surface water and 600 million m³/yr of groundwater.

2.2 Water reservoirs in the YRB

Three reservoirs control the Yaqui River and its tributaries in the YRB. These reservoirs are: Angostura, Novillo, and Oviachic (Figure 6). Angostura Dam is located in the upper basin. It was built in 1942 and it is the oldest dam in the watershed. Angostura has a storage capacity of 900 million m³, which is the smallest of the three. Its elevation is 789 m, making it the highest in terms of altitude above sea level. It supplies water to Pueblos Ribereños and to a copper mining industry.

El Novillo Dam is located in between the two other reservoirs. The Federal Electricity Commission (CFE) built this dam in 1967 to generate more electricity in the region. It is the highest and has the largest storage capacity (3,407 million m³) compared to other reservoirs in the YRB.

Oviachic Dam was constructed in 1952 downstream of the Yaqui River. Its main purpose of extraction is irrigation. The dam has two water intakes known as the Canal Alto (with an elevation of 80 m) and Canal Bajo (with an elevation of 68 m). These two channels are managed by the Irrigation District No. 041 whereas the three reservoirs are managed by the National Water Commission (CNA).

Figure 6: Location and hydrologic features of the YRB
(Source: Hernandez, Mayer and Watkins, 2011)

Table 1: Physical characteristic of Yaqui River reservoirs
(Source: Addams, 2004)

	Angostura	Novillo	Oviachic
Official Name	Lazaro Cardenas	Plutarco Elias Calles	Alvaro Obregon
Type	Gravity arch	Double-arch	Earth fill
Completion date	1942	1965	1952
Discharge elevation	789 m	199 m	68 m
Spillway elevation	832 m	275 m	107 m
Maximum area	3,945 ha	12,030 ha	17,200 ha
Usable Storage	900 10^6 m ³	3,407 10^6 m ³	3,160 10^6 m ³
Hydropower capacity	None	135, 000 kW	19,200 kW

2.3 Novillo-Hermosillo aqueduct & water crisis

Hermosillo is the capital of the state of Sonora (Figure 1). It is the largest city in Sonora, and it hosts the main companies in the region. Almost 1 million people live in Hermosillo, which is a third of the entire state's population (Scott and Pablos, 2011). Sonora is traditionally supplied by water from a neighboring watershed called the Sonora River Basin (SRB). The main river in SRB is the Sonora River, which is divided upstream into the Sonora and San Miguel rivers.

Hermosillo is facing groundwater and surface water scarcity. Its aquifer levels are lower than sea level. Zanjón is a good example of the aquifers overuse because it is subject to extractions by Hermosillo exceeding recharge by 42% (Scott and Pablos, 2011). This city faced a state of emergency due to pipeline closure. During this period, the majority of the city was supplied only 3 hr/d, while some neighborhoods received water for just 1 hr/d.

In 2010, Sonora's governor suggested a project called Independencia that consisted of building the Novillo-Hermosillo aqueduct. This structure is 162 km long, extending over the mountains from El Novillo reservoir to the Río Yaqui (Barry, 2015).

Figure 7: Novillo-Hermosillo aqueduct

Barry (2015) explained that plans for the Novillo-Hermosillo aqueduct were made without consultation from local farmers who had control of the Yaqui reservoirs. The growers' opposition to this aqueduct project is politically important due to the powerful Distrito de Riego del Rio Yaqui (DRRY). Yaqui people claim that the Independencia aqueduct negatively affected several indigenous communities. Therefore, resistance campaigns took place at a national level highlighting government disregard for the rights of the Yaqui.

2.4 Previous research in YRB

The operation of the Yaqui reservoir system has been studied by several researchers. Minijares (2004) was the first to design an optimized operation of this system using results he obtained in his dissertation. In his work, he estimated monthly discharge using an adjustment of historical observations using probability density functions. Minijares (2004) developed an optimized short term model, which used genetic algorithms. The two objectives of this model were maximizing agricultural benefits and minimizing spills and water shortages. He then adapted this model into a long term model by taking into account changes in water availability in the reservoirs and changes of agricultural water demands. He also explained how several parameters ensured that operational decisions suggested by his model are reliable, reversible, equitable and not vulnerable.

Addams (2004) also conducted research in the Yaqui Valley, and focused on managing groundwater use during periods of droughts. Because the availability of surface water greatly varies through the years, he studied how increased use of groundwater may result in a more sustainable use of water resources. In fact, State-employed hydraulic experts claimed in 2010 that "357 million out of the 599 million cubic meters of groundwater allocated to the agricultural sector annually are not extracted" (Narchi & Radonic, 2015). He examined the long-term effects of different water resource policies by developing a hydrologic-economic-agronomic model. His hydrological model integrated a surface water distribution model with a complete groundwater flow model. The economic model deals with the decision-making process of farmers in the Yaqui

Valley. Using these results, he then determined potential improvements for water rights in the valley.

Munoz-Hernandez (2009) provided insight into the way water resources are managed in the YRB by adjoining a hydrologic-economic model to an institutional model. The hydrologic model she developed is based on integrating a surface water model to a groundwater model, which corresponds to the water sources used by farmers in the region. The discharge is estimated via a calibrated linear relationship with precipitation. The economic model incorporates agricultural activities, residential uses and the environment. This last use was analyzed in the context of a hypothetical water market she created because of the lack of allocation of water for environmental purposes in this region. Her economic model also incorporates the operation rules developed by Miniñares (2004), as well as water rights established in the National Water Law (CNA, 2004). Munoz-Hernandez also took into account climate change and climate variability using the precipitation forecasted with the Canadian Global Climate Model (CGCM) and by fitting an Autoregressive–moving-average (ARMA) model to a 104-year historical record of precipitation. She finally studied the impacts of different water allocations strategies including environmental flows, which aim to protect or restore river ecosystems.

González Parra (2015) developed a semi-distributed hydrologic model of the YRB using the Hydrologic Modeling System (HEC-HMS) developed by the US Army Corps of Engineers (USACE) Hydrologic Engineering Center. He selected hydrological process equations in order to transform rainfall to runoff based on the existing data products. To

my knowledge, his model is the first complete hydrologic model in this region which is able to simulate rainfall-runoff processes. González Parra's simulation was used in this thesis work. His semi-distributed hydrologic model was finished and several improvements were introduced. These modifications are mentioned in the methodology section.

2.5 Relevance of this work

Narchi & Radonic (2015, p.35) mentioned that Sonora has “an overabundance of water” but suffers “from poor management and uneven distribution”. Managers of the Yaqui reservoir system have to overcome several challenges to operate the reservoirs sustainably. The first challenge is to estimate the water available in different regions of the watershed. The hydrologic simulation developed by González Parra (2015) could tackle this challenge by estimating the water in the Yaqui River and its main tributaries. It would also help managers control several illegal unauthorized water extractions, using embankments and other means, in different regions of the watershed. Other hydrological forcing scenarios were tested using González Parra's model in order to improve the initial simulation. Another challenge is to optimize the water releases to different users. This can be accomplished via a reservoir operation optimization technique, which has already been developed. However, the optimization model developed was not linked to a semi-distributed or distributed hydrologic simulation which is important for good water allocation strategies. The model developed in this thesis successfully links a semi-distributed hydrologic simulation to an optimization model in an automated fashion. The model is time efficient because of how the different programs, which are needed to

perform the hydrologic simulation and the mathematical optimization, communicate. This tool can also help make daily operation decisions. In this thesis project, the combined hydrologic-optimization model is used to assess/improve the current operation rules followed by the managers of the Yaqui system.

CHAPTER 3 - LITERATURE REVIEW

3.1 Optimization modeling

3.1.1 Optimization problem formulation

Planning and managing reservoir systems to be highly efficient requires the use of an optimization technique. Optimization modeling consists of computing a set of decision variable values that minimize or maximize an objective function subject to constraints. Therefore, the main parts of an optimization formulation include the objective function, the decision variables, and the constraints. These three parts are explained in detail in the following paragraphs.

3.1.1.1 Objective function

In reservoir operations, the objective function is a mathematical expression that describes the performance criteria of the system (Mays and Tung, 1992). For example, achieving large values of an objective function that expresses the net economic benefit generated by agricultural products would mean reaching a better performance. In general, these performance criteria have to ensure that the system is sustainable and efficient (ASCE Task committee on Sustainability Criteria, 1998). Minijares (2004) defines the most important criteria as ensuring sustainability. These criteria are reliability, reversibility, non-vulnerability, and equity. Labadie (2004) presents a generalized objective function expression as follows (equation (1)):

$$\max (or \min) \sum_{t=1}^T \alpha_t f_t(\mathbf{s}_t, \mathbf{r}_t) + \alpha_{T+1} \phi_{T+1}(\mathbf{s}_{T+1}) \quad (1)$$

where $\mathbf{r}_t$ = n-dimensional set of decision variables during period t ; T = length of the operational time horizon; $\mathbf{s}_t$ = n -dimensional state vector of storage in each reservoir at

the beginning of period t ; $f_t(\mathbf{s}_t, \mathbf{r}_t)$ = objective to be maximized (or minimized); $\varphi_{T+1}(\mathbf{s}_{T+1})$ = final term representing future estimated benefits (or costs) beyond time horizon T ; and α_t = discount factors for determining present values of future benefits (or costs).

3.1.1.2 *Decision variables*

Decision variables are parameters that operators control in order to reach a desired value for the objective function. Solving an optimization problem in the context of reservoir operation involves determining the amount of water to allocate to each user at different times. These amounts of water would be the decision variables that decision makers are interested in regulating in order to optimize a specified objective function.

3.1.1.3 *Constraints*

Mays and Tung (1992) explain that constraints “describe the system or process that is being designed or analyzed and can be of two forms: equality constraints and inequality constraints” (p. 13). Fayaed, El-Shafie, & Jaafar (2013) consider four types of constraints that reservoir operations are subjected to. The first constraint is based on the mass balance in the reservoir from one time step to another time step. This can be expressed by the following continuity expression:

$$S_{t+1} = S_t + Q_t - R_t - E_t - O_t \quad (2)$$

where S_{t+1} = final storage at the time t ; S_t = initial storage at the time t ; Q_t = inflow during the time t ; R_t = optimal release from the reservoir during time period t ; E_t = evaporation loss in the reservoir during time t ; O_t = surplus from the reservoir during time t .

The second type of constraint is related to the water released from the reservoir which should be less than or equal to the estimated target release. This condition is mathematically expressed by the following equation:

$$0 \leq R_t \leq TR_t \quad (3)$$

where TR_t = target release during time period t .

The third constraint is related to the water stored in the reservoir during every month which should be less than the capacity of the reservoir but should not be less than the desired target storage. Mathematically, this condition is represented by the following equation:

$$S_{min} \leq S_t \leq S_{max} \quad (4)$$

where S_t = Storage during time period t ; S_{min} = desired target storage; S_{max} = capacity of the reservoir in million cubic meters.

The fourth constraint takes into account the water loss that occurs in every pool due to evaporation. This reservoir evaporation loss that occurs every month can be computed as the evaporation rate times the average water spread area at the beginning and at the end of the time period (Fayaed & Jaafar, 2013, p. 1754). Equation (5) gives the mathematical expression of this evaporation loss during period t :

$$E_t = A_d e_t + m e_t \left(\frac{SA_t + SA_{t+1}}{2} \right) \quad (5)$$

where E_t = evaporation loss during time period t ; e_t = the evaporation rate in mm/mo during time period t ; A_d = water surface area at the top of the minimum storage level (m^2); m = the slope of the straight line with water surface area against reservoir active

storage; SA_t = the active initial storage at the beginning of time period t ; SA_{t+1} = the active final storage at the end of time period t .

The last constraint involves over flow. This is the amount of water spilled when the final storage exceeds the capacity of the reservoir. Equation (6) is a mathematical representation of the overflow constraint:

$$O_t = S_{t+1} - S_{max} \text{ and } O_t \geq 0 \quad (6)$$

Labadie (2004) considers additional constraints which satisfy the water demands of the different users. These constraints can be expressed as “alternative objectives that must be maintained at desired target levels ... [and] may be adjusted parametrically to compute tradeoff relations between the primary objective of equation (1) and secondary objectives as a means of providing multiple objective solutions” (Labadie, 2004, p. 96). This condition can be expressed as follows:

$$\bar{\mathbf{f}}(\mathbf{s}, \mathbf{r}) \geq \varepsilon \quad (7)$$

where ε is the target levels; $\bar{\mathbf{f}}(\mathbf{s}, \mathbf{r})$ is the alternative objective that depends on the decision variables ($\mathbf{r}$) and storage in each reservoir ($\mathbf{s}$).

3.1.2 *Linear programming*

Linear programming (LP) has been extensively used as a method to optimize river reservoir system. Labadie (2004) presents advantages to make this technique appealing, primarily that it can solve large-scale problems, converges to global optimal solution and does not require initial solutions from the user. Fayaed, El-Shafie, & Jaafar (2013) added another advantage: the available software packages using this method. Mays and Tung (1992) expressed the general algebraic form of an LP model:

$$\text{Max (or Min)} x_0 = c_1x_1 + c_2x_2 + \cdots + c_nx_n \quad (8.a)$$

Subject to

$$a_{11}x_1 + a_{12}x_2 + \cdots + c_{1n}x_n \leq b_1$$

$$a_{21}x_1 + a_{22}x_2 + \cdots + c_{2n}x_n \leq b_2$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$a_{m1}x_1 + a_{m2}x_2 + \cdots + c_{mn}x_n \leq b_m$$

$$x_1 \geq 0, x_2 \geq 0, \dots, x_n \geq 0$$

(8.b)

Mays and Tung (1992) explain that LP requires that both objective functions and constraints are linear functions of the decision variables. The most used method to solve an LP model is the simplex algorithm (Labadie, 2004). Terlaky (1996) states that other algorithms like the affine scaling and interior projection methods can be better than the simplex method when the optimization problem is highly large-scaled. The simplex algorithm is based on two fundamental conditions: the optimality condition and the feasibility condition. The first condition makes sure that while the algorithm seeks the optimal solution, it dismisses all inferior solutions. On the other hand, the second condition ensures that, when starting with a basic feasible solution, no unfeasible solution is taking into account during the course of computation (Mays and Tung, 1992, p.68). Labadie (2004) notes alternative methods to use LP in case of nonlinearity or non-convexity, such as extending LP into binary, integer, and mixed-integer programming.

However, he also notes that these extensions might use excessive iterations during the computation.

3.1.3 Nonlinear programming

The set of all possible solutions of an optimization problem that satisfies the problem's constraints is called the feasible region. In linear programming, the objective function and feasible region are both convex which ensures the optimal solution is a global one. However, it is not always true that both the objective function and the feasible region are convex in a nonlinear programming problem. Consequently, the optimal solution might be local (Mays and Tung, 1992). When the piecewise linearization of a nonlinear problem, discussed in section 3.1, fails to provide realistic solutions, a nonlinear programming (NLP) algorithm is needed. This is often the case when hydropower generation is part of the objective function (Fayaed, El-Shafie & Jaafar, 2013).

Labadie (2004) discusses the common algorithms used in NLP. The most efficient algorithm is the successive linear programming (SLP) algorithm. This method starts from an estimation of the optimal solution, and then linearizes the problem by considering the first two terms of the Taylor series expansion. This linearization is performed inside a trust region to ensure the stability of the convergence. Labadie (2004) also notes that SLP is probably the most favorable because of the large number of available software packages based on this algorithm. However, SLP does not always converge.

Successive quadratic programming (SQP) is another NLP algorithm. In SQP, constraints are linearized just like SLP but the objective function is optimized using a

quadratic model. The latter approximates nonlinear functions better than linear approximations. The major shortcoming of this algorithm is the amount of computations required to solve large-scale quadratic problems (QP). Labadie (2004) indicates the existence of a method developed by Arnold et al. (1994), which reduces the number of computations needed to solve a QP in the context of a reservoir system optimization.

The Augmented Lagrangian method is another NLP algorithm. This method replaces the original constrained optimization problem by a series of easier unconstrained problems with the addition of two new terms to the objective function. The first term is a penalty term and the second term mimics a Lagrange multiplier. Arnold et al. (1994) compared the Augmented Lagrangian method and SQP in a nonlinear reservoir system operation. The study concluded that the former algorithm converges faster but results in a less accurate solution. Generalized reduced gradient method (GRG) is also an NLP algorithm. It is essentially a constrained gradient search technique that solves a reduced optimization problem. (Labadie, 2004, p. 99). The GRG method was used in this thesis project and will be discussed in the methodology section.

3.1.4 Network flow programming

Network Flow Programming (NFP) can be used as a method to optimize reservoir systems, if both the objective function and constraints are linear or linearizable. This numerical method was found to be more efficient than linear programming when the system included a large number of reservoirs and/or the simulation was conducted during a long time horizon (Paredes et al., 2012). When the operators wish to include nonlinear constraints in their NFP, different methods can be used, such as generalized network flow

algorithms, equal flow algorithms, and successive solutions of the pure network with arc parameters adjusted until convergence (Labadie, 2004).

There are similarities between reservoir systems and Network Flow Optimization Models. A reservoir system can be represented as a network of nodes and arcs (Figure 8). Labadie (2004) explained that nodes represent the points of convergence or divergence whereas arcs would be the releases, channels, carryover storage, and losses. He then introduced the way to formulate the minimum cost network flow problem as follows:

$$\text{minimize } \sum_{t=1}^T \sum_{l \in A} c_{lt} x_{lt} \quad (9.a)$$

Subject to:

$$\sum_{j \in \mathbf{O}_i} x_{jt} - \sum_{k \in \mathbf{I}_i} x_{kt} = 0 \quad (\text{For all } i \in \mathbf{N}; \text{ for all } t=1, \dots, T) \quad (9.b)$$

$$l_{lt} \leq x_{lt} \leq u_{lt} \quad (\text{For all } l \in \mathbf{A}; \text{ for all } t=1, \dots, T) \quad (9.c)$$

where $\mathbf{A}$ = set of all arcs in the network; $\mathbf{N}$ = set of nodes; $\mathbf{O}_i$ = set of all outflow arcs; $\mathbf{I}_i$ = set of all inflow arcs; x_{lt} = flow rate in arc l during period t ; c_{lt} = costs per unit of flow rate in arc l during period t ; and l_{lt} and u_{lt} = lower and upper bounds, respectively, on flow in arc l .

Paredes et al. (2012) used NFP to develop a model that optimizes water allocation in the Duero River Basin in Spain. Their model included nonlinear constraints (evaporation from reservoirs) and water returns from the different users. These two constraints were introduced as non-network aspects by solving the network iteratively. They used and compared three different NFP algorithms, which are Out-Of-Kilter, NETFLO, and RELAX-VI.

Figure 8: Reservoir system represented as a network of nodes and arcs

3.1.5 *Dynamic programming:*

Dynamic programming (DP) is another popular and effective method of solving optimization problems in reservoir system operations. This method is extensively used because it can include nonlinear functions, can solve non-convex problems, and can overcome noncontinuity. It consists of decomposing a complex problem into a series of separate single-stage problems that are interrelated, each containing only one or a few variables. DP has another advantage, which is that its operation constraints improve solution efficiency unlike any other method. In fact, while computations increase exponentially with the number of variables, they only increase linearly when using decomposition in DP (Mays and Tung, 1992). The shortcoming of DP is that many computer programs that use this method have been developed for specific applications and cannot be compatible with all optimization projects (Minijares, 2004). For more insight, Yakowitz (1982) gives an extensive review of DP in the context of water resources applications.

DP can also be extended to explicit stochastic optimization problems (Labadie, 2004). Therefore, depending on how reservoir inflows are calculated, DP can be either deterministic or stochastic. The former uses historical inflow data or synthetically generated inflow. The stochastic dynamic programming (SDP), on the other hand, uses inflow time series generated by a stochastic process. The deterministic DP converges faster than SDP since inflow is not included as a state variable in its formulation (Fayaed, El-Shafie, & Jaafar, 2013). However, not including the stochasticity in the formulation may result in over simplification of the problem as well as the introduction of a bias (Loucks et al., 1981).

The main limitation of DP is known as the 'curse of dimensionality'. Mays and Tung (1992) define this problem as a rapid growth in computation length and core memory requirements when the variable contains multiple states. Rani and Moreira (2010) explained that researchers introduced different modifications to DP in order to overcome the curse of dimensionality. Their modifications included discrete differential DP (DDDP), DP with successive approximation, and incremental DP with successive approximations. Mays and Tung (1992) describe DDDP as an iterative DP procedure that searches for the optimum solution over a portion of the stage-state domain. Because the classic DP method searches over the entire stage-state domain, one can deduce that DDDP saves computer time and memory. However, using DDDP introduces issues the programmer has to take into account, such as the need to choose an 'initial trajectory' and the fact that the method converges to a local optimum instead of a global one (Mays and

Tung, 1992). The operator's choice of the initial trajectory, which is a sequence of states that are admissible for different stages, affects the efficiency of the method.

3.1.6 Stochastic optimization

Rani and Moreira (2010) distinguish between two types of optimization methods for reservoir systems: implicit stochastic optimization (ISO) and explicit stochastic optimization (ESO). The former is a deterministic approach that uses historical inflow data or synthetically generated inflow. In order to generate operating rules, decision-makers usually resort to one of the regression techniques when using ISO. ESO, on the other hand, requires direct introduction to a probabilistic description of random streamflow processes or other uncertain parameters, such as economic parameters or climatological variables. The advantage of ESO is being able to infer operating policies without regression techniques. Fayaed, El-Shafie and Jaafar (2013) note that ESO methods require more computations than ISO when applied to multi-reservoir systems.

Linear programming (LP) was introduced previously as a deterministic or ISO method. In this chapter, LP will be discussed as an ESO method. Rani and Moreira (2010) explain that LP exists in different explicit stochastic forms such as the stochastic LP and the chance constrained LP (CCLP). The stochastic LP results in a set of probabilities of a particular release decision. However, these decisions need to be interpreted by operators in order to be applied in a real situation. Moreover, it is difficult to apply this method to a system of more than one reservoir because of the large-scale model that results from using discrete joint probabilities (Labadie, 2004). CCLP relies on relaxing the problem into equivalent deterministic problems. This method was applied by

Sreenivasan and Vedula (1996) to maximize the hydropower energy produced in a multi-reservoir system.

Labadie (2004) indicated that stochastic nonlinear methods are rarely used due to the large number of computations involved. Therefore, stochastic nonlinear programming models are not presented in this literature review. However, stochastic dynamic programming (SDP) models are discussed in the next paragraph.

SDP models solve a DP relation in a stochastic form by explicitly introducing streamflow uncertainty in its recursive function. This is known as the Markov decision process. Fayaed, El-Shafie and Jaafar (2013) explain that this method is based on the discretization of the stochastic variables to infer the optimal operating rule for each discrete state of a reservoir system. The optimal policy is then obtained by approximating the discrete cost-to-go function by a continuous function through interpolation. The cost-to-go function can be explained simply as the next step of the recursion. Fayaed, El-Shafie and Jaafar (2013) then note that many studies were focused on how to represent uncertainty in future streamflow. Labadie (2004) notes that few researchers applied SDP to multi-reservoir systems due to the high state dimensionality. However, he notes that a reservoirs' aggregation into a hypothetical single reservoir can solve the dimensionality problem but might result in a loss of information.

3.1.7 Multiobjective optimization models

The optimization problem formulated in the beginning of the literature review in equations (1) through (7) considers only one objective function (equation (1)). Labadie (2004) notes that the objective function can be expressed as $f(s,r)$ where the vector s,r

represents reservoir storage and release in every reservoir. Therefore, equation (1) can be replaced by the following, more concise, equation:

$$\text{Optimize}_{\mathbf{s}, \mathbf{r}} f(\mathbf{s}, \mathbf{r}) \quad (10)$$

The formulation using equations (1) through (7) is known as the epsilon-constraint method because some of the objectives are perceived as constraints. Another formulation for these equations would be the multi-objective optimization model. This method is used when decision-makers want to achieve several goals simultaneously even if they are conflicting with each other. An example of a multi-objective model could include all of the following objectives: maximizing benefits of hydroelectric stations, maximizing the minimum downstream discharges for water supply and water quality, and maximizing the reliability of meeting water supply demands. The multiobjective approach treats constraints parametrically and adds them as complementary objectives. Mays and Tung (1992) expressed the general form of multiobjective programming as follows:

$$\text{Optimize}_{\mathbf{s}, \mathbf{r}} f(\mathbf{s}, \mathbf{r}) = [f_1(\mathbf{s}, \mathbf{r}), f_2(\mathbf{s}, \mathbf{r}), \dots, f_K(\mathbf{s}, \mathbf{r})] \quad (11)$$

where $f(\mathbf{s}, \mathbf{r}) = K$ -dimensional vector of objective functions.

A second method to incorporate constraints as objectives consists of adding the constraints as scalar values in the objective function and assigning subjective weights to each constraint (Labadie, 2004). Therefore equation (1) becomes:

$$\text{Optimize}_{\mathbf{s}, \mathbf{r}} f(\mathbf{s}, \mathbf{r}) + \sum_{j=1}^m w_j \bar{f}_j(\mathbf{s}, \mathbf{r}) \quad (12)$$

where m = the number of constraints; and $\bar{f}_j$ = the j^{th} constraint function.

Preemptive Goal Programming (GP) is a multi-objective optimization method that selects the most preferred solution (Fayaed, El-Shafie, & Jaafar, 2013). Labadie (2004) explains that GP starts by focusing on one objective and ignoring all other objectives. This first step might result in multiple solutions. In which case, achieving the second objective is done over this set of multiple solutions, and so on. Labadie (2004) notes that this method only works well if a massive non-uniqueness of solutions is attained at each level. Fayaed, El-Shafie, & Jaafar (2013) claim that a major disadvantage of GP is the fact that while it is good at optimizing important objectives it often performs poorly with lower priority objectives.

3.1.8 Evolutionary computation

Researchers use this kind of computational mechanism when a problem is too complex for a classical analytical optimization method. Examples of such complexities can include multi-objectives, uncertainty, nonlinearity, discontinuity and discreteness. Evolutionary computation (EC) was inspired by biological evolution and can be described as a family of algorithms able to find a global solution for an optimization problem. These methods have a metaheuristic or stochastic optimization character. EC is a famous principle in computational intelligence. Other principles include fuzzy logic and neural networks which are discussed in Fayaed, El-Shafie and Jaafar (2013); Labadie (2004); and Rani and Moreira (2010). Several EC techniques are used in problems related to river reservoir systems. The most common are Evolutionary Algorithms, Swarm Intelligence, Simulated Annealing, and Tabu Search. Labadie (2004) notes an

inconvenience of EC programming, which is that, unlike most of the optimization algorithms, EC cannot guarantee convergence to even local optimal solutions.

Evolutionary algorithms (EA) include genetic algorithms (GA), evolutionary programming, evolution strategy, and genetic programming. GA is the most famous application of EA in reservoir optimization problems. Minjares (2004) describes GA as search algorithms which are based on the mechanics of natural selection and natural genetics. He used this method to develop an annual short-term optimization model in irrigation district 41 of the Yaqui River Basin (YRB). This was done using a Microsoft Excel add-in called Evolver that maximizes total agricultural net benefits. The process can be started by a random generation of organisms consisting of possible solutions. The good organisms are updated by swapping their variables (genes) using crossover and mutation to produce “offspring.” The new generation is removed if they produce bad results and, therefore, two different parents are chosen. If the new generation produces good results, it is reintroduced in the population. This surviving offspring is identified as “fit” and helps improve the population. Therefore, GA results in populations of solutions producing offspring fitter than parents. Minjares concluded that agricultural benefits and the planted area do not depend on crossover rates, mutation rates, or population size. Labadie (2004) claims it is difficult to explicitly consider constraints and maintain feasible solutions while using GA. However, he notes that these algorithms are attractive due to the possible direct link to hydrologic simulation models.

Swarm Intelligence has two commonly used models in reservoir operation problems: The Ant Colony Optimization (ACO) and the Particle Swarm Optimization

(PSO). ACO is a metaheuristic optimization algorithm that aims to find good paths through graphs, and was inspired by ants creating optimal paths toward their food source. Fayaed, El-Shafie and Jaafar (2013) claim that applying this is a recent method to solve water resources problems. PSO is another metaheuristic method. Rani and Moreira (2010) note that PSO resembles GA in the fitness concept and the need to randomly initialize the population but does not include evolution operators such as crossover or mutation. Fayaed, El-Shafie and Jaafar (2013) note a great advantage of these algorithms, namely that they require few computations.

Simulated annealing (SA) is a metaheuristic algorithm commonly used in discrete optimization problems. Teegavarapu and Simonovic (2002) were the first to apply this method to reservoir systems operations, according to Rani and Moreira (2010). They concluded that SA provides a faster and more accurate solution. Li and Wei (2008) improved this method by combining SA with GA into one improved algorithm. However, they also concluded that this hybrid GA-SA is more efficient than SA, GA and DP.

Tabu Search (TS) is similar SA in that they both test immediate neighbors of current solutions. Rani and Moreira (2010) note that this method has not been used in many applications of the optimization problem of reservoir systems. They noted that Mantawy et al. (2002, 2003) successfully used this algorithm for long term hydro-scheduling of a reservoirs' hydropower system.

3.2 Simulation modeling

Rani and Moreira (2010) describe simulation models as practical tools used in reservoir system planning, management, and water allocation studies. These tools are

based on water balance equations and the hydrological behavior of reservoir systems. They also noted that simulation models may incorporate the economic performance of the system. These models can either be specific or generalized. Software packages that are based on generalized simulation models do not require modifications of the computer code and can be used in a variety of applications. HEC models are a well-known example of generalized pure simulation models. They are developed at the Hydrologic Engineering Centre (HEC), U.S. Army Corps of Engineers (USACE), in Davis, California. Rani and Moreira (2010) note that the reservoir system simulation packages (HEC-3, HEC-5, and HEC-ResSim) are free and can perform flood management, water supply, and hydropower operations. Other generalized pure simulation models include the WRAP Modeling System,

Resorting to a pure simulation to determine reservoir releases is a challenging task when multiple reservoirs exist in the system or when the simulation time horizon is long. This challenge can be overcome by adding an optimization model to the simulation. In the past, both analytical optimization methods and evolutionary computation have been combined with simulation models. In fact, Labadie (1993) affirms that combining both methods with a simulation model has been done in several studies in the past. Suiadee and Tingsanchali (2007) combined a simulation with genetic algorithms (GA) model software. GA was used to determine the optimal upper and lower rule curves which were used in simulation. Che (2015) used a combined optimization simulation model to optimize reservoir operations during flooding events. He then applied his model to the 2010 flood event that occurred in the Cumberland River watershed in Nashville,

Tennessee. A GA was used as an optimization method to simultaneously search for multiple optimal solutions, and the results proved that if a similar model had been used, the flood damage in downtown Nashville would have been less severe. The reader is referred to Rani and Moreira (2010) to learn about examples of generalized simulation–optimization models, namely, MODISM, RiverWare, CalSim, CalSim II, ARSP, OASIS, MIKEBASIN, RIBASIN, WATHNET, and WEAP.

The method discussed in the previous paragraph was chosen for this thesis project. It consists of combining a nonlinear programming optimization model to a hydrologic simulation. This technique is able to incorporate an economic performance of the system, namely agricultural profit. The methodology section explains the method in details.

CHAPTER 4 - METHODOLOGY

4.1 Description of the HEC-HMS hydrological simulation

4.1.1 Hydrologic modeling system HEC-HMS

HEC-HMS is a program developed by the U.S. Army Corps of Engineers (USACE)-Hydrologic Engineering Center (HEC) to simulate the precipitation-runoff process. This program is focused on watershed systems having several streams that flow into tributaries of a main river. This program is an improvement of an existing program called HEC-1, which was developed by USACE as well. Results of HEC-HMS simulations are stored in the Data Storage System HEC-DSS. These two programs make it possible to be used together with other software in order to solve problems related to “water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and system operations” (Scharffenberg and Fleming, 2010, p.1).

HEC-HMS hydrologic simulation begins by the precipitation falling on land surface, vegetation, or bodies of water. Part of this water returns to the atmosphere via evaporation and transpiration. The remaining water on land surface can either form ponds or infiltrate to the upper layers of soil. HEC-HMS considers that some infiltrated water will follow a horizontal movement just under the surface as interflow before joining the stream channel, while the other part of the infiltrated water will percolate vertically towards the aquifer (Che, 2015). The water that is not ponding or infiltrating will join one of the streams. The total outflow is the streamflow resulting from all water reaching the

stream network. The next figure illustrates the hydrologic process followed by HEC-HMS:

Figure 9: Diagram of the runoff process followed by HEC-HMS
(Source: Feldman (2000))

HEC-HMS allows the user to represent the watershed physically as a basin composed of several subbasins, reaches, junctions, reservoirs, diversions, sources, and sinks. The hydrologic simulation computations begin from upstream elements moving downstream. During the storm simulation, the user can select one of the several methods provided to simulate infiltration losses, transform excess precipitation into surface runoff, represent baseflow contributions to subbasin outflow, and simulate flow in open

channels. HEC-HMS also offers different methods to analyze historical precipitation and produce synthetic precipitation.

4.1.2 Hydrologic simulation

The hydrologic simulation using HEC-HMS is the first component of the reservoir operation model. The goal of this simulation is to compute the watershed runoff after a storm event. The semi-distributed hydrological model used in this study is an improvement of an existing model developed by González Parra (2015). His work aimed to be a tool that can be used by Mexico's national water authority (CONAGUA).

González Parra (2015) was interested in developing the HEC-HMS model, because it was noticed that estimations of water inputs to the three reservoirs in YRB conflicted with the CONAGUA official measurements. The official method used to determine the availability of surface water in Mexico is described in the Official Mexican Standard (NOM-011-CNA-2000). This standard describes the methodology for determining the availability of surface water, which is a simple water balance calculated on the basis of the difference between the mean annual volume of runoff in a basin and the current annual volume downstream. This methodology is based on empirical and arithmetic methods for the application of mass balances in basins. The purpose of the standard is to determine whether it is possible to authorize new water use without affecting the natural environment or users that are already granted or assigned. Therefore, a tool capable of generating acceptable estimations of water availability in the watershed was needed.

The simulation developed by González Parra (2015) allows the exploration of the spatial variability of runoff by explicitly incorporating changes in topography and climate (i.e. precipitation, air temperature, solar radiation), as well as incorporating physical properties of vegetation and soils. However, the limited information provided by the existing hydrometric stations in and around the basin is a challenge that needs to be tackled in order to develop a reliable hydrologic simulation. With such concerns in mind, his model was finished and then several modifications were introduced as explained in the following paragraphs.

In this hydrologic simulation, the YRB is divided into three contribution areas (see Figure 10) as it was presented in the annual average surface water availability study of the Official Gazette of the Federation (DOF, 2003-2007) (Table 2). Therefore, the YRB is managed as three hydrological basins: the hydrological basin VIII that forms the area of the Angostura dam, the hydrological basin IX formed by the area of the Novillo dam, and the hydrological basin X that forms the area of contribution of the Oviáchic dam (Table 2).

Table 2: Availability of surface water from Yaqui River System
(C_p is the average annual volume of natural runoff)

Hydrological Basin	Name and Description	C_p (Million m ³)
VIII	Rio Yaqui 1: From the Lázaro Cárdenas dam (La Angostura) to the Plutarco E Calles dam (El Novillo)	2203
IX	Rio Yaqui 2: From the Plutarco E Calles (El Novillo) to the Álvaro Obregón (El Oviáchic)	379.43
X	Rio Yaqui 3: From the Ivaro Obregón (El Oviáchic) to its mouth in the Sea of Cortez	48.4
Total		2630.83

Figure 10: Contribution areas of the Yaqui River Basin system and hydrographic characteristics of the YRB

Figure 11: Digital elevation model, land use and soil classification in the YRB
 (a) 30-m ASTER elevation distribution, YRB boundary, main channel network, location of existing reservoirs and stream gauges; (c) 463-m AVHRR vegetation classification; (d) 446-m INEGI-INIFAP soil classification.

The domain of the HEC-HMS model was generated by González Parra (2015) from the digital elevation model terrain analysis of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) using the HEC-GeoHMS tool. It was decided to delimit the number of subbasins to 53 subbasins due to the configuration of the terrain, thereby capturing the main tributaries of the Yaqui River. Figure 12 shows the distribution of the subbasins and their internal connections. The channel network is composed of the connection of the tributaries in the rivers, the rivers' nodes, and existing dams (Right hand side of Figure 12).

Figure 12: Representation of the subbasins in the Yaqui River Basin (with hydrographic characteristics, hydrometric stations and dams; the right hand side is a schematic representation of the model in HEC-HMS)

Methods and parameters chosen by González Parra (2015) in his hydrological simulation are detailed in this paragraph. For the transformation rainfall-runoff in the subbasins, the simple canopy storage method was chosen for canopy storage, a simple surface was selected as a surface depression storage method, the soil moisture accounting system to track losses through infiltration and soil water movement, and the Priestley-Taylor approach to estimate evapotranspiration. The surplus of the rain turned into surface runoff using the kinematic wave method that tracks the runoff in the area of each subbasin. Runoffs were routed using the finite-difference Muskingum-Cunge method.

The set of processing equations selected for the HEC-HMS model required initial parameters and conditions for each of the sub basins. Previous studies (Vivoni et al., 2010, Robles-Morua, 2012, Méndez-Barroso et al., 2008) were used to parameterize and determine the initial conditions. These values were based on results of field work to determine the properties of different soils and vegetation. It was assumed that the vegetation, depression and water storage in the soil at the beginning of the simulation are negligible (Vivoni et al., 2010).

In this study, several parameters were calibrated using the Nelder-Mead optimization algorithm (Feldman 2000) method. The automatic calibration routine was applied to the following parameters: canopy initial storage capacity percentage, tension zone capacity, surface initial storage percentage, groundwater 1 capacity, groundwater 1 initial storage percentage, groundwater 1 percolation rate. The routine chooses the best parameter values by comparing computed daily discharge with respect to the observed daily discharge upstream of each of the three dams of the YRB system. HEC-HMS includes scale factors which adjust values of these parameters until computed hydrographs fit observed hydrographs; these scale factors are specified in section 6.1.1. The root means square error (RMSE) and mean absolute error (MAE) were computed to quantify the accuracy of the simulation results. This process was carried out during the period 10/01/2001-3/31/2006 and the validation period was 4/1/2006-9/30/2010.

4.2 Description of the GAMS optimization model

4.2.1 *GAMS*

The General Algebraic Modeling System (GAMS) is a programming system for mathematical optimization that is based on a high level modeling language. GAMS helps users model and solve different optimization problems, such as linear, nonlinear or stochastic optimization problems. The system is suitable for complex and large-scale models. The World Bank was the first to fund the Research and Development of GAMS at the Development Research Center in Washington, D.C. before GAMS Development Corporation took over the research and development of the program in 1987. The original application of this system was economics and management science due to the need for mathematical programming in these fields. Bussieck and Meeraus (2004) explain that the initial objective was to design GAMS in order to improve modeling processes such as productivity, costs, reliability and credibility. GAMS Development Corporation is still working to improve these aspects of the system without modifying the model representation.

GAMS was the first algebraic modeling language, which is the best way to represent and solve mathematical programming problems (Bussieck and Meeraus, 2004). Bussieck and Meeraus (2004) note that this program is often used in academic research models. This is due to the different model types provided by this system. These include but are not limited to mixed integer linear and nonlinear programming model types, mixed complementarity problem types, mathematical programs with equilibrium constraints, and models with cone constraints. Another great advantage of GAMS is the

language used that can support new model types and a large number of solvers. In fact, the system is currently connected to more than twenty third-party programming solvers. It also allows the modeler to combine different solvers.

4.2.2 Optimization model formulation

This section describes the mathematical formulation of the optimization problems. An optimization problem was developed for every reservoir independently. This is important in order to manage with high efficiency the reservoir system existing in the Yaqui River basin. The parts which will be explained in details in the following paragraphs are: the objective function, the decision variables, and the constraints.

4.2.2.1 Objective functions

In this study, the performance of the overall Yaqui system was based on the purpose of extractions for each reservoir, which is mentioned in section 5.6. The following two criteria were chosen to describe this performance:

- (a) Total agriculture water use benefits need to be maximized,
- (b) Deviations from ideal target water allocations need to be minimized.

Optimization objectives for Angostura, Novillo, and Oviáchic, respectively, can be described as follow:

$$\text{Min } Z = \sum_{t=t_0}^T d_t^2 \quad (13)$$

$$\text{Max } Z = \sum_{t=t_0}^T R_t \quad (14)$$

$$Max Z = \sum_{t=t_0}^T \sum_{k=1}^K A_k (Cp_k Cy_{k,t} - C_{k,t}) \quad (15)$$

where d_t is the absolute value of the difference between the water flow released for a user and the target flow assigned to the same user at time t ; R_t is the outflow of El Novillo reservoir; A_k is the planted area for crop k ; Cp_k is the price for crop k ; $Cy_{k,t}$ is the k^{th} crop yield at time t ; C_k is the cost for crop k ; t is a daily period index.

4.2.2.2 *Decision variables*

The operators will control the amount of water to allocate to each user in order to optimize the previously specified objective function. This means that the decision variables for the optimization problem are the water flows delivered for each user. Reservoir users are mentioned in section 5.6.

4.2.2.3 *Constraints*

Constraints of the three optimization problems can be categorized into six main types:

(a) Conservation of mass (also known as continuity equation) throughout the system is the first constraint. This constraint is valid for all three reservoirs. The continuity equation is expressed on a discrete time basis, because the hydrologic data are available at discrete time intervals (equation (16)).

$$\int_{S_{j-1}}^{S_j} dS = \int_{(j-1)\Delta t}^{j\Delta t} I(t)dt - \int_{(j-1)\Delta t}^{j\Delta t} Q(t)dt \quad (16)$$

where I and Q are flow rates corresponding to incoming flows to the system and outgoing flows from the system; S_j is the volume of the storage at the j^{th} time interval; j is a time interval index.

If S_0 is the initial storage at time 0, then the discrete time continuity equation can be written as:

$$S_j = S_0 + \sum_{i=1}^j (I_i - Q_i) \quad (17)$$

Equation (17) can be furthermore simplified into a more practical equation (18):

$$S_{t+1} = S_t + I_t - Q_t \quad (18)$$

where I_t and Q_t are average reservoir inflow and outflow, respectively, during time period t ; S_{t+1} and S_t are reservoir storage volume at time period $t+1$ and t , respectively. Q_t is defined as:

$$Q_t = R_t + E_t \quad (19)$$

where R_t is the total release and E_t is the net evaporation. E_t is defined as:

$$E_t = PP_t - EV_t \quad (20)$$

where PP_t is the precipitation on reservoir surface and EV_t is the evaporation. R_t is defined as:

$$R_t = R_{ir,t} + R_{ws,t} + R_{in,t} \text{ and } R_{in,t} = R_{hp,t} \quad (21)$$

where $R_{ir,t}$, $R_{ws,t}$, $R_{in,t}$ and $R_{hp,t}$ are, respectively, releases for irrigation, water supply and/or industrial, instream flow requirement, and hydropower generation during period t . These types of releases depend on the users of the reservoirs. For example, Novillo's optimization only includes releases toward hydropower plants.

Figure 13 illustrates the routing of flow through a single reservoir using the continuity equation. It is a combination of equation (18) through (21), which can be expressed as the following (equation (22)):

$$S_{t+1} = S_t + I_t - (R_{ir,t} + R_{ws,t} + R_{in,t}) - E_t \quad (22)$$

Figure 13: A single multi-purpose reservoir

Equation (22) is used for all three reservoirs. The type of releases depends on the user sectors for each reservoir. This information is provided in section 5.6.

The evaporation is computed by multiplying the evaporation rate by upper surface area of the pool. The evaporation rate from each reservoir is obtained from historical data of the irrigation district. The evaporation mathematical expression is then:

$$EV_{i,t} = e_{i,t} * AS_{i,t} \quad (23)$$

where $EV_{i,t}$ is the evaporation volume from reservoir i during period t ; $e_{i,t}$ is the evaporation rate in each reservoir i during period t ; $AS_{i,t}$ is the upper surface area of the pool.

The area $AS_{i,t}$ follows the equation (24):

$$AS_{i,t} = a * (S_{i,t})^b \quad (24)$$

where $S_{i,t}$ is the volume of water stored in reservoir i at the beginning of period t ; a and b are, respectively, a regression coefficient and regression exponent.

It is noteworthy to mention the nonlinearity of equation (24). For this reason, the optimization problem cannot be solved by any method requiring the linearity of constraints. In this study, a nonlinear optimization programming method is chosen.

Minjares (2004) determined the values of the coefficients a and b for each reservoir. These values are summarized in the following table:

Table 3: Regression coefficient a and regression exponent b for the storage-area equation in each reservoir

Reservoir	a	b
Angostura	1.8753	0.56
Novillo	0.71	0.642
Oviachic	1.079	0.6464

(b) Reservoir storage constraints are defined by upper and lower borders that the volume of water stored should be within. These limits are specific to each reservoir and can be expressed by the following equation:

$$S_{min,t} \leq S_t \leq S_{max,t} - F_t \quad (25)$$

where S_t is the reservoir storage at the end of period t ; $S_{min,t}$ is the minimum storage allowed, $S_{max,t}$ is the maximum storage capacity; and F_t is the storage volume for flood control.

The minimum storage limit is a condition that ensures a low chance to have a deficit for water supply to different users. Values of these minimum levels are specified in the following table for each reservoir according to Minjares (2004, p.99):

Table 4: Storage constraints in the Yaqui River System

Reservoir	Storage lower bound (in 10^6 m^3)	Reason for the lower bound value	Storage upper bound (in 10^6 m^3)
Angostura	85	Supply Pueblos Ribereños	618.4
Novillo	265	Head for hydropower	2755
Oviachic	550	Head to supply water into Alto canal	2439.1

Always keeping extra storage volume for flood control (F_t) provides operators with additional time when they are emptying the pool. Therefore, it is a way to minimize the risk of releasing water downstream through spillways and bottom outlets with a flow high enough to cause flooding or representing outlet capacities. The upper bounds are set according to the minimum flood control level.

(c) Reservoir releases constraints are defined for each reservoir. They represent two bounds that the release flow rate has to be within. The lower limit ensures that there is enough flow for municipal and industrial use, and the upper limit is controlling potential flooding or representing outlet capacities. The following equation is the mathematical expression of this constraint:

$$R_{min,t} \leq R_t \leq R_{max,t} \quad (26)$$

where R_t is a release from the reservoir's outlet during period t ; $R_{min,t}$ are minimum releases from the reservoir during period t ; $R_{max,t}$ are maximum releases from the reservoir during period t .

The following table summarizes the values of both minimum and maximum releases from the reservoir in each reservoir:

Table 5: Minimum and maximum releases for reservoirs' outlets

Reservoir	Minimum Releases for Outlet Reservoir's Structure (in m ³ /s)	Maximum Releases for Outlet Reservoir's Structure (in m ³ /s)
Angostura	1.6	40.0
Novillo	4.0	155.0
Oviachic	10.0	210.0

(d) Water deliveries for irrigation purposes from the El Oviachic reservoir are important in the Yaqui valley and are subject to a set of constraints. These constraints can define the correlation between water and production of crops although other important factors (i.e. water quality, solar radiation, precipitation) affect this relationship.

It is critical that irrigated agriculture makes a good profit. In fact, Minjares (2004) explained that each irrigation district in Mexico aims to be self-sustaining. Minjares (2004) also presented a constraint (equation (27)) which expresses the fact that the land irrigated during any season must be less or equal to the total irrigated area in the irrigation district:

$$\sum_{t=t_0}^T \sum_{k=1}^K A_{k,t} \leq 227,224 \text{ Hectares} \quad (27)$$

where $A_{k,t}$ is the area planted with different crops during an irrigation season.

The amount of water delivered by Oviachic towards the Irrigation District 41 for irrigation purposes is based upon the amount of water required, the conveyance efficiency, and the amount of groundwater extracted. This constraint is represented mathematically as follows:

$$R_{ir,t} = \lambda \sum_{k=1}^T q_{k,t} - R_{gr,t} \quad (28)$$

where $q_{k,t}$ is the amount of water required by the crop k during period t ; $R_{ir,t}$ is El Oviáchic's releases to the Irrigation District 41 for irrigation; λ is the conveyance efficiency; $R_{gr,t}$ is groundwater extraction for irrigation during period t .

(e) The urban water use is subject to a final constraint. This constraint satisfies urban users' needs because they have the highest priority (Table 14). This constraint expresses the fact that releases toward treatment plants is greater than a target value while constraint (c) is about total releases:

$$R_{ws,t} \geq W_t \quad (29)$$

where $R_{ws,t}$ is the volume of water released from a reservoir for water supply during period t, W_t water required for urban use during period t.

4.2.3 Optimization summary

This section summarizes objective functions and constraints used for the optimization of the Yaqui system. All equations were mentioned in details in the previous section.

4.2.3.1 Angostura

Objective function:
$$\text{Min } Z = \sum_{t=t_0}^T d_t^2 \quad (30)$$

Constraints:
$$S_{t+1} = S_t + I_t - (R_{ws,t} + R_{in,t}) - E_t \quad (31)$$

where $R_{ws,t}$ are urban and industrial releases

$$S_{min,t} \leq S_t \leq S_{max,t} - F_t \quad (32)$$

$$R_{min,t} \leq R_t \leq R_{max,t} \quad (33)$$

$$R_{ws,t} \geq W_t \quad (34)$$

4.2.3.2 Novillo

Objective function:
$$\text{Max } Z = \sum_{t=t_0}^T R_t \quad (35)$$

Constraints:
$$S_{t+1} = S_t + I_t - R_{in,t} - E_t \quad (36)$$

$$S_{min,t} \leq S_t \leq S_{max,t} - F_t \quad (37)$$

$$R_{min,t} \leq R_t \leq R_{max,t} \quad (38)$$

4.2.3.3 Oviachic

$$\text{Objective function:} \quad \text{Max } Z = \sum_{t=t_0}^T \sum_{k=1}^K A_k (Cp_k Cy_{k,t} - C_{k,t}) \quad (39)$$

$$\text{Constraints:} \quad S_{t+1} = S_t + I_t - (R_{ir,t} + R_{ws,t} + R_{in,t}) - E_t \quad (40)$$

$$S_{min,t} \leq S_t \leq S_{max,t} - F_t \quad (41)$$

$$R_{min,t} \leq R_t \leq R_{max,t} \quad (42)$$

$$R_{ir,t} = \lambda \sum_{k=1}^T q_{k,t} - R_{gr,t} \quad (43)$$

$$\sum_{t=t_0}^T \sum_{k=1}^K A_{k,t} \leq 227,224 \text{ Hectares} \quad (44)$$

$$R_{ws,t} \geq W_t \quad (45)$$

4.2.4 Solution approach

The solver used to solve these optimization models is CONOPT3 version 3.14U. This solver is able to perform the nonlinear programming required due to the nonlinear evaporation constraint. CONOPT belongs to the groups of solvers attempting to find a local solution. Locating a global solver is not possible because of the large number of variables included in this optimization problem. Finding a global optimum was not guaranteed, and therefore initializing releases and introducing an upper bound to the urban use constraint was necessary for the algorithm to converge to a desired solution. The nonlinear programming (NLP) class of GAMS cannot be used to optimize Angostura and Oviachic reservoirs because of the existence of the absolute value function in some

constraints. This function is smooth but has a discontinuous derivative. Although, the function could have been reformulated in order to use an NLP class, the Nonlinear Programming with Discontinuous Derivatives (DNLP) model was chosen to find the solution without having to reformulate the problem. CONOPT (Drud, 1985) is a solver designed for static and dynamic large-scale problems with nonlinear constraints. It is based on the GRG algorithm explained in section 3.1.3. This solver works best in the particular case where the number of variables is close to the number of constraints. The following table specifies the number of single variables and equations used for the optimization of every reservoir:

Table 6: Number of single equations and variables used for reservoirs' optimization

	Number of equations	Number of variables	Time steps
Angostura	29,594	19,729	3287
Novillo	23,018	13,153	3287
Oviachic	85,490	65,761	3287

4.3 Integration of the hydrologic simulation and optimization model

The main objective of this study is to develop a tool capable of helping schedule water allocations to different users. That is why the reservoirs' operations suggested by this model will be compared to real operations to ensure that the model's results are reasonable. This optimization model can also help decide what type of crops farmers will be growing in the upcoming agricultural year. This application of this tool will be discussed in more details in section 5.6.

This section explains the routine followed to optimize the operations of the Yaqui river system based on the HEC-HMS hydrologic simulation and the GAMS optimization

model. The goal is to be able to click only once to run the model although more than one program is needed to complete the task. In order to achieve this objective, an open source programming language Python was chosen to automate the process. The code developed in this study facilitates the communication between the different programs (HEC-HMS, HEC-DSSVUE, EXCEL and GAMS) without the need of a human intervention. The operator only makes sure all the hydrologic and optimization settings are correct before running the program.

The Yaqui watershed is simplified in this section for an easy illustration of the integration routine. This simplification will not introduce new restrictions to the problem. The basin can be described as three watersheds having the reservoirs (Angostura, Novillo and Oviachic) as outlets. These watersheds are in series and are connected by the main channel (i.e. the Yaqui River). The overall basin has an outlet at the sea of Cortez. The following figure illustrates the schematic of this simple model:

Figure 14: Schematic of a simple model

The HEC-HMS hydrologic simulation is the first component of the model. The simulation uses precipitation, temperature and solar radiation data to simulate a discharge time series inflowing to the upstream reservoir (Angostura). These hydrographs are then inputted in the GAMS optimization model to determine the releases of the first reservoir. Once the optimal releases are determined, the outflow obtained is then fed back to the hydrologic simulation. The HEC-HMS simulation will be run again to transform rainfall into runoff using the new information acquired from GAMS. This operation will generate a discharge time series inflowing from the Yaqui River and its main tributaries to the

second reservoir (Novillo), which will be inputted into the GAMS optimization model. This model will optimize the operation of the second reservoir and generate an outflow time series. These hydrographs generated are inputted into the HEC-HMS simulation. Once more, the simulation will estimate the water flowing from the Yaqui River and its main tributaries into the last reservoir (Oviachic). GAMS will use this information to determine the best solutions (i.e. reservoir releases). This routine is summarized in the following flow chart:

Figure 15: Reservoir operation optimization routine

The routine explained above was implemented by modifying the HEC-HMS hydrologic modeling. Reservoirs in the simulation were replaced by two hydrologic elements, a sink and a source. Therefore, all three watersheds mentioned in Figure 14 have a sink as an outlet. Watersheds 2 and 3 have a source on the most upstream part of the basins. The reason why reservoirs are excluded from the hydrologic simulation is the fact that reservoirs' operations are taking care of by the optimization model, which

include all the necessary reservoirs' characteristics (i.e. reservoirs' capacities, storage-area curves, elevation-storage curves, flood control volumes, spillway heights). Having these characteristics in HEC-HMS will then be redundant.

Running the HEC-HMS hydrologic simulation is still the first step in the model. This will allow the transformation rainfall-runoff and provide the discharge time series into the first sink. This inflow is exactly the same as the Angostura inflow hydrographs explained in Figure 15. Results of HEC-HMS simulations are stored in HEC-DSSVue. This program plays the role of mediator between HEC-HMS and other programs. The time series is then extracted from HEC-DSSVue into an excel workbook. Next, these hydrographs are added from Excel to the GAMS optimization model, which will determine the optimal operation strategy of the Angostura reservoir and provide the flow of water to release to the different users. The outflow from the Angostura, decided by the optimization model, is saved in a new Excel spreadsheet. These time series are fed back to the hydrologic simulation as a discharge from the source via HEC-DSSVue. HEC-HMS will simulate the hydrologic process in the second watershed and estimate the inflow to the second sink. GAMS will optimize the operation of Novillo considering the sink's inflow in the same way described for the 1st reservoir. The resulting outflow is inputted into HEC-HMS (following the same process explained in the 1st reservoir) as a discharge time series of the 3rd watershed's source. After running the HEC-HMS one last time, the obtained discharge time series of the water flowing into the last sink is added to the optimization model. GAMS will then be run in order to optimize the operation of the

Oviachic reservoir. All four programs are run in a batch mode or background mode. The following two figures illustrate the whole process described in this paragraph:

Figure 16: Programs interacting in the simulation optimization model

Figure 17: Integration of the hydrologic simulation and optimization model

In Figure 17, i refers to the order of the watershed. The reservoirs being in series is the basis for repeating a subroutine in a loop fashion. All reservoirs' releases from GAMS are stored in excel sheets and compared to real operations. The python script can be found in Appendix E.

CHAPTER 5 - MODEL DATA AND ASSUMPTIONS

The observed daily runoff, reservoir releases, and evaporation rate were obtained as Excel spreadsheets from the Irrigation District No.041. The official ideal target flows for different user sectors and economic data were obtained from Minjares (2004). Accuracy of results of the model developed in this study depended on the truthfulness of these data. However, these results illustrated the usefulness of the model and how it can serve as a Decision Support System.

5.1 Reservoirs inflow

The time series of water flowing into the three reservoirs were used to calibrate and validate the hydrologic simulation. This information was obtained from the Irrigation District No.041. It is noteworthy to mention that several months were missing in these records and had to be added based upon observations from preceding and succeeding days. These hydrographs are available in the appendix A.

5.2 Atmospheric data

The atmospheric data considered in this work were precipitation, temperature, solar radiation, and evaporation rate. These three parameters were measured in weather stations, and we obtained such data from the Irrigation District No.41. The station network was made of 27 stations with daily observations and includes an interpolation using Thiessen polygons. Because of how sparse these stations were, we also studied a re-analysis dataset from the North American Land Data Assimilation System (NLDAS). NLDAS fields had a spatial resolution of $1/8^\circ$ (almost 12 km) and an hourly temporal resolution; we aggregated it to a daily scale (Mitchell et al, 2004).

NLDAS rainfall fields were based on a temporal disaggregation of adjusted gauge-only U.S.–Mexico daily analyses. Temporal disaggregation was based on a remote sensing product (Joyce et al. 2004). Beside the use of the NLDAS dataset, we also used a bias-corrected NLDAS dataset. This bias correction has been performed in previous studies such as Robles-Morua, Vivoni, & Mayer (2012). They corrected the precipitation given by NLDAS datasets through the averaged ratio of means multiplicative factor (RM, equation (46)). These bias corrections were used on a daily basis. They also used the mean field bias (B, equation (47)) of Bedient et al. (2008) as an indicator of the fit. The same procedure was followed to adjust the NLDAS precipitation, temperature and solar radiation forcing.

$$RM(t) = \frac{\sum_{i=1}^N g_i(t)}{\sum_{i=1}^N p_i(t)} \quad (46)$$

where N is the number of stations (i) and corresponding pixels ($N = 27$), and $g_i(t)$ and $p_i(t)$ are daily precipitations, temperature, or solar radiation at the station and the pixel, respectively.

$$B = \frac{1}{N} \sum_{i=1}^N \frac{P_i}{G_i} \quad (47)$$

where G_i and P_i are the total precipitation, average temperature, or average solar radiation during the considered time period.

Figure 18: Spatial variability of annual precipitation for study period

This figure compares how annual precipitation varies spatially using the three meteorological forcing cases, namely station network observations, NLDAS fields, and bias-corrected NLDAS fields. The NLDAS fields moderately overestimate the precipitations; especially in the southeastern region. The corresponding mean field bias of Bedient is 1.092. This bias has to be close to 1 in order to have accurate estimations. The bias-corrected NLDAS fields mitigate moderately the overestimation (Figure 19). The mean field bias of Bedient is 1.033 after adjusting NLDAS fields. The average annual precipitation in the YRB is 464 mm for NLDAS forcing and 444 mm for bias corrected NLDAS fields. These two values are not significantly different. Figure 18-c is able to

replicate Figure 18-a in the Yaqui valley and in the northern region. However, precipitations are underestimated in the western Oviachic contribution area and overestimated in the eastern region of this area.

Figure 19: Annual precipitation in the Yaqui River basin

The temperature NLDAS forcing approximates the ground observations considerably with a slight underestimation. The bias correction method used was not able to improve this approximation. Figure 20 illustrates how ground observation signal is picked up by the NLDAS fields. The mean field bias of Bedient is 1.075 for raw NLDAS forcing and 1.073 after adjusting NLDAS fields.

The solar radiation NLDAS forcing greatly overestimates the ground observations. The bias correction method used was able to approximate solar radiation

measured in ground stations. The mean field bias of Bedient is 2.445 for raw NLDAS forcing and 1.071 after adjusting NLDAS fields (Figure 21).

Figure 20: Average annual temperature in the Yaqui River basin

Average annual solar radiation in the YRB

Figure 21: Average annual solar radiation in the Yaqui River basin

The evaporation rate measured by CONAGUA is summarized in a table at the appendix. This parameter is used in equation (23).

5.3 Economic data and agricultural crops

The economic study in this project focuses only on the profit from agriculture in the irrigation district No. 041. Benefits generated by other sectors such as hydropower generation cannot be quantified due to the lack of the necessary data. The irrigation district No. 041 develop a crop pattern every agricultural year based on different factors such as surface water and groundwater available, farmers' preference, crop prices, and subsidy programs. The agricultural year starts on October 1 and ends at September 30.

The volume of water needed from El Oviachic reservoir in order to grow a specific crop depends on the required depth of that crop and its irrigated area. The following equation expresses how that can be computed:

$$\text{Water volume required (Oviachic)} = \text{irrigated area} * \text{required gross depth} \quad (48)$$

The required gross depth for each crop includes all loss through evapotranspiration, infiltration, runoff, and channel conveyance. The values of this parameter are shown in the following table:

Table 7: Gross crops' water requirements
(*Source*: Miniñares (2004))

Crops	Gross water requirements (cm)
Maize	127.9
Wheat	87.0
Safflower	56.4
Barley	53.7
Garbanzo	57.0
Vegetables	98.4
Sorghum	113.7
Cotton	121.0
Alfalfa	180.5
Fruits	118.1
Soybeans	136.6
Sesame	62.5

The monthly irrigated area is the function of the total area for the crop (Appendix) and the irrigation percent (Table 8). The following equation explains how to compute the monthly irrigated area for a specific crop:

$$\text{Monthly irrigated area} = \text{Total irrigated area} * \text{Monthly Irrigation Percent} \quad (49)$$

Table 8: Monthly irrigation percent for each crop
(*Source*: Minjares (2004))

[illegible]

The profit produced by each crop can be computed using the following equation:

$$Profit(\frac{\$}{hectare}) = Yield(\frac{tons}{hectare}) * Price(\frac{\$}{ton}) - Cost(\frac{\$}{hectare}) \quad (50)$$

where \$ = Mexican pesos.

The optimization model of the Oviachic reservoir developed in this study can be used to choose the most profitable crops to grow. This is accomplished by allowing GAMS to vary the total planted area for every crop. In the optimization language, this means that the decision variable is the planted area. The crops grown in the irrigation district No. 41 are wheat, safflower, barley, garbanzo beans, vegetables, sorghum, cotton, corn, soybeans, sesame, alfalfa, and fruits. Minjares (2004) presented the prices and costs of every crop from 1993 to 2003 and estimated the same prices and costs from 2004 to 2008 (Table 9 to 11):

Table 9: Crop prices in Mexican pesos/ton
(Source: Minjares (2004))

Year	Wheat	Saffl	Garb	Veg	Sorgh	Cotton	Maize	Soy	Sesa	Alfalfa	Fruits
93	630	750	2200	1468	600	1400	838	856	1800	400	6200
94	850	1500	1900	1007	650	3600	800	1600	1900	500	5946
95	1750	1875	4000	3084	1141	3644	1628	1600	1900	800	6200
96	1400	1875	4000	3476	1200	4000	1850	1800	2000	850	2110
97	1400	2350	5300	3422	910	4400	1317	1800	5000	800	2855
98	1360	1989	4100	2057	1700	4136	1320	1800	4000	800	2855
99	1515	1728	4800	1325	1000	4700	1319	1800	4000	1400	2653
00	1680	1964	4930	2266	1200	4930	1440	1800	5000	1145	1280
01	1811	3500	5300	3941	1950	5250	2000	1800	5000	1200	890
02	1951	3550	4520	2850	1285	3000	1650	1800	5000	1400	890
03	1951	3550	4520	2850	1285	3000	1850	1800	5000	1400	890
04	1951	3550	4520	2850	1285	3000	1850	1800	5000	1400	890
05	1951	3550	4520	2850	1285	3000	1930	1800	5000	1400	890
06	1951	3550	4520	2850	1285	3000	2010	1800	5000	1400	890
07	1951	3550	4520	2850	1285	3000	2050	1800	5000	1400	890

Table 10: Crop yield in ton/hectare
(Source: Minjares (2004))

Wheat	Saffl	Garb	Veg	Sorgh	Cotton	Maize	Soy	Sesa	Alfalfa	Fruits
5.98	1.41	1.85	24.4	4.8	3.01	5.94	2.1	0.96	13.85	6.71

Table 11: Crop costs in Mexican pesos/hectare
(Source: Minjares (2004))

Year	Whe.	Saffl	Garb	Veg	Sorgh	Cot.	Mai.	Soy	Sesa	Alfa.	Fru.
93	2559	1628	2658	8556	2194	4000	2804	2156	2187	2802	6348
94	2947	1722	2780	7441	2309	6877	3029	2268	2500	2905	9290
95	2947	1838	2913	9233	3573	6877	3175	3973	2500	3025	14966
96	4178	2719	4094	16300	4496	9316	5410	7000	6000	4671	6348
97	5853	4037	10500	17705	4035	9316	5807	4014	3193	4825	15472
98	5850	3950	5870	16600	6600	11500	6300	4200	3300	4700	7500
99	6300	4000	7800	22000	4500	13500	7600	4200	3300	9400	7500
00	7300	3800	8300	25700	6000	13500	8100	4200	3300	9400	7500
01	7800	6000	8300	28000	6000	13500	8400	7000	6000	9800	7800
02	9195	7225	9487	30000	7785	13250	9981	7000	6000	12205	9500
03	9195	7225	9487	30000	7785	13250	9981	7000	6000	12205	9500
04	9195	7225	9487	30000	7785	13250	9981	7000	6000	12205	9500
05	9195	7225	9487	30000	7785	13250	9981	7000	6000	12205	9500
06	9195	7225	9487	30000	7785	13250	9981	7000	6000	12205	9500
07	9195	7225	9487	30000	7785	13250	9981	7000	6000	12205	9500

5.4 Industrial water allocations assumptions

The industrial water allocation in the Yaqui reservoir system consists of water delivered to a copper mining complex by La Angostura reservoir. Minjares (2004) specifies the average monthly volume of water used for this activity (Table 12):

Table 12: Monthly volume of water assigned for mining use in 10^6 m^3
(Source: Minjares (2004))

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1.5	1.6	1.8	1.6	1.9	2.0	3.2	2.7	2.2	3.2	3.5	3.2

5.5 Urban water allocations assumptions

The urban water use has the highest priority in the Yaqui watershed. The two urban areas in the city are Pueblos Ribereños in the upper basin and cities in the Yaqui Valley. The following table summarizes the monthly volume of urban water assigned:

Table 13: Monthly volume of urban water assigned in 10^6 m^3
(Source: Minjares (2004))

Type of urban use	Reservoir	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Pueblos Ribereños	La Angostura	4.5	4.8	5.0	5.0	5.2	5.2	5.5	5.5	5.0	5.0	4.8	4.5
Cities in the valley	El Oviachic	5.0	4.8	4.5	4.5	4.8	5.0	5.0	5.2	5.2	5.5	5.5	5.0

The main city in the valley is the city of Obregon and other small cities include Villa Bonita, Esperanza, and Providencia. While modeling it was assumed that annual water demand for this urban use grows by 3% every year.

5.6 Reservoir operation data and assumptions

Minjares (2004, p.61) explained that the Mexican Federal Law, published by the Mexico's national water authority (CONAGUA) in 1992, sets the water uses priorities as shown in the following table:

Table 14: Water uses' priorities according to the Mexican federal law
(*Source*: Minjares (2004, p.61) and Addams (2004, 9.56))

Water Use	Priority
Urban use	First priority
Agricultural use	Second priority
Industrial use	Third priority
Hydropower	Fourth priority
Recreation use	Fifth priority
Environmental use	Not considered a priority in the irrigation district

Based on the priorities mentioned earlier, providing less than the urban water assigned is not tolerated. Therefore satisfying urban demands is a constraint to obey, not an objective to try to attend. The El Novillo reservoir has one sole purpose which is generating hydropower energy. We couldn't find data related to energy generation and therefore decided to maximize the volume of water transferred to Oviachic. Table 14 explained that environmental use is not a priority in the irrigation district in 2004. However, recently, it is decided that Oviachic reserves water flow for environmental use (Munoz-Hernandez, Mayer, & Watkins, 2011). This type of use was not considered during the optimization process due to lack of information but can be taking into account

in future work. The uses considered in this work were urban, industrial, and agricultural, as shown in the following table:

Table 15: Users supplied by each reservoir in the Yaqui system and objective of the optimization

Reservoir	User	Type of use	Objective
La Angostura	Pueblos Ribereños	Urban	No urban deficit (1 st priority)
	Mining complex	Industrial	Minimize Industrial deficit
El Novillo	Hydropower production site	Hydropower generation	Maximize water transferred to Oviachic
El Oviachic	Cities of the valley	Urban	No urban deficit (1 st priority)
	Irrigation District	Irrigation District	Maximize agricultural profit
	Ecological Flow	Environmental	Not considered (no data)

Figure 22: Conceptualization of hydrologic system in the YRB
(Source: Munoz-Hernandez, Mayer, & Watkins, 2011)

The records of the water released from reservoirs to the different users were obtained from the Irrigation District No.41. The conveyance efficiency is assumed to be 67%. This value was chosen based upon the fact that the average conveyance efficiency in the agricultural year 2001-2002 was 66.4% (Minjares, 2004, p.96), and efforts were made to improve the efficiency.

The Oviachic reservoir also delivers water towards Irrigation District No.018. These extractions were fixed and the annual volume was 250 million m³ (Minjares 2004).

These extractions were taken into consideration when simulating the releases towards Irrigation District No.041.

The groundwater extractions were specified by Minjares (2004) as follow:

Table 16: Monthly volume of groundwater extracted in 10^6 m^3

(Source: Minjares (2004))

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	60	60	60	60	60	25	10	10	5.	5	4

CHAPTER 6 -MODEL APPLICATION, RESULTS AND DISCUSSION

The hydrologic simulation was run using three types of forcing: ground station network observations, NLDAS datasets and bias corrected NLDAS datasets. The first part of this chapter will describe the results obtained with each of these datasets. It will also compare and explain these results. The second part of this chapter analyzes the overall results of the model i.e. the operation optimization of the three reservoirs, and compares them to the authorized operations. The third part is an economic analysis of the agricultural products in the Irrigation District No.041 in the year 2001-2002. The last part of this chapter discusses the application of the reservoir system operation model in the YRB.

6.1 Hydrologic simulation results analysis

6.1.1 *Ground observations*

The first dataset used for the hydrologic simulation was based on ground observations. The simulation was calibrated by adjusting with respect to daily observed hydrographs upstream of the three dams. The calibration process was carried out during the period 10/01/2001-3/31/2006 and the validation period was 4/1/2006-9/30/2010. Table 17 showed scale factors of the parameters calibrated. Except for ground water percolation rate, all other parameters had a scale factor close to 1 meaning that parameters initial estimates were good.

Table 17: Scale factor values of parameters calibrated in HEC-HMS

Parameter	Initial estimates*	Scale factor
Canopy initial storage percentage	1.4868 %	1
Tension zone capacity	50 mm	1.15
Surface initial storage percentage	1%	1
Groundwater 1 capacity	1000 mm	0.988
Groundwater 1 initial storage percentage	0%	1
Groundwater 1 percolation rate	0.0000001 mm/hr	0.01

*Initial estimates were decided by González Parra (2015)

Figure 23 shows how the simulation was well calibrated in Angostura and Oviachic reservoirs compared to Novillo. On the other hand, the validation of Angostura and Novillo were better than Oviachic. As expected, all simulated discharge peaks followed precipitation peaks. However, several high discharge peaks were simulated but not observed during the calibration of Novillo and validation of Novillo and Oviachic. The first factor that might be the cause for this disparity was the existence of several unregulated embankments retaining water in the Yaqui River tributaries, which was not taken into account by the simulation. The second factor was related to the equations used by HEC-HMS. The program might have underestimated the losses from evapotranspiration and infiltration. This hypothesis can be studied in the future using a higher resolution soil type dataset.

Figure 23: Calibration (10/01/2001-3/31/2006) and validation (4/1/2006-9/30/2010) of the hydrologic simulation using ground observations

6.1.2 Raw NLDAS forcing

Figure 24 represents the calibration and validation of the hydrologic simulation using raw NLDAS forcing. The root mean square error (RMSE) value of El Novillo calibration decreased from 103.2 m³/s in ground observation simulation to 76.6 m³/s in NLDAS forcing simulation. However, the validation of this reservoir did not improve when using NLDAS forcing. Angostura calibration and validation both improved when NLDAS datasets were used. These results were in favor of using the high resolution NLDAS fields in the hydrologic simulation. On the other hand, ground observation simulation provided better results compared to NLDAS forcing simulation. This might be caused by the fact that NLDAS precipitation is overestimated during runoff peaks; for example, in the years 2000 to 2005, 2007, and 2010 (Figure 19). Moreover, temperature

was underestimated by NLDAS datasets. These two factors might have resulted in overestimation of runoff.

Figure 24: Calibration (10/01/2001-3/31/2006) and validation (4/1/2006-9/30/2010) of the hydrologic simulation using raw NLDAS forcing

6.1.3 Bias corrected NLDAS forcing

Figure 25 represents the calibration and validation of the hydrologic simulation using bias corrected NLDAS forcing. It is notable how similar the RMSE is in Figure 24 and Figure 25. This means that the bias correction did not affect the hydrologic simulation. This might be due to the fact that solar radiation fields were the only fields with significant correction. Precipitation and temperature fields were not greatly modified by the bias correction procedure used.

Figure 25: Calibration (10/01/2001-3/31/2006) and validation (4/1/2006-9/30/2010) of the hydrologic simulation using bias corrected NLDAS forcing

Table 18: RMSE and MAE for the three types of forcing used in HEC-HMS

	Angostura				Novillo				Oviachic			
	Calibration		Validation		Calibration		Validation		Calibration		Validation	
	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE
Ground observation	4.6	10.6	8.2	14.3	103.2	38.4	153.3	69.7	42.8	22.5	145	43.8
NLDAS	33.2	9.6	36.7	13.9	76.6	33.2	182.6	70.6	53.4	27.1	162	39.6
Corrected NLDAS	33.2	9.6	36.7	13.9	76.6	33.2	184.1	70.8	54	27.1	164	39.6

It is interesting to investigate the effect of other correction procedures on the hydrologic simulation. Table 18 summarizes the RMSE and mean absolute error (MAE) for all three types of forcing used. Based on these results, atmospheric ground

observations were used to simulate rainfall runoff transformations in Oviachic, whereas gridded NLDAS fields were used for the other two reservoirs.

6.2 Reservoir system operation analysis

In this section, the water allocation schedule of the three reservoirs obtained from the model will be compared to the observed daily releases in order to assess the operation policies implemented in the Yaqui reservoir system. The different users extracting water from each reservoir and the order of priority of these users were mentioned in section 5.6.

6.2.1 *Angostura*

Figure 26 is about Pueblos Ribereños, the urban user and also the highest priority user of Angostura reservoir. Comparing the authorized releases to the ideal target flow rates showed that Angostura operators often allocated more water than needed. Moreover, releases were less than targets on several occasions. This highlights the poor operation policy implemented in this reservoir. The GAMS optimization of Angostura resulted in an infeasible solution meaning that not all constraints were satisfied. In fact, the solver failed to satisfy the ideal target releases towards Pueblos Ribereños and the copper mine in a few instances (Figure 26 and Figure 27). However, the model satisfied the Pueblos Ribereños needs during the majority of the simulation period (Figure 25).

Figure 26: Simulated, observed, and target urban releases from Angostura

Figure 27 highlights how authorized releases towards the mining complex almost never satisfied the ideal target flow rates. This is more evidence of the defective management of this reservoir. On the other hand, the model was able to allocate the water needed by this industry during the majority of the simulation period.

Figure 27: Simulated, observed, and target industrial releases from Angostura

Figure 28 and Figure 29 illustrate that authorized releases denote the uneven water allocations. In fact, urban releases are exaggerated in general whereas industrial water needs are often unsatisfied. The simulated water allocation was able to meet the competing demands, thereby improving Angostura operations.

Figure 28: Simulated, observed, and target cumulative urban releases from Angostura

Figure 29: Simulated, observed, and target cumulative industrial releases (Angostura)

6.2.2 Novillo

El Novillo had one purpose, which was hydropower generation. Because of the lack of information regarding hydropower generation, it was decided that the objective function consisted of maximizing the reservoir outflow. The GAMS optimization of Novillo resulted in a feasible optimum. Therefore, the simulated releases were the maximum releases satisfying all operation constraints. However Figure 30 and Figure 31 showed that authorized releases exceed the simulated releases. This was due to instances when Novillo operators opened emergency gates for several days. The fact that operators used emergency gates indicated the weakness of the operation.

Figure 30: Simulated, observed, and maximum outflow Novillo

Figure 31: Simulated, observed, and maximum outflow from Novillo

6.2.3 Oviachic

The GAMS optimization of Oviachic resulted in an infeasible solution because urban target flow rates were not met in some instances (Figure 32). However, the simulated water allocation often satisfied urban needs. On the other hand, observed releases were never able to reach the ideal target values. This is a sign of how poor the operation policies implemented in Oviachic reservoir were. Because urban use had the highest priority, operation policies of Oviachic need to be improved.

Figure 32: Simulated, observed, and maximum urban releases from Oviachic

Figure 33: Simulated, observed, and target cumulative urban releases from Oviachic

The authorized crop pattern was inputted in the optimization model in order to validate how the model was able to reproduce the irrigation releases. The model estimated daily water volumes required by each crop and simulated Oviachic irrigation releases based on that information. Figure 34 showed how the simulated releases plot reproduced the observed releases. Figure 35 signaled that the model somewhat overestimated the irrigation releases. These deviations of the observed releases resulted from assumptions that groundwater extractions were constant, even though farmers pump more groundwater when surface water is not enough. Therefore, operations suggested by the model may have resulted in more sustainable aquifer levels.

Figure 34: Simulated vs observed irrigation releases from Oviachic

Figure 35: Simulated vs observed cumulative irrigation releases from Oviachic

6.3 Economic analysis

In the previous section, the model proved to be capable of estimating daily irrigation needs and allocated the necessary volume of water to satisfy these needs. In this section, GAMS was allowed to vary crop irrigated areas in order to maximize the profit of agricultural products in the agricultural years of 2001 to 2002. This approach was only an illustration of a potential application of the model. Several important factors in defining a crop pattern, such as governmental subsidies were disregarded.

The most profitable crop pattern was simulated assuming Oviachic was supplying farmers during all twelve months. Water releases were also simulated in order to satisfy the needs generated by this profitable crop pattern and obey all operational constraints.

The following table compared water demands by real crop pattern to simulated crop pattern:

Table 19: Real crop pattern and simulated crop pattern of the year 2001-2002

Crop	Simulated irrigated area (ha)	Real irrigated area (ha)	Simulated gross water volume (10⁶ m³)	Real gross water volume (10⁶ m³)
Maize	5609	16450	72	210
Wheat	40318	165574	351	1440
Safflower	0	2750	0	16
Garbanzo beans	0	4274	0	24
Vegetables	139592	11891	1374	117
Sorghum	0	1057	0	12
Cotton	0	1415	0	17
Alfalfa	21705	5003	392	90
Fruits	0	1876	0	22
Soybeans	0	0	0	0
Sesame	0	0	0	0
Total	207223	210290	2188	1949

Table 20: Real/simulated profits generated by agriculture in the year 2001-2002

Crop	Area (ha)	Price (\$/ton)	Yield (ton/ha)	Cost (\$/ha)	Simulated Profit (10⁶ \$)	Real Profit (10⁶ \$)
Maize	5609	1650	6	9981	-1	-3
Wheat	40318	1951	6	9195	100	409
Safflower	0	3550	1	7225	0	-6
Garbanzo beans	0	4520	2	9487	0	-5
Vegetables	139592	2850	24	30000	5519	470
Sorghum	0	1285	5	7785	0	-2
Cotton	0	3000	3	13250	0	-6
Alfalfa	21705	1400	14	12205	156	36
Fruits	0	890	7	9500	0	-7
Soybeans	0	1800	2	7000	0	0
Sesame	0	5000	1	6000	0	0
Total					5774	887

\$ = Mexican pesos

Table 19 showed that the crop pattern simulated required more water than the actual crop pattern. However the total irrigated simulated area was smaller than the real one. Therefore the model tended to suggest crops which were more water demanding. Table 20 showed that the model profit was considerably greater than the real profit. The model chose four crops to plant including the only crops with positive profit (i.e. wheat, vegetables, and alfalfa). Maize was also suggested by the simulation even if its profit was negative. This was explained by the fact that the model always allocated water for irrigation; however, wheat, vegetables, and alfalfa were not irrigated during August and September (Table 8). Moreover, the high simulation profit was mainly due to the large area allocated to vegetables. Therefore farmers should consider assigning larger planted areas to vegetables due to the high profit it could generate.

6.4 Discussion

The model was able to schedule releases better than the actual water allocations. This accentuated the fact that operation policies of the Yaqui system needed to be improved in order to satisfy the competing demands. The simulated urban releases were able to satisfy the demands throughout almost the entire simulation period unlike the observed releases. In addition, the optimization of Novillo highlighted the fact that operators of the reservoir resort to opening emergency gates therefore endangering downstream regions. Furthermore, the simulated irrigation releases have the same general trend as the real irrigation releases, even though the model irrigation releases were moderately greater than authorized releases. This fact stressed that farmers had to look

for an additional source of water, such as groundwater or tap water, to irrigate their crops. Moreover, by keeping Oviáchic's pool elevation high, operators were losing more water via evaporation. Finally, from an economic point of view, the crop pattern in the year 2001 to 2002 could have been more profitable, if more vegetables were grown. Even if vegetables have a high water requirement, the simulation proved that allocating larger areas for vegetables does not increase the overall water demand drastically.

CHAPTER 7 - CONCLUSIONS, RECOMMENDATIONS, AND FUTURE WORK

7.1 Conclusions

Good operations of reservoir systems depend upon good estimation of water availability and sound optimization modeling. The main contribution of this thesis is the development of a combined hydrologic simulation and optimization model to assess and improve the operation policy implemented in the Yaqui system. The integration of the hydrologic simulation to the optimization model, described in section 4.3, was completely automated in order to establish an efficient model. Python scripts provided in Appendix E were able to automate this interaction.

The semi-distributed daily watershed simulation was developed by González Parra (2015) using the Hydrologic Modeling System (HEC-HMS) developed by the US Army Corps of Engineers (USACE) Hydrologic Engineering Center. The choice of HEC-HMS is justified by its common use in both academic field and industry. Hydrologic information (precipitation, temperature, and solar radiation) is required by the HEC-HMS simulation. In this study, we obtained this information from a network of ground observations from Mexican water agencies during the historical period of 1990-2010. Because of the sparsity of these weather stations, a denser atmospheric dataset was used and compared to the first type of forcing. This dataset is in the form of gridded fields from the North America Land Data Assimilation System (NLDAS) at 12 km resolution. In addition, bias correction was introduced to NLDAS fields and tested on the hydrologic simulation. The NLDAS forcing and bias corrected NLDAS performed better for Angostura and Novillo whereas ground observation datasets provided the best simulation

for Oviachic. NLDAS and bias corrected NLDAS caused the simulation to not perform well in this last reservoir (i.e. Oviachic), because its precipitations were overestimated during runoff peaks. Other bias correction methods might improve this hydrologic simulation.

The overall HEC-HMS hydrologic model was able to simulate water availability in the Yaqui River and its main tributaries. NLDAS forcing was used to simulate hydrographs inflowing to Angostura and Novillo while ground observations were used to simulate hydrographs inflowing to Oviachic.

The three reservoirs which control the YRB are Angostura, Novillo, and Oviachic. Angostura supplies water for urban (Pueblos Ribereños) and industrial use (a mining complex). Novillo's sole purpose is hydropower generation. Oviachic supplies water for urban (city of Obregon and other towns) and agricultural use (Yaqui Valley Irrigation District). All three reservoir operations were optimized according to water rights established in Mexico's National Water Law.

The optimization model is developed using the General Algebraic Modeling System (GAMS). Optimization problems were solved using a Nonlinear Programming with Discontinuous Derivatives (DNLP) model. GAMS was able to find a feasible optimum only for Novillo. The other two reservoirs had the urban and industrial use constraints unsatisfied in some instances. The real operations of Angostura were shown to have uneven water allocations unlike the simulated operations. The results of Novillo's optimization showed that real releases exceeded maximum allowed releases. In fact, operators of Novillo resort to opening emergency gates and therefore endangering

downstream regions. Oviachic optimization modeling was able to simulate urban water allocation that is better than the real allocation. Moreover, GAMS could estimate daily water required by crops and schedule releases accordingly. It was also able to generate a crop pattern that is more profitable than the actual crop pattern.

The model developed in this thesis is a real world application of an approach that combines hydrologic simulation and optimization modeling. Although limited by all the assumptions described in chapter 5, this model proved to be a tool capable of improving the existing reservoir operation policy in the Yaqui system.

7.2 Recommendations and future work

The Yaqui watershed impacts the sociopolitical climate of the region because of the Independencia project and especially the Novillo-Hermosillo aqueduct. Unfortunately, information related to reservoir operations after the construction of the aqueduct couldn't be obtained. It would be interesting to investigate the performance of this model when Novillo started supplying the city of Hermosillo. Updating data inputted in this model would be able to assess the operations of the Novillo reservoir.

This work aimed to improve the hydrologic simulation developed by González Parra (2015) by testing the high resolution NLDAS forcing. One way to further improve this hydrological simulation is by studying different bias correction methods of NLDAS dataset. Another way is to use a higher resolution hydrological model. Increasing the number of subbasins in the YRB and using the high resolution NLDAS dataset might improve the simulation.

The only economic analysis performed in this thesis was related to agriculture. This analysis was limited to developing a crop pattern to maximize profit. This approach is also limited because I did not take into consideration governmental subsidies to farmers. Taking into account these subsidies makes the model more realistic. Moreover, hydropower generation profits have to be included to have a more accurate economic analysis of the system. This approach is known as the Food, Energy, and Water Nexus (FEW Nexus). Understanding the connection between these three components is critical to managing water resources.

Environmental flows are another important component that was beyond the scope of this work. Although this component would affect the economic benefits of the system, considering this water allocation is critical for a healthy river ecosystem. Furthermore, Munoz-Hernandez (2009) proved that having a hypothetical water market with water allocations serving environmental purposes could positively impact the overall economic performance of the system.

Another limitation of this work is the fact that groundwater extractions were considered fixed in this thesis even if farmers' pumping varies from year to year. Addams (2004) developed a groundwater model in the Yaqui Valley to account for this variability. Combining his simulation with the HEC-HMS hydrologic model developed in this thesis could result in better operations of Oviachic. It is essential to optimize both sources of water because farmers have surface water rights as well as ground water rights.

The reservoirs were optimized independently in a linear fashion starting from the most upstream reservoir of Angostura and ending with Oviachic. This is justified by the

fact that the YRB is managed as three hydrological basins: the hydrological basin VIII that forms the area of the Angostura dam, the hydrological basin IX formed by the area of the Novillo dam, and the hydrological basin X that forms the area of contribution of the Oviáchic dam (Table 2). However, integrated management performs better than managing each basin individually. Therefore, it is advised to optimize the system by giving the highest priority to the urban use in both Angostura and Oviachic, then agricultural use in Oviachic, then industrial use in Angostura, and finally hydropower generation in Novillo.

This work aimed to assess operational strategies and that is why the data used is historical. Forecasting studies have to be performed in order to improve these strategies. Several sources of forecasted atmospheric data, such as the climatological dataset generated by WRF at 10-km resolutions, can be applied to the HEC-HMS hydrologic simulation. Future operational policies can be inferred based on the obtained future hydrographs inflowing to the reservoirs. The addition of a future forecast forcing scenario is also recommended because of the climate variability in the YRB.

CHAPTER 8 -FINAL THOUGHTS

This project aims to assist in the management of water resources in the YRB. That is why the software programs chosen in this research are often used in both academia and industry. HEC-HMS is a free program and Python is a free open source programming language with easy code readability. Although GAMS is not free, it is commonly used by researchers and engineers.

In order to improve management of the Yaqui system, efforts are made to include local authorities in this project. Collaboration has been initiated with Dr. Minjares from the National Water Commission. Working with Dr. Minjares is a great step forward toward applying the model developed in this thesis into real-life use. We are hoping that workshops would be organized in order to introduce this model. Moreover, we are hoping to improve this work and make it more practical by addressing recommendations from the previous chapter.

The python scripts developed in this study were able to successfully link HEC-HMS to GAMS. Although they were written for the specific case of the Yaqui River System, they can be used for any other reservoir system problem requiring an interaction between a semi-distributed/distributed hydrologic simulation and an optimization model. Furthermore, it is true that they successfully link both models; however, they need to be modified to improve time efficiency.

Appendix E also includes a python script used to input information in HEC-DSSVue using batch mode. This method was useful for testing different forcing scenarios. Using the graphical user interface is time consuming and can lead to errors,

especially because the same operation must be repeated 318 times when entering NLDAS fields and corrected NLDAS fields. In this watershed there are 53 NLDAS field with three different atmospheric data (i.e. precipitation, temperature, and solar radiation).

Finally, it was my pleasure to be part of a project that aims to strengthen water security in a region with increasing demands. Through this work, I developed an interest in integrated water resources management as an approach to sustain water, which is becoming vulnerable as more pressure is placed on this resource all over the globe. Good allocation, regulation and conservation of these resources are critical for human beings to stay alive. It is an honor to keep learning about ways to preserve water on earth and encourage a more careful use of fresh water.

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APPENDIX A RESERVOIRS INFLOW AND EVAPORATION RATE

The following information was obtained from the Irrigation District No.041 as Excel spreadsheets, some omissions have been filled based on data of preceding and succeeding days. (Reservoir inflows are in m^3/s and evaporation rates are in mm/day)

Angostura			Novillo		Oviachic		Angostura			Novillo		Oviachic	
Day	inflow	evap.rate	inflow	evap.rate	inflow	evap.rate	Day	inflow	evap.rate	inflow	evap.rate	inflow	evap.rate
10/1/2001	1.00	252.6	3.20	94.7	1.00	770.0	4/1/2006	1.00	757.7	3.40	604.5	7.70	365.8
10/2/2001	1.00	362.7	3.20	469.7	1.00	354.2	4/2/2006	1.00	608.3	3.30	691.5	7.50	746.9
10/3/2001	1.00	401.2	5.20	314.9	1.00	338.8	4/3/2006	1.00	573.7	3.30	646.0	7.20	462.0
10/4/2001	2.73	477.4	7.10	236.4	1.00	454.3	4/4/2006	1.00	733.0	3.30	602.1	7.00	616.0
10/5/2001	9.93	401.9	7.20	246.4	1.00	373.5	4/5/2006	1.00	600.6	3.30	638.3	6.80	662.2
10/6/2001	12.52	449.7	5.60	445.8	1.00	288.8	4/6/2006	1.00	542.9	3.30	817.7	6.60	696.9
10/7/2001	10.69	457.4	4.60	345.7	1.00	462.0	4/7/2006	1.00	515.9	3.30	704.6	6.40	512.1
10/8/2001	7.86	375.8	4.10	408.1	1.00	338.8	4/8/2006	1.00	696.9	3.30	913.2	6.30	739.2
10/9/2001	5.66	422.0	3.80	371.9	1.00	423.5	4/9/2006	1.00	712.3	3.20	775.4	6.10	847.0
10/10/2001	4.16	467.4	3.60	375.8	1.00	438.9	4/10/2006	1.00	699.2	3.20	609.1	6.00	631.4
10/11/2001	3.16	577.5	3.50	577.5	1.00	415.8	4/11/2006	1.00	721.5	3.20	641.4	5.90	569.8
10/12/2001	2.51	505.9	3.40	405.8	1.00	766.2	4/12/2006	1.00	763.1	3.20	932.5	5.80	639.1
10/13/2001	2.08	373.5	3.40	418.1	1.00	385.0	4/13/2006	1.00	807.7	3.20	884.7	5.60	735.4
10/14/2001	1.80	557.5	3.30	383.5	1.00	562.1	4/14/2006	1.00	644.5	3.20	573.7	5.50	623.7
10/15/2001	1.61	430.4	3.30	345.0	1.00	454.3	4/15/2006	1.00	832.4	3.20	646.8	5.50	519.8
10/16/2001	1.48	539.8	3.30	485.1	1.00	369.6	4/16/2006	1.00	781.6	3.20	431.2	5.40	631.4
10/17/2001	1.38	589.8	3.30	428.1	1.00	592.9	4/17/2006	1.00	946.3	3.20	581.4	5.30	592.9
10/18/2001	1.31	537.5	3.30	457.4	1.00	581.4	4/18/2006	1.00	766.2	3.20	773.9	5.20	677.6
10/19/2001	1.25	474.3	3.30	489.7	1.00	496.7	4/19/2006	1.00	870.1	3.20	890.9	5.20	739.2
10/20/2001	1.21	583.7	3.20	367.3	1.00	423.5	4/20/2006	1.00	485.1	3.20	808.5	5.10	862.4
10/21/2001	1.18	567.5	3.20	445.1	1.00	481.3	4/21/2006	1.00	779.2	3.20	723.8	5.00	800.8
10/22/2001	1.15	532.1	3.20	487.4	1.00	492.8	4/22/2006	1.00	669.1	3.20	754.6	5.00	643.0
10/23/2001	1.13	561.3	3.20	440.4	1.00	489.0	4/23/2006	1.00	918.6	3.20	858.6	4.90	700.7
10/24/2001	1.11	394.2	3.20	392.7	1.00	527.5	4/24/2006	1.00	902.4	3.20	870.9	4.90	785.4

10/25/2001	1.10	570.6	3.20	463.5	1.00	392.7	4/25/2006	1.00	765.4	3.20	412.7	4.80	550.6
10/26/2001	1.09	478.2	3.20	427.4	1.00	358.1	4/26/2006	1.00	642.2	3.20	833.9	4.80	974.1
10/27/2001	1.08	488.2	3.20	415.0	1.00	408.1	4/27/2006	1.00	885.5	3.20	880.9	4.80	639.1
10/28/2001	1.07	447.4	3.20	449.7	1.00	639.1	4/28/2006	1.00	654.5	3.20	862.4	4.70	800.8
10/29/2001	1.06	393.5	3.30	432.7	1.00	392.7	4/29/2006	1.00	643.0	3.20	785.4	4.70	708.4
10/30/2001	1.05	512.8	3.30	448.9	1.00	388.9	4/30/2006	1.00	760.0	3.20	685.3	4.70	839.3
10/31/2001	1.05	686.1	3.30	341.9	1.00	327.3	5/1/2006	1.00	781.6	3.20	431.2	4.60	631.4
11/1/2001	1.04	314.2	3.40	274.1	1.00	369.6	5/2/2006	1.00	946.3	3.20	581.4	4.60	592.9
11/2/2001	1.04	308.0	3.40	479.7	1.00	385.0	5/3/2006	1.00	766.2	3.20	773.9	4.60	677.6
11/3/2001	1.04	393.5	3.30	535.9	1.00	458.2	5/4/2006	1.00	870.1	3.20	890.9	4.50	739.2
11/4/2001	1.03	457.4	3.30	432.7	1.00	404.3	5/5/2006	1.00	485.1	3.20	808.5	4.50	862.4
11/5/2001	1.03	341.1	3.30	344.2	1.00	469.7	5/6/2006	1.00	779.2	3.20	723.8	4.50	800.8
11/6/2001	1.04	219.5	3.30	194.0	1.00	485.1	5/7/2006	1.00	669.1	3.20	754.6	4.50	643.0
11/7/2001	1.05	318.0	3.30	403.5	1.00	508.2	5/8/2006	1.00	918.6	3.20	858.6	4.50	700.7
11/8/2001	1.06	427.4	3.30	562.9	1.00	592.9	5/9/2006	1.00	902.4	3.20	870.9	4.50	785.4
11/9/2001	1.08	292.6	3.30	314.9	1.00	292.6	5/10/2006	1.00	765.4	3.20	412.7	4.40	550.6
11/10/2001	1.10	339.6	3.30	357.3	1.00	361.9	5/11/2006	1.00	642.2	3.20	833.9	4.40	974.1
11/11/2001	1.12	368.8	3.20	341.9	1.00	346.5	5/12/2006	1.00	885.5	3.20	880.9	4.40	639.1
11/12/2001	1.13	361.9	3.20	335.0	1.00	396.6	5/13/2006	1.00	654.5	3.20	862.4	4.40	800.8
11/13/2001	1.13	502.0	3.20	337.3	1.00	435.1	5/14/2006	1.00	643.0	3.20	785.4	4.40	708.4
11/14/2001	1.12	129.4	3.20	253.3	1.00	396.6	5/15/2006	1.00	760.0	3.20	685.3	4.40	839.3
11/15/2001	1.11	329.6	3.20	338.8	1.00	377.3	5/16/2006	1.00	980.2	3.20	1050.3	4.40	1093.4
11/16/2001	1.09	209.4	3.20	204.1	1.00	485.1	5/17/2006	1.00	1216.6	3.70	785.4	4.40	1116.5
11/17/2001	1.08	338.8	3.20	317.2	1.00	327.3	5/18/2006	1.00	889.4	6.30	800.8	4.40	1085.7
11/18/2001	1.07	311.1	3.20	203.3	1.00	292.6	5/19/2006	1.00	944.0	9.40	746.9	4.50	816.2
11/19/2001	1.06	327.3	3.20	274.1	1.00	234.9	5/20/2006	1.00	951.0	9.80	485.1	4.80	1035.7

11/20/2001	1.05	245.6	3.20	449.7	1.00	438.9	5/21/2006	1.00	666.8	7.90	786.2	5.20	900.9
11/21/2001	1.04	408.9	3.20	327.3	1.00	396.6	5/22/2006	1.00	664.5	5.90	1040.3	5.40	1116.5
11/22/2001	1.04	342.7	3.20	237.9	1.00	431.2	5/23/2006	1.00	812.4	4.70	991.8	5.60	1105.0
11/23/2001	1.04	304.2	3.20	292.6	1.00	342.7	5/24/2006	1.00	952.5	4.10	862.4	5.70	1066.5
11/24/2001	1.03	281.1	3.20	261.8	1.00	261.8	5/25/2006	1.00	985.6	3.80	931.7	5.60	1008.7
11/25/2001	1.03	184.8	3.20	304.9	1.00	261.8	5/26/2006	1.00	1118.8	3.60	931.7	5.60	1155.0
11/26/2001	1.03	510.5	3.20	272.6	1.00	258.0	5/27/2006	1.00	851.6	3.50	924.8	5.50	770.0
11/27/2001	1.02	266.4	3.20	208.7	1.00	296.5	5/28/2006	1.00	1034.9	3.40	903.2	5.50	931.7
11/28/2001	1.02	231.0	3.20	410.4	1.00	284.9	5/29/2006	1.00	1088.0	3.40	1055.7	5.40	1016.4
11/29/2001	1.02	291.1	3.20	309.5	1.00	292.6	5/30/2006	1.00	1199.7	3.30	924.8	5.30	877.8
11/30/2001	1.02	170.9	3.20	177.1	1.00	346.5	5/31/2006	1.00	787.7	3.30	800.8	5.30	900.9
12/1/2001	1.02	240.2	3.20	405.8	1.00	246.4	6/1/2006	1.00	980.2	3.30	1050.3	5.20	1093.4
12/2/2001	1.02	242.6	3.20	404.3	1.00	408.1	6/2/2006	1.00	1216.6	3.30	785.4	5.10	1116.5
12/3/2001	1.01	288.0	3.20	274.9	1.00	342.7	6/3/2006	1.00	889.4	3.30	800.8	5.10	1085.7
12/4/2001	1.01	341.9	3.20	263.3	1.00	173.3	6/4/2006	1.00	944.0	3.30	746.9	5.00	816.2
12/5/2001	1.01	241.8	3.20	309.5	1.00	281.1	6/5/2006	1.00	951.0	3.30	485.1	5.00	1035.7
12/6/2001	1.01	231.8	3.20	338.0	1.00	300.3	6/6/2006	1.00	666.8	3.30	786.2	4.90	900.9
12/7/2001	1.01	274.1	3.20	214.8	1.00	369.6	6/7/2006	1.00	664.5	3.70	1040.3	4.90	1116.5
12/8/2001	1.01	398.9	3.20	509.0	1.00	462.0	6/8/2006	1.00	812.4	5.00	991.8	4.90	1105.0
12/9/2001	1.01	317.2	3.20	402.7	1.00	450.5	6/9/2006	1.00	952.5	6.80	862.4	4.90	1066.5
12/10/2001	1.02	259.5	3.20	201.0	1.00	311.9	6/10/2006	1.00	985.6	7.40	931.7	5.10	1008.7
12/11/2001	1.04	281.1	3.20	117.8	1.00	238.7	6/11/2006	1.00	1118.8	6.70	931.7	5.30	1155.0
12/12/2001	1.11	129.4	3.20	227.9	1.00	157.9	6/12/2006	1.00	851.6	5.60	924.8	5.40	770.0
12/13/2001	1.22	151.7	3.20	221.8	1.00	365.8	6/13/2006	1.00	1034.9	4.70	903.2	5.50	931.7
12/14/2001	1.39	98.6	3.20	227.2	1.00	323.4	6/14/2006	1.00	1088.0	4.20	1055.7	5.60	1016.4
12/15/2001	2.23	308.0	3.20	261.8	1.00	304.2	6/15/2006	1.00	1199.7	3.90	924.8	5.60	877.8

12/16/2001	4.49	78.5	3.30	361.9	1.00	231.0	6/16/2006	1.00	787.7	3.70	800.8	5.50	900.9
12/17/2001	5.49	261.8	3.50	300.3	1.00	246.4	6/17/2006	1.00	941.7	3.60	998.7	5.50	862.4
12/18/2001	4.94	101.6	3.80	294.1	1.00	377.3	6/18/2006	1.00	913.2	3.50	998.7	5.40	1193.5
12/19/2001	3.91	355.0	4.10	452.0	1.00	400.4	6/19/2006	1.00	989.5	3.40	881.7	5.40	1232.0
12/20/2001	3.00	212.5	4.10	317.2	1.00	377.3	6/20/2006	1.00	802.3	3.40	752.3	5.30	831.6
12/21/2001	2.38	478.2	4.00	239.5	1.00	315.7	6/21/2006	1.00	577.5	3.30	711.5	5.20	877.8
12/22/2001	1.99	119.4	3.80	240.2	1.00	254.1	6/22/2006	1.00	571.3	3.30	848.5	5.20	970.2
12/23/2001	1.74	239.5	3.60	252.6	1.00	335.0	6/23/2006	1.00	737.7	3.30	858.6	5.10	939.4
12/24/2001	1.57	280.3	3.50	35.4	1.00	273.4	6/24/2006	1.00	677.6	3.50	754.6	5.10	962.5
12/25/2001	1.44	259.5	3.40	254.1	1.00	442.8	6/25/2006	1.00	727.7	4.60	673.0	5.00	793.1
12/26/2001	1.35	259.5	3.40	404.3	1.00	396.6	6/26/2006	1.00	549.0	5.80	620.6	5.10	862.4
12/27/2001	1.29	300.3	3.30	278.0	1.00	400.4	6/27/2006	1.00	552.1	6.30	472.0	5.10	354.2
12/28/2001	1.24	226.4	3.30	215.6	1.00	331.1	6/28/2006	1.00	631.4	6.50	538.2	5.30	423.5
12/29/2001	1.20	442.0	3.30	238.7	1.00	396.6	6/29/2006	1.01	403.5	32.90	790.8	6.80	754.6
12/30/2001	1.17	295.7	3.30	211.0	1.00	373.5	6/30/2006	1.01	737.7	222.40	696.1	31.40	758.5
12/31/2001	1.14	348.8	3.30	148.6	1.00	304.2	7/1/2006	1.02	736.1	136.90	654.5	65.90	477.4
1/1/2002	1.12	193.3	3.30	170.2	1.00	335.0	7/2/2006	4.27	683.0	338.90	696.1	176.10	758.5
1/2/2002	1.11	96.3	3.20	294.9	1.00	254.1	7/3/2006	377.00	589.8	627.60	646.8	193.20	966.4
1/3/2002	1.09	265.7	3.20	254.1	1.00	292.6	7/4/2006	351.44	614.5	394.10	533.6	209.00	843.2
1/4/2002	1.08	297.2	3.20	237.2	1.00	284.9	7/5/2006	84.27	702.2	178.40	765.4	234.80	985.6
1/5/2002	1.07	188.7	3.20	347.3	1.00	177.1	7/6/2006	25.48	440.4	85.10	400.4	232.30	808.5
1/6/2002	1.06	291.8	3.20	472.0	1.00	419.7	7/7/2006	11.77	713.8	49.60	904.0	207.00	1001.0
1/7/2002	1.06	340.3	3.20	389.6	1.00	327.3	7/8/2006	6.79	808.5	36.60	808.5	176.10	608.3
1/8/2002	1.05	315.7	3.20	333.4	1.00	269.5	7/9/2006	4.53	840.8	29.70	716.1	148.00	924.0
1/9/2002	1.05	316.5	3.20	242.6	1.00	354.2	7/10/2006	3.32	840.8	23.40	766.2	124.80	870.1
1/10/2002	1.04	325.7	3.50	233.3	1.00	346.5	7/11/2006	2.64	714.6	18.00	753.1	105.90	485.1

1/11/2002	1.04	316.5	4.80	206.4	1.00	223.3	7/12/2006	2.21	862.4	14.00	663.0	90.40	900.9
1/12/2002	1.04	228.7	5.70	277.2	1.00	415.8	7/13/2006	1.92	702.2	11.00	630.6	77.50	592.9
1/13/2002	1.03	287.2	5.00	178.6	1.00	415.8	7/14/2006	1.73	559.0	8.90	700.7	66.80	924.0
1/14/2002	1.03	196.4	4.40	203.3	1.00	223.3	7/15/2006	1.59	896.3	7.50	654.5	57.90	877.8
1/15/2002	1.03	476.6	4.10	198.7	1.00	250.3	7/16/2006	1.48	633.7	8.60	440.4	50.60	746.9
1/16/2002	1.03	431.2	3.90	240.2	1.00	331.1	7/17/2006	1.40	797.0	12.90	681.5	44.70	885.5
1/17/2002	1.02	408.1	3.70	278.7	1.00	346.5	7/18/2006	1.33	685.3	15.60	867.8	40.30	800.8
1/18/2002	1.02	450.5	3.60	200.2	1.00	419.7	7/19/2006	1.28	512.8	14.10	488.2	36.80	985.6
1/19/2002	1.02	300.3	3.60	277.2	1.00	331.9	7/20/2006	1.24	877.8	11.10	728.4	33.90	939.4
1/20/2002	1.02	345.7	3.50	292.6	1.00	423.5	7/21/2006	1.21	1039.5	9.20	839.3	31.20	708.4
1/21/2002	1.02	282.6	3.40	294.9	1.00	438.9	7/22/2006	1.18	1028.0	8.20	808.5	28.70	954.8
1/22/2002	1.02	495.9	3.40	183.3	1.00	184.8	7/23/2006	1.16	873.2	7.30	713.0	26.30	993.3
1/23/2002	1.02	405.8	3.40	281.1	1.00	446.6	7/24/2006	1.15	914.8	6.30	689.2	24.20	500.5
1/24/2002	1.01	288.8	3.30	395.0	1.00	361.9	7/25/2006	1.22	552.9	5.60	643.7	22.30	523.6
1/25/2002	1.01	233.3	3.30	331.1	1.00	369.6	7/26/2006	7.10	632.2	5.90	646.8	20.60	546.7
1/26/2002	1.01	298.0	3.30	415.8	1.00	415.8	7/27/2006	22.41	221.0	13.30	521.3	19.80	431.2
1/27/2002	1.01	385.0	3.30	375.8	1.00	292.6	7/28/2006	43.53	131.7	190.70	662.2	30.50	900.9
1/28/2002	1.01	371.9	3.30	317.2	1.00	288.8	7/29/2006	91.25	249.5	137.80	700.7	52.40	500.5
1/29/2002	1.01	47.0	3.30	142.5	1.00	246.4	7/30/2006	107.03	239.5	119.20	141.7	85.10	531.3
1/30/2002	1.01	160.2	3.60	472.8	1.00	300.3	7/31/2006	64.92	89.3	75.60	149.4	98.40	431.2
1/31/2002	1.01	191.0	3.80	358.8	1.00	354.2	8/1/2006	28.65	498.2	55.40	434.3	88.30	377.3
2/1/2002	1.01	263.3	4.00	277.2	1.00	231.0	8/2/2006	13.01	440.4	51.10	426.6	76.20	646.8
2/2/2002	1.01	46.2	4.20	207.9	1.00	207.9	8/3/2006	7.16	465.1	84.60	243.3	70.10	693.0
2/3/2002	1.01	80.9	9.00	130.9	1.00	181.0	8/4/2006	5.92	335.0	52.80	290.3	68.10	323.4
2/4/2002	1.01	332.6	42.40	323.4	1.00	100.1	8/5/2006	7.21	453.5	24.70	489.7	65.50	716.1
2/5/2002	1.01	43.1	36.60	94.7	1.00	238.7	8/6/2006	7.13	522.1	13.20	435.1	60.40	619.9

2/6/2002	1.01	197.9	26.00	251.8	1.00	254.1	8/7/2006	5.68	461.2	8.70	442.8	54.10	527.5
2/7/2002	1.01	207.1	18.00	355.7	1.00	261.8	8/8/2006	4.21	428.1	7.00	496.7	47.80	531.3
2/8/2002	1.01	313.4	12.00	295.7	1.00	342.7	8/9/2006	3.22	563.6	6.90	496.7	42.20	693.0
2/9/2002	1.01	374.2	8.10	277.2	1.00	369.6	8/10/2006	3.03	570.6	36.20	407.3	38.50	600.6
2/10/2002	1.01	468.9	6.10	703.0	1.00	527.5	8/11/2006	3.62	556.7	41.90	394.2	37.40	361.9
2/11/2002	1.01	507.4	5.00	548.2	1.00	392.7	8/12/2006	3.96	761.5	31.90	408.1	37.50	604.5
2/12/2002	1.01	205.6	4.40	515.1	1.00	361.9	8/13/2006	3.63	208.7	26.60	459.7	37.20	458.2
2/13/2002	1.01	345.0	4.10	388.1	1.00	346.5	8/14/2006	3.06	388.1	20.30	428.1	36.20	392.7
2/14/2002	1.00	340.3	3.90	257.2	1.00	454.3	8/15/2006	2.63	525.1	15.60	244.1	34.50	619.9
2/15/2002	1.00	365.8	3.70	409.6	1.00	465.9	8/16/2006	3.61	347.3	11.10	367.3	32.40	458.2
2/16/2002	1.00	396.6	3.60	396.6	1.00	431.2	8/17/2006	6.74	367.3	7.80	586.7	30.00	562.1
2/17/2002	1.00	500.5	3.50	298.0	1.00	412.0	8/18/2006	7.51	456.6	6.10	767.7	27.50	562.1
2/18/2002	1.00	373.5	3.50	363.4	1.00	523.6	8/19/2006	6.03	446.6	6.20	654.5	25.20	804.7
2/19/2002	1.00	388.9	3.40	366.5	1.00	381.2	8/20/2006	4.32	532.8	7.80	473.6	23.10	581.4
2/20/2002	1.00	365.8	3.40	488.2	1.00	531.3	8/21/2006	3.24	498.2	8.50	623.7	21.40	577.5
2/21/2002	1.00	592.9	3.40	951.0	1.00	816.2	8/22/2006	2.66	531.3	10.20	443.5	20.10	939.4
2/22/2002	1.00	512.1	3.30	246.4	1.00	669.9	8/23/2006	2.66	454.3	15.70	531.3	19.10	531.3
2/23/2002	1.00	531.3	3.30	354.2	1.00	708.4	8/24/2006	32.14	485.1	57.30	500.5	19.60	546.7
2/24/2002	1.00	512.8	3.30	300.3	1.00	489.0	8/25/2006	50.59	498.2	64.70	500.5	22.30	454.3
2/25/2002	1.00	421.2	3.30	465.9	1.00	462.0	8/26/2006	25.77	531.3	43.90	577.5	26.10	631.4
2/26/2002	1.00	559.8	3.30	620.6	1.00	569.8	8/27/2006	11.17	577.5	30.10	519.0	28.80	554.4
2/27/2002	1.00	444.3	3.30	425.0	1.00	415.8	8/28/2006	6.11	869.3	218.50	406.6	35.30	523.6
2/28/2002	1.00	517.4	3.30	485.1	1.00	377.3	8/29/2006	3.99	378.1	109.50	251.8	48.90	592.9
3/1/2002	1.00	428.1	3.30	395.0	1.00	269.5	8/30/2006	3.15	314.2	40.90	402.7	59.20	823.9
3/2/2002	1.00	519.0	3.30	412.0	1.00	481.3	8/31/2006	3.14	435.8	26.20	576.7	60.90	677.6
3/3/2002	1.00	489.7	3.20	612.2	1.00	465.9	9/1/2006	11.12	654.5	21.70	408.1	57.30	569.8

3/4/2002	1.00	521.3	3.20	663.7	1.00	585.2	9/2/2006	23.04	230.2	28.70	477.4	52.80	577.5
3/5/2002	1.00	415.0	3.20	420.4	1.00	481.3	9/3/2006	35.50	241.8	229.80	346.5	55.70	338.8
3/6/2002	1.00	529.0	3.20	398.1	1.00	539.0	9/4/2006	58.99	219.5	132.80	320.3	69.00	238.7
3/7/2002	1.00	667.6	3.20	468.9	1.00	569.8	9/5/2006	42.55	496.7	60.80	482.8	80.00	269.5
3/8/2002	1.00	536.7	3.20	400.4	1.00	504.4	9/6/2006	20.56	345.7	50.00	339.6	81.70	616.0
3/9/2002	1.00	435.1	3.20	485.1	1.00	377.3	9/7/2006	12.35	244.1	53.30	254.9	78.40	284.9
3/10/2002	1.00	564.4	3.20	479.7	1.00	539.0	9/8/2006	11.00	90.9	45.60	431.2	74.10	477.4
3/11/2002	1.00	629.1	3.20	540.5	1.00	592.9	9/9/2006	8.95	380.4	29.70	392.7	69.40	435.1
3/12/2002	1.00	513.6	3.20	495.9	1.00	581.4	9/10/2006	6.46	522.1	16.90	495.9	63.70	361.9
3/13/2002	1.00	688.4	3.20	615.2	1.00	535.2	9/11/2006	4.77	318.8	10.00	401.9	57.30	396.6
3/14/2002	1.00	589.1	3.20	629.1	1.00	569.8	9/12/2006	7.58	423.5	6.90	458.2	50.70	465.9
3/15/2002	1.00	559.0	3.20	485.1	1.00	546.7	9/13/2006	14.83	428.1	5.40	341.9	44.70	385.0
3/16/2002	1.00	454.3	3.20	342.7	1.00	431.2	9/14/2006	13.21	467.4	4.80	453.5	39.50	412.0
3/17/2002	1.00	490.5	3.20	346.5	1.00	261.8	9/15/2006	8.56	577.5	11.10	485.1	35.20	573.7
3/18/2002	1.00	480.5	3.20	599.8	1.00	515.9	9/16/2006	5.58	443.5	14.70	457.4	32.00	631.4
3/19/2002	1.00	321.9	3.20	458.2	1.00	542.9	9/17/2006	4.03	564.4	10.40	438.1	29.60	438.9
3/20/2002	1.00	626.8	3.20	625.2	1.00	512.1	9/18/2006	3.17	391.9	7.00	462.0	27.40	338.8
3/21/2002	1.00	478.9	3.20	574.4	1.00	500.5	9/19/2006	2.58	552.9	5.40	582.1	25.20	616.0
3/22/2002	1.00	807.7	3.20	582.1	1.00	627.6	9/20/2006	2.22	585.2	4.60	179.4	23.10	423.5
3/23/2002	1.00	500.5	3.20	653.7	1.00	573.7	9/21/2006	1.97	442.8	4.20	438.1	21.20	492.8
3/24/2002	1.00	779.2	3.20	632.2	1.00	554.4	9/22/2006	1.79	508.2	3.90	415.8	19.40	421.2
3/25/2002	1.00	538.2	3.20	552.9	1.00	639.1	9/23/2006	1.65	495.1	3.80	500.5	17.90	619.1
3/26/2002	1.00	502.0	3.20	591.4	1.00	646.8	9/24/2006	1.55	664.5	4.10	689.9	16.50	452.0
3/27/2002	1.00	609.1	3.20	592.9	1.00	616.0	9/25/2006	1.47	589.1	6.50	831.6	15.40	505.1
3/28/2002	1.00	736.9	3.20	596.0	1.00	485.1	9/26/2006	1.41	509.7	9.40	412.7	14.60	723.8
3/29/2002	1.00	585.2	3.20	676.1	1.00	616.0	9/27/2006	1.36	579.8	9.80	594.4	14.00	400.4

3/30/2002	1.00	540.5	3.20	662.2	1.00	623.7	9/28/2006	1.31	610.6	8.00	465.9	13.70	500.5
3/31/2002	1.00	644.5	3.20	644.5	1.00	800.8	9/29/2006	1.28	442.0	6.00	452.8	13.20	442.0
4/1/2002	1.00	470.5	3.20	683.0	1.00	369.6	9/30/2006	1.25	450.5	4.80	204.1	12.70	455.1
4/2/2002	1.00	709.2	3.20	624.5	1.00	635.3	10/1/2006	1.22	567.5	4.20	389.6	12.10	461.2
4/3/2002	1.00	732.3	3.20	587.5	1.00	481.3	10/2/2006	1.20	452.8	3.90	569.8	11.50	417.3
4/4/2002	1.00	831.6	3.20	770.0	1.00	723.8	10/3/2006	1.18	581.4	3.70	545.2	10.90	601.4
4/5/2002	1.00	720.0	3.20	660.7	1.00	823.9	10/4/2006	1.17	525.1	3.60	480.5	10.40	536.7
4/6/2002	1.00	823.9	3.20	922.5	1.00	700.7	10/5/2006	1.16	568.3	3.50	504.4	9.90	623.7
4/7/2002	1.00	423.5	3.20	513.6	1.00	673.8	10/6/2006	1.16	341.1	3.40	311.1	9.40	392.7
4/8/2002	1.00	681.5	3.20	686.8	1.00	654.5	10/7/2006	1.30	455.8	4.30	492.8	9.00	177.1
4/9/2002	1.00	622.9	3.20	744.6	1.00	766.2	10/8/2006	2.04	355.7	9.20	267.2	8.80	485.9
4/10/2002	1.00	806.2	3.20	755.4	1.00	781.6	10/9/2006	3.53	408.9	21.90	416.6	8.90	164.8
4/11/2002	1.00	642.2	3.20	634.5	1.00	600.6	10/10/2006	4.10	392.7	28.70	268.7	9.70	457.4
4/12/2002	1.00	654.5	3.20	681.5	1.00	577.5	10/11/2006	3.67	351.9	16.50	422.7	10.90	391.9
4/13/2002	1.00	246.4	3.20	663.0	1.00	750.8	10/12/2006	3.14	458.2	9.50	335.0	11.80	611.4
4/14/2002	1.00	783.9	3.20	790.8	1.00	731.5	10/13/2006	2.60	359.6	6.60	461.2	12.00	385.0
4/15/2002	1.00	713.8	3.20	633.7	1.00	585.2	10/14/2006	2.18	284.9	5.30	361.1	11.70	523.6
4/16/2002	1.00	726.9	3.20	749.2	1.00	604.5	10/15/2006	1.89	441.2	4.60	468.2	11.30	462.0
4/17/2002	1.00	568.3	3.20	634.5	1.00	658.4	10/16/2006	1.68	383.5	4.20	399.6	10.80	358.1
4/18/2002	1.00	757.7	3.20	642.2	1.00	485.1	10/17/2006	1.54	544.4	4.00	367.3	10.30	458.2
4/19/2002	1.00	824.7	3.20	844.7	1.00	627.6	10/18/2006	1.44	382.7	3.80	316.5	9.90	392.7
4/20/2002	1.00	804.7	3.20	673.8	1.00	650.7	10/19/2006	1.36	332.6	3.70	544.4	9.50	246.4
4/21/2002	1.00	701.5	3.20	645.3	1.00	623.7	10/20/2006	1.30	571.3	3.60	477.4	9.10	238.7
4/22/2002	1.00	741.5	3.20	681.5	1.00	669.9	10/21/2006	1.25	402.7	3.50	546.7	8.70	223.3
4/23/2002	1.00	646.8	3.20	714.6	1.00	716.1	10/22/2006	1.37	295.7	3.60	508.2	8.40	646.8
4/24/2002	1.00	693.0	3.20	837.0	1.00	870.1	10/23/2006	3.31	421.2	40.20	477.4	19.80	554.4

4/25/2002	1.00	713.0	3.20	836.2	1.00	577.5	10/24/2006	9.91	141.7	39.60	111.7	20.30	438.9
4/26/2002	1.00	1098.0	3.20	725.3	1.00	323.4	10/25/2006	10.78	90.9	24.40	264.9	16.50	184.8
4/27/2002	1.00	773.9	3.20	750.8	1.00	804.7	10/26/2006	7.59	447.4	20.10	290.3	15.50	608.3
4/28/2002	1.00	835.5	3.20	706.9	1.00	746.9	10/27/2006	4.94	475.9	16.00	354.2	15.50	361.9
4/29/2002	1.00	896.3	3.20	908.6	1.00	954.8	10/28/2006	3.46	336.5	11.20	319.6	15.60	246.4
4/30/2002	1.00	1044.1	3.20	974.1	1.00	1070.3	10/29/2006	2.64	255.6	7.80	247.9	15.30	500.5
5/1/2002	1.00	882.4	3.20	981.8	1.00	970.2	10/30/2006	2.15	461.2	5.90	357.3	14.80	284.9
5/2/2002	1.00	880.9	3.20	785.4	1.00	596.8	10/31/2006	1.84	257.2	4.90	284.1	14.10	238.7
5/3/2002	1.00	590.6	3.20	685.3	1.00	808.5	11/1/2006	1.64	369.6	4.30	414.3	13.30	577.5
5/4/2002	1.00	790.0	3.20	816.2	1.00	870.1	11/2/2006	1.50	304.2	4.00	459.7	12.60	265.7
5/5/2002	1.00	1021.0	3.20	819.3	1.00	696.9	11/3/2006	1.40	298.8	3.80	185.6	11.90	304.2
5/6/2002	1.00	808.5	3.20	815.4	1.00	951.0	11/4/2006	1.32	249.5	3.70	201.0	11.20	315.7
5/7/2002	1.00	970.2	3.20	885.5	1.00	854.7	11/5/2006	1.27	316.5	3.60	506.7	10.70	469.7
5/8/2002	1.00	790.8	3.20	876.3	1.00	924.0	11/6/2006	1.23	428.1	3.50	398.9	10.10	485.1
5/9/2002	1.00	685.3	3.20	918.6	1.00	939.4	11/7/2006	1.19	306.5	3.50	531.3	9.70	377.3
5/10/2002	1.00	911.7	3.20	985.6	1.00	912.5	11/8/2006	1.17	263.3	3.40	309.5	9.20	323.4
5/11/2002	1.00	928.6	3.20	629.9	1.00	720.0	11/9/2006	1.14	441.2	3.40	305.7	8.80	269.5
5/12/2002	1.00	814.7	3.20	975.6	1.00	850.9	11/10/2006	1.13	201.7	3.40	431.2	8.40	300.3
5/13/2002	1.00	792.3	3.20	995.6	1.00	870.1	11/11/2006	1.11	421.2	3.30	361.9	8.10	369.6
5/14/2002	1.00	808.5	3.20	1047.2	1.00	716.1	11/12/2006	1.10	288.0	3.30	307.2	7.80	408.1
5/15/2002	1.00	1083.4	3.20	864.7	1.00	793.1	11/13/2006	1.09	326.5	3.30	334.2	7.50	169.4
5/16/2002	1.00	818.5	3.20	875.5	1.00	739.2	11/14/2006	1.08	371.1	3.30	383.5	7.30	454.3
5/17/2002	1.00	976.4	3.20	893.2	1.00	716.1	11/15/2006	1.07	407.3	3.30	532.8	7.10	446.6
5/18/2002	1.00	951.0	3.20	754.6	1.00	854.7	11/16/2006	1.07	393.5	3.30	531.3	6.90	346.5
5/19/2002	1.00	952.5	3.20	859.3	1.00	900.9	11/17/2006	1.06	371.1	3.30	469.7	6.70	292.6
5/20/2002	1.00	991.0	3.20	967.1	1.00	912.5	11/18/2006	1.06	417.3	3.30	446.6	6.50	315.7

5/21/2002	1.00	1108.0	3.20	1050.3	1.00	854.7	11/19/2006	1.05	398.9	3.30	477.4	6.30	385.0
5/22/2002	1.00	877.0	3.20	1074.2	1.00	858.6	11/20/2006	1.05	417.3	3.30	477.4	6.20	369.6
5/23/2002	1.00	991.0	3.20	1017.2	1.00	870.1	11/21/2006	1.04	319.6	3.30	394.2	6.00	361.9
5/24/2002	1.00	1005.6	3.20	938.6	1.00	850.9	11/22/2006	1.04	241.0	3.20	444.3	5.90	369.6
5/25/2002	1.00	853.9	3.20	1008.7	1.00	685.3	11/23/2006	1.04	201.7	3.20	353.4	5.80	562.1
5/26/2002	1.00	874.0	3.20	793.1	1.00	916.3	11/24/2006	1.04	302.6	3.20	369.6	5.70	361.9
5/27/2002	1.00	1041.8	3.20	877.8	1.00	646.8	11/25/2006	1.03	346.5	3.20	335.7	5.60	261.8
5/28/2002	1.00	777.7	3.20	793.1	1.00	954.8	11/26/2006	1.03	408.1	3.20	95.5	5.50	104.0
5/29/2002	1.00	930.9	3.20	996.4	1.00	935.6	11/27/2006	1.03	241.0	3.20	191.7	5.40	300.3
5/30/2002	1.00	1061.8	3.20	1112.7	1.00	947.1	11/28/2006	1.03	221.8	3.20	197.9	5.30	157.9
5/31/2002	1.00	956.3	3.20	1044.9	1.00	989.5	11/29/2006	1.03	335.0	3.30	312.6	5.20	338.8
6/1/2002	1.00	1084.2	3.20	960.2	1.00	935.6	11/30/2006	1.02	328.0	3.30	338.8	5.20	608.3
6/2/2002	1.00	1030.3	3.20	970.2	1.00	916.3	12/1/2006	1.02	241.8	3.30	392.7	5.10	300.3
6/3/2002	1.00	1043.4	3.20	880.1	1.00	777.7	12/2/2006	1.02	298.0	3.30	438.9	5.10	331.1
6/4/2002	1.00	970.2	3.20	769.2	1.00	793.1	12/3/2006	1.02	287.2	3.30	591.4	5.00	454.3
6/5/2002	1.00	815.4	3.20	925.5	1.00	927.9	12/4/2006	1.02	422.0	4.50	410.4	5.00	342.7
6/6/2002	1.00	940.2	3.30	797.7	1.00	924.0	12/5/2006	1.02	120.1	5.60	362.7	5.00	377.3
6/7/2002	1.00	860.1	3.50	870.1	1.00	962.5	12/6/2006	1.02	221.0	5.90	354.2	5.10	361.9
6/8/2002	1.00	985.6	3.50	964.0	1.00	954.8	12/7/2006	1.02	381.9	5.30	275.7	5.20	115.5
6/9/2002	1.00	1068.8	3.60	961.0	1.00	835.5	12/8/2006	1.02	351.9	4.50	369.6	5.20	184.8
6/10/2002	1.00	974.1	3.60	854.7	1.00	797.0	12/9/2006	1.02	529.8	4.20	438.9	5.30	254.1
6/11/2002	1.00	994.1	3.60	837.0	1.00	808.5	12/10/2006	1.02	262.6	5.40	592.9	5.30	215.6
6/12/2002	1.00	1108.8	3.50	1028.7	1.00	889.4	12/11/2006	1.01	291.8	6.10	434.3	5.40	146.3
6/13/2002	1.00	860.9	3.40	981.0	1.00	858.6	12/12/2006	1.01	51.6	5.90	452.8	5.40	346.5
6/14/2002	1.00	1055.7	3.40	893.2	1.00	862.4	12/13/2006	1.01	343.4	5.10	460.5	5.50	361.9
6/15/2002	1.00	1052.6	3.40	816.2	1.00	854.7	12/14/2006	1.01	134.8	4.40	400.4	5.60	207.9

6/16/2002	1.00	1001.0	3.30	1001.0	1.00	924.0	12/15/2006	1.01	309.5	4.00	331.1	5.60	677.6
6/17/2002	1.00	1068.0	3.30	1120.4	1.00	1001.0	12/16/2006	1.01	191.0	3.80	323.4	5.60	246.4
6/18/2002	1.00	1185.8	3.30	1141.1	1.00	935.6	12/17/2006	1.01	392.7	3.60	258.7	5.50	292.6
6/19/2002	1.00	1131.9	3.30	1058.0	1.00	1028.0	12/18/2006	1.01	311.9	3.50	207.1	5.50	154.0
6/20/2002	1.00	1170.4	3.30	976.4	1.00	935.6	12/19/2006	1.01	329.6	3.50	159.4	5.40	38.5
6/21/2002	1.00	1283.6	3.30	1123.4	1.00	997.2	12/20/2006	1.01	102.4	3.40	432.0	5.30	284.9
6/22/2002	1.00	1090.3	3.20	1220.5	1.00	997.2	12/21/2006	1.01	224.1	3.40	303.4	5.30	250.3
6/23/2002	1.00	1061.1	3.20	1116.5	1.00	1074.2	12/22/2006	1.01	222.5	3.30	246.4	5.20	319.6
6/24/2002	1.00	1098.0	3.20	1109.6	1.00	1078.0	12/23/2006	1.01	268.0	3.30	277.2	5.20	515.9
6/25/2002	1.00	1081.9	3.20	1081.1	1.00	1074.2	12/24/2006	1.01	201.7	3.30	293.4	5.10	469.7
6/26/2002	1.00	962.5	3.20	974.1	1.00	866.3	12/25/2006	1.01	314.9	3.30	525.1	5.10	292.6
6/27/2002	1.00	827.8	3.20	989.5	1.00	854.7	12/26/2006	1.01	291.1	3.30	512.1	5.00	515.9
6/28/2002	1.00	1028.0	3.20	942.5	1.00	920.2	12/27/2006	1.01	328.8	3.30	125.5	5.00	385.0
6/29/2002	1.00	673.8	3.20	894.7	1.00	1008.7	12/28/2006	1.01	16.9	4.10	9.2	4.90	138.6
6/30/2002	1.00	941.7	3.20	1070.3	1.00	981.8	12/29/2006	1.02	137.1	8.00	238.7	5.00	246.4
7/1/2002	1.00	847.8	3.20	850.9	1.00	920.2	12/30/2006	1.02	146.3	7.60	184.8	5.10	342.7
7/2/2002	1.00	1027.2	3.30	993.3	1.00	774.3	12/31/2006	1.03	123.2	5.90	246.4	5.30	242.6
7/3/2002	1.00	979.4	3.70	906.3	1.00	962.5	1/1/2007	1.04	120.1	4.80	150.2	5.40	338.8
7/4/2002	1.00	1193.5	4.70	1026.4	1.00	993.3	1/2/2007	1.04	223.3	6.80	272.6	5.50	338.8
7/5/2002	1.00	1004.9	5.50	1016.4	1.00	954.8	1/3/2007	1.05	170.9	13.10	229.5	5.70	138.6
7/6/2002	1.00	1018.7	6.50	970.2	1.00	696.9	1/4/2007	1.05	180.2	16.90	166.3	6.20	177.1
7/7/2002	1.00	926.3	73.60	1045.7	1.00	773.9	1/5/2007	1.06	328.0	14.60	277.2	6.90	231.0
7/8/2002	1.00	644.5	147.90	538.2	1.00	854.7	1/6/2007	1.06	263.3	10.10	400.4	7.50	265.7
7/9/2002	1.00	590.6	136.50	796.2	1.00	731.5	1/7/2007	1.05	345.0	6.80	618.3	7.90	392.7
7/10/2002	1.00	895.5	77.90	663.0	1.00	924.0	1/8/2007	1.05	485.1	5.10	505.9	8.00	523.6
7/11/2002	1.00	907.1	42.30	839.3	65.80	935.6	1/9/2007	1.05	188.7	4.40	355.0	8.00	308.0

7/12/2002	1.00	1004.9	27.30	965.6	27.50	823.9	1/10/2007	1.04	265.7	4.00	171.7	7.80	369.6
7/13/2002	1.00	868.6	18.00	497.4	8.40	446.6	1/11/2007	1.04	134.0	3.70	224.1	7.60	223.3
7/14/2002	1.00	837.0	14.10	763.1	3.40	627.6	1/12/2007	1.03	194.8	3.60	284.9	7.40	107.8
7/15/2002	1.05	400.4	14.20	753.1	2.10	793.1	1/13/2007	1.03	320.3	3.50	238.7	7.20	438.9
7/16/2002	1.45	515.1	23.90	838.5	1.60	735.4	1/14/2007	1.03	134.0	3.50	219.5	7.00	223.3
7/17/2002	3.78	492.8	58.20	693.8	1.30	905.5	1/15/2007	1.02	245.6	3.40	223.3	6.80	107.8
7/18/2002	5.52	385.0	43.90	391.9	3.90	716.1	1/16/2007	1.02	150.9	3.40	245.6	6.60	323.4
7/19/2002	5.28	491.3	104.30	391.2	242.10	862.4	1/17/2007	1.18	221.8	3.40	285.7	6.40	423.5
7/20/2002	20.56	258.0	88.20	48.5	83.30	165.6	1/18/2007	3.50	54.7	11.80	246.4	6.40	147.8
7/21/2002	87.98	292.6	76.20	385.0	23.20	1051.1	1/19/2007	12.91	91.6	27.60	177.1	6.80	292.6
7/22/2002	125.73	105.5	69.90	739.2	9.10	643.0	1/20/2007	14.05	308.0	27.00	169.4	8.00	173.3
7/23/2002	99.95	696.1	50.30	336.5	5.00	335.0	1/21/2007	9.27	209.4	19.50	168.6	9.40	215.6
7/24/2002	59.53	593.7	33.60	489.7	18.90	1031.8	1/22/2007	5.73	170.2	12.40	271.0	10.50	92.4
7/25/2002	29.74	555.9	26.00	616.0	9.90	585.2	1/23/2007	3.87	348.0	8.10	371.9	11.00	244.1
7/26/2002	49.63	708.4	22.10	585.2	4.20	623.7	1/24/2007	2.87	106.3	6.00	401.9	11.00	306.5
7/27/2002	55.59	308.8	17.80	504.4	2.40	666.1	1/25/2007	2.29	211.8	5.10	197.9	10.80	300.3
7/28/2002	33.19	382.7	15.00	770.0	1.90	619.9	1/26/2007	1.93	138.6	4.90	392.7	10.40	423.5
7/29/2002	21.46	595.2	13.60	901.7	1.60	770.0	1/27/2007	1.69	63.1	4.80	363.4	10.00	361.9
7/30/2002	13.91	685.3	13.30	221.0	1.40	685.3	1/28/2007	1.53	240.2	4.70	335.7	9.70	269.5
7/31/2002	8.88	445.8	36.00	458.9	1.30	469.7	1/29/2007	1.42	212.5	4.40	257.2	9.30	57.8
8/1/2002	10.46	875.5	45.80	262.6	1.30	658.4	1/30/2007	1.33	75.5	4.20	209.4	9.00	196.4
8/2/2002	16.80	562.1	454.40	792.3	60.40	669.9	1/31/2007	1.27	75.5	6.00	63.1	8.70	92.4
8/3/2002	14.03	270.3	142.00	546.7	73.20	546.7	2/1/2007	1.23	136.3	10.00	152.5	8.60	462.0
8/4/2002	8.92	305.7	47.00	317.2	41.00	231.0	2/2/2007	1.19	110.9	9.20	92.4	8.60	354.2
8/5/2002	6.35	442.8	31.20	578.3	17.90	777.7	2/3/2007	1.16	380.4	6.60	319.6	8.70	246.4
8/6/2002	5.63	258.7	28.40	471.2	8.80	400.4	2/4/2007	1.14	472.8	5.10	354.2	8.70	323.4

8/7/2002	5.09	422.7	17.70	544.4	5.20	404.3	2/5/2007	1.12	361.9	4.40	400.4	8.50	292.6
8/8/2002	4.27	468.9	12.10	646.8	3.60	338.8	2/6/2007	1.10	307.2	4.00	322.6	8.30	485.1
8/9/2002	3.47	758.5	10.50	647.6	2.70	993.3	2/7/2007	1.09	268.0	3.80	381.9	8.10	504.4
8/10/2002	2.85	466.6	10.40	619.9	2.20	635.3	2/8/2007	1.08	345.0	3.60	207.9	7.80	465.9
8/11/2002	2.41	506.7	9.90	484.3	1.90	558.3	2/9/2007	1.07	311.9	3.60	392.7	7.60	231.0
8/12/2002	2.10	522.8	9.50	646.0	1.70	646.8	2/10/2007	1.06	223.3	3.50	408.1	7.30	385.0
8/13/2002	1.88	592.9	60.50	515.9	1.80	823.9	2/11/2007	1.06	754.6	3.40	276.4	7.10	288.8
8/14/2002	1.72	607.5	49.30	460.5	2.10	685.3	2/12/2007	1.05	299.5	3.40	269.5	6.90	354.2
8/15/2002	1.61	550.6	25.70	613.7	2.40	500.5	2/13/2007	1.05	365.8	3.40	300.3	6.70	361.9
8/16/2002	1.63	494.3	14.50	589.8	2.50	562.1	2/14/2007	1.04	189.4	3.30	200.2	6.50	438.9
8/17/2002	1.83	538.2	54.40	756.1	6.80	554.4	2/15/2007	1.04	333.4	3.30	542.1	6.40	284.9
8/18/2002	2.07	369.6	40.40	1016.4	12.70	897.1	2/16/2007	1.04	343.4	3.30	383.5	6.20	431.2
8/19/2002	2.19	194.0	22.00	182.5	13.40	885.5	2/17/2007	1.03	378.1	3.30	392.7	6.10	477.4
8/20/2002	2.12	381.2	25.80	436.6	15.40	735.4	2/18/2007	1.03	327.3	3.30	576.0	6.00	531.3
8/21/2002	1.95	569.8	15.70	415.0	17.10	639.1	2/19/2007	1.03	364.2	3.30	227.9	5.80	92.4
8/22/2002	1.80	542.9	8.50	612.9	14.40	681.5	2/20/2007	1.03	276.4	3.30	207.1	5.70	338.8
8/23/2002	1.67	585.2	6.20	531.3	9.60	908.6	2/21/2007	1.02	348.0	3.30	462.8	5.60	331.1
8/24/2002	1.56	723.8	5.10	743.8	6.00	935.6	2/22/2007	1.02	278.7	3.30	391.9	5.50	419.7
8/25/2002	1.47	693.0	4.50	763.8	4.00	546.7	2/23/2007	1.02	410.4	3.30	446.6	5.40	311.9
8/26/2002	1.40	839.3	4.70	757.7	2.90	569.8	2/24/2007	1.02	331.1	3.30	373.5	5.40	412.0
8/27/2002	1.35	766.2	44.70	525.1	2.30	762.3	2/25/2007	1.02	342.7	3.20	462.0	5.30	246.4
8/28/2002	1.40	779.2	48.00	519.8	2.00	800.8	2/26/2007	1.02	462.0	3.20	438.9	5.20	500.5
8/29/2002	1.60	145.5	24.20	574.4	1.70	816.2	2/27/2007	1.02	654.5	3.20	474.3	5.20	454.3
8/30/2002	1.86	672.2	12.70	674.5	1.60	916.3	2/28/2007	1.02	589.1	3.20	395.0	5.10	392.7
8/31/2002	2.01	356.5	27.10	751.5	7.10	831.6	3/1/2007	1.01	433.5	3.20	438.1	5.00	415.8
9/1/2002	2.01	567.5	17.50	535.9	15.00	708.4	3/2/2007	1.01	318.8	3.20	408.1	5.00	435.1

9/2/2002	2.17	590.6	10.20	425.8	15.70	708.4	3/3/2007	1.01	551.3	3.20	608.3	4.90	311.9
9/3/2002	2.68	555.2	7.20	582.1	11.00	492.8	3/4/2007	1.01	564.4	3.20	726.9	4.90	503.6
9/4/2002	3.06	685.3	6.50	511.3	43.80	731.5	3/5/2007	1.01	335.7	3.20	586.0	4.80	539.0
9/5/2002	2.98	599.1	6.30	519.0	31.50	592.9	3/6/2007	1.01	388.1	3.20	601.4	4.80	462.0
9/6/2002	2.70	679.9	6.00	576.0	11.70	577.5	3/7/2007	1.01	585.2	3.20	518.2	4.80	739.2
9/7/2002	3.45	548.2	9.90	472.8	4.80	577.5	3/8/2007	1.01	454.3	3.20	571.3	4.70	492.8
9/8/2002	20.98	562.9	34.10	454.3	3.00	542.9	3/9/2007	1.01	537.5	3.20	463.5	4.70	489.0
9/9/2002	33.93	254.1	28.60	445.8	2.30	388.9	3/10/2007	1.01	554.4	3.20	469.7	4.70	627.6
9/10/2002	20.19	572.1	15.40	509.0	1.90	539.0	3/11/2007	1.01	511.3	3.20	640.6	4.60	639.1
9/11/2002	9.95	679.1	9.00	502.0	1.70	577.5	3/12/2007	1.01	539.0	3.20	562.1	4.60	523.6
9/12/2002	5.69	546.7	6.30	355.7	1.50	462.0	3/13/2007	1.01	666.1	3.20	590.6	4.60	646.8
9/13/2002	3.80	571.3	5.10	622.9	1.40	662.2	3/14/2007	1.01	521.3	3.20	589.1	4.60	546.7
9/14/2002	2.81	579.0	4.50	565.2	1.30	539.0	3/15/2007	1.01	597.5	3.20	722.3	4.50	677.6
9/15/2002	2.25	606.0	4.10	480.5	1.30	662.2	3/16/2007	1.01	634.5	3.20	485.1	4.50	631.4
9/16/2002	1.90	524.4	3.90	571.3	10.40	523.6	3/17/2007	1.01	619.9	3.20	585.2	4.50	408.1
9/17/2002	1.68	590.6	3.80	424.3	8.10	404.3	3/18/2007	1.01	719.2	3.20	562.1	4.50	227.2
9/18/2002	1.52	226.4	3.80	119.4	5.20	504.4	3/19/2007	1.01	726.1	3.20	672.2	4.50	658.4
9/19/2002	1.42	428.1	3.80	413.5	4.10	346.5	3/20/2007	1.03	673.8	3.20	645.3	4.50	677.6
9/20/2002	1.34	499.0	3.80	508.2	3.80	508.2	3/21/2007	1.16	191.0	3.20	327.3	4.40	392.7
9/21/2002	1.28	561.3	3.70	649.9	3.60	531.3	3/22/2007	4.39	287.2	3.20	395.0	4.40	577.5
9/22/2002	1.23	635.3	3.60	873.2	3.60	504.4	3/23/2007	14.21	205.6	3.20	315.7	4.40	192.5
9/23/2002	1.20	629.9	3.50	748.4	3.50	677.6	3/24/2007	14.65	376.5	3.20	415.8	4.40	546.7
9/24/2002	1.17	637.6	3.40	702.2	3.30	600.6	3/25/2007	9.64	237.2	3.20	278.7	4.40	385.0
9/25/2002	1.15	619.1	3.40	707.6	2.80	623.7	3/26/2007	5.97	669.9	3.30	434.3	4.40	600.6
9/26/2002	1.13	571.3	3.40	566.7	2.40	650.7	3/27/2007	4.02	819.3	3.30	679.1	4.40	623.7
9/27/2002	1.11	739.2	3.30	556.7	2.10	643.0	3/28/2007	2.95	636.0	3.30	691.5	4.40	669.9

9/28/2002	1.10	653.7	3.30	473.6	1.90	793.1	3/29/2007	2.33	485.9	3.40	704.6	4.40	777.7
9/29/2002	1.09	223.3	3.40	580.6	1.80	720.0	3/30/2007	1.95	616.0	3.40	639.1	4.40	700.7
9/30/2002	1.09	375.8	3.70	429.7	1.70	335.0	3/31/2007	1.71	577.5	3.50	523.6	4.40	669.9
10/1/2002	1.09	269.5	4.10	402.7	1.60	338.8	4/1/2007	1.54	850.9	3.50	705.3	4.40	785.4
10/2/2002	1.09	501.3	4.20	527.5	1.50	485.1	4/2/2007	1.43	924.0	3.40	669.9	4.40	546.7
10/3/2002	1.09	524.4	4.00	74.7	1.40	569.8	4/3/2007	1.34	718.4	3.40	656.8	4.40	646.8
10/4/2002	1.09	461.2	3.80	475.1	1.40	585.2	4/4/2007	1.28	683.0	3.40	694.5	4.40	658.4
10/5/2002	1.10	637.6	3.60	482.8	1.30	554.4	4/5/2007	1.23	757.7	3.40	677.6	4.40	669.9
10/6/2002	1.11	535.2	3.50	609.8	1.30	477.4	4/6/2007	1.19	699.9	3.30	696.9	4.40	708.4
10/7/2002	1.13	418.1	3.70	722.3	1.30	408.1	4/7/2007	1.16	666.1	3.30	646.8	4.40	581.4
10/8/2002	1.18	305.7	4.20	510.5	1.30	523.6	4/8/2007	1.14	408.1	3.30	413.5	4.40	623.7
10/9/2002	1.24	354.2	5.10	611.4	1.20	515.9	4/9/2007	1.12	534.4	3.30	385.0	4.40	554.4
10/10/2002	1.28	468.9	5.40	586.0	1.20	546.7	4/10/2007	1.10	601.4	3.30	559.0	4.40	677.6
10/11/2002	1.30	555.9	5.10	530.5	1.20	746.9	4/11/2007	1.09	613.7	3.30	621.4	4.40	677.6
10/12/2002	1.28	448.9	4.60	396.6	1.20	523.6	4/12/2007	1.08	841.6	3.30	780.0	4.40	531.3
10/13/2002	1.25	464.3	4.20	622.9	1.20	546.7	4/13/2007	1.07	517.4	3.30	685.3	4.30	646.8
10/14/2002	1.20	345.7	3.90	488.2	1.10	627.6	4/14/2007	1.06	609.1	3.20	608.3	4.30	469.7
10/15/2002	1.17	549.0	3.70	669.1	1.10	412.0	4/15/2007	1.06	860.9	3.20	824.7	4.30	712.3
10/16/2002	1.14	508.2	3.50	356.5	1.10	296.5	4/16/2007	1.05	642.2	3.20	795.4	4.30	539.0
10/17/2002	1.12	308.0	3.50	280.3	1.10	515.9	4/17/2007	1.05	616.0	3.20	671.4	4.30	566.0
10/18/2002	1.10	395.0	3.40	428.1	1.10	562.1	4/18/2007	1.04	810.0	3.20	799.3	4.30	485.1
10/19/2002	1.08	403.5	3.40	531.3	1.10	539.0	4/19/2007	1.04	746.9	3.20	782.3	4.30	700.7
10/20/2002	1.07	263.3	3.30	426.6	1.10	523.6	4/20/2007	1.04	832.4	3.20	781.6	4.30	754.6
10/21/2002	1.06	364.2	3.30	348.0	1.10	284.9	4/21/2007	1.03	706.9	3.20	739.2	4.30	639.1
10/22/2002	1.06	268.7	3.30	278.0	1.10	381.2	4/22/2007	1.03	720.7	3.20	670.7	4.30	500.5
10/23/2002	1.05	355.0	3.30	392.7	1.10	350.4	4/23/2007	1.03	725.3	3.20	836.2	4.30	631.4

10/24/2002	1.04	433.5	3.30	424.3	1.10	385.0	4/24/2007	1.03	655.3	3.20	762.3	4.30	577.5
10/25/2002	1.04	375.8	3.40	340.3	1.10	515.9	4/25/2007	1.02	771.5	3.20	812.4	4.30	716.1
10/26/2002	1.04	218.7	3.40	485.1	1.10	331.1	4/26/2007	1.02	797.7	3.20	820.1	4.30	662.2
10/27/2002	1.03	342.7	3.40	454.3	1.10	431.2	4/27/2007	1.02	760.0	3.20	850.9	4.30	970.2
10/28/2002	1.03	304.2	3.40	386.5	1.10	419.7	4/28/2007	1.02	476.6	3.20	821.6	4.30	569.8
10/29/2002	1.03	396.6	3.40	475.9	1.10	265.7	4/29/2007	1.02	643.7	3.20	749.2	4.30	693.0
10/30/2002	1.03	332.6	3.40	472.8	1.00	381.2	4/30/2007	1.02	701.5	3.20	762.3	4.30	854.7
10/31/2002	1.02	361.1	3.30	375.8	1.00	311.9	5/1/2007	1.02	642.2	3.20	795.4	4.30	539.0
11/1/2002	1.02	382.7	3.30	346.5	1.00	400.4	5/2/2007	1.01	616.0	3.20	671.4	4.30	566.0
11/2/2002	1.02	401.9	3.30	485.1	1.00	515.9	5/3/2007	1.01	810.0	3.20	799.3	4.30	485.1
11/3/2002	1.02	363.4	3.30	411.2	1.00	492.8	5/4/2007	1.01	746.9	3.20	782.3	4.30	700.7
11/4/2002	1.02	435.8	3.30	412.0	1.00	431.2	5/5/2007	1.01	832.4	3.20	781.6	4.30	754.6
11/5/2002	1.02	335.7	3.30	561.3	1.00	569.8	5/6/2007	1.01	706.9	3.20	739.2	4.20	639.1
11/6/2002	1.02	264.9	3.30	559.8	1.00	177.1	5/7/2007	1.01	720.7	3.20	670.7	4.20	500.5
11/7/2002	1.02	478.9	3.30	369.6	1.00	388.9	5/8/2007	1.01	725.3	3.20	836.2	4.20	631.4
11/8/2002	1.01	405.8	3.20	485.1	1.00	338.8	5/9/2007	1.01	655.3	3.20	762.3	4.20	577.5
11/9/2002	1.01	343.4	3.20	351.9	1.00	485.1	5/10/2007	1.01	771.5	3.20	812.4	4.20	716.1
11/10/2002	1.01	383.5	3.20	317.2	1.00	442.8	5/11/2007	1.01	797.7	3.20	820.1	4.20	662.2
11/11/2002	1.01	381.9	3.20	631.4	1.00	458.2	5/12/2007	1.01	760.0	3.20	850.9	4.20	970.2
11/12/2002	1.01	402.7	3.20	698.4	1.00	650.7	5/13/2007	1.01	476.6	3.20	821.6	4.20	569.8
11/13/2002	1.01	431.2	3.20	529.0	1.00	427.4	5/14/2007	1.01	643.7	3.20	749.2	4.20	693.0
11/14/2002	1.01	388.1	3.20	358.1	1.00	392.7	5/15/2007	1.01	701.5	3.20	762.3	4.20	854.7
11/15/2002	1.01	361.1	3.20	686.1	1.00	462.0	5/16/2007	1.01	854.7	3.30	862.4	4.20	688.4
11/16/2002	1.01	428.9	3.20	580.6	1.00	446.6	5/17/2007	1.01	939.4	4.30	946.3	4.20	931.7
11/17/2002	1.01	415.8	3.20	536.7	1.00	535.2	5/18/2007	1.01	1107.3	6.10	998.7	4.30	754.6
11/18/2002	1.01	256.4	3.20	200.2	1.00	473.6	5/19/2007	1.01	1017.9	6.90	1078.8	4.40	700.7

11/19/2002	1.01	482.8	3.20	415.8	1.00	515.9	5/20/2007	1.01	1068.8	6.40	1038.7	4.60	939.4
11/20/2002	1.01	531.3	3.20	446.6	1.00	554.4	5/21/2007	1.01	1158.1	5.30	1106.5	4.80	831.6
11/21/2002	1.01	345.0	3.20	683.0	1.00	585.2	5/22/2007	1.01	1031.0	4.50	964.0	4.90	735.4
11/22/2002	1.01	268.0	3.20	479.7	1.00	354.2	5/23/2007	1.01	850.9	4.00	965.6	5.00	870.1
11/23/2002	1.01	388.9	3.20	381.2	1.00	284.9	5/24/2007	1.01	889.4	3.70	908.6	5.00	881.7
11/24/2002	1.01	351.9	3.20	304.2	1.00	184.8	5/25/2007	1.00	980.2	3.60	785.4	5.00	847.0
11/25/2002	1.01	315.7	3.20	243.3	1.00	287.2	5/26/2007	1.00	337.3	3.50	519.8	5.00	415.8
11/26/2002	1.01	242.6	3.20	322.6	1.00	308.0	5/27/2007	1.00	704.6	3.40	774.6	4.90	743.1
11/27/2002	1.02	331.1	3.20	567.5	1.00	130.9	5/28/2007	1.00	830.8	3.40	1051.8	4.90	764.0
11/28/2002	1.03	233.3	3.20	322.6	1.00	412.0	5/29/2007	1.00	1047.2	3.30	995.6	4.90	1028.0
11/29/2002	1.04	318.8	3.20	143.2	1.00	346.5	5/30/2007	1.00	897.8	3.30	916.3	4.80	1043.4
11/30/2002	1.05	254.1	3.20	306.5	1.00	331.1	5/31/2007	1.00	740.7	3.30	900.9	4.80	962.5
12/1/2002	1.07	428.9	3.30	580.6	1.00	446.6	6/1/2007	1.00	854.7	3.30	862.4	4.80	688.4
12/2/2002	2.33	415.8	15.50	536.7	1.00	535.2	6/2/2007	1.00	939.4	3.30	946.3	4.70	931.7
12/3/2002	6.53	256.4	34.00	200.2	1.00	473.6	6/3/2007	1.00	1107.3	3.30	998.7	4.70	754.6
12/4/2002	7.83	482.8	28.70	415.8	1.00	515.9	6/4/2007	1.00	1017.9	3.20	1078.8	4.70	700.7
12/5/2002	6.48	531.3	20.10	446.6	1.00	554.4	6/5/2007	1.00	1068.8	3.20	1038.7	4.60	939.4
12/6/2002	4.56	345.0	13.00	683.0	1.00	585.2	6/6/2007	1.00	1158.1	3.20	1106.5	4.60	831.6
12/7/2002	3.27	268.0	8.60	479.7	1.00	354.2	6/7/2007	1.00	1031.0	3.20	964.0	4.60	735.4
12/8/2002	2.54	388.9	6.30	381.2	1.00	284.9	6/8/2007	1.00	850.9	3.20	965.6	4.60	870.1
12/9/2002	2.08	351.9	5.20	304.2	1.00	184.8	6/9/2007	1.01	889.4	3.20	908.6	4.60	881.7
12/10/2002	1.80	315.7	4.50	243.3	1.00	287.2	6/10/2007	1.06	980.2	3.20	785.4	4.50	847.0
12/11/2002	1.60	242.6	4.20	322.6	1.00	308.0	6/11/2007	1.59	337.3	3.30	519.8	4.50	415.8
12/12/2002	1.47	331.1	3.90	567.5	1.00	130.9	6/12/2007	4.27	704.6	3.80	774.6	4.50	743.1
12/13/2002	1.37	233.3	3.80	322.6	1.00	412.0	6/13/2007	6.03	830.8	4.20	1051.8	4.50	764.0
12/14/2002	1.30	318.8	3.60	143.2	1.00	346.5	6/14/2007	5.51	1047.2	4.00	995.6	4.50	1028.0

12/15/2002	1.25	254.1	3.60	306.5	1.00	331.1	6/15/2007	4.20	897.8	3.80	916.3	4.60	1043.4
12/16/2002	1.21	271.0	3.50	328.0	1.00	361.9	6/16/2007	3.13	740.7	3.60	900.9	4.60	962.5
12/17/2002	1.17	227.9	3.80	594.4	1.00	311.9	6/17/2007	2.44	995.6	3.50	908.6	4.60	1193.5
12/18/2002	1.15	221.8	5.40	413.5	1.00	465.9	6/18/2007	2.03	947.9	3.40	896.3	4.60	800.8
12/19/2002	1.13	253.3	5.30	469.7	1.00	308.0	6/19/2007	1.76	803.9	3.40	670.7	4.60	908.6
12/20/2002	1.12	248.7	4.50	415.8	1.00	415.8	6/20/2007	1.58	914.0	3.40	1073.4	4.60	877.8
12/21/2002	1.12	163.2	4.20	199.4	1.00	531.3	6/21/2007	1.45	970.2	3.40	985.6	4.60	816.2
12/22/2002	1.23	251.0	30.30	330.3	1.00	227.2	6/22/2007	1.36	924.0	3.40	970.2	4.60	885.5
12/23/2002	1.57	118.6	42.60	217.1	1.00	46.2	6/23/2007	1.29	1048.7	3.70	947.1	4.50	893.2
12/24/2002	2.02	198.7	26.80	102.4	1.00	169.4	6/24/2007	1.24	868.6	5.40	769.2	4.60	958.7
12/25/2002	2.28	172.5	17.80	149.4	1.00	284.9	6/25/2007	1.20	887.8	6.10	909.4	4.60	1081.9
12/26/2002	2.21	159.4	11.80	279.5	1.00	373.5	6/26/2007	1.17	917.8	5.20	669.9	4.80	954.8
12/27/2002	2.02	270.3	8.20	226.4	1.00	365.8	6/27/2007	1.15	822.4	4.50	894.7	4.90	954.8
12/28/2002	1.86	275.7	6.20	443.5	1.00	392.7	6/28/2007	1.12	706.1	6.10	785.4	5.00	777.7
12/29/2002	1.70	342.7	5.10	262.6	1.00	408.1	6/29/2007	1.11	904.8	10.70	744.6	5.10	793.1
12/30/2002	1.56	204.8	4.50	319.6	1.00	450.5	6/30/2007	1.09	879.3	9.10	718.4	5.40	1016.4
12/31/2002	1.45	420.4	4.10	459.7	1.00	442.8	7/1/2007	1.08	887.0	6.50	861.6	5.70	997.2
1/1/2003	1.36	271.0	3.90	328.0	1.00	361.9	7/2/2007	1.08	940.9	5.10	807.7	5.90	947.1
1/2/2003	1.30	227.9	3.80	594.4	1.00	311.9	7/3/2007	1.29	875.5	4.40	912.5	6.00	1097.3
1/3/2003	1.25	221.8	3.60	413.5	1.00	465.9	7/4/2007	9.09	1007.9	5.70	1042.6	6.00	939.4
1/4/2003	1.21	253.3	3.60	469.7	1.00	308.0	7/5/2007	26.49	788.5	7.80	812.4	6.00	793.1
1/5/2003	1.18	248.7	3.50	415.8	1.00	415.8	7/6/2007	18.91	1101.9	6.60	905.5	6.10	1031.8
1/6/2003	1.15	163.2	3.40	199.4	1.00	531.3	7/7/2007	9.87	731.5	9.40	460.5	6.30	877.8
1/7/2003	1.13	251.0	3.40	330.3	1.00	227.2	7/8/2007	5.78	1089.6	119.10	823.1	8.30	654.5
1/8/2003	1.11	118.6	3.40	217.1	1.00	46.2	7/9/2007	4.01	476.6	221.30	559.0	17.60	608.3
1/9/2003	1.10	198.7	3.40	102.4	1.00	169.4	7/10/2007	3.08	662.2	199.80	602.9	36.80	770.0

1/10/2003	1.09	172.5	3.30	149.4	1.00	284.9	7/11/2007	2.58	773.1	119.50	773.1	57.40	823.9
1/11/2003	1.08	159.4	3.30	279.5	1.00	373.5	7/12/2007	2.30	497.4	62.40	545.2	69.60	616.0
1/12/2003	1.07	270.3	3.30	226.4	1.00	365.8	7/13/2007	2.12	743.8	39.10	656.0	72.00	600.6
1/13/2003	1.06	275.7	3.30	443.5	1.00	392.7	7/14/2007	2.27	559.0	29.70	569.0	68.60	770.0
1/14/2003	1.06	342.7	3.30	262.6	1.00	408.1	7/15/2007	2.77	789.3	22.50	976.4	63.20	939.4
1/15/2003	1.05	204.8	3.30	319.6	1.00	450.5	7/16/2007	3.05	623.7	14.80	801.6	57.30	639.1
1/16/2003	1.05	420.4	3.30	459.7	1.00	442.8	7/17/2007	2.86	683.8	9.70	703.8	51.40	1008.7
1/17/2003	1.04	198.7	3.30	330.3	1.00	234.9	7/18/2007	2.53	600.6	22.40	763.1	46.40	631.4
1/18/2003	1.04	352.7	3.30	375.8	1.00	323.4	7/19/2007	2.34	716.1	267.50	693.0	72.10	423.5
1/19/2003	1.03	220.2	3.20	234.9	1.00	273.4	7/20/2007	3.37	756.9	130.90	178.6	87.00	724.6
1/20/2003	1.03	220.2	3.20	465.1	1.00	365.8	7/21/2007	7.74	908.6	53.10	552.9	91.50	608.3
1/21/2003	1.03	276.4	3.20	291.1	1.00	450.5	7/22/2007	10.00	677.6	40.20	512.1	88.10	778.5
1/22/2003	1.03	308.0	3.20	466.6	1.00	323.4	7/23/2007	8.25	612.2	35.40	284.9	80.10	862.4
1/23/2003	1.03	295.7	3.20	548.2	1.00	438.9	7/24/2007	5.82	470.5	25.90	466.6	71.90	639.1
1/24/2003	1.02	345.0	3.20	485.1	1.00	404.3	7/25/2007	8.22	529.0	19.70	478.9	64.60	346.5
1/25/2003	1.02	294.1	3.20	431.2	1.00	446.6	7/26/2007	15.26	459.7	19.50	411.2	57.90	361.9
1/26/2003	1.02	335.0	3.20	477.4	1.00	458.2	7/27/2007	14.64	419.7	21.00	550.6	52.20	612.2
1/27/2003	1.02	307.2	3.20	492.8	1.00	600.6	7/28/2007	12.11	219.5	21.10	309.5	47.60	589.1
1/28/2003	1.02	291.8	3.20	311.9	1.00	392.7	7/29/2007	9.68	301.8	16.00	531.3	43.70	639.1
1/29/2003	1.02	292.6	3.20	357.3	1.00	496.7	7/30/2007	6.98	602.1	22.30	442.8	40.40	442.8
1/30/2003	1.02	430.4	3.20	643.7	1.00	554.4	7/31/2007	5.01	235.6	32.70	107.8	38.10	612.2
1/31/2003	1.01	285.7	3.20	285.7	1.00	573.7	8/1/2007	3.75	419.7	31.90	468.2	36.90	527.5
2/1/2003	1.01	396.6	3.20	496.7	1.00	496.7	8/2/2007	2.95	361.9	28.90	509.7	36.20	535.2
2/2/2003	1.01	451.2	3.20	435.8	1.00	369.6	8/3/2007	2.47	323.4	55.80	477.4	36.20	685.3
2/3/2003	1.01	316.5	3.20	394.2	1.00	288.8	8/4/2007	3.11	388.9	83.20	500.5	38.50	7.7
2/4/2003	1.01	317.2	3.50	400.4	1.00	396.6	8/5/2007	5.65	80.1	59.80	162.5	42.50	269.5

2/5/2003	1.01	164.0	5.20	58.5	1.00	161.7	8/6/2007	6.58	429.7	34.80	325.7	45.10	446.6
2/6/2003	1.01	240.2	7.70	231.8	1.00	281.1	8/7/2007	5.59	431.2	20.10	593.7	44.90	477.4
2/7/2003	1.01	115.5	8.40	83.2	1.00	50.1	8/8/2007	4.24	478.9	12.70	458.9	42.40	554.4
2/8/2003	1.02	97.8	7.20	197.9	1.00	315.7	8/9/2007	21.37	511.3	21.10	412.0	39.20	177.1
2/9/2003	1.02	183.3	5.70	268.7	1.00	377.3	8/10/2007	32.50	432.7	19.30	534.4	36.60	723.8
2/10/2003	1.03	130.1	4.60	346.5	1.00	207.9	8/11/2007	17.55	462.8	12.70	554.4	34.20	739.2
2/11/2003	1.03	348.8	4.10	356.5	1.00	419.7	8/12/2007	7.00	642.2	8.60	716.1	31.80	654.5
2/12/2003	1.04	192.5	7.00	415.0	1.00	207.9	8/13/2007	4.03	692.2	7.60	439.7	29.20	531.3
2/13/2003	1.05	172.5	77.90	485.1	3.30	427.4	8/14/2007	3.10	457.4	8.00	534.4	26.80	631.4
2/14/2003	1.05	130.1	78.70	477.4	7.60	346.5	8/15/2007	3.25	494.3	7.00	640.6	24.70	454.3
2/15/2003	1.06	210.2	38.40	301.1	9.90	369.6	8/16/2007	3.62	602.1	5.80	332.6	22.80	723.8
2/16/2003	1.06	238.7	20.20	344.2	8.30	331.1	8/17/2007	3.52	746.1	5.00	616.0	21.00	785.4
2/17/2003	1.06	294.1	12.10	302.6	5.60	454.3	8/18/2007	3.08	462.8	37.00	477.4	33.00	777.7
2/18/2003	1.05	415.8	8.30	233.3	3.80	127.1	8/19/2007	2.64	451.2	13.80	221.8	48.60	323.4
2/19/2003	1.05	318.0	7.10	339.6	2.80	258.0	8/20/2007	2.29	516.7	16.90	269.5	43.00	646.8
2/20/2003	1.04	182.5	8.20	205.6	2.30	300.3	8/21/2007	6.35	715.3	111.80	346.5	47.50	1008.7
2/21/2003	1.04	235.6	10.00	231.0	1.90	354.2	8/22/2007	16.95	472.0	119.10	472.0	46.50	631.4
2/22/2003	1.04	277.2	9.90	326.5	1.70	415.8	8/23/2007	19.92	553.6	96.70	521.3	46.90	585.2
2/23/2003	1.04	389.6	8.20	352.7	1.50	415.8	8/24/2007	13.38	467.4	71.50	546.7	51.10	554.4
2/24/2003	1.05	273.4	6.40	272.6	1.40	392.7	8/25/2007	8.93	339.6	49.60	291.8	54.10	462.0
2/25/2003	1.29	284.1	5.20	303.4	1.30	408.1	8/26/2007	5.85	552.1	27.80	367.3	54.00	585.2
2/26/2003	2.10	214.1	4.50	161.7	1.30	323.4	8/27/2007	4.07	444.3	18.00	462.0	51.20	577.5
2/27/2003	3.03	342.7	4.10	328.8	1.20	338.8	8/28/2007	3.07	636.8	17.20	604.5	47.20	947.1
2/28/2003	3.20	385.8	3.90	341.9	1.20	254.1	8/29/2007	2.46	606.8	18.00	672.2	43.20	577.5
3/1/2003	2.91	503.6	3.70	341.9	1.20	154.0	8/30/2007	2.07	576.0	15.60	752.3	39.70	778.5
3/2/2003	2.55	358.1	3.60	302.6	1.10	431.2	8/31/2007	1.81	754.6	11.50	685.3	36.60	515.9

3/3/2003	2.18	110.9	3.50	315.7	1.10	369.6	9/1/2007	1.63	588.3	8.50	431.2	33.50	431.2
3/4/2003	1.88	473.6	3.50	346.5	1.10	385.0	9/2/2007	1.50	701.5	7.10	778.5	30.60	446.6
3/5/2003	1.67	237.9	3.40	234.9	1.10	300.3	9/3/2007	1.41	793.9	9.50	622.2	28.00	831.6
3/6/2003	1.52	410.4	3.40	519.0	1.10	454.3	9/4/2007	1.46	522.8	126.00	513.6	468.40	315.7
3/7/2003	1.41	192.5	3.40	446.6	1.10	438.9	9/5/2007	5.80	387.3	2067.50	431.2	4716.00	161.7
3/8/2003	1.33	412.0	3.30	392.7	1.10	454.3	9/6/2007	18.29	161.7	512.70	167.1	1879.40	192.5
3/9/2003	1.27	468.9	3.30	506.7	1.10	554.4	9/7/2007	16.81	698.4	148.40	431.2	889.80	592.9
3/10/2003	1.23	434.3	3.30	458.2	1.00	600.6	9/8/2007	10.73	472.0	61.00	380.4	579.70	862.4
3/11/2003	1.19	462.0	3.30	469.7	1.00	693.0	9/9/2007	6.65	529.0	32.50	413.5	416.90	396.6
3/12/2003	1.16	482.8	3.30	469.7	1.00	658.4	9/10/2007	4.48	710.7	21.20	405.0	310.70	585.2
3/13/2003	1.14	575.2	3.30	449.7	1.00	712.3	9/11/2007	3.29	493.6	16.60	479.7	238.30	531.3
3/14/2003	1.12	356.5	3.30	251.8	1.00	323.4	9/12/2007	2.59	426.6	14.20	397.3	187.00	438.9
3/15/2003	1.10	427.4	3.30	578.3	1.00	608.3	9/13/2007	2.15	512.8	12.10	512.8	149.90	412.0
3/16/2003	1.09	452.0	3.30	523.6	1.00	569.8	9/14/2007	1.87	596.8	10.00	485.1	122.40	431.2
3/17/2003	1.08	267.2	3.30	351.1	1.00	446.6	9/15/2007	1.67	596.8	8.40	320.3	101.50	797.0
3/18/2003	1.07	134.8	3.30	437.4	1.00	462.0	9/16/2007	1.53	623.7	11.30	247.9	115.00	57.8
3/19/2003	1.06	264.1	3.30	302.6	1.00	392.7	9/17/2007	1.43	375.0	13.30	432.0	83.60	361.9
3/20/2003	1.06	394.2	3.30	451.2	1.00	346.5	9/18/2007	1.66	463.5	13.10	431.2	67.00	400.4
3/21/2003	1.05	482.0	3.30	485.1	1.00	423.5	9/19/2007	100.76	344.2	256.50	431.2	66.00	616.0
3/22/2003	1.05	372.7	3.30	550.6	1.00	546.7	9/20/2007	117.18	324.2	163.80	404.3	79.90	308.0
3/23/2003	1.04	712.3	3.30	294.1	1.00	446.6	9/21/2007	44.16	429.7	53.90	308.0	92.30	300.3
3/24/2003	1.04	284.9	3.30	595.2	1.00	523.6	9/22/2007	19.44	504.4	20.90	395.8	91.90	361.9
3/25/2003	1.04	485.9	3.30	591.4	1.00	608.3	9/23/2007	10.00	238.7	14.70	361.1	83.20	462.0
3/26/2003	1.03	741.5	3.30	563.6	1.00	577.5	9/24/2007	6.17	400.4	13.30	326.5	72.80	554.4
3/27/2003	1.03	851.6	3.30	646.8	1.00	816.2	9/25/2007	4.33	251.8	11.70	422.7	63.60	492.8
3/28/2003	1.03	566.0	3.30	663.0	1.00	581.4	9/26/2007	3.31	525.9	9.70	410.4	55.80	585.2

3/29/2003	1.03	1174.3	3.30	662.2	1.00	777.7	9/27/2007	2.72	491.3	8.10	456.6	49.20	423.5
3/30/2003	1.02	588.3	3.30	630.6	1.00	673.8	9/28/2007	2.34	554.4	6.90	438.1	43.60	600.6
3/31/2003	1.02	746.1	3.30	485.1	1.00	654.5	9/29/2007	2.06	314.2	6.10	331.9	38.70	361.9
4/1/2003	1.02	746.1	3.20	533.6	1.00	758.5	9/30/2007	1.85	314.2	5.60	322.6	34.60	531.3
4/2/2003	1.02	613.7	3.20	716.1	1.00	308.0	10/1/2007	1.69	166.3	5.40	364.2	31.10	354.2
4/3/2003	1.02	703.8	3.20	659.9	1.00	673.8	10/2/2007	1.56	406.6	5.40	496.7	28.10	369.6
4/4/2003	1.02	755.4	3.20	603.7	1.00	623.7	10/3/2007	1.46	272.6	5.20	487.4	25.50	693.0
4/5/2003	1.02	653.0	3.20	582.9	1.00	685.3	10/4/2007	1.39	476.6	5.00	419.7	23.30	492.8
4/6/2003	1.01	713.8	3.20	718.4	1.00	619.9	10/5/2007	1.33	415.8	4.70	458.2	21.30	592.9
4/7/2003	1.01	619.9	3.20	277.2	1.00	650.7	10/6/2007	1.28	386.5	4.50	470.5	19.60	423.5
4/8/2003	1.01	606.8	3.20	485.1	1.00	770.0	10/7/2007	1.24	377.3	4.30	433.5	18.10	485.1
4/9/2003	1.01	512.1	3.20	431.2	1.00	723.8	10/8/2007	1.21	499.7	4.10	453.5	16.80	527.5
4/10/2003	1.01	548.2	3.20	609.8	1.00	677.6	10/9/2007	1.19	358.1	4.00	377.3	15.60	689.2
4/11/2003	1.01	681.5	3.20	590.6	1.00	623.7	10/10/2007	1.16	328.8	3.90	428.9	14.60	361.9
4/12/2003	1.01	703.0	3.20	685.3	1.00	839.3	10/11/2007	1.15	492.8	3.80	476.6	13.70	608.3
4/13/2003	1.01	804.7	3.20	542.1	1.00	762.3	10/12/2007	1.13	552.9	3.70	477.4	12.80	762.3
4/14/2003	1.01	642.2	3.20	562.1	1.00	331.1	10/13/2007	1.12	563.6	3.70	469.7	12.10	539.0
4/15/2003	1.01	776.2	3.20	558.3	1.00	546.7	10/14/2007	1.10	282.6	3.60	430.4	11.40	177.1
4/16/2003	1.01	737.7	3.20	530.5	1.00	600.6	10/15/2007	1.09	676.1	3.60	392.7	10.80	415.8
4/17/2003	1.01	916.3	3.20	515.9	1.00	623.7	10/16/2007	1.09	400.4	3.50	462.8	10.30	369.6
4/18/2003	1.01	749.2	3.20	535.2	1.00	562.1	10/17/2007	1.08	522.1	3.50	403.5	9.80	319.6
4/19/2003	1.01	485.1	3.20	639.1	1.00	612.2	10/18/2007	1.07	241.8	3.50	462.8	9.30	400.4
4/20/2003	1.01	631.4	3.20	481.3	1.00	689.2	10/19/2007	1.07	515.9	3.40	387.3	8.90	281.1
4/21/2003	1.01	585.2	3.20	711.5	1.00	666.1	10/20/2007	1.06	201.7	3.40	377.3	8.60	361.9
4/22/2003	1.01	477.4	3.20	893.2	1.00	600.6	10/21/2007	1.06	684.5	3.40	469.7	8.20	569.8
4/23/2003	1.01	661.4	3.20	708.4	1.00	654.5	10/22/2007	1.05	577.5	3.40	785.4	7.90	577.5

4/24/2003	1.01	779.2	3.20	749.2	1.00	643.0	10/23/2007	1.05	557.5	3.40	762.3	7.70	596.8
4/25/2003	1.01	768.5	3.20	608.3	1.00	716.1	10/24/2007	1.04	511.3	3.40	479.7	7.40	600.6
4/26/2003	1.01	723.0	3.20	639.1	1.00	743.1	10/25/2007	1.04	341.1	3.30	454.3	7.20	473.6
4/27/2003	1.01	943.3	3.20	881.7	1.00	619.9	10/26/2007	1.04	395.8	3.30	525.1	7.00	385.0
4/28/2003	1.01	820.1	3.20	833.1	1.00	700.7	10/27/2007	1.04	428.9	3.30	492.8	6.80	485.1
4/29/2003	1.00	1040.3	3.20	825.4	1.00	700.7	10/28/2007	1.03	391.2	3.30	523.6	6.60	408.1
4/30/2003	1.00	891.7	3.20	916.3	1.00	920.2	10/29/2007	1.03	412.7	3.30	494.3	6.40	400.4
5/1/2003	1.00	746.1	3.20	485.1	1.00	654.5	10/30/2007	1.03	410.4	3.30	373.5	6.30	577.5
5/2/2003	1.00	746.1	3.20	533.6	1.00	758.5	10/31/2007	1.03	369.6	3.30	402.7	6.10	720.0
5/3/2003	1.00	613.7	3.20	716.1	1.00	308.0	11/1/2007	1.03	368.1	3.30	458.2	6.00	616.0
5/4/2003	1.00	703.8	3.20	659.9	1.00	673.8	11/2/2007	1.03	336.5	3.30	454.3	5.90	315.7
5/5/2003	1.00	755.4	3.20	603.7	1.00	623.7	11/3/2007	1.02	390.4	3.30	531.3	5.80	254.1
5/6/2003	1.00	653.0	3.20	582.9	1.00	685.3	11/4/2007	1.02	346.5	3.30	400.4	5.70	469.7
5/7/2003	1.00	713.8	3.20	718.4	1.00	619.9	11/5/2007	1.02	394.2	3.30	418.1	5.60	469.7
5/8/2003	1.00	619.9	3.20	277.2	1.00	650.7	11/6/2007	1.02	452.8	3.30	508.2	5.50	315.7
5/9/2003	1.00	606.8	3.20	485.1	1.00	770.0	11/7/2007	1.02	234.9	3.30	365.0	5.40	361.9
5/10/2003	1.00	512.1	3.20	431.2	1.00	723.8	11/8/2007	1.02	481.3	3.30	423.5	5.30	419.7
5/11/2003	1.00	548.2	3.20	609.8	1.00	677.6	11/9/2007	1.02	273.4	3.30	423.5	5.30	319.6
5/12/2003	1.00	681.5	3.20	590.6	1.00	623.7	11/10/2007	1.02	385.8	3.30	469.7	5.20	469.7
5/13/2003	1.00	703.0	3.20	685.3	1.00	839.3	11/11/2007	1.02	420.4	3.30	408.1	5.10	496.7
5/14/2003	1.00	804.7	3.20	542.1	1.00	762.3	11/12/2007	1.02	112.4	3.30	308.0	5.10	596.8
5/15/2003	1.00	642.2	3.20	562.1	1.00	331.1	11/13/2007	1.01	429.7	3.20	430.4	5.00	385.0
5/16/2003	1.00	776.2	3.20	558.3	1.00	546.7	11/14/2007	1.01	266.4	3.20	287.2	5.00	485.1
5/17/2003	1.00	737.7	3.20	530.5	1.00	600.6	11/15/2007	1.01	495.9	3.20	431.2	4.90	500.5
5/18/2003	1.00	916.3	3.20	515.9	1.00	623.7	11/16/2007	1.01	324.2	3.20	515.9	4.90	469.7
5/19/2003	1.00	749.2	3.20	535.2	1.00	562.1	11/17/2007	1.01	294.9	3.20	408.1	4.80	396.6

5/20/2003	1.00	485.1	3.20	639.1	1.00	612.2	11/18/2007	1.01	227.2	3.20	454.3	4.80	319.6
5/21/2003	1.00	631.4	3.20	481.3	1.00	689.2	11/19/2007	1.01	276.4	3.20	331.1	4.80	246.4
5/22/2003	1.00	585.2	3.20	711.5	1.00	666.1	11/20/2007	1.01	385.8	3.20	292.6	4.70	315.7
5/23/2003	1.00	477.4	3.20	893.2	1.00	600.6	11/21/2007	1.01	346.5	3.20	246.4	4.70	373.5
5/24/2003	1.00	661.4	3.20	708.4	1.00	654.5	11/22/2007	1.01	292.6	3.20	310.3	4.70	404.3
5/25/2003	1.00	779.2	3.20	749.2	1.00	643.0	11/23/2007	1.01	368.1	3.40	392.7	4.60	308.0
5/26/2003	1.00	768.5	3.20	608.3	1.00	716.1	11/24/2007	1.01	92.4	5.10	369.6	4.60	100.1
5/27/2003	1.00	723.0	3.20	639.1	1.00	743.1	11/25/2007	1.01	138.6	9.50	323.4	4.70	57.8
5/28/2003	1.00	943.3	3.40	881.7	1.00	619.9	11/26/2007	1.01	192.5	12.90	258.0	5.00	304.2
5/29/2003	1.00	820.1	14.10	833.1	1.00	700.7	11/27/2007	1.01	277.2	12.20	290.3	5.50	115.5
5/30/2003	1.00	1040.3	25.70	825.4	1.00	700.7	11/28/2007	1.01	408.1	9.10	247.9	6.00	358.1
5/31/2003	1.00	891.7	16.50	916.3	1.00	920.2	11/29/2007	1.08	354.2	8.50	164.8	6.40	231.0
6/1/2003	1.00	777.7	11.00	802.3	1.00	781.6	11/30/2007	52.75	400.4	215.60	47.7	10.30	250.3
6/2/2003	1.00	754.6	7.90	773.9	1.00	608.3	12/1/2007	61.85	276.4	105.90	261.0	21.60	323.4
6/3/2003	1.00	978.7	6.10	971.0	1.00	847.0	12/2/2007	19.85	236.4	37.90	306.5	32.60	323.4
6/4/2003	1.00	870.1	5.10	793.9	1.00	816.2	12/3/2007	7.36	338.0	17.10	474.3	36.80	231.0
6/5/2003	1.00	1058.0	4.50	885.5	1.00	839.3	12/4/2007	4.35	223.3	10.50	367.3	36.00	301.1
6/6/2003	1.00	921.7	4.20	834.7	1.00	931.7	12/5/2007	3.26	227.9	7.70	187.9	33.40	314.9
6/7/2003	1.00	850.9	3.90	779.2	1.00	1081.9	12/6/2007	2.74	190.2	6.40	246.4	30.40	207.9
6/8/2003	1.00	905.5	9.40	956.3	1.00	866.3	12/7/2007	2.38	232.5	5.70	392.7	27.60	207.9
6/9/2003	1.00	982.5	20.90	776.9	1.00	1001.0	12/8/2007	2.07	57.0	7.80	415.8	25.60	215.6
6/10/2003	1.00	763.1	25.80	558.3	1.00	500.5	12/9/2007	1.87	287.2	77.10	269.5	213.20	38.5
6/11/2003	1.00	908.6	20.90	839.3	1.00	808.5	12/10/2007	2.87	270.3	216.30	60.1	97.60	38.5
6/12/2003	1.00	934.8	13.50	862.4	1.00	816.2	12/11/2007	7.50	37.7	104.10	129.4	77.10	242.6
6/13/2003	1.00	1111.1	8.50	959.4	1.00	893.2	12/12/2007	8.99	246.4	53.90	209.4	76.80	223.3
6/14/2003	1.00	783.1	6.00	923.2	1.00	993.3	12/13/2007	7.20	77.0	39.20	150.9	72.40	227.2

6/15/2003	1.00	1107.3	4.80	940.9	1.00	800.8	12/14/2007	4.98	175.6	28.90	161.7	65.60	277.2
6/16/2003	1.00	1094.2	4.30	907.8	1.00	916.3	12/15/2007	3.58	301.8	19.40	246.4	59.10	165.6
6/17/2003	1.00	518.2	3.90	885.5	1.00	797.0	12/16/2007	2.78	283.4	13.00	146.3	53.00	234.9
6/18/2003	1.00	501.3	3.70	539.0	1.00	619.9	12/17/2007	2.28	224.1	9.40	193.3	47.30	246.4
6/19/2003	1.00	889.4	3.60	632.9	1.00	708.4	12/18/2007	1.96	177.9	7.50	190.2	42.00	146.3
6/20/2003	1.00	706.1	3.50	713.0	1.00	793.1	12/19/2007	1.75	157.9	6.40	161.7	37.50	331.1
6/21/2003	1.00	687.6	3.50	314.2	1.00	746.9	12/20/2007	1.59	142.5	5.60	298.0	33.50	304.2
6/22/2003	1.00	693.0	3.40	354.2	1.00	843.2	12/21/2007	1.48	113.2	5.10	277.2	30.10	190.2
6/23/2003	1.00	723.0	3.40	715.3	1.00	843.2	12/22/2007	1.40	271.8	4.70	315.7	27.10	360.4
6/24/2003	1.00	647.6	3.40	675.3	1.00	800.8	12/23/2007	1.33	394.2	4.50	246.4	24.60	361.9
6/25/2003	1.00	532.1	87.20	375.0	1.00	604.5	12/24/2007	1.28	106.3	4.20	377.3	22.40	277.2
6/26/2003	1.00	638.3	180.40	800.8	1.00	735.4	12/25/2007	1.24	277.2	4.10	208.7	20.40	469.7
6/27/2003	1.00	288.8	165.00	415.8	1.00	600.6	12/26/2007	1.21	224.1	3.90	355.0	18.80	343.4
6/28/2003	1.00	561.3	92.30	504.4	1.00	485.1	12/27/2007	1.18	213.3	3.80	178.6	17.30	83.9
6/29/2003	1.00	236.4	40.90	584.4	1.80	1039.5	12/28/2007	1.16	170.2	3.80	304.2	16.00	188.7
6/30/2003	1.00	665.3	18.80	579.0	57.20	639.1	12/29/2007	1.14	261.8	3.70	369.6	14.90	231.0
7/1/2003	1.00	777.7	11.00	802.3	26.80	781.6	12/30/2007	1.13	138.6	3.60	369.6	13.90	238.7
7/2/2003	1.00	754.6	7.90	773.9	8.70	608.3	12/31/2007	1.12	127.8	3.60	332.6	13.00	254.1
7/3/2003	1.00	978.7	6.40	971.0	3.50	847.0	1/1/2008	1.10	505.1	3.50	482.8	12.20	331.1
7/4/2003	1.00	870.1	5.50	793.9	2.10	816.2	1/2/2008	1.09	210.2	3.50	544.4	11.50	346.5
7/5/2003	1.00	1058.0	5.00	885.5	1.60	839.3	1/3/2008	1.09	256.4	3.50	350.4	10.90	323.4
7/6/2003	1.00	921.7	34.60	834.7	1.40	931.7	1/4/2008	1.08	127.1	3.40	246.4	10.30	292.6
7/7/2003	1.00	850.9	73.50	779.2	1.20	1081.9	1/5/2008	1.07	221.8	3.40	177.1	9.80	240.2
7/8/2003	1.00	905.5	73.80	956.3	1.20	866.3	1/6/2008	1.07	343.4	3.40	210.2	9.40	191.0
7/9/2003	1.00	982.5	47.30	776.9	1.10	1001.0	1/7/2008	1.06	149.4	3.40	116.3	8.90	200.2
7/10/2003	1.00	763.1	24.40	558.3	1.10	500.5	1/8/2008	1.06	187.9	3.40	257.2	8.60	292.6

7/11/2003	1.00	908.6	12.60	839.3	1.10	808.5	1/9/2008	1.05	123.2	3.40	171.7	8.20	123.2
7/12/2003	1.00	934.8	7.80	862.4	1.10	816.2	1/10/2008	1.05	251.0	3.30	214.8	7.90	269.5
7/13/2003	1.00	1111.1	5.80	959.4	1.00	893.2	1/11/2008	1.04	177.1	3.30	246.4	7.60	195.6
7/14/2003	1.00	783.1	4.90	923.2	1.00	993.3	1/12/2008	1.04	241.0	3.30	214.8	7.40	269.5
7/15/2003	1.00	1107.3	4.40	940.9	1.00	800.8	1/13/2008	1.04	169.4	3.30	161.7	7.10	216.4
7/16/2003	1.00	1094.2	4.10	907.8	1.00	916.3	1/14/2008	1.04	448.1	3.30	183.3	6.90	260.3
7/17/2003	1.00	518.2	3.90	885.5	1.00	797.0	1/15/2008	1.03	289.5	3.30	313.4	6.70	323.4
7/18/2003	1.00	501.3	4.60	539.0	1.00	619.9	1/16/2008	1.03	268.0	3.30	244.1	6.60	284.9
7/19/2003	1.00	889.4	11.10	632.9	1.00	708.4	1/17/2008	1.03	88.6	3.30	268.7	6.40	154.0
7/20/2003	1.01	706.1	126.20	713.0	4.70	793.1	1/18/2008	1.03	246.4	3.30	177.1	6.20	192.5
7/21/2003	1.01	687.6	63.00	314.2	11.20	746.9	1/19/2008	1.03	310.3	3.30	177.1	6.10	258.0
7/22/2003	1.05	693.0	23.70	354.2	13.30	843.2	1/20/2008	1.02	183.3	3.30	308.8	6.00	241.0
7/23/2003	1.20	723.0	12.90	715.3	9.90	843.2	1/21/2008	1.02	241.0	3.30	137.1	5.80	213.3
7/24/2003	1.59	647.6	10.20	675.3	6.20	800.8	1/22/2008	1.02	247.9	3.30	261.0	5.70	206.4
7/25/2003	2.15	532.1	16.00	375.0	4.10	604.5	1/23/2008	1.02	89.3	3.30	71.6	5.60	274.9
7/26/2003	2.43	638.3	67.50	800.8	3.00	735.4	1/24/2008	1.02	69.3	3.30	46.2	5.50	50.1
7/27/2003	2.32	288.8	58.30	415.8	2.30	600.6	1/25/2008	1.02	171.7	3.30	53.9	5.40	100.1
7/28/2003	2.14	561.3	31.50	504.4	2.00	485.1	1/26/2008	1.02	147.8	3.30	69.3	5.40	188.7
7/29/2003	2.00	236.4	18.30	584.4	1.70	1039.5	1/27/2008	1.02	210.2	5.50	280.3	5.30	125.5
7/30/2003	1.86	665.3	13.20	579.0	1.50	639.1	1/28/2008	1.02	209.4	8.10	223.3	5.40	171.7
7/31/2003	1.71	406.6	32.70	580.6	1.40	446.6	1/29/2008	1.02	229.5	7.00	230.2	5.50	331.1
8/1/2003	1.57	777.7	40.20	802.3	1.30	781.6	1/30/2008	1.02	138.6	5.50	296.5	5.70	275.7
8/2/2003	1.46	754.6	23.70	773.9	1.30	608.3	1/31/2008	1.01	223.3	4.60	421.2	5.80	243.3
8/3/2003	1.38	978.7	13.70	971.0	1.20	847.0	2/1/2008	1.01	299.5	4.10	421.2	5.80	300.3
8/4/2003	1.31	870.1	9.20	793.9	1.20	816.2	2/2/2008	1.01	290.3	3.80	385.0	5.80	165.6
8/5/2003	1.26	1058.0	9.00	885.5	1.20	839.3	2/3/2008	1.01	422.7	3.70	398.9	5.70	273.4

8/6/2003	1.22	921.7	8.70	834.7	12.40	931.7	2/4/2008	1.01	211.8	3.60	297.2	5.70	261.8
8/7/2003	1.19	850.9	9.00	779.2	7.30	1081.9	2/5/2008	1.01	299.5	3.50	273.4	5.60	151.7
8/8/2003	1.21	905.5	10.00	956.3	3.20	866.3	2/6/2008	1.01	250.3	3.50	283.4	5.50	371.9
8/9/2003	1.30	982.5	8.00	776.9	1.90	1001.0	2/7/2008	1.01	246.4	3.50	379.6	5.40	289.5
8/10/2003	1.42	763.1	6.00	558.3	1.50	500.5	2/8/2008	1.01	292.6	3.40	177.1	5.40	511.3
8/11/2003	1.51	908.6	4.90	839.3	1.30	808.5	2/9/2008	1.01	267.2	3.40	383.5	5.30	346.5
8/12/2003	1.54	934.8	10.00	862.4	1.20	816.2	2/10/2008	1.01	215.6	3.40	485.9	5.20	331.1
8/13/2003	1.52	1111.1	12.30	959.4	1.10	893.2	2/11/2008	1.01	335.7	3.30	363.4	5.20	438.9
8/14/2003	1.67	783.1	9.40	923.2	1.10	993.3	2/12/2008	1.01	399.6	3.30	366.5	5.10	246.4
8/15/2003	2.15	1107.3	6.60	940.9	1.10	800.8	2/13/2008	1.01	360.4	3.30	281.8	5.10	502.8
8/16/2003	2.59	1094.2	5.20	907.8	1.10	916.3	2/14/2008	1.01	468.2	3.30	456.6	5.00	412.0
8/17/2003	2.68	518.2	5.20	885.5	1.10	797.0	2/15/2008	1.01	82.4	3.60	456.6	5.00	249.5
8/18/2003	2.84	501.3	15.40	539.0	1.10	619.9	2/16/2008	1.01	150.2	4.90	454.3	5.00	437.4
8/19/2003	3.33	889.4	15.10	632.9	1.10	708.4	2/17/2008	1.01	238.7	5.50	415.0	5.00	354.2
8/20/2003	3.57	706.1	11.80	713.0	1.00	793.1	2/18/2008	1.01	306.5	5.10	391.2	5.10	354.2
8/21/2003	3.27	687.6	8.90	314.2	1.00	746.9	2/19/2008	1.01	312.6	4.50	307.2	5.10	365.8
8/22/2003	2.80	693.0	9.00	354.2	1.00	843.2	2/20/2008	1.01	460.5	4.10	382.7	5.20	290.3
8/23/2003	2.37	723.0	18.90	715.3	1.00	843.2	2/21/2008	1.01	479.7	3.80	311.9	5.20	325.7
8/24/2003	2.03	647.6	27.10	675.3	1.10	800.8	2/22/2008	1.01	492.8	3.60	308.0	5.20	387.3
8/25/2003	1.82	532.1	17.80	375.0	21.00	604.5	2/23/2008	1.01	275.7	3.50	308.0	5.10	505.1
8/26/2003	1.98	638.3	15.70	800.8	9.70	735.4	2/24/2008	1.01	609.8	3.40	523.6	5.10	689.9
8/27/2003	2.91	288.8	18.40	415.8	3.40	600.6	2/25/2008	1.01	546.7	3.40	365.0	5.10	585.2
8/28/2003	3.94	561.3	18.60	504.4	1.90	485.1	2/26/2008	1.01	512.8	3.40	706.9	5.00	377.3
8/29/2003	3.91	236.4	14.70	584.4	1.40	1039.5	2/27/2008	1.01	438.1	3.30	788.5	5.00	716.1
8/30/2003	3.36	665.3	13.10	579.0	1.20	639.1	2/28/2008	1.01	698.4	3.30	472.8	4.90	361.9
8/31/2003	2.84	406.6	20.80	580.6	1.20	446.6	2/29/2008	1.01	345.7	3.30	478.2	4.90	412.7

9/1/2003	2.40	774.6	31.10	686.1	1.10	562.1	3/1/2008	1.00	546.7	3.30	485.9	4.90	566.7
9/2/2003	2.07	718.4	22.10	604.5	1.10	515.9	3/2/2008	1.00	529.0	3.30	458.9	4.80	596.0
9/3/2003	1.82	470.5	14.00	581.4	1.10	388.9	3/3/2008	1.00	461.2	3.30	780.0	4.80	334.2
9/4/2003	21.75	733.0	17.10	451.2	1.10	450.5	3/4/2008	1.00	396.6	3.30	478.2	4.70	531.3
9/5/2003	33.61	524.4	16.60	494.3	1.00	408.1	3/5/2008	1.00	487.4	3.20	448.1	4.70	400.4
9/6/2003	17.29	509.7	13.30	538.2	1.00	361.9	3/6/2008	1.00	394.2	3.20	506.7	4.70	462.0
9/7/2003	6.64	276.4	11.60	552.1	1.00	385.0	3/7/2008	1.00	435.8	3.20	625.2	4.70	619.1
9/8/2003	3.70	343.4	11.90	389.6	1.00	161.7	3/8/2008	1.00	440.4	3.20	475.9	4.60	381.9
9/9/2003	2.56	121.7	12.60	205.6	1.00	138.6	3/9/2008	1.00	406.6	3.20	478.9	4.60	576.0
9/10/2003	2.02	473.6	11.50	405.0	1.00	281.1	3/10/2008	1.00	463.5	3.20	575.2	4.60	508.2
9/11/2003	1.71	294.9	9.10	331.1	1.00	677.6	3/11/2008	1.00	454.3	3.20	496.7	4.60	689.2
9/12/2003	1.52	382.7	7.00	321.9	1.00	423.5	3/12/2008	1.00	677.6	3.20	482.0	4.50	623.7
9/13/2003	1.40	366.5	5.70	345.0	1.00	377.3	3/13/2008	1.00	473.6	3.20	437.4	4.50	596.8
9/14/2003	1.32	533.6	4.90	369.6	1.00	504.4	3/14/2008	1.00	575.2	3.20	514.4	4.50	666.1
9/15/2003	1.26	470.5	4.40	316.5	1.00	469.7	3/15/2008	1.00	803.1	3.20	503.6	4.50	656.8
9/16/2003	1.21	424.3	4.10	482.8	1.00	415.8	3/16/2008	1.00	554.4	3.20	539.8	4.50	474.3
9/17/2003	1.18	565.2	3.90	400.4	1.00	492.8	3/17/2008	1.00	354.2	3.20	275.7	4.50	309.5
9/18/2003	1.15	462.0	3.80	575.2	1.00	562.1	3/18/2008	1.00	359.6	3.20	442.0	4.40	320.3
9/19/2003	1.13	636.8	3.70	512.8	1.00	600.6	3/19/2008	1.00	474.3	3.20	481.3	4.40	499.0
9/20/2003	1.11	485.1	3.60	489.7	1.00	616.0	3/20/2008	1.00	471.2	3.20	607.5	4.40	739.2
9/21/2003	1.10	546.7	3.60	488.2	20.20	515.9	3/21/2008	1.00	492.8	3.20	477.4	4.40	746.9
9/22/2003	1.10	621.4	4.20	489.7	344.50	415.8	3/22/2008	1.00	729.2	3.20	539.0	4.40	646.8
9/23/2003	1.12	512.1	10.10	433.5	91.60	392.7	3/23/2008	1.00	572.1	3.20	839.3	4.40	660.7
9/24/2003	1.87	549.0	17.20	380.4	25.10	435.1	3/24/2008	1.00	559.8	3.20	645.3	4.40	585.2
9/25/2003	4.63	670.7	17.70	442.0	10.70	454.3	3/25/2008	1.00	652.2	3.20	731.5	4.40	474.3
9/26/2003	6.23	481.3	12.60	508.2	6.70	847.0	3/26/2008	1.00	776.2	3.20	606.8	4.30	577.5

9/27/2003	5.57	525.9	8.70	540.5	5.00	492.8	3/27/2008	1.00	731.5	3.20	480.5	4.30	682.2
9/28/2003	4.21	393.5	6.50	490.5	4.10	342.7	3/28/2008	1.00	631.4	3.20	649.9	4.30	739.2
9/29/2003	3.15	620.6	5.30	345.7	3.70	496.7	3/29/2008	1.00	770.0	3.20	718.4	4.30	662.2
9/30/2003	2.47	396.6	4.60	345.7	3.40	477.4	3/30/2008	1.00	532.8	3.20	669.9	4.30	669.9
10/1/2003	2.05	774.6	4.20	686.1	3.10	562.1	3/31/2008	1.00	660.7	3.20	617.5	4.30	535.2
10/2/2003	1.78	718.4	4.00	604.5	2.70	515.9	4/1/2008	1.00	700.7	3.20	543.6	4.30	646.0
10/3/2003	1.60	470.5	3.80	581.4	2.30	388.9	4/2/2008	1.00	760.0	3.20	432.0	4.30	604.5
10/4/2003	1.47	733.0	3.70	451.2	2.10	450.5	4/3/2008	1.00	619.1	3.20	589.1	4.30	826.2
10/5/2003	1.37	524.4	3.60	494.3	1.90	408.1	4/4/2008	1.00	482.8	3.20	659.1	4.30	670.7
10/6/2003	1.30	509.7	3.50	538.2	1.80	361.9	4/5/2008	1.00	713.8	3.20	734.6	4.30	739.2
10/7/2003	1.25	276.4	7.40	552.1	2.30	385.0	4/6/2008	1.00	705.3	3.20	589.1	4.30	700.7
10/8/2003	1.24	343.4	138.00	389.6	60.60	161.7	4/7/2008	1.00	705.3	3.20	744.6	4.30	585.2
10/9/2003	1.35	121.7	73.40	205.6	68.30	138.6	4/8/2008	1.00	840.8	3.20	746.9	4.30	757.7
10/10/2003	1.72	473.6	35.80	405.0	37.90	281.1	4/9/2008	1.00	733.0	3.20	686.8	4.30	555.9
10/11/2003	2.17	294.9	19.80	331.1	17.20	677.6	4/10/2008	1.00	810.8	3.20	606.8	4.30	707.6
10/12/2003	2.39	382.7	11.90	321.9	8.70	423.5	4/11/2008	1.00	713.8	3.20	577.5	4.30	735.4
10/13/2003	2.27	366.5	8.10	345.0	5.30	377.3	4/12/2008	1.00	788.5	3.20	677.6	4.30	581.4
10/14/2003	2.06	533.6	6.40	369.6	3.70	504.4	4/13/2008	1.00	698.4	3.20	850.9	4.30	758.5
10/15/2003	1.88	470.5	5.50	316.5	2.90	469.7	4/14/2008	1.00	775.4	3.20	793.1	4.30	585.2
10/16/2003	1.71	424.3	5.00	482.8	2.40	415.8	4/15/2008	1.00	880.9	3.20	765.4	4.20	785.4
10/17/2003	1.56	565.2	4.60	400.4	2.00	492.8	4/16/2008	1.00	995.6	3.20	991.0	4.20	807.0
10/18/2003	1.45	462.0	4.30	575.2	1.80	562.1	4/17/2008	1.00	712.3	3.20	780.0	4.20	653.0
10/19/2003	1.37	636.8	4.00	512.8	1.70	600.6	4/18/2008	1.00	635.3	3.20	780.0	4.20	817.7
10/20/2003	1.30	485.1	3.80	489.7	1.50	616.0	4/19/2008	1.00	790.8	3.20	786.2	4.20	477.4
10/21/2003	1.25	546.7	3.70	488.2	1.50	515.9	4/20/2008	1.00	810.8	3.20	780.0	4.20	800.8
10/22/2003	1.21	621.4	3.60	489.7	1.40	415.8	4/21/2008	1.00	787.7	3.20	693.0	4.20	854.7

10/23/2003	1.18	512.1	3.50	433.5	1.30	392.7	4/22/2008	1.00	718.4	3.20	823.1	4.20	646.8
10/24/2003	1.15	549.0	3.50	380.4	1.30	435.1	4/23/2008	1.00	807.0	3.20	894.0	4.20	908.6
10/25/2003	1.13	670.7	3.40	442.0	1.30	454.3	4/24/2008	1.00	369.6	3.20	720.0	4.20	924.0
10/26/2003	1.11	481.3	3.40	508.2	1.20	847.0	4/25/2008	1.00	644.5	3.20	866.3	4.20	700.7
10/27/2003	1.10	525.9	3.40	540.5	1.20	492.8	4/26/2008	1.00	830.8	3.20	847.8	4.20	948.6
10/28/2003	1.09	393.5	3.30	490.5	1.20	342.7	4/27/2008	1.00	834.7	3.20	982.5	4.20	867.0
10/29/2003	1.08	620.6	3.30	345.7	1.20	496.7	4/28/2008	1.00	783.9	3.20	896.3	4.20	766.9
10/30/2003	1.07	396.6	3.30	345.7	1.20	477.4	4/29/2008	1.00	889.4	3.20	936.3	4.20	934.8
10/31/2003	1.06	446.6	3.30	263.3	1.10	396.6	4/30/2008	1.00	809.3	3.20	936.3	4.20	756.1
11/1/2003	1.06	390.4	3.30	265.7	1.10	385.0	5/1/2008	1.00	708.4	3.20	900.1	4.20	1047.2
11/2/2003	1.05	345.0	3.30	485.1	1.10	454.3	5/2/2008	1.00	839.3	3.20	900.1	4.20	754.6
11/3/2003	1.05	422.0	3.30	469.7	1.10	342.7	5/3/2008	1.00	850.9	3.20	900.1	4.20	877.8
11/4/2003	1.04	327.3	3.30	246.4	1.10	496.7	5/4/2008	1.00	849.3	3.20	794.6	4.20	562.1
11/5/2003	1.04	381.9	3.30	277.2	1.10	500.5	5/5/2008	1.00	852.4	3.20	970.2	4.20	676.1
11/6/2003	1.04	461.2	3.30	195.6	1.10	392.7	5/6/2008	1.00	808.5	3.20	720.0	4.20	753.1
11/7/2003	1.03	395.0	3.30	408.1	1.10	477.4	5/7/2008	1.00	744.6	3.20	773.1	4.20	626.8
11/8/2003	1.03	399.6	3.20	321.1	1.10	473.6	5/8/2008	1.00	720.0	3.20	770.8	4.20	581.4
11/9/2003	1.03	366.5	3.20	346.5	1.10	462.0	5/9/2008	1.00	693.0	3.20	808.5	4.20	681.5
11/10/2003	1.03	484.3	3.20	514.4	1.10	535.2	5/10/2008	1.00	746.9	3.20	555.2	4.20	269.5
11/11/2003	1.04	259.5	3.20	368.8	1.10	581.4	5/11/2008	1.00	944.8	3.20	884.7	4.20	754.6
11/12/2003	1.13	378.1	3.20	512.8	1.10	623.7	5/12/2008	1.00	1069.5	3.20	942.5	4.20	723.8
11/13/2003	1.79	100.1	3.50	325.7	1.10	465.9	5/13/2008	1.00	1080.3	3.20	1077.2	4.20	705.3
11/14/2003	4.15	185.6	4.50	117.0	1.10	77.0	5/14/2008	1.00	600.6	3.20	636.0	4.20	691.5
11/15/2003	5.31	225.6	5.30	331.1	1.00	535.2	5/15/2008	1.00	810.0	3.20	875.5	4.20	682.2
11/16/2003	4.74	269.5	4.80	251.8	1.00	250.3	5/16/2008	1.00	525.1	3.20	811.6	4.20	606.8
11/17/2003	3.85	279.5	4.20	290.3	1.00	331.1	5/17/2008	1.00	813.9	3.20	866.3	4.20	243.3

11/18/2003	2.98	362.7	3.90	409.6	1.00	177.1	5/18/2008	1.00	295.7	3.20	970.2	4.20	739.2
11/19/2003	2.38	370.4	3.70	392.7	1.00	146.3	5/19/2008	1.00	1058.0	3.20	870.1	4.20	924.0
11/20/2003	1.99	317.2	3.50	429.7	1.00	485.1	5/20/2008	1.00	843.2	3.20	907.1	4.20	646.8
11/21/2003	1.74	368.8	3.50	348.0	1.00	423.5	5/21/2008	1.00	789.3	3.20	819.3	4.20	766.2
11/22/2003	1.56	365.8	3.40	359.6	1.00	477.4	5/22/2008	1.00	811.6	3.20	776.9	4.20	800.0
11/23/2003	1.44	328.8	3.40	295.7	1.00	338.8	5/23/2008	1.00	554.4	3.20	579.0	4.20	646.8
11/24/2003	1.35	278.7	3.30	426.6	1.00	273.4	5/24/2008	1.00	555.2	3.20	635.3	4.20	672.2
11/25/2003	1.29	446.6	3.30	265.7	1.00	288.8	5/25/2008	1.00	707.6	3.20	812.4	4.20	880.1
11/26/2003	1.24	214.8	3.30	184.8	1.00	377.3	5/26/2008	1.00	710.7	3.20	956.3	4.20	646.8
11/27/2003	1.20	377.3	3.30	577.5	1.00	150.2	5/27/2008	1.00	542.9	3.20	817.7	4.20	885.5
11/28/2003	1.17	293.4	3.30	739.2	1.00	515.9	5/28/2008	1.00	558.3	3.20	951.0	4.20	1024.1
11/29/2003	1.14	336.5	3.30	608.3	1.00	677.6	5/29/2008	1.00	576.0	3.20	969.4	4.20	717.6
11/30/2003	1.12	210.2	3.30	321.9	1.00	315.7	5/30/2008	1.00	999.5	3.20	958.7	4.20	971.7
12/1/2003	1.11	299.5	3.30	340.3	1.00	338.8	5/31/2008	1.00	999.5	3.20	958.7	4.20	1050.3
12/2/2003	1.09	199.4	3.50	405.8	1.00	392.7	6/1/2008	1.00	906.3	3.20	961.0	4.20	939.4
12/3/2003	1.08	278.7	3.80	193.3	1.00	404.3	6/2/2008	1.00	928.6	3.20	962.5	4.20	1062.6
12/4/2003	1.07	247.9	3.90	288.0	1.00	369.6	6/3/2008	1.00	613.7	3.20	1155.0	4.20	1008.7
12/5/2003	1.07	242.6	3.90	431.2	1.00	173.3	6/4/2008	1.00	567.5	3.20	1134.2	4.20	823.9
12/6/2003	1.06	348.8	3.90	300.3	1.00	361.9	6/5/2008	1.00	858.6	3.20	662.2	4.20	708.4
12/7/2003	1.05	324.9	3.80	360.4	1.00	223.3	6/6/2008	1.00	819.3	3.20	819.3	4.20	638.3
12/8/2003	1.05	169.4	3.60	315.7	1.00	292.6	6/7/2008	1.00	910.9	3.20	778.5	4.20	890.1
12/9/2003	1.04	230.2	3.50	238.7	1.00	377.3	6/8/2008	1.00	787.7	3.20	903.2	4.20	773.9
12/10/2003	1.04	291.1	3.40	235.6	1.00	269.5	6/9/2008	1.00	886.3	3.20	991.0	4.20	1024.1
12/11/2003	1.04	252.6	3.40	235.6	1.00	254.1	6/10/2008	1.00	1074.9	3.20	900.1	4.20	831.6
12/12/2003	1.03	219.5	3.40	234.9	1.00	323.4	6/11/2008	1.00	726.9	3.20	585.2	4.20	823.9
12/13/2003	1.03	90.9	3.30	392.7	1.00	392.7	6/12/2008	1.00	808.5	3.50	840.8	4.20	569.8

12/14/2003	1.03	195.6	3.30	350.4	1.00	200.2	6/13/2008	1.00	839.3	5.30	870.1	4.20	954.8
12/15/2003	1.03	462.8	3.30	324.9	1.00	331.1	6/14/2008	1.00	1189.7	8.40	841.6	4.40	645.3
12/16/2003	1.02	375.8	3.30	277.2	1.00	392.7	6/15/2008	1.00	773.9	9.60	880.9	4.60	782.3
12/17/2003	1.02	328.8	3.30	506.7	1.00	231.0	6/16/2008	1.00	835.5	8.50	1001.0	4.90	774.6
12/18/2003	1.02	317.2	3.30	449.7	1.00	315.7	6/17/2008	1.00	720.7	10.40	1110.3	5.30	736.1
12/19/2003	1.02	362.7	3.30	377.3	1.00	188.7	6/18/2008	1.00	623.7	15.40	961.7	5.70	1061.1
12/20/2003	1.02	285.7	3.30	485.1	1.00	242.6	6/19/2008	1.00	866.3	10.50	1097.3	6.30	885.5
12/21/2003	1.02	272.6	3.30	331.1	1.00	331.1	6/20/2008	1.00	1021.0	7.20	945.6	6.70	1062.6
12/22/2003	1.02	294.1	3.30	395.8	1.00	377.3	6/21/2008	1.00	1066.5	5.60	945.6	6.90	754.6
12/23/2003	1.01	244.9	3.30	519.0	1.00	438.9	6/22/2008	1.00	619.9	4.80	626.8	7.00	947.1
12/24/2003	1.01	241.0	3.30	331.1	1.00	423.5	6/23/2008	1.00	616.0	4.60	767.7	6.90	888.6
12/25/2003	1.01	221.0	3.30	346.5	1.00	427.4	6/24/2008	1.00	554.4	8.80	710.7	6.90	920.2
12/26/2003	1.01	368.8	3.30	261.8	1.00	327.3	6/25/2008	1.00	534.4	12.50	752.3	7.00	828.5
12/27/2003	1.01	323.4	3.30	315.7	1.00	415.8	6/26/2008	1.00	546.7	10.60	1044.1	7.40	989.5
12/28/2003	1.01	204.1	3.30	331.1	1.00	246.4	6/27/2008	1.00	847.0	7.40	958.7	7.70	770.0
12/29/2003	1.02	300.3	3.30	277.2	1.00	431.2	6/28/2008	1.00	780.8	5.70	1021.0	7.80	1008.7
12/30/2003	1.02	196.4	3.20	300.3	1.00	92.4	6/29/2008	1.00	852.4	4.90	836.2	7.80	1131.9
12/31/2003	1.23	166.3	3.20	277.2	1.00	277.2	6/30/2008	1.00	844.7	4.50	892.4	7.70	806.2
1/1/2004	2.01	222.5	3.20	277.2	1.00	308.0	7/1/2008	1.00	864.7	5.90	852.4	7.60	879.3
1/2/2004	2.94	270.3	3.20	322.6	1.00	308.0	7/2/2008	1.00	698.4	41.20	853.2	8.00	701.5
1/3/2004	3.19	348.0	3.20	346.5	1.00	181.0	7/3/2008	1.00	698.4	43.00	638.3	9.80	677.6
1/4/2004	2.91	271.0	3.20	361.9	1.00	261.8	7/4/2008	1.01	768.5	21.10	638.3	17.10	685.3
1/5/2004	2.55	186.3	3.20	366.5	1.00	319.6	7/5/2008	1.03	766.2	12.30	627.6	19.30	762.3
1/6/2004	2.18	251.0	3.20	358.1	1.00	315.7	7/6/2008	1.21	734.6	11.30	505.1	17.90	893.2
1/7/2004	1.88	312.6	3.20	315.7	1.00	223.3	7/7/2008	2.49	506.7	51.40	489.7	34.50	1028.7
1/8/2004	1.66	214.8	3.20	237.9	1.00	415.8	7/8/2008	4.20	392.7	36.70	202.5	43.80	291.1

1/9/2004	1.52	375.0	3.20	331.1	1.00	438.9	7/9/2008	4.72	446.6	245.70	358.8	378.90	355.0
1/10/2004	1.41	201.0	3.20	315.7	1.00	323.4	7/10/2008	6.51	530.5	186.90	275.7	243.20	324.2
1/11/2004	1.33	258.7	3.30	270.3	1.00	338.8	7/11/2008	9.48	298.0	213.80	400.4	166.90	429.7
1/12/2004	1.27	125.5	3.50	248.7	1.20	392.7	7/12/2008	19.43	442.0	255.90	418.9	146.10	725.3
1/13/2004	1.30	271.8	14.40	292.6	14.30	500.5	7/13/2008	26.99	582.1	205.50	441.2	148.60	758.5
1/14/2004	1.80	66.2	215.80	69.3	245.40	477.4	7/14/2008	19.13	630.6	116.50	545.2	152.80	496.7
1/15/2004	3.60	124.7	899.10	130.9	142.00	92.4	7/15/2008	12.33	620.6	56.30	539.8	146.90	777.7
1/16/2004	4.90	198.7	1513.10	277.2	55.80	223.3	7/16/2008	8.14	533.6	35.00	549.0	132.40	719.2
1/17/2004	5.80	147.1	1207.00	315.7	21.30	292.6	7/17/2008	5.79	658.4	27.30	508.2	115.30	800.8
1/18/2004	7.26	124.0	607.50	166.3	10.10	304.2	7/18/2008	26.33	718.4	22.80	508.2	99.50	77.0
1/19/2004	6.84	177.1	234.30	223.3	5.90	165.6	7/19/2008	43.04	275.7	17.60	508.2	86.10	462.0
1/20/2004	5.29	233.3	83.50	200.2	4.00	204.1	7/20/2008	23.51	358.1	19.80	351.1	75.00	669.9
1/21/2004	3.93	105.5	35.90	184.8	3.00	150.2	7/21/2008	10.79	577.5	25.90	538.2	66.20	677.6
1/22/2004	3.04	139.4	20.60	188.7	2.40	123.2	7/22/2008	6.01	500.5	27.90	361.9	59.90	315.7
1/23/2004	2.46	120.9	14.30	138.6	2.00	114.7	7/23/2008	3.91	606.8	270.30	280.3	259.10	254.1
1/24/2004	2.09	176.3	10.90	215.6	1.80	146.3	7/24/2008	2.86	525.1	380.60	365.0	167.50	365.8
1/25/2004	1.83	122.4	8.90	30.0	1.60	261.8	7/25/2008	2.41	361.9	546.60	365.0	195.30	553.6
1/26/2004	1.64	170.2	7.50	192.5	1.50	300.3	7/26/2008	17.23	338.8	237.50	92.4	258.90	260.3
1/27/2004	1.51	241.0	6.60	307.2	1.40	254.1	7/27/2008	36.24	331.1	106.10	315.7	257.60	294.1
1/28/2004	1.41	284.1	6.00	329.6	1.30	304.2	7/28/2008	24.72	606.8	217.70	120.1	235.60	458.9
1/29/2004	1.33	224.1	5.50	134.8	1.30	385.0	7/29/2008	20.69	283.4	117.20	499.0	219.50	562.1
1/30/2004	1.27	261.0	5.10	269.5	1.20	458.2	7/30/2008	18.88	447.4	54.90	495.9	199.50	573.7
1/31/2004	1.22	262.6	4.80	261.8	1.20	138.6	7/31/2008	12.55	613.7	32.90	462.8	172.60	766.2
2/1/2004	1.19	170.9	4.50	177.1	1.20	385.0	8/1/2008	7.49	597.5	24.60	597.5	145.40	369.6
2/2/2004	1.16	275.7	4.30	247.2	1.10	284.9	8/2/2008	4.76	591.4	21.10	308.0	122.00	449.7
2/3/2004	1.14	328.8	4.20	361.9	1.10	342.7	8/3/2008	3.36	716.9	19.80	411.2	103.20	740.0

2/4/2004	1.12	97.0	4.20	238.7	1.10	315.7	8/4/2008	2.62	360.4	41.90	474.3	89.20	658.4
2/5/2004	1.10	136.3	4.40	238.7	1.10	296.5	8/5/2008	3.73	564.4	56.50	561.3	80.30	608.3
2/6/2004	1.09	194.0	4.50	530.5	1.10	300.3	8/6/2008	7.51	497.4	50.50	648.3	75.00	877.8
2/7/2004	1.08	302.6	4.60	519.8	1.10	354.2	8/7/2008	8.49	408.9	50.60	356.5	75.50	77.0
2/8/2004	1.07	338.8	4.70	519.8	1.10	319.6	8/8/2008	33.19	440.4	51.80	409.6	80.50	523.6
2/9/2004	1.06	214.8	4.60	473.6	1.10	254.1	8/9/2008	45.73	395.0	39.70	202.5	75.10	354.2
2/10/2004	1.06	321.1	4.30	169.4	1.10	292.6	8/10/2008	23.90	434.3	28.00	726.1	67.40	988.7
2/11/2004	1.05	300.3	4.10	355.7	1.10	273.4	8/11/2008	11.03	492.0	24.90	514.4	74.90	570.6
2/12/2004	1.05	428.9	3.90	277.2	1.00	338.8	8/12/2008	17.89	348.8	42.60	426.6	63.50	392.7
2/13/2004	1.04	264.1	3.80	351.9	1.00	377.3	8/13/2008	29.09	470.5	126.40	482.0	134.10	658.4
2/14/2004	1.04	355.0	3.70	277.2	1.00	365.8	8/14/2008	18.79	381.9	172.60	489.7	104.10	400.4
2/15/2004	1.03	297.2	3.60	631.4	1.00	277.2	8/15/2008	9.73	431.2	143.20	243.3	93.90	585.2
2/16/2004	1.03	314.9	3.60	508.2	1.00	569.8	8/16/2008	5.63	368.1	89.30	378.8	98.30	454.3
2/17/2004	1.03	351.1	3.50	592.9	1.00	477.4	8/17/2008	3.73	335.7	53.00	401.2	355.70	211.8
2/18/2004	1.03	650.7	3.50	586.7	1.00	500.5	8/18/2008	2.78	339.6	35.50	469.7	205.80	379.6
2/19/2004	1.03	472.8	3.50	457.4	1.10	519.8	8/19/2008	2.22	497.4	28.10	568.3	131.00	515.9
2/20/2004	1.02	404.3	3.40	392.7	1.10	84.7	8/20/2008	1.88	497.4	25.60	481.3	102.50	609.8
2/21/2004	1.03	381.9	3.40	485.1	1.10	531.3	8/21/2008	1.66	503.6	23.50	465.9	166.70	361.9
2/22/2004	1.06	321.1	5.30	408.1	2.10	315.7	8/22/2008	1.50	531.3	26.80	408.1	169.20	500.5
2/23/2004	1.16	121.7	10.80	177.1	46.40	323.4	8/23/2008	1.40	473.6	36.10	406.6	99.30	515.9
2/24/2004	1.69	4.6	15.30	377.3	47.10	361.9	8/24/2008	1.32	277.2	49.10	335.0	69.50	469.7
2/25/2004	2.36	347.3	12.70	277.2	22.30	462.0	8/25/2008	1.27	253.3	58.50	46.2	275.60	500.5
2/26/2004	2.75	294.9	10.90	394.2	12.80	184.8	8/26/2008	1.49	159.4	57.80	284.9	124.50	323.4
2/27/2004	4.20	505.9	8.80	323.4	9.60	431.2	8/27/2008	9.27	264.9	48.10	355.7	70.90	432.7
2/28/2004	7.72	158.6	6.90	184.8	8.10	308.0	8/28/2008	25.55	390.4	35.40	454.3	111.40	480.5
2/29/2004	8.08	296.5	5.60	177.1	7.00	346.5	8/29/2008	18.53	284.9	27.30	405.8	69.60	549.8

3/1/2004	6.20	350.4	4.80	261.8	5.40	342.7	8/30/2008	13.17	479.7	24.60	283.4	52.50	500.5
3/2/2004	4.45	237.2	5.30	543.6	4.20	519.8	8/31/2008	13.38	439.7	23.70	355.0	46.90	284.9
3/3/2004	4.89	104.7	29.60	908.6	4.50	500.5	9/1/2008	10.57	530.5	62.70	428.9	44.60	346.5
3/4/2004	7.87	100.1	29.50	190.2	6.30	100.1	9/2/2008	6.97	642.2	109.50	474.3	46.60	791.6
3/5/2004	8.07	332.6	17.60	261.8	7.40	223.3	9/3/2008	4.61	435.8	104.30	552.1	52.80	589.8
3/6/2004	6.16	294.1	10.50	283.4	7.20	431.2	9/4/2008	3.28	574.4	67.20	545.2	59.20	551.3
3/7/2004	4.35	516.7	7.20	410.4	5.80	358.1	9/5/2008	2.54	760.8	37.90	558.3	61.60	828.5
3/8/2004	3.17	547.5	5.70	500.5	4.40	435.1	9/6/2008	2.08	679.1	23.60	559.0	59.70	357.3
3/9/2004	2.48	590.6	4.80	560.6	3.40	473.6	9/7/2008	1.79	515.1	17.60	552.1	55.30	531.3
3/10/2004	2.07	616.8	4.40	517.4	2.80	477.4	9/8/2008	1.60	520.5	15.30	284.9	50.40	377.3
3/11/2004	1.95	271.0	4.10	458.9	2.40	539.0	9/9/2008	1.52	377.3	17.00	371.9	47.20	696.9
3/12/2004	2.09	138.6	4.00	388.9	2.10	377.3	9/10/2008	1.90	539.0	297.60	13.9	992.00	500.5
3/13/2004	2.28	249.5	4.00	485.1	1.90	508.2	9/11/2008	3.29	523.6	418.50	346.5	1298.10	377.3
3/14/2004	2.31	239.5	3.90	495.1	1.80	523.6	9/12/2008	4.38	335.0	328.40	177.1	477.90	468.2
3/15/2004	2.16	441.2	3.80	562.1	1.70	585.2	9/13/2008	4.16	524.4	177.40	342.7	295.10	352.7
3/16/2004	1.95	493.6	3.70	515.9	1.60	616.0	9/14/2008	3.49	606.8	81.00	420.4	236.80	495.9
3/17/2004	1.76	535.9	3.60	523.6	1.50	666.1	9/15/2008	2.81	742.3	39.30	431.2	305.30	254.1
3/18/2004	1.61	495.1	3.50	473.6	1.40	854.7	9/16/2008	2.30	490.5	38.30	753.1	692.60	254.1
3/19/2004	1.50	551.3	3.50	492.8	1.40	677.6	9/17/2008	1.95	520.5	24.30	357.3	343.80	200.2
3/20/2004	1.40	295.7	3.50	523.6	1.30	554.4	9/18/2008	1.71	567.5	15.50	407.3	178.50	408.1
3/21/2004	1.33	508.2	3.60	755.4	1.30	870.1	9/19/2008	1.54	501.3	12.40	537.5	124.60	361.9
3/22/2004	1.27	499.7	16.90	580.6	1.30	662.2	9/20/2008	1.43	569.8	10.80	502.0	96.80	408.1
3/23/2004	1.23	417.3	27.90	546.7	1.20	708.4	9/21/2008	1.34	555.2	9.80	458.9	78.80	438.9
3/24/2004	1.19	607.5	18.10	603.7	1.20	643.0	9/22/2008	1.28	560.6	9.10	426.6	66.00	477.4
3/25/2004	1.16	639.1	11.50	569.0	1.20	627.6	9/23/2008	1.23	508.2	8.60	559.0	56.40	377.3
3/26/2004	1.14	677.6	8.20	395.8	1.20	643.0	9/24/2008	1.31	701.5	8.20	455.1	48.90	431.2

3/27/2004	1.12	622.9	6.40	523.6	1.20	723.8	9/25/2008	3.61	384.2	7.80	576.0	42.90	616.0
3/28/2004	1.11	646.8	5.30	736.1	1.20	639.1	9/26/2008	11.18	511.3	7.60	500.5	38.10	446.6
3/29/2004	1.09	666.1	4.70	698.4	1.10	746.9	9/27/2008	11.66	537.5	7.50	431.2	34.10	323.4
3/30/2004	1.08	629.1	4.30	485.1	1.10	631.4	9/28/2008	7.86	533.6	7.70	442.8	30.70	358.1
3/31/2004	1.12	544.4	4.10	600.6	1.10	693.0	9/29/2008	5.00	610.6	8.00	459.7	27.90	328.8
4/1/2004	1.86	606.8	8.80	272.6	1.10	192.5	9/30/2008	3.47	622.9	8.20	373.5	25.60	839.3
4/2/2004	6.62	144.0	11.80	315.7	1.10	246.4	10/1/2008	2.63	494.3	8.30	689.2	23.60	508.2
4/3/2004	9.84	334.2	10.60	277.2	1.10	385.0	10/2/2008	2.14	495.1	8.20	356.5	22.00	331.1
4/4/2004	7.28	397.3	9.50	475.9	1.10	523.6	10/3/2008	1.83	512.8	8.00	361.9	20.50	392.7
4/5/2004	5.41	367.3	8.80	377.3	1.10	438.9	10/4/2008	1.62	729.2	7.90	485.1	19.30	237.2
4/6/2004	4.21	373.5	7.50	445.8	1.10	554.4	10/5/2008	1.48	550.6	7.70	315.7	18.20	396.6
4/7/2004	3.33	501.3	6.30	542.9	1.10	354.2	10/6/2008	1.38	654.5	7.50	665.3	17.20	492.8
4/8/2004	2.70	648.3	5.40	546.7	1.10	785.4	10/7/2008	1.31	354.2	7.30	515.9	16.30	408.9
4/9/2004	2.36	423.5	4.80	500.5	1.10	604.5	10/8/2008	1.25	562.1	7.10	472.8	15.50	435.8
4/10/2004	3.69	333.4	4.50	554.4	1.10	669.9	10/9/2008	1.21	542.9	7.00	443.5	14.80	327.3
4/11/2004	8.08	392.7	4.60	176.3	1.10	746.9	10/10/2008	1.18	237.9	6.80	240.2	14.10	388.9
4/12/2004	8.93	494.3	4.90	624.5	1.10	515.9	10/11/2008	1.15	223.3	6.70	273.4	13.50	312.6
4/13/2004	6.85	512.8	4.90	659.1	1.10	746.9	10/12/2008	1.13	431.2	6.70	274.1	12.90	381.2
4/14/2004	4.71	740.0	4.70	206.4	1.00	723.8	10/13/2008	1.11	517.4	7.50	459.7	12.50	596.8
4/15/2004	3.38	766.2	4.50	617.5	1.00	592.9	10/14/2008	1.10	632.2	9.10	434.3	12.10	384.2
4/16/2004	2.61	681.5	4.20	592.9	1.00	616.0	10/15/2008	1.09	472.8	9.80	512.8	11.90	367.3
4/17/2004	2.15	745.4	4.00	677.6	1.00	627.6	10/16/2008	1.08	522.1	9.20	631.4	11.70	384.2
4/18/2004	1.85	722.3	3.80	469.7	1.00	523.6	10/17/2008	1.07	539.0	8.00	449.7	11.60	392.7
4/19/2004	1.65	619.1	3.70	476.6	1.00	770.0	10/18/2008	1.06	377.3	7.10	531.3	11.40	523.6
4/20/2004	1.50	648.3	3.60	731.5	1.00	485.1	10/19/2008	1.05	604.5	6.60	426.6	11.10	315.7
4/21/2004	1.40	747.7	3.50	612.2	1.00	731.5	10/20/2008	1.05	502.0	6.20	445.8	10.80	425.0

4/22/2004	1.33	793.9	3.50	704.6	1.00	515.9	10/21/2008	1.04	556.7	6.00	623.7	10.50	383.5
4/23/2004	1.27	761.5	3.40	689.2	1.00	662.2	10/22/2008	1.04	465.9	5.80	602.1	10.20	437.4
4/24/2004	1.23	485.1	3.40	646.8	1.00	646.8	10/23/2008	1.04	527.5	5.70	599.8	9.90	286.4
4/25/2004	1.19	693.0	3.40	787.7	1.00	708.4	10/24/2008	1.03	492.8	5.60	499.7	9.70	400.4
4/26/2004	1.17	797.0	3.80	408.9	1.00	681.5	10/25/2008	1.03	585.2	5.50	566.0	9.40	400.4
4/27/2004	1.14	305.7	9.90	448.9	1.00	974.1	10/26/2008	1.03	392.7	5.40	528.2	9.20	308.0
4/28/2004	1.13	577.5	18.60	701.5	1.00	777.7	10/27/2008	1.03	512.1	5.30	611.4	8.90	300.3
4/29/2004	1.11	942.5	20.10	766.2	1.00	739.2	10/28/2008	1.02	519.8	5.20	573.7	8.70	425.0
4/30/2004	1.10	733.8	15.10	739.2	1.00	808.5	10/29/2008	1.02	515.9	5.20	515.9	8.50	251.0
5/1/2004	1.09	777.7	9.70	739.2	1.00	839.3	10/30/2008	1.02	217.1	5.10	355.0	8.30	288.0
5/2/2004	1.08	730.0	6.40	762.3	1.00	804.7	10/31/2008	1.02	441.2	5.10	446.6	8.20	446.6
5/3/2004	1.07	784.6	4.90	853.9	1.00	862.4	11/1/2008	1.02	472.0	5.00	346.5	8.00	406.6
5/4/2004	1.06	797.0	4.20	753.1	1.00	893.2	11/2/2008	1.02	458.9	5.00	406.6	7.80	300.3
5/5/2004	1.06	668.4	3.80	793.1	1.00	843.2	11/3/2008	1.02	453.5	5.00	356.5	7.70	277.2
5/6/2004	1.05	815.4	3.70	531.3	1.00	658.4	11/4/2008	1.01	440.4	4.90	478.9	7.60	346.5
5/7/2004	1.05	907.8	3.50	746.9	1.00	908.6	11/5/2008	1.01	430.4	4.90	246.4	7.40	319.6
5/8/2004	1.04	666.8	3.50	739.2	1.00	885.5	11/6/2008	1.01	428.1	4.80	373.5	7.30	338.0
5/9/2004	1.04	820.8	3.40	969.4	1.00	777.7	11/7/2008	1.01	460.5	4.80	531.3	7.20	315.7
5/10/2004	1.04	914.8	3.40	770.8	1.00	908.6	11/8/2008	1.01	363.4	4.80	377.3	7.10	274.1
5/11/2004	1.03	944.8	3.30	785.4	1.00	874.0	11/9/2008	1.01	468.2	4.80	435.8	7.00	192.5
5/12/2004	1.03	948.6	3.30	920.2	1.00	881.7	11/10/2008	1.01	308.0	4.70	272.6	6.90	231.0
5/13/2004	1.03	770.0	3.30	711.5	1.00	847.0	11/11/2008	1.01	392.7	4.70	391.2	6.80	200.2
5/14/2004	1.03	773.1	3.30	772.3	1.00	816.2	11/12/2008	1.01	223.3	4.70	410.4	6.70	338.8
5/15/2004	1.03	632.2	3.30	770.8	1.00	1004.9	11/13/2008	1.01	383.5	4.70	233.3	6.70	327.3
5/16/2004	1.02	1177.3	3.30	800.8	1.00	785.4	11/14/2008	1.01	186.3	4.60	585.2	6.60	277.2
5/17/2004	1.02	808.5	3.30	700.7	1.00	770.0	11/15/2008	1.01	369.6	4.60	492.8	6.50	292.6

5/18/2004	1.02	1197.4	3.30	723.8	1.00	870.1	11/16/2008	1.01	223.3	4.60	569.8	6.50	423.5
5/19/2004	1.02	1043.4	3.30	700.7	1.00	1078.0	11/17/2008	1.01	446.6	4.60	746.9	6.40	404.3
5/20/2004	1.02	1051.1	3.30	971.0	1.00	1039.5	11/18/2008	1.01	348.8	4.60	648.3	6.30	246.4
5/21/2004	1.02	983.3	3.30	839.3	1.00	904.8	11/19/2008	1.01	396.6	4.60	545.9	6.30	523.6
5/22/2004	1.02	1004.9	3.30	839.3	1.00	804.7	11/20/2008	1.01	477.4	4.50	279.5	6.20	246.4
5/23/2004	1.02	1074.9	3.30	789.3	1.00	754.6	11/21/2008	1.01	304.9	4.50	279.5	6.20	331.1
5/24/2004	1.01	1021.0	3.30	847.8	1.00	877.8	11/22/2008	1.01	382.7	4.50	471.2	6.10	257.2
5/25/2004	1.01	988.7	3.20	858.6	1.00	831.6	11/23/2008	1.01	182.5	4.50	450.5	6.10	185.6
5/26/2004	1.01	1026.4	3.20	908.6	1.00	920.2	11/24/2008	1.01	388.1	4.50	297.2	6.10	345.7
5/27/2004	1.01	962.5	3.20	839.3	1.00	927.9	11/25/2008	1.04	194.0	4.50	339.6	6.00	492.8
5/28/2004	1.01	983.3	3.20	839.3	1.00	870.1	11/26/2008	1.59	228.7	5.00	163.2	6.00	261.8
5/29/2004	1.01	1009.5	3.20	850.1	1.00	862.4	11/27/2008	3.64	331.9	7.90	124.7	6.00	315.7
5/30/2004	1.01	850.9	3.20	700.7	1.00	777.7	11/28/2008	5.24	118.6	8.20	183.3	6.10	246.4
5/31/2004	1.01	970.2	3.20	793.1	1.00	985.6	11/29/2008	4.93	210.2	6.90	255.6	6.30	191.7
6/1/2004	1.01	1141.1	3.20	797.0	1.00	1031.8	11/30/2008	3.97	278.0	6.10	254.1	6.50	299.5
6/2/2004	1.01	1064.1	3.20	931.7	1.00	746.9	12/1/2008	3.04	191.7	5.80	325.7	6.50	267.2
6/3/2004	1.01	1034.9	3.20	823.1	1.00	893.2	12/2/2008	2.40	241.0	5.60	196.4	6.60	271.8
6/4/2004	1.01	867.8	3.20	920.2	1.00	854.7	12/3/2008	2.00	406.6	5.50	217.1	6.60	309.5
6/5/2004	1.01	984.1	3.20	930.9	1.00	1062.6	12/4/2008	1.74	146.3	5.40	157.9	6.60	300.3
6/6/2004	1.01	1028.0	3.20	961.7	1.00	1081.9	12/5/2008	1.57	196.4	5.30	124.0	6.60	223.3
6/7/2004	1.01	1098.8	3.20	1023.3	1.00	785.4	12/6/2008	1.45	204.1	5.30	251.0	6.60	200.2
6/8/2004	1.01	895.5	3.30	962.5	1.00	785.4	12/7/2008	1.36	196.4	5.20	351.1	6.50	146.3
6/9/2004	1.01	1126.5	4.00	1044.1	1.00	870.1	12/8/2008	1.29	304.2	5.20	258.7	6.50	104.0
6/10/2004	1.01	1053.4	5.40	958.7	1.00	947.1	12/9/2008	1.24	277.2	5.10	292.6	6.50	369.6
6/11/2004	1.01	1058.0	6.20	931.7	1.00	989.5	12/10/2008	1.20	185.6	5.10	519.8	6.50	348.0
6/12/2004	1.01	1143.5	5.90	853.9	1.00	977.9	12/11/2008	1.17	224.8	5.10	394.2	6.40	448.9

6/13/2004	1.01	899.4	5.10	877.8	1.00	1008.7	12/12/2008	1.14	241.0	5.00	220.2	6.40	269.5
6/14/2004	1.01	1037.2	4.40	1101.9	1.00	1047.2	12/13/2008	1.12	386.5	5.00	243.3	6.40	84.7
6/15/2004	1.01	1034.1	4.00	931.7	1.00	731.5	12/14/2008	1.11	261.8	5.00	259.5	6.40	196.4
6/16/2004	1.01	1025.6	3.70	795.4	1.00	1008.7	12/15/2008	1.10	149.4	4.90	274.9	6.30	115.5
6/17/2004	1.00	1033.3	3.60	739.2	1.00	970.2	12/16/2008	1.13	215.6	4.90	224.1	6.30	161.7
6/18/2004	1.00	1168.9	3.50	1011.8	1.00	985.6	12/17/2008	1.21	238.7	4.90	120.1	6.30	104.0
6/19/2004	1.00	1106.5	3.40	1008.7	1.00	1008.7	12/18/2008	1.32	107.0	4.80	120.9	6.20	227.2
6/20/2004	1.00	1084.2	3.40	877.8	1.00	1031.8	12/19/2008	1.43	134.8	4.80	149.4	6.20	346.5
6/21/2004	1.00	458.2	4.50	1008.7	6.90	1043.4	12/20/2008	1.48	204.1	4.80	269.5	6.20	127.1
6/22/2004	1.00	1014.9	9.60	539.8	107.50	1093.4	12/21/2008	1.46	213.3	4.80	361.1	6.20	231.0
6/23/2004	1.00	900.9	13.00	887.0	47.80	1366.8	12/22/2008	1.39	276.4	4.80	204.1	6.10	269.5
6/24/2004	1.00	777.7	12.00	990.2	12.60	970.2	12/23/2008	1.33	195.6	4.80	274.9	6.10	111.7
6/25/2004	1.00	823.9	9.00	1085.7	4.00	939.4	12/24/2008	1.28	247.2	4.80	194.0	6.10	120.9
6/26/2004	1.00	1096.5	6.50	1043.4	2.20	1085.7	12/25/2008	1.24	277.2	4.70	220.2	6.10	225.6
6/27/2004	1.00	951.0	5.00	1094.9	1.60	997.2	12/26/2008	1.21	293.4	4.70	268.0	6.00	142.5
6/28/2004	1.00	995.6	4.30	890.9	1.40	947.1	12/27/2008	1.18	299.5	4.70	338.0	6.00	92.4
6/29/2004	1.00	1009.5	3.90	897.8	1.20	962.5	12/28/2008	1.16	238.7	4.70	433.5	6.00	146.3
6/30/2004	1.00	1078.0	3.70	1002.5	1.20	1047.2	12/29/2008	1.14	265.7	4.70	453.5	6.00	246.4
7/1/2004	1.00	985.6	3.60	1218.9	1.10	993.3	12/30/2008	1.13	174.8	4.70	378.8	6.00	396.6
7/2/2004	1.00	1132.7	3.50	1147.3	1.10	877.8	12/31/2008	1.11	174.8	4.70	246.4	5.90	157.9
7/3/2004	1.00	857.8	3.40	1007.2	1.10	877.8	1/1/2009	1.10	247.2	4.60	292.6	5.90	323.4
7/4/2004	1.00	977.9	3.40	979.4	1.10	916.3	1/2/2009	1.09	101.6	4.60	351.9	5.90	146.3
7/5/2004	1.00	1026.4	3.30	981.8	1.10	850.9	1/3/2009	1.08	269.5	4.60	284.9	5.90	204.1
7/6/2004	1.00	1016.4	3.30	997.2	1.00	689.2	1/4/2009	1.07	96.3	4.60	207.9	5.90	88.6
7/7/2004	1.01	862.4	3.30	896.3	1.00	881.7	1/5/2009	1.06	175.6	4.60	207.9	5.80	215.6
7/8/2004	1.05	747.7	4.30	864.7	1.00	696.9	1/6/2009	1.06	211.0	4.60	200.2	5.80	292.6

7/9/2004	2.69	592.9	5.30	668.4	1.10	800.8	1/7/2009	1.05	150.2	4.60	429.7	5.80	238.7
7/10/2004	8.76	730.7	5.60	930.2	1.10	962.5	1/8/2009	1.05	222.5	4.50	263.3	5.80	92.4
7/11/2004	9.63	636.0	5.30	719.2	1.70	793.1	1/9/2009	1.04	268.0	4.50	284.1	5.80	154.0
7/12/2004	8.47	774.6	30.00	0.0	310.70	681.5	1/10/2009	1.04	275.7	4.50	494.3	5.80	458.2
7/13/2004	7.83	515.9	325.10	525.9	164.70	754.6	1/11/2009	1.04	383.5	4.50	653.7	5.70	419.7
7/14/2004	7.44	515.9	234.90	639.9	79.20	735.4	1/12/2009	1.03	265.7	4.50	393.5	5.70	539.0
7/15/2004	11.39	522.1	256.00	596.8	41.40	550.6	1/13/2009	1.03	273.4	4.50	502.8	5.70	392.7
7/16/2004	12.56	594.4	216.80	616.0	19.80	854.7	1/14/2009	1.03	352.7	4.50	446.6	5.70	177.1
7/17/2004	7.56	619.9	125.40	654.5	10.50	369.6	1/15/2009	1.03	317.2	4.50	470.5	5.70	327.3
7/18/2004	4.97	736.9	58.90	566.0	6.70	646.8	1/16/2009	1.02	303.4	4.50	507.4	5.70	254.1
7/19/2004	3.70	653.0	28.50	736.1	4.80	816.2	1/17/2009	1.02	325.7	4.40	324.9	5.70	342.7
7/20/2004	5.87	781.6	16.40	525.9	4.10	1128.1	1/18/2009	1.02	247.2	4.40	375.8	5.60	146.3
7/21/2004	12.42	685.3	18.00	622.2	42.90	627.6	1/19/2009	1.02	287.2	4.40	372.7	5.60	327.3
7/22/2004	11.97	585.2	1255.50	0.0	16.70	800.8	1/20/2009	1.02	274.1	4.40	502.0	5.60	331.1
7/23/2004	7.99	719.2	870.80	232.5	5.50	123.2	1/21/2009	1.02	239.5	4.40	415.0	5.60	211.8
7/24/2004	5.13	409.6	246.20	585.2	3.10	585.2	1/22/2009	1.03	89.3	4.40	99.3	5.60	130.9
7/25/2004	3.60	539.0	389.20	182.5	2.50	546.7	1/23/2009	1.06	57.8	4.40	231.8	5.60	369.6
7/26/2004	2.86	202.5	156.80	513.6	2.20	631.4	1/24/2009	1.22	248.7	4.40	199.4	5.60	146.3
7/27/2004	226.95	203.3	400.60	546.7	2.00	977.9	1/25/2009	1.45	413.5	4.40	317.2	5.50	292.6
7/28/2004	253.59	472.0	246.90	483.6	9.50	181.0	1/26/2009	1.66	263.3	4.40	192.5	5.50	423.5
7/29/2004	84.31	599.8	101.20	425.0	26.30	666.1	1/27/2009	1.73	470.5	4.40	395.8	5.50	181.0
7/30/2004	30.87	682.2	51.90	0.0	39.60	369.6	1/28/2009	1.66	252.6	4.40	358.1	5.50	400.4
7/31/2004	15.31	648.3	33.00	0.0	44.60	0.0	1/29/2009	1.56	372.7	4.50	410.4	5.50	308.0
8/1/2004	9.07	458.9	27.00	336.5	44.60	15.4	1/30/2009	1.48	356.5	4.50	763.1	5.50	200.2
8/2/2004	6.11	507.4	29.00	371.1	43.30	338.8	1/31/2009	1.42	373.5	4.50	324.9	5.50	331.1
8/3/2004	4.54	522.8	196.40	646.8	55.40	839.3	2/1/2009	1.36	450.5	4.60	357.3	5.50	234.9

8/4/2004	3.62	706.9	91.60	272.6	77.30	500.5	2/2/2009	1.31	269.5	4.60	580.6	5.50	323.4
8/5/2004	3.02	599.1	33.20	460.5	82.20	1039.5	2/3/2009	1.26	333.4	4.60	559.0	5.50	527.5
8/6/2004	2.58	612.2	44.30	277.2	74.50	354.2	2/4/2009	1.22	313.4	4.60	465.1	5.50	412.0
8/7/2004	2.25	294.9	44.80	583.7	66.80	693.0	2/5/2009	1.18	473.6	4.50	439.7	5.50	558.3
8/8/2004	1.99	558.3	24.70	288.8	61.20	673.8	2/6/2009	1.16	400.4	4.50	454.3	5.50	423.5
8/9/2004	1.80	710.7	16.00	519.8	55.90	1112.7	2/7/2009	1.14	308.0	4.50	400.4	5.50	200.2
8/10/2004	1.65	621.4	12.30	520.5	50.40	438.9	2/8/2009	1.12	238.7	4.50	227.2	5.50	211.8
8/11/2004	1.55	746.1	24.80	436.6	45.50	554.4	2/9/2009	1.10	374.2	4.50	221.0	5.50	215.6
8/12/2004	1.49	588.3	33.40	420.4	42.30	639.1	2/10/2009	1.09	265.7	4.50	85.5	5.50	107.8
8/13/2004	1.73	434.3	48.80	650.7	41.00	600.6	2/11/2009	1.08	167.1	4.50	304.2	5.50	296.5
8/14/2004	4.20	261.0	44.20	369.6	41.20	862.4	2/12/2009	1.07	174.0	4.50	318.0	5.50	104.0
8/15/2004	8.55	969.4	26.80	478.2	41.20	508.2	2/13/2009	1.06	481.3	4.50	346.5	5.50	515.9
8/16/2004	8.43	197.1	16.10	528.2	40.00	581.4	2/14/2009	1.06	343.4	4.40	401.9	5.50	527.5
8/17/2004	7.89	389.6	10.50	520.5	37.40	596.8	2/15/2009	1.05	277.2	4.40	385.8	5.50	242.6
8/18/2004	8.24	345.7	7.60	428.1	34.30	885.5	2/16/2009	1.05	174.8	4.40	89.3	5.50	215.6
8/19/2004	8.45	621.4	6.10	485.1	31.20	215.6	2/17/2009	1.04	400.4	4.40	200.2	5.50	246.4
8/20/2004	8.15	764.6	5.30	669.9	28.30	592.9	2/18/2009	1.04	405.8	4.40	377.3	5.50	331.1
8/21/2004	6.70	740.0	5.20	627.6	25.70	519.8	2/19/2009	1.04	324.2	4.40	569.0	5.50	323.4
8/22/2004	4.99	673.0	7.20	478.9	23.50	758.5	2/20/2009	1.03	354.2	4.40	610.6	5.50	477.4
8/23/2004	3.69	702.2	22.40	543.6	22.00	596.8	2/21/2009	1.03	269.5	4.40	602.9	5.50	408.1
8/24/2004	2.85	485.1	41.40	369.6	21.90	419.7	2/22/2009	1.03	496.7	4.40	676.1	5.50	454.3
8/25/2004	2.32	617.5	42.40	740.0	23.30	777.7	2/23/2009	1.03	446.6	4.40	683.0	5.50	585.2
8/26/2004	1.97	652.2	29.20	686.1	25.10	897.1	2/24/2009	1.02	410.4	4.40	564.4	5.50	619.9
8/27/2004	1.74	686.1	16.70	500.5	26.00	515.9	2/25/2009	1.02	341.9	4.40	670.7	5.50	415.8
8/28/2004	1.57	670.7	9.70	623.7	25.50	596.8	2/26/2009	1.02	653.0	4.40	601.4	5.40	623.7
8/29/2004	1.46	545.9	7.60	704.6	24.20	639.1	2/27/2009	1.02	831.6	4.40	490.5	5.40	412.0

8/30/2004	1.40	720.0	10.50	781.6	22.60	485.1	2/28/2009	1.02	677.6	4.30	786.9	5.40	850.9
8/31/2004	10.12	751.5	19.80	726.9	21.50	893.2	3/1/2009	1.02	513.6	4.30	966.4	5.40	589.1
9/1/2004	21.21	816.2	15.80	596.0	21.00	654.5	3/2/2009	1.02	577.5	4.30	570.6	5.40	419.7
9/2/2004	15.22	693.0	9.00	610.6	20.50	616.0	3/3/2009	1.01	495.9	4.30	697.6	5.40	388.9
9/3/2004	6.18	515.1	5.90	395.0	20.50	446.6	3/4/2009	1.01	636.8	4.30	589.1	5.40	704.6
9/4/2004	3.49	20.0	27.20	114.7	687.90	377.3	3/5/2009	1.01	321.1	4.30	601.4	5.40	485.1
9/5/2004	2.43	329.6	43.40	206.4	130.20	184.8	3/6/2009	1.01	569.0	4.30	530.5	5.40	196.4
9/6/2004	1.93	726.9	25.60	492.0	48.00	377.3	3/7/2009	1.01	574.4	4.30	309.5	5.40	492.8
9/7/2004	1.64	416.6	13.40	327.3	33.20	0.0	3/8/2009	1.01	613.7	4.30	324.2	5.40	150.2
9/8/2004	1.47	807.0	8.40	598.3	28.60	408.1	3/9/2009	1.01	53.9	4.30	85.5	5.40	84.7
9/9/2004	1.36	696.1	6.20	531.3	25.80	450.5	3/10/2009	1.01	380.4	4.30	390.4	5.40	254.1
9/10/2004	1.29	689.9	5.20	477.4	23.60	504.4	3/11/2009	1.01	508.2	4.30	452.8	5.40	423.5
9/11/2004	1.23	698.4	4.60	577.5	21.70	454.3	3/12/2009	1.01	415.8	4.30	539.8	5.40	566.0
9/12/2004	1.19	609.1	4.20	617.5	19.70	639.1	3/13/2009	1.01	419.7	4.30	400.4	5.40	418.9
9/13/2004	1.16	666.8	4.00	561.3	17.80	462.0	3/14/2009	1.01	490.5	4.30	669.9	5.40	473.6
9/14/2004	1.14	623.7	3.90	474.3	16.20	419.7	3/15/2009	1.01	481.3	4.30	465.9	5.40	450.5
9/15/2004	1.12	664.5	4.50	523.6	15.10	400.4	3/16/2009	1.01	469.7	4.40	532.8	5.40	666.1
9/16/2004	1.11	602.1	5.80	585.2	66.60	404.3	3/17/2009	1.01	454.3	4.40	675.3	5.40	600.6
9/17/2004	1.11	453.5	6.70	500.5	30.20	292.6	3/18/2009	1.01	246.4	4.40	675.3	5.40	600.6
9/18/2004	1.40	241.8	9.10	570.6	85.10	300.3	3/19/2009	1.01	586.7	4.40	607.5	5.40	562.1
9/19/2004	38.45	200.2	518.40	485.1	266.30	246.4	3/20/2009	1.01	368.1	4.30	546.7	5.40	308.0
9/20/2004	57.23	430.4	125.90	319.6	226.20	477.4	3/21/2009	1.01	524.4	4.30	619.9	5.40	348.8
9/21/2004	27.63	643.0	34.90	381.9	139.70	654.5	3/22/2009	1.01	614.5	4.30	720.7	5.40	481.3
9/22/2004	11.55	522.8	17.10	389.6	100.50	177.1	3/23/2009	1.01	696.1	4.30	773.9	5.40	596.8
9/23/2004	6.25	587.5	10.40	446.6	81.10	377.3	3/24/2009	1.00	557.5	4.30	489.7	5.30	423.5
9/24/2004	4.03	669.1	7.20	277.2	67.90	261.8	3/25/2009	1.00	566.0	4.30	639.9	5.30	627.6

9/25/2004	2.93	404.3	5.70	361.9	57.90	539.0	3/26/2009	1.00	771.5	4.30	702.2	5.30	512.1
9/26/2004	2.32	485.1	4.90	399.6	49.90	422.7	3/27/2009	1.00	697.6	4.30	634.5	5.30	585.2
9/27/2004	1.95	431.2	4.40	456.6	43.40	438.9	3/28/2009	1.00	654.5	4.30	632.2	5.30	569.8
9/28/2004	1.71	431.2	4.10	482.0	38.10	562.1	3/29/2009	1.00	698.4	4.30	775.4	5.30	374.2
9/29/2004	1.54	485.1	3.90	364.2	33.70	315.7	3/30/2009	1.00	539.8	4.30	365.0	5.30	396.6
9/30/2004	1.43	508.2	3.70	438.9	30.00	500.5	3/31/2009	1.00	500.5	4.30	639.9	5.30	485.1
10/1/2004	1.34	546.7	3.60	323.4	26.90	346.5	4/1/2009	1.00	735.4	4.30	646.8	5.30	412.0
10/2/2004	1.28	542.9	3.60	485.1	24.20	335.0	4/2/2009	1.00	569.8	4.30	615.2	5.30	504.4
10/3/2004	1.23	498.2	3.50	457.4	22.00	589.1	4/3/2009	1.00	519.8	4.20	633.7	5.30	438.9
10/4/2004	1.20	677.6	3.50	489.7	20.00	415.8	4/4/2009	1.00	566.0	4.20	559.0	5.30	454.3
10/5/2004	1.17	558.3	3.40	531.3	18.30	554.4	4/5/2009	1.00	465.9	4.20	586.0	5.30	569.8
10/6/2004	1.15	642.2	3.40	0.0	16.90	573.7	4/6/2009	1.00	685.3	4.20	669.9	5.30	462.0
10/7/2004	1.13	519.0	3.40	408.1	15.60	400.4	4/7/2009	1.00	662.2	4.20	840.8	5.30	355.0
10/8/2004	1.11	577.5	3.40	320.3	14.50	654.5	4/8/2009	1.00	68.5	4.20	860.9	5.30	284.9
10/9/2004	1.10	585.2	3.40	496.7	13.50	431.2	4/9/2009	1.00	700.7	4.20	793.9	5.30	700.7
10/10/2004	1.09	471.2	3.60	490.5	12.70	562.1	4/10/2009	1.00	773.1	4.20	822.4	5.30	612.2
10/11/2004	1.08	314.2	3.90	456.6	11.90	408.1	4/11/2009	1.00	519.0	4.20	539.8	5.30	785.4
10/12/2004	1.07	479.7	4.10	499.0	11.30	454.3	4/12/2009	1.00	494.3	4.20	552.9	5.30	585.2
10/13/2004	1.06	500.5	4.10	447.4	10.70	477.4	4/13/2009	1.00	648.3	4.20	773.1	5.30	646.8
10/14/2004	1.06	680.7	3.90	545.9	10.20	396.6	4/14/2009	1.00	737.7	4.20	710.7	5.30	358.1
10/15/2004	1.05	419.7	3.80	500.5	9.70	469.7	4/15/2009	1.00	669.1	4.20	529.0	5.30	261.8
10/16/2004	1.05	452.8	3.60	531.3	9.30	685.3	4/16/2009	1.00	679.1	4.20	665.3	5.30	708.4
10/17/2004	1.04	611.4	3.50	418.9	8.90	531.3	4/17/2009	1.00	501.3	4.20	767.7	5.30	608.3
10/18/2004	1.04	408.9	3.50	464.3	8.60	338.8	4/18/2009	1.00	632.9	4.20	827.8	5.30	712.3
10/19/2004	1.04	509.7	3.40	401.9	8.30	546.7	4/19/2009	1.00	741.5	4.20	1006.4	5.30	646.8
10/20/2004	1.03	519.8	3.40	409.6	8.00	296.5	4/20/2009	1.00	607.5	4.20	713.0	5.30	1070.3

10/21/2004	1.03	449.7	3.40	130.9	7.70	204.1	4/21/2009	1.00	635.3	4.20	915.5	5.30	546.7
10/22/2004	1.03	420.4	3.30	277.2	7.40	177.1	4/22/2009	1.00	558.3	4.20	870.9	5.30	677.6
10/23/2004	1.04	284.9	3.40	238.7	7.20	508.2	4/23/2009	1.00	546.7	4.20	863.2	5.30	612.2
10/24/2004	1.11	505.9	5.20	204.8	7.00	69.3	4/24/2009	1.00	441.2	4.20	720.7	5.20	562.1
10/25/2004	1.44	104.0	13.00	63.9	7.00	215.6	4/25/2009	1.00	579.0	4.20	786.2	5.20	696.9
10/26/2004	13.67	298.0	27.60	96.3	7.50	7.7	4/26/2009	1.00	546.7	4.20	843.2	5.20	546.7
10/27/2004	30.47	284.9	34.60	244.1	8.80	346.5	4/27/2009	1.00	546.7	4.20	767.7	5.20	777.7
10/28/2004	19.85	382.7	26.00	383.5	10.60	154.0	4/28/2009	1.00	542.9	4.20	611.4	5.20	531.3
10/29/2004	10.02	225.6	16.70	338.8	12.20	292.6	4/29/2009	1.00	532.8	4.20	842.4	5.20	754.6
10/30/2004	5.73	294.9	11.10	184.8	13.00	165.6	4/30/2009	1.00	654.5	4.20	712.3	5.20	746.9
10/31/2004	3.80	398.1	9.20	284.9	13.20	104.0	5/1/2009	1.00	815.4	4.20	789.3	5.20	704.6
11/1/2004	2.80	409.6	9.30	429.7	13.00	539.0	5/2/2009	1.00	965.6	4.20	853.2	5.20	781.6
11/2/2004	2.23	371.9	8.80	423.5	12.80	616.0	5/3/2009	1.00	815.4	4.20	650.7	5.20	820.1
11/3/2004	1.88	219.5	7.40	382.7	12.50	346.5	5/4/2009	1.00	954.0	4.20	559.0	5.20	789.3
11/4/2004	1.66	315.7	5.90	392.7	12.10	0.0	5/5/2009	1.00	885.5	4.20	913.2	5.20	745.4
11/5/2004	1.51	365.8	4.90	246.4	11.70	211.8	5/6/2009	1.00	826.2	4.20	951.7	5.20	708.4
11/6/2004	1.40	256.4	4.30	281.1	11.20	331.1	5/7/2009	1.00	983.3	4.20	863.9	5.20	854.7
11/7/2004	1.32	387.3	4.00	425.0	10.70	346.5	5/8/2009	1.00	556.7	4.20	1061.1	5.20	793.1
11/8/2004	1.26	308.8	3.80	308.8	10.20	338.8	5/9/2009	1.00	824.7	4.20	928.6	5.20	770.0
11/9/2004	1.22	281.1	3.60	277.2	9.80	446.6	5/10/2009	1.00	962.5	4.20	941.7	5.20	793.1
11/10/2004	1.18	760.8	3.60	313.4	9.30	331.1	5/11/2009	1.00	720.7	4.20	957.1	5.20	812.4
11/11/2004	1.16	338.8	3.50	380.4	8.90	284.9	5/12/2009	1.00	768.5	4.20	937.9	5.20	820.1
11/12/2004	1.14	343.4	3.50	292.6	8.60	331.1	5/13/2009	1.00	700.7	4.20	774.6	5.20	716.1
11/13/2004	1.14	211.0	4.80	377.3	8.30	204.1	5/14/2009	1.00	635.3	4.20	954.8	5.20	808.5
11/14/2004	1.23	88.6	159.80	127.8	10.80	342.7	5/15/2009	1.00	789.3	4.20	860.9	5.20	708.4
11/15/2004	1.55	166.3	100.00	192.5	19.10	107.8	5/16/2009	1.00	789.3	4.20	961.7	5.20	727.7

11/16/2004	2.05	113.2	45.60	168.6	28.20	219.5	5/17/2009	1.00	548.2	4.20	1054.9	5.20	850.9
11/17/2004	2.29	87.8	25.30	258.7	32.80	238.7	5/18/2009	1.00	761.5	4.20	832.4	5.20	843.2
11/18/2004	2.09	254.9	15.80	170.9	33.30	215.6	5/19/2009	1.00	566.0	4.20	566.7	5.20	746.9
11/19/2004	1.80	246.4	10.40	165.6	31.80	207.9	5/20/2009	1.00	513.6	4.70	513.6	5.20	451.2
11/20/2004	1.59	177.1	7.50	177.1	29.60	254.1	5/21/2009	1.00	509.7	7.10	518.2	5.30	315.7
11/21/2004	1.49	100.1	5.90	300.3	27.20	242.6	5/22/2009	1.00	447.4	9.00	539.0	5.40	562.1
11/22/2004	1.81	269.5	5.00	174.8	24.90	323.4	5/23/2009	1.00	689.2	8.30	776.9	5.70	916.3
11/23/2004	2.88	115.5	4.50	165.6	22.80	231.0	5/24/2009	1.00	914.8	7.70	810.0	5.90	696.9
11/24/2004	3.71	136.3	4.20	170.9	20.90	269.5	5/25/2009	1.00	828.5	7.10	914.0	6.10	631.4
11/25/2004	3.62	298.0	4.00	177.1	19.20	284.9	5/26/2009	1.00	875.5	6.30	856.2	6.30	781.6
11/26/2004	3.16	251.8	3.80	246.4	17.70	300.3	5/27/2009	1.00	883.2	5.60	850.1	6.40	777.7
11/27/2004	2.65	264.9	3.70	354.2	16.30	92.4	5/28/2009	1.00	930.2	5.20	851.6	6.40	770.0
11/28/2004	2.21	351.1	3.60	7.7	15.20	169.4	5/29/2009	1.00	951.0	4.90	947.1	6.40	704.6
11/29/2004	1.90	66.2	3.60	374.2	14.10	231.0	5/30/2009	1.00	746.9	4.70	1001.0	6.40	877.8
11/30/2004	1.68	335.7	3.70	375.8	13.20	377.3	5/31/2009	1.00	767.7	4.60	982.5	6.30	659.1
12/1/2004	1.53	160.9	3.80	238.7	12.40	127.1	6/1/2009	1.00	685.3	4.50	941.7	6.30	847.0
12/2/2004	1.42	149.4	4.00	169.4	11.70	258.0	6/2/2009	1.00	720.0	4.40	990.2	6.20	981.8
12/3/2004	1.35	32.3	4.10	242.6	11.10	308.0	6/3/2009	1.00	1141.1	4.40	1059.5	6.20	847.0
12/4/2004	1.75	198.7	26.10	177.1	10.90	308.0	6/4/2009	1.00	999.5	4.40	971.0	6.10	773.9
12/5/2004	3.47	246.4	35.30	94.7	11.80	15.4	6/5/2009	1.00	927.1	4.30	877.8	6.10	693.0
12/6/2004	5.07	66.2	21.60	123.2	13.30	115.5	6/6/2009	1.00	1059.5	4.30	943.3	6.00	762.3
12/7/2004	4.80	98.6	14.70	118.6	14.50	223.3	6/7/2009	1.00	1097.3	4.30	1014.1	6.00	623.7
12/8/2004	3.93	47.0	10.50	224.8	14.90	238.7	6/8/2009	1.00	654.5	4.30	763.8	5.90	1062.6
12/9/2004	3.08	154.0	7.70	247.2	14.80	265.7	6/9/2009	1.00	736.9	4.30	1067.2	5.90	812.4
12/10/2004	2.46	250.3	6.00	331.1	14.30	238.7	6/10/2009	1.00	963.3	4.30	1090.3	5.80	789.3
12/11/2004	2.05	170.9	5.00	277.2	13.70	246.4	6/11/2009	1.00	1115.0	4.30	945.6	5.80	870.1

12/12/2004	1.78	268.0	4.50	227.2	13.00	238.7	6/12/2009	1.00	1007.2	4.30	965.6	5.80	985.6
12/13/2004	1.59	246.4	4.10	370.4	12.30	392.7	6/13/2009	1.00	832.4	4.20	941.7	5.70	693.0
12/14/2004	1.47	326.5	3.90	498.2	11.70	392.7	6/14/2009	1.00	1023.3	4.20	934.8	5.70	785.4
12/15/2004	1.37	150.9	3.80	325.7	11.10	404.3	6/15/2009	1.00	1211.2	4.20	1028.7	5.70	1062.6
12/16/2004	1.30	344.2	3.60	280.3	10.50	300.3	6/16/2009	1.00	978.7	4.20	944.8	5.60	723.8
12/17/2004	1.25	130.9	3.60	335.0	10.00	242.6	6/17/2009	1.00	1013.3	4.50	851.6	5.60	720.0
12/18/2004	1.21	196.4	3.50	238.7	9.50	231.0	6/18/2009	1.00	702.2	9.40	773.9	5.70	1012.6
12/19/2004	1.17	241.0	3.50	313.4	9.10	354.2	6/19/2009	1.00	297.2	10.60	716.1	5.90	847.0
12/20/2004	1.15	177.9	3.40	227.9	8.70	269.5	6/20/2009	1.00	531.3	8.70	154.0	6.20	704.6
12/21/2004	1.13	244.9	3.40	177.1	8.40	154.0	6/21/2009	1.00	685.3	6.90	442.0	6.40	731.5
12/22/2004	1.11	172.5	3.40	0.0	8.10	177.1	6/22/2009	1.00	770.0	5.70	723.8	6.60	970.2
12/23/2004	1.10	204.1	3.30	161.7	7.80	161.7	6/23/2009	1.00	685.3	5.20	850.9	6.70	646.8
12/24/2004	1.09	70.1	3.30	161.7	7.50	234.9	6/24/2009	1.00	685.3	5.60	408.9	6.70	924.0
12/25/2004	1.08	318.0	3.30	200.2	7.20	227.2	6/25/2009	1.00	708.4	9.10	670.7	6.70	650.7
12/26/2004	1.07	193.3	3.30	231.0	7.00	242.6	6/26/2009	1.08	758.5	24.30	608.3	7.10	669.9
12/27/2004	1.06	244.9	3.30	169.4	6.80	392.7	6/27/2009	2.33	685.3	58.40	479.7	8.60	415.8
12/28/2004	1.05	173.3	3.30	161.7	6.60	254.1	6/28/2009	8.07	177.1	269.00	207.9	23.50	138.6
12/29/2004	1.05	33.1	3.30	60.8	6.50	177.1	6/29/2009	16.79	400.4	492.70	471.2	55.90	408.1
12/30/2004	1.05	208.7	3.30	168.6	6.30	154.0	6/30/2009	21.47	331.1	237.00	429.7	100.20	693.0
12/31/2004	1.08	431.2	3.30	168.6	6.10	165.6	7/1/2009	22.50	499.7	173.60	513.6	134.80	546.7
1/1/2005	1.41	180.2	3.40	150.2	6.00	146.3	7/2/2009	22.52	562.9	148.00	401.2	149.20	608.3
1/2/2005	3.95	177.1	3.70	28.5	5.90	65.5	7/3/2009	14.79	478.2	97.70	535.2	149.80	789.3
1/3/2005	19.09	171.7	38.00	123.2	136.40	38.5	7/4/2009	8.39	480.5	56.00	365.8	142.60	696.9
1/4/2005	29.77	123.2	37.60	315.7	36.90	369.6	7/5/2009	5.14	670.7	442.80	666.1	194.10	365.8
1/5/2005	20.00	130.1	22.70	92.4	17.10	346.5	7/6/2009	3.53	421.2	238.80	406.6	229.50	504.4
1/6/2005	10.78	151.7	17.20	194.8	14.70	238.7	7/7/2009	2.66	566.0	129.50	452.8	223.50	669.9

1/7/2005	6.27	241.8	13.80	138.6	14.40	184.8	7/8/2009	2.17	619.9	69.20	786.2	199.70	708.4
1/8/2005	4.14	244.1	10.30	138.6	14.10	238.7	7/9/2009	2.10	709.9	37.50	736.9	172.20	569.8
1/9/2005	3.01	198.7	7.40	205.6	13.70	319.6	7/10/2009	2.46	712.3	23.60	0.0	145.60	970.2
1/10/2005	2.37	185.6	5.80	195.6	13.10	385.0	7/11/2009	2.81	654.5	17.40	619.9	122.20	735.4
1/11/2005	1.98	358.8	4.80	145.5	12.50	300.3	7/12/2009	2.82	685.3	14.40	267.2	102.80	662.2
1/12/2005	1.72	331.1	4.30	157.9	11.80	281.1	7/13/2009	2.65	754.6	21.10	523.6	87.50	315.7
1/13/2005	1.55	228.7	4.00	275.7	11.20	385.0	7/14/2009	4.64	712.3	39.40	628.3	76.40	754.6
1/14/2005	1.43	161.7	3.80	306.5	10.60	415.8	7/15/2009	10.00	712.3	54.10	742.3	69.70	646.8
1/15/2005	1.34	349.6	3.70	292.6	10.10	223.3	7/16/2009	10.14	522.1	46.10	546.7	65.90	639.1
1/16/2005	1.28	202.5	3.60	217.1	9.60	242.6	7/17/2009	7.18	523.6	29.70	587.5	62.60	662.2
1/17/2005	1.23	227.9	3.50	384.2	9.20	315.7	7/18/2009	4.73	525.1	19.40	578.3	58.20	639.1
1/18/2005	1.19	285.7	3.50	384.2	8.80	335.0	7/19/2009	3.35	527.5	39.90	655.3	53.90	874.0
1/19/2005	1.17	249.5	3.40	335.7	8.40	315.7	7/20/2009	2.57	543.6	29.00	701.5	50.60	423.5
1/20/2005	1.20	63.1	3.80	138.6	8.10	323.4	7/21/2009	2.10	535.9	20.20	670.7	47.70	589.1
1/21/2005	1.33	73.2	5.80	92.4	7.90	177.1	7/22/2009	1.80	551.3	19.30	495.9	44.40	729.2
1/22/2005	1.55	144.0	8.60	146.3	7.80	215.6	7/23/2009	1.62	512.1	22.20	555.2	41.30	284.9
1/23/2005	1.74	164.8	9.10	115.5	7.80	231.0	7/24/2009	1.50	505.1	25.30	582.1	38.70	681.5
1/24/2005	1.79	160.2	7.60	165.6	7.90	200.2	7/25/2009	1.43	642.2	28.30	643.0	37.00	735.4
1/25/2005	1.83	228.7	5.90	161.7	8.00	27.0	7/26/2009	1.37	697.6	26.30	756.9	35.70	993.3
1/26/2005	3.76	273.4	6.20	142.5	109.40	388.9	7/27/2009	1.32	771.5	20.50	736.1	34.50	1021.8
1/27/2005	8.52	1509.2	10.10	107.0	48.40	396.6	7/28/2009	1.28	680.7	15.00	471.2	33.00	604.5
1/28/2005	8.79	92.4	13.20	165.6	17.70	288.8	7/29/2009	1.30	549.8	11.90	408.1	31.10	335.0
1/29/2005	6.68	219.5	12.20	191.7	11.10	292.6	7/30/2009	1.96	554.4	119.40	765.4	34.70	500.5
1/30/2005	4.59	227.9	8.90	212.5	9.90	277.2	7/31/2009	4.39	554.4	213.40	685.3	290.90	566.0
1/31/2005	3.29	211.8	6.30	245.6	9.60	238.7	8/1/2009	5.74	700.7	391.30	531.3	166.50	523.6
2/1/2005	2.53	198.7	5.00	194.8	9.30	188.7	8/2/2009	5.13	701.5	207.80	401.2	138.50	504.4

2/2/2005	2.08	323.4	4.50	351.9	9.00	273.4	8/3/2009	4.01	685.3	88.50	507.4	148.70	693.0
2/3/2005	1.88	286.4	5.90	260.3	8.70	115.5	8/4/2009	3.08	608.3	45.70	529.8	144.90	689.2
2/4/2005	3.30	46.2	24.50	107.8	8.80	154.0	8/5/2009	2.48	555.9	30.50	572.1	129.00	762.3
2/5/2005	9.19	26.2	42.00	150.2	9.80	392.7	8/6/2009	2.10	552.1	22.40	654.5	111.00	920.2
2/6/2005	11.26	144.0	35.90	131.7	11.90	146.3	8/7/2009	1.85	557.5	18.30	576.7	95.00	770.0
2/7/2005	8.61	127.8	33.30	194.8	14.30	207.9	8/8/2009	1.67	532.1	19.30	547.5	81.80	537.5
2/8/2005	5.69	315.7	25.50	147.8	16.30	346.5	8/9/2009	1.53	474.3	21.80	253.3	71.50	793.1
2/9/2005	3.90	159.4	16.80	215.6	17.50	238.7	8/10/2009	1.43	469.7	24.00	439.7	63.60	569.8
2/10/2005	3.00	38.5	29.70	207.1	18.80	92.4	8/11/2009	1.35	574.4	19.30	458.9	80.60	377.3
2/11/2005	5.94	186.3	386.10	269.5	215.10	7.7	8/12/2009	1.29	418.9	14.20	305.7	63.20	519.8
2/12/2005	13.92	11.6	155.50	115.5	112.70	58.9	8/13/2009	1.24	539.0	11.40	368.8	52.10	446.6
2/13/2005	12.82	266.4	52.60	246.4	91.70	100.1	8/14/2009	1.23	613.7	10.50	555.2	46.00	527.5
2/14/2005	8.14	224.8	25.80	241.8	85.80	223.3	8/15/2009	1.50	535.2	10.60	636.0	41.30	770.0
2/15/2005	5.10	314.2	15.60	187.1	77.30	107.8	8/16/2009	2.45	666.1	10.50	676.8	37.40	639.1
2/16/2005	3.51	54.7	10.40	166.3	67.50	369.6	8/17/2009	3.37	613.7	10.10	566.7	34.10	708.4
2/17/2005	2.65	154.0	7.60	131.7	58.60	300.3	8/18/2009	3.43	523.6	10.80	453.5	31.10	616.0
2/18/2005	2.15	184.8	6.00	215.6	51.00	200.2	8/19/2009	3.07	606.0	15.40	576.7	28.60	377.3
2/19/2005	1.84	291.8	5.20	292.6	44.60	284.9	8/20/2009	2.61	537.5	24.20	231.8	27.00	385.0
2/20/2005	1.63	287.2	4.60	348.8	39.20	338.8	8/21/2009	2.19	323.4	26.60	400.4	26.60	377.3
2/21/2005	1.48	275.7	4.30	291.1	34.70	431.2	8/22/2009	1.89	469.7	40.80	623.7	97.10	361.9
2/22/2005	1.38	371.1	4.00	271.0	30.90	169.4	8/23/2009	1.67	161.7	65.20	492.8	49.00	458.2
2/23/2005	1.31	312.6	3.90	368.1	27.70	315.7	8/24/2009	1.52	200.2	84.30	448.1	35.70	365.8
2/24/2005	1.25	295.7	3.70	209.4	24.90	431.2	8/25/2009	1.41	542.1	72.20	551.3	38.70	292.6
2/25/2005	1.21	208.7	3.70	346.5	22.60	388.9	8/26/2009	1.33	554.4	95.00	822.4	75.70	816.2
2/26/2005	1.18	276.4	3.60	281.1	20.60	377.3	8/27/2009	1.27	545.9	125.00	547.5	71.10	700.7
2/27/2005	1.15	298.0	3.50	258.7	18.80	385.0	8/28/2009	1.22	479.7	110.20	550.6	66.60	770.0

2/28/2005	1.13	302.6	3.50	349.6	17.30	319.6	8/29/2009	1.19	532.1	77.30	478.2	69.60	616.0
3/1/2005	1.11	213.3	3.40	269.5	16.00	350.4	8/30/2009	1.16	532.1	50.20	585.2	71.50	639.1
3/2/2005	1.10	238.7	3.40	297.2	14.80	246.4	8/31/2009	1.14	569.8	116.50	514.4	93.20	539.0
3/3/2005	1.09	279.5	3.40	318.8	13.80	462.0	9/1/2009	1.17	559.0	99.90	197.9	90.30	207.9
3/4/2005	1.08	371.1	3.40	319.6	12.90	300.3	9/2/2009	1.51	327.3	71.60	403.5	85.00	400.4
3/5/2005	1.08	239.5	3.30	319.6	12.10	415.8	9/3/2009	4.53	240.2	43.30	177.9	241.30	38.5
3/6/2005	1.11	246.4	3.30	315.7	11.40	404.3	9/4/2009	8.61	526.7	26.60	338.0	95.20	161.7
3/7/2005	1.14	338.8	3.30	338.8	10.80	269.5	9/5/2009	8.27	481.3	202.30	408.9	228.40	377.3
3/8/2005	1.18	313.4	3.30	369.6	10.20	442.8	9/6/2009	6.01	540.5	223.30	338.0	160.90	485.1
3/9/2005	1.21	505.9	3.30	463.5	9.70	438.9	9/7/2009	4.18	536.7	147.10	365.0	120.60	554.4
3/10/2005	1.23	447.4	3.30	475.1	9.20	554.4	9/8/2009	3.06	546.7	68.50	199.4	117.90	404.3
3/11/2005	1.22	468.2	3.30	381.2	8.80	354.2	9/9/2009	2.41	554.4	30.60	656.8	112.20	473.6
3/12/2005	1.19	334.2	3.30	392.7	8.40	438.9	9/10/2009	2.01	560.6	17.40	467.4	100.40	462.0
3/13/2005	1.16	539.8	3.30	417.3	8.10	450.5	9/11/2009	1.75	485.1	13.70	325.7	87.10	608.3
3/14/2005	1.14	244.1	7.80	288.8	7.90	462.0	9/12/2009	1.57	477.4	25.40	381.2	75.60	623.7
3/15/2005	1.11	468.2	9.40	328.0	7.80	354.2	9/13/2009	1.44	527.5	29.90	381.2	67.00	951.0
3/16/2005	1.10	452.0	5.90	522.8	7.90	323.4	9/14/2009	1.35	519.0	33.80	560.6	61.00	616.0
3/17/2005	1.08	398.1	5.00	457.4	7.90	342.7	9/15/2009	1.29	496.7	34.80	439.7	56.60	631.4
3/18/2005	1.07	332.6	4.40	454.3	7.80	454.3	9/16/2009	1.24	542.9	27.50	648.3	53.10	319.6
3/19/2005	1.06	383.5	4.00	462.8	7.60	477.4	9/17/2009	1.20	503.6	18.90	501.3	54.70	658.4
3/20/2005	1.05	385.0	3.80	415.8	7.40	654.5	9/18/2009	1.17	502.0	342.80	589.1	363.80	473.6
3/21/2005	1.05	457.4	3.60	461.2	7.20	369.6	9/19/2009	1.14	503.6	355.00	488.2	225.20	315.7
3/22/2005	1.04	495.9	3.50	431.2	7.00	531.3	9/20/2009	1.12	550.6	217.20	513.6	153.90	462.0
3/23/2005	1.04	540.5	3.50	446.6	6.80	542.9	9/21/2009	1.11	550.6	90.20	400.4	154.80	515.9
3/24/2005	1.03	539.8	3.40	392.7	6.70	523.6	9/22/2009	1.09	525.1	34.40	624.5	149.30	577.5
3/25/2005	1.03	451.2	3.40	454.3	6.50	539.0	9/23/2009	1.08	535.2	17.30	649.1	132.40	885.5

3/26/2005	1.03	527.5	3.30	515.9	6.30	446.6	9/24/2009	1.07	557.5	11.80	657.6	112.60	346.5
3/27/2005	1.03	392.7	3.30	589.8	6.20	554.4	9/25/2009	1.06	539.8	9.50	559.0	94.80	354.2
3/28/2005	1.02	647.6	3.30	488.2	6.10	608.3	9/26/2009	1.06	582.1	8.40	659.9	80.20	700.7
3/29/2005	1.02	516.7	3.30	539.8	5.90	554.4	9/27/2009	1.05	542.9	7.70	1072.6	68.40	539.0
3/30/2005	1.02	545.2	3.30	421.2	5.80	654.5	9/28/2009	1.05	566.0	7.20	236.4	59.00	492.8
3/31/2005	1.02	582.1	3.30	725.3	5.70	816.2	9/29/2009	1.04	554.4	6.70	592.1	51.30	500.5
4/1/2005	1.02	603.7	3.30	623.7	5.60	716.1	9/30/2009	1.04	566.0	6.40	251.8	45.00	462.0
4/2/2005	1.02	557.5	3.30	539.8	5.50	808.5	10/1/2009	1.04	549.0	6.10	226.4	39.70	96.3
4/3/2005	1.01	542.1	3.30	569.8	5.40	746.9	10/2/2009	1.04	400.4	16.70	17.7	35.70	130.9
4/4/2005	1.01	879.3	3.20	689.2	5.40	623.7	10/3/2009	1.07	38.5	120.30	76.2	40.30	38.5
4/5/2005	1.01	510.5	3.20	492.8	5.30	643.0	10/4/2009	1.10	542.9	713.60	111.7	758.90	38.5
4/6/2005	1.01	562.9	3.20	523.6	5.20	693.0	10/5/2009	1.14	525.9	626.60	188.7	448.50	223.3
4/7/2005	1.01	652.2	3.20	638.3	5.10	643.0	10/6/2009	1.18	369.6	342.80	258.0	316.00	308.0
4/8/2005	1.01	857.0	3.20	561.3	5.10	581.4	10/7/2009	1.20	531.3	131.00	454.3	304.40	454.3
4/9/2005	1.01	702.2	3.20	485.1	5.00	662.2	10/8/2009	1.20	550.6	44.70	412.0	273.00	254.1
4/10/2005	1.01	453.5	3.20	528.2	5.00	539.0	10/9/2009	1.18	559.0	20.30	432.7	226.60	412.0
4/11/2005	1.01	498.2	3.20	549.8	4.90	700.7	10/10/2009	1.15	482.8	14.20	377.3	190.20	346.5
4/12/2005	1.01	519.0	3.20	717.6	4.90	770.0	10/11/2009	1.13	367.3	453.40	288.8	981.60	88.6
4/13/2005	1.01	631.4	3.20	606.8	4.80	554.4	10/12/2009	1.11	311.9	619.40	40.8	1611.00	38.5
4/14/2005	1.01	559.8	3.20	812.4	4.80	758.5	10/13/2009	1.09	481.3	494.30	221.8	664.20	115.5
4/15/2005	1.01	687.6	3.20	700.7	4.80	789.3	10/14/2009	1.08	525.9	301.70	318.0	444.30	361.9
4/16/2005	1.01	588.3	3.20	770.8	4.70	820.1	10/15/2009	1.06	334.2	161.10	310.3	379.70	308.0
4/17/2005	1.01	770.0	3.20	648.3	4.70	400.4	10/16/2009	1.06	407.3	79.20	527.5	323.70	739.2
4/18/2005	1.01	947.9	3.20	764.6	4.70	700.7	10/17/2009	1.05	415.8	38.80	221.8	267.20	612.2
4/19/2005	1.01	816.2	3.20	656.0	4.60	731.5	10/18/2009	1.04	458.9	21.10	254.9	216.40	308.0
4/20/2005	1.01	700.7	3.20	763.1	4.60	704.6	10/19/2009	1.04	193.3	13.60	493.6	174.50	304.2

4/21/2005	1.01	673.8	3.20	723.8	4.60	770.0	10/20/2009	1.03	541.3	10.30	243.3	141.60	323.4
4/22/2005	1.01	632.9	3.20	569.8	4.60	658.4	10/21/2009	1.03	537.5	8.80	426.6	116.10	331.1
4/23/2005	1.01	688.4	3.20	554.4	4.50	700.7	10/22/2009	1.03	540.5	8.00	309.5	96.40	211.8
4/24/2005	1.01	712.3	3.20	658.4	4.50	400.4	10/23/2009	1.02	454.3	7.40	250.3	81.00	304.2
4/25/2005	1.02	519.0	3.20	716.1	4.50	777.7	10/24/2009	1.02	432.7	6.70	211.8	68.90	234.9
4/26/2005	1.02	602.9	3.20	637.6	4.50	512.1	10/25/2009	1.02	525.9	6.20	231.8	59.20	388.9
4/27/2005	1.03	716.9	3.20	700.7	4.50	704.6	10/26/2009	1.02	511.3	5.80	260.3	51.40	119.4
4/28/2005	1.04	813.1	3.20	864.7	4.40	646.8	10/27/2009	1.02	415.8	5.60	513.6	44.90	281.1
4/29/2005	1.04	735.4	3.20	736.9	4.40	700.7	10/28/2009	1.02	412.7	5.40	498.2	39.60	616.0
4/30/2005	1.05	1114.2	3.20	704.6	4.40	816.2	10/29/2009	1.01	369.6	5.20	121.7	35.20	643.0
5/1/2005	1.05	747.7	3.20	779.2	4.40	770.0	10/30/2009	1.01	236.4	5.10	352.7	31.40	323.4
5/2/2005	1.06	934.8	3.20	757.7	4.40	931.7	10/31/2009	1.01	275.7	5.00	394.2	28.30	412.0
5/3/2005	1.05	432.0	3.20	689.9	4.40	700.7	11/1/2009	1.01	343.4	4.90	328.0	25.60	308.0
5/4/2005	1.05	580.6	3.20	685.3	4.40	823.9	11/2/2009	1.01	448.9	4.80	423.5	23.30	277.2
5/5/2005	1.05	792.3	3.20	793.1	4.40	585.2	11/3/2009	1.01	386.5	4.80	341.9	21.30	423.5
5/6/2005	1.04	832.4	3.20	177.1	4.30	754.6	11/4/2009	1.01	249.5	4.70	234.9	19.60	161.7
5/7/2005	1.04	590.6	3.20	773.9	4.30	631.4	11/5/2009	1.01	450.5	4.70	234.9	18.10	361.9
5/8/2005	1.03	822.4	3.20	672.2	4.30	885.5	11/6/2009	1.01	255.6	4.70	271.0	16.80	146.3
5/9/2005	1.03	671.4	3.20	646.8	4.30	585.2	11/7/2009	1.01	290.3	4.60	327.3	15.70	358.1
5/10/2005	1.03	979.4	3.20	820.8	4.30	604.5	11/8/2009	1.01	284.9	4.60	281.1	14.70	358.1
5/11/2005	1.02	989.5	3.20	562.1	4.30	951.0	11/9/2009	1.01	292.6	4.60	429.7	13.80	165.6
5/12/2005	1.02	841.6	3.20	755.4	4.30	619.9	11/10/2009	1.01	262.6	4.50	229.5	13.00	323.4
5/13/2005	1.02	775.4	3.20	639.1	4.30	939.4	11/11/2009	1.01	458.9	4.50	432.7	12.30	265.7
5/14/2005	1.02	837.8	3.20	754.6	4.30	758.5	11/12/2009	1.01	420.4	4.50	247.9	11.70	296.5
5/15/2005	1.02	830.1	3.20	793.1	4.30	843.2	11/13/2009	1.01	393.5	4.50	201.7	11.10	277.2
5/16/2005	1.01	966.4	3.20	798.5	4.30	885.5	11/14/2009	1.01	380.4	4.50	226.4	10.60	188.7

5/17/2005	1.01	767.7	3.20	721.5	4.30	662.2	11/15/2009	1.01	300.3	4.40	231.0	10.20	427.4
5/18/2005	1.01	760.0	3.20	782.3	4.30	631.4	11/16/2009	1.01	323.4	4.40	231.0	9.80	200.2
5/19/2005	1.01	703.8	3.20	804.7	4.30	931.7	11/17/2009	1.00	311.9	4.40	540.5	9.40	304.2
5/20/2005	1.01	900.9	3.20	816.2	4.30	943.3	11/18/2009	1.00	324.9	4.40	142.5	9.10	215.6
5/21/2005	1.01	979.4	3.20	777.7	4.30	924.0	11/19/2009	1.00	351.1	4.40	193.3	8.80	142.5
5/22/2005	1.01	941.7	3.20	974.1	4.30	870.1	11/20/2009	1.00	315.7	4.40	303.4	8.50	423.5
5/23/2005	1.01	749.2	3.20	793.1	4.30	677.6	11/21/2009	1.00	315.7	4.40	415.8	8.30	288.8
5/24/2005	1.01	800.8	3.20	744.6	4.30	708.4	11/22/2009	1.00	403.5	4.40	224.1	8.00	277.2
5/25/2005	1.01	839.3	3.20	485.1	4.20	662.2	11/23/2009	1.00	225.6	4.40	231.8	7.80	215.6
5/26/2005	1.01	450.5	20.90	731.5	4.40	754.6	11/24/2009	1.00	369.6	4.40	282.6	7.60	231.0
5/27/2005	1.03	365.8	33.10	377.3	5.30	820.1	11/25/2009	1.00	431.2	4.30	402.7	7.40	308.0
5/28/2005	1.10	440.4	23.40	492.8	6.80	238.7	11/26/2009	1.00	323.4	4.30	298.8	7.30	200.2
5/29/2005	1.39	366.5	16.30	783.9	8.20	558.3	11/27/2009	1.00	400.4	4.40	239.5	7.10	258.0
5/30/2005	1.81	820.1	11.30	754.6	9.20	823.9	11/28/2009	1.01	325.7	6.20	301.1	7.00	250.3
5/31/2005	2.11	874.0	8.00	831.6	9.60	793.1	11/29/2009	1.01	331.1	13.00	188.7	7.10	292.6
6/1/2005	2.07	743.1	6.00	930.9	9.70	885.5	11/30/2009	1.03	297.2	12.90	12.3	7.40	100.1
6/2/2005	1.91	839.3	5.00	600.6	9.60	839.3	12/1/2009	1.06	324.9	11.50	91.6	7.80	315.7
6/3/2005	1.79	743.8	4.40	639.1	9.30	739.2	12/2/2009	1.10	374.2	8.90	140.9	8.20	30.8
6/4/2005	1.67	806.2	4.10	646.8	9.00	746.9	12/3/2009	1.14	311.9	7.00	154.0	8.40	161.7
6/5/2005	1.55	744.6	3.90	781.6	8.70	696.9	12/4/2009	1.17	162.5	6.00	364.2	8.40	200.2
6/6/2005	1.44	891.7	3.70	843.2	8.40	770.0	12/5/2009	1.18	246.4	5.60	170.9	8.40	304.2
6/7/2005	1.36	974.8	3.60	908.6	8.10	916.3	12/6/2009	1.17	317.2	5.30	146.3	8.20	157.9
6/8/2005	1.30	805.4	3.50	940.2	7.80	939.4	12/7/2009	1.14	274.1	5.20	174.8	8.10	188.7
6/9/2005	1.24	974.1	3.50	951.7	7.60	1016.4	12/8/2009	1.12	251.0	5.00	131.7	8.00	196.4
6/10/2005	1.20	551.3	3.40	939.4	7.30	870.1	12/9/2009	1.10	295.7	4.90	213.3	7.80	200.2
6/11/2005	1.17	821.6	3.40	839.3	7.10	669.9	12/10/2009	1.08	169.4	4.70	145.5	7.70	123.2

6/12/2005	1.15	684.5	3.40	773.1	6.90	793.1	12/11/2009	1.07	161.7	4.60	99.3	7.50	207.9
6/13/2005	1.13	831.6	3.30	1028.0	6.70	847.0	12/12/2009	1.06	172.5	4.60	161.7	7.40	223.3
6/14/2005	1.11	918.6	3.30	916.3	6.50	931.7	12/13/2009	1.05	145.5	4.50	206.4	7.20	261.8
6/15/2005	1.10	902.4	3.30	934.0	6.40	754.6	12/14/2009	1.04	232.5	4.50	177.1	7.10	385.0
6/16/2005	1.09	972.5	3.30	945.6	6.20	592.9	12/15/2009	1.04	242.6	4.50	495.1	7.00	165.6
6/17/2005	1.08	1033.3	3.30	739.2	6.10	847.0	12/16/2009	1.03	243.3	4.40	268.0	6.90	219.5
6/18/2005	1.07	944.0	3.30	739.2	6.00	639.1	12/17/2009	1.03	232.5	4.40	489.0	6.80	323.4
6/19/2005	1.06	708.4	3.30	797.0	5.80	1001.0	12/18/2009	1.02	315.7	4.40	175.6	6.70	319.6
6/20/2005	1.05	661.4	3.30	879.3	5.70	658.4	12/19/2009	1.02	320.3	4.40	246.4	6.60	342.7
6/21/2005	1.05	975.6	3.30	831.6	5.60	893.2	12/20/2009	1.02	269.5	4.40	201.0	6.50	161.7
6/22/2005	1.04	918.6	3.30	797.0	5.50	816.2	12/21/2009	1.02	198.7	4.40	198.7	6.40	204.1
6/23/2005	1.04	850.9	3.60	785.4	5.40	943.3	12/22/2009	1.02	345.0	4.30	294.1	6.30	192.5
6/24/2005	1.04	744.6	5.40	777.7	5.40	935.6	12/23/2009	1.01	151.7	4.30	57.0	6.30	273.4
6/25/2005	1.03	781.6	6.10	770.8	5.40	870.1	12/24/2009	1.01	55.4	4.30	114.7	6.20	192.5
6/26/2005	1.03	891.7	5.10	847.0	5.50	847.0	12/25/2009	1.01	264.1	4.30	128.6	6.10	104.0
6/27/2005	1.03	993.3	4.40	1002.5	5.50	1024.1	12/26/2009	1.01	281.1	4.30	117.0	6.10	184.8
6/28/2005	1.03	962.5	4.00	1059.5	5.60	1078.0	12/27/2009	1.01	226.4	4.30	156.3	6.00	377.3
6/29/2005	1.02	1024.9	3.80	1036.4	5.50	1051.1	12/28/2009	1.01	323.4	5.00	194.0	6.00	173.3
6/30/2005	1.02	870.1	3.90	989.5	5.50	1031.8	12/29/2009	1.01	323.4	7.40	198.7	6.00	231.0
7/1/2005	1.02	615.2	4.10	985.6	5.50	1078.0	12/30/2009	1.01	251.0	7.50	163.2	6.10	242.6
7/2/2005	1.02	763.1	4.10	785.4	5.40	577.5	12/31/2009	1.01	323.4	6.50	286.4	6.20	254.1
7/3/2005	1.02	819.3	4.10	966.4	5.40	808.5	1/1/2010	1.01	311.9	5.70	361.9	6.30	234.9
7/4/2005	1.02	739.2	4.00	743.1	5.40	977.9	1/2/2010	1.01	315.7	5.20	246.4	6.40	354.2
7/5/2005	1.02	798.5	4.10	856.2	5.40	900.9	1/3/2010	1.01	317.2	4.90	383.5	6.40	250.3
7/6/2005	1.01	938.6	10.30	784.6	5.40	627.6	1/4/2010	1.01	297.2	4.70	364.2	6.40	331.1
7/7/2005	1.01	850.9	108.60	777.7	8.30	831.6	1/5/2010	1.01	240.2	4.60	350.4	6.30	223.3

7/8/2005	1.01	766.9	61.20	838.5	15.20	862.4	1/6/2010	1.01	267.2	4.50	199.4	6.30	304.2
7/9/2005	1.01	900.9	25.10	800.8	21.40	962.5	1/7/2010	1.00	215.6	4.40	215.6	6.20	442.8
7/10/2005	1.01	924.0	14.90	1085.7	24.10	1016.4	1/8/2010	1.00	219.5	4.40	435.8	6.20	277.2
7/11/2005	1.01	910.9	9.90	711.5	23.30	816.2	1/9/2010	1.00	242.6	4.40	292.6	6.10	246.4
7/12/2005	1.01	768.5	6.90	709.2	21.40	662.2	1/10/2010	1.00	161.7	4.30	519.8	6.10	331.1
7/13/2005	1.01	894.0	5.40	649.9	19.60	700.7	1/11/2010	1.00	201.0	4.30	371.1	6.00	227.2
7/14/2005	1.01	723.8	4.70	539.8	18.00	1131.9	1/12/2010	1.00	383.5	4.30	361.1	6.00	177.1
7/15/2005	1.01	732.3	5.20	708.4	16.60	885.5	1/13/2010	1.00	434.3	4.30	193.3	5.90	308.0
7/16/2005	1.01	784.6	7.60	800.8	15.50	746.9	1/14/2010	1.00	341.9	4.30	382.7	5.90	258.0
7/17/2005	1.01	662.2	7.40	964.8	14.60	839.3	1/15/2010	1.00	198.7	4.30	440.4	5.80	400.4
7/18/2005	1.01	708.4	7.60	605.2	13.90	1208.9	1/16/2010	1.00	207.1	4.30	231.8	5.80	346.5
7/19/2005	1.01	477.4	8.00	631.4	13.40	631.4	1/17/2010	1.01	183.3	4.30	277.2	5.80	319.6
7/20/2005	1.01	562.1	11.80	658.4	13.00	600.6	1/18/2010	1.01	411.2	4.30	266.4	5.70	192.5
7/21/2005	1.01	841.6	11.60	505.1	12.80	731.5	1/19/2010	1.02	346.5	4.30	244.9	5.70	308.0
7/22/2005	1.01	841.6	73.10	400.4	29.10	358.1	1/20/2010	1.10	217.9	4.30	10.8	5.70	288.8
7/23/2005	1.01	841.6	42.90	392.7	32.20	627.6	1/21/2010	3.78	185.6	10.60	185.6	6.60	412.0
7/24/2005	98.56	716.1	67.70	332.4	30.10	423.5	1/22/2010	52.45	160.2	658.10	160.2	588.20	264.1
7/25/2005	118.19	644.5	52.80	582.1	31.40	989.5	1/23/2010	69.01	144.8	592.10	144.8	332.10	200.2
7/26/2005	47.22	485.1	33.50	654.5	32.80	654.5	1/24/2010	33.72	170.2	333.20	317.2	225.90	419.7
7/27/2005	20.95	733.8	25.20	766.2	32.90	552.1	1/25/2010	14.35	117.0	148.60	293.4	236.60	600.6
7/28/2005	10.65	497.4	17.70	321.1	31.90	438.9	1/26/2010	7.94	130.1	68.70	143.2	226.80	200.2
7/29/2005	13.82	346.5	14.50	255.6	30.30	392.7	1/27/2010	11.13	114.0	42.40	14.6	197.50	127.1
7/30/2005	85.93	437.4	42.30	236.4	29.30	388.9	1/28/2010	20.48	73.2	33.20	342.7	166.10	100.1
7/31/2005	89.97	455.1	74.80	478.2	30.60	962.5	1/29/2010	15.92	268.0	29.00	149.4	139.40	173.3
8/1/2005	38.13	530.5	76.80	492.8	34.60	308.0	1/30/2010	9.25	140.9	28.40	149.4	118.00	188.7
8/2/2005	17.82	408.1	54.90	387.3	39.20	554.4	1/31/2010	5.62	51.6	28.10	111.7	101.30	281.1

8/3/2005	10.79	490.5	33.70	408.1	41.90	446.6	2/1/2010	3.86	254.9	25.60	162.5	88.20	154.0
8/4/2005	7.33	400.4	21.40	547.5	41.80	581.4	2/2/2010	3.79	148.6	26.10	127.1	77.80	346.5
8/5/2005	5.35	467.4	16.50	485.1	39.90	585.2	2/3/2010	6.78	134.8	39.20	41.6	69.80	119.4
8/6/2005	4.16	496.7	15.30	523.6	37.20	650.7	2/4/2010	9.44	154.0	33.50	140.1	64.00	150.2
8/7/2005	3.96	596.8	15.80	295.7	36.00	685.3	2/5/2010	8.21	114.7	23.40	261.8	59.20	215.6
8/8/2005	7.38	619.9	419.20	663.0	130.20	677.6	2/6/2010	5.84	267.2	18.30	305.7	54.30	288.8
8/9/2005	11.50	546.7	128.10	270.3	160.80	412.0	2/7/2010	4.11	226.4	16.10	208.7	49.40	242.6
8/10/2005	10.20	409.6	41.40	434.3	132.70	558.3	2/8/2010	3.05	210.2	14.90	206.4	44.90	265.7
8/11/2005	7.11	668.4	21.70	468.9	105.50	546.7	2/9/2010	2.53	258.7	14.10	198.7	41.00	350.4
8/12/2005	5.44	485.1	14.60	770.8	87.20	438.9	2/10/2010	4.19	171.7	14.50	33.9	37.50	154.0
8/13/2005	5.24	410.4	10.80	785.4	73.80	585.2	2/11/2010	9.40	197.1	16.50	199.4	34.60	134.8
8/14/2005	7.41	411.2	16.30	592.9	64.20	477.4	2/12/2010	9.89	192.5	15.70	300.3	32.30	496.7
8/15/2005	10.77	492.0	386.50	408.9	157.00	600.6	2/13/2010	7.12	204.1	14.00	315.7	30.30	308.0
8/16/2005	9.62	673.8	269.70	381.2	189.40	627.6	2/14/2010	4.75	272.6	13.00	308.8	28.50	192.5
8/17/2005	6.83	418.1	125.20	353.4	169.80	589.1	2/15/2010	3.38	300.3	12.30	371.1	26.80	296.5
8/18/2005	5.80	450.5	59.40	600.6	149.90	646.8	2/16/2010	2.60	246.4	11.80	314.2	25.20	596.8
8/19/2005	6.62	362.7	39.80	468.2	132.00	596.8	2/17/2010	2.12	315.7	11.30	366.5	23.80	254.1
8/20/2005	6.43	756.1	47.60	529.0	115.50	658.4	2/18/2010	1.82	274.1	10.80	290.3	22.50	361.9
8/21/2005	5.16	618.3	152.70	485.1	109.20	708.4	2/19/2010	1.63	200.2	10.30	244.9	21.30	107.8
8/22/2005	3.90	656.8	105.40	271.0	111.90	523.6	2/20/2010	1.49	256.4	9.90	394.2	20.20	335.0
8/23/2005	3.07	515.1	60.40	606.8	112.10	900.9	2/21/2010	1.39	202.5	9.50	203.3	19.20	242.6
8/24/2005	2.60	406.6	39.70	385.0	105.00	323.4	2/22/2010	1.31	152.5	9.10	170.2	18.30	115.5
8/25/2005	2.54	512.8	41.90	530.5	94.50	300.3	2/23/2010	1.26	311.1	8.80	507.4	17.40	348.8
8/26/2005	2.81	469.7	54.50	408.1	85.40	646.8	2/24/2010	1.22	299.5	8.50	415.0	16.70	542.9
8/27/2005	2.93	608.3	52.30	700.7	79.00	246.4	2/25/2010	1.18	380.4	8.20	412.0	15.90	527.5
8/28/2005	2.71	703.0	38.30	549.0	73.90	770.0	2/26/2010	1.16	341.1	7.90	407.3	15.30	365.8

8/29/2005	2.36	713.0	27.50	481.3	68.50	654.5	2/27/2010	1.13	391.9	7.70	115.5	14.60	284.9
8/30/2005	2.07	720.0	22.00	494.3	62.70	492.8	2/28/2010	1.12	112.4	7.50	38.5	14.10	315.7
8/31/2005	1.85	646.0	19.40	442.0	56.80	662.2	3/1/2010	1.10	177.1	7.30	536.7	13.50	265.7
9/1/2005	1.68	676.8	14.70	663.7	51.40	385.0	3/2/2010	1.09	245.6	7.10	608.3	13.00	350.4
9/2/2005	1.55	504.4	10.10	485.1	46.30	400.4	3/3/2010	1.08	264.1	6.90	508.2	12.60	377.3
9/3/2005	1.45	284.9	7.90	492.8	41.50	569.8	3/4/2010	1.07	192.5	6.70	343.4	12.20	473.6
9/4/2005	1.37	542.9	8.60	486.6	37.30	485.1	3/5/2010	1.06	266.4	6.60	177.1	11.80	127.1
9/5/2005	1.31	544.4	11.10	515.9	33.70	585.2	3/6/2010	1.06	223.3	6.50	491.7	11.40	192.5
9/6/2005	1.26	488.2	13.00	579.0	30.80	646.8	3/7/2010	1.05	165.6	6.30	177.1	11.00	465.9
9/7/2005	1.22	411.2	13.10	574.4	28.60	431.2	3/8/2010	1.05	240.2	6.20	79.3	10.70	400.4
9/8/2005	1.19	332.6	11.30	412.0	26.80	608.3	3/9/2010	1.04	241.8	6.10	200.2	10.40	319.6
9/9/2005	1.16	485.1	8.70	485.1	25.10	616.0	3/10/2010	1.04	267.2	6.00	114.0	10.10	327.3
9/10/2005	1.14	485.1	6.60	375.0	23.30	438.9	3/11/2010	1.04	345.7	5.90	392.7	9.90	454.3
9/11/2005	1.13	355.0	5.30	406.6	21.60	985.6	3/12/2010	1.03	379.6	5.80	448.1	9.60	546.7
9/12/2005	1.11	584.4	4.50	545.2	20.00	616.0	3/13/2010	1.03	532.1	5.70	424.3	9.40	385.0
9/13/2005	1.10	674.5	4.10	566.0	18.50	716.1	3/14/2010	1.03	569.8	5.60	458.2	9.20	658.4
9/14/2005	1.09	621.4	3.90	526.7	17.10	639.1	3/15/2010	1.03	548.2	5.60	674.5	8.90	331.1
9/15/2005	1.08	576.0	3.70	605.2	15.80	569.8	3/16/2010	1.02	565.2	5.50	590.6	8.80	569.8
9/16/2005	1.07	689.9	3.60	669.9	14.70	770.0	3/17/2010	1.02	542.1	5.40	622.9	8.60	735.4
9/17/2005	1.07	807.7	3.50	669.9	13.70	700.7	3/18/2010	1.02	614.5	5.40	564.4	8.40	542.9
9/18/2005	1.06	669.9	3.50	480.5	12.90	781.6	3/19/2010	1.02	414.3	5.30	431.2	8.20	354.2
9/19/2005	1.05	696.9	3.40	505.9	12.10	785.4	3/20/2010	1.02	547.5	5.20	431.2	8.10	585.2
9/20/2005	1.05	698.4	3.40	576.0	11.40	581.4	3/21/2010	1.02	481.3	5.20	679.1	7.90	489.0
9/21/2005	1.05	663.0	3.40	619.1	10.80	639.1	3/22/2010	1.04	265.7	5.10	505.9	7.80	473.6
9/22/2005	1.04	471.2	3.40	614.5	10.20	608.3	3/23/2010	1.13	408.1	5.10	305.7	7.70	581.4
9/23/2005	1.04	623.7	3.30	558.3	9.70	693.0	3/24/2010	1.42	287.2	5.10	576.7	7.50	847.0

9/24/2005	1.04	745.4	3.30	562.1	9.20	585.2	3/25/2010	1.84	303.4	5.00	518.2	7.40	631.4
9/25/2005	1.03	612.2	3.30	546.7	8.80	492.8	3/26/2010	2.14	335.0	5.00	555.2	7.30	739.2
9/26/2005	1.03	594.4	3.30	537.5	8.50	623.7	3/27/2010	2.10	500.5	5.00	481.3	7.20	685.3
9/27/2005	1.03	746.9	3.30	566.7	8.10	84.7	3/28/2010	1.94	462.0	5.00	692.2	7.10	546.7
9/28/2005	1.03	614.5	3.30	529.8	7.80	758.5	3/29/2010	1.80	400.4	5.00	705.3	7.00	643.0
9/29/2005	1.03	690.7	3.30	673.8	7.50	616.0	3/30/2010	1.68	258.7	5.00	667.6	7.00	535.2
9/30/2005	1.02	612.9	3.30	491.3	7.30	523.6	3/31/2010	1.55	531.3	5.00	763.1	6.90	650.7
10/1/2005	1.02	458.2	3.30	661.4	7.10	373.5	4/1/2010	1.44	597.5	5.00	709.9	6.80	535.2
10/2/2005	1.02	219.5	3.30	244.1	6.80	123.2	4/2/2010	1.36	422.0	5.00	700.7	6.80	477.4
10/3/2005	1.02	365.0	3.40	496.7	6.70	431.2	4/3/2010	1.30	611.4	5.00	772.3	6.70	650.7
10/4/2005	1.02	467.4	3.60	380.4	6.50	492.8	4/4/2010	1.24	755.4	5.00	207.1	6.70	623.7
10/5/2005	1.02	611.4	4.10	609.8	6.30	585.2	4/5/2010	1.21	760.0	5.00	571.3	6.60	523.6
10/6/2005	1.02	428.9	7.80	840.1	6.30	608.3	4/6/2010	1.17	638.3	4.90	682.2	6.60	596.8
10/7/2005	1.02	489.0	14.00	642.2	6.40	569.8	4/7/2010	1.15	612.9	4.90	595.2	6.50	677.6
10/8/2005	1.02	452.8	16.20	546.7	6.90	639.1	4/8/2010	1.13	562.1	4.90	685.3	6.50	519.8
10/9/2005	1.02	706.1	13.30	525.9	7.50	408.1	4/9/2010	1.11	808.5	4.90	731.5	6.40	654.5
10/10/2005	1.01	685.3	9.10	448.1	8.10	539.0	4/10/2010	1.10	571.3	4.80	549.8	6.40	666.1
10/11/2005	1.01	423.5	6.30	418.1	8.30	592.9	4/11/2010	1.09	328.0	4.80	555.9	6.30	569.8
10/12/2005	1.01	507.4	4.80	457.4	8.40	454.3	4/12/2010	1.08	332.6	4.80	527.5	6.30	874.0
10/13/2005	1.01	525.9	4.10	433.5	8.20	485.1	4/13/2010	1.07	348.0	4.80	564.4	6.30	542.9
10/14/2005	1.01	576.0	3.80	703.8	8.00	465.9	4/14/2010	1.06	324.9	4.70	742.3	6.20	650.7
10/15/2005	1.01	356.5	3.60	465.9	7.80	554.4	4/15/2010	1.06	355.7	4.70	643.0	6.20	627.6
10/16/2005	1.01	492.0	3.50	423.5	7.50	238.7	4/16/2010	1.05	570.6	4.70	696.9	6.20	446.6
10/17/2005	1.01	447.4	3.40	470.5	7.30	492.8	4/17/2010	1.05	346.5	4.70	750.8	6.10	685.3
10/18/2005	1.01	510.5	3.40	427.4	7.10	546.7	4/18/2010	1.04	306.5	4.70	967.9	6.10	608.3
10/19/2005	1.01	467.4	3.40	457.4	6.90	423.5	4/19/2010	1.04	304.9	4.60	299.5	6.10	388.9

10/20/2005	1.01	519.0	3.30	610.6	6.70	469.7	4/20/2010	1.03	328.0	4.60	593.7	6.00	531.3
10/21/2005	1.01	409.6	3.30	453.5	6.50	477.4	4/21/2010	1.03	954.8	4.60	561.3	6.00	458.2
10/22/2005	1.01	482.8	3.30	459.7	6.40	423.5	4/22/2010	1.03	525.1	4.60	573.7	6.00	569.8
10/23/2005	1.01	448.9	3.30	448.1	6.20	280.3	4/23/2010	1.03	251.8	4.60	499.7	6.00	462.0
10/24/2005	1.01	358.8	3.30	422.7	6.10	546.7	4/24/2010	1.02	466.6	4.60	555.2	5.90	685.3
10/25/2005	1.01	515.1	3.30	414.3	5.90	454.3	4/25/2010	1.02	653.0	4.50	617.5	5.90	600.6
10/26/2005	1.01	408.1	3.30	395.8	5.80	446.6	4/26/2010	1.02	666.8	4.50	476.6	5.90	658.4
10/27/2005	1.01	378.1	3.20	369.6	5.70	438.9	4/27/2010	1.02	699.2	4.50	737.7	5.90	770.0
10/28/2005	1.01	381.2	3.20	412.7	5.60	284.9	4/28/2010	1.02	971.7	4.50	703.8	5.80	658.4
10/29/2005	1.01	381.9	3.20	346.5	5.50	323.4	4/29/2010	1.02	808.5	4.50	981.0	5.80	831.6
10/30/2005	1.01	485.1	3.20	400.4	5.40	492.8	4/30/2010	1.02	466.6	4.50	847.8	5.80	754.6
10/31/2005	1.01	401.9	3.20	714.6	5.30	831.6	5/1/2010	1.02	472.8	4.50	665.3	5.80	720.0
11/1/2005	1.01	419.7	3.20	570.6	5.30	646.8	5/2/2010	1.01	740.0	4.50	700.7	5.70	804.7
11/2/2005	1.01	441.2	3.20	448.1	5.20	469.7	5/3/2010	1.01	583.7	4.40	803.9	5.70	600.6
11/3/2005	1.01	557.5	3.20	389.6	5.10	477.4	5/4/2010	1.01	548.2	4.40	951.0	5.70	904.8
11/4/2005	1.01	559.0	3.20	400.4	5.10	531.3	5/5/2010	1.01	876.3	4.40	793.9	5.70	573.7
11/5/2005	1.01	435.1	3.20	315.7	5.00	519.8	5/6/2010	1.01	964.0	4.40	942.5	5.70	1008.7
11/6/2005	1.01	435.1	3.20	375.0	5.00	446.6	5/7/2010	1.01	1020.3	4.40	659.1	5.70	900.9
11/7/2005	1.00	381.2	3.20	227.2	4.90	408.1	5/8/2010	1.01	800.8	4.40	754.6	5.60	924.0
11/8/2005	1.00	348.0	3.20	227.2	4.90	473.6	5/9/2010	1.01	789.3	4.40	858.6	5.60	677.6
11/9/2005	1.00	348.0	3.20	401.9	4.80	377.3	5/10/2010	1.01	827.8	4.40	871.6	5.60	823.9
11/10/2005	1.00	458.2	3.20	409.6	4.80	438.9	5/11/2010	1.01	1074.2	4.40	777.7	5.60	943.3
11/11/2005	1.00	472.8	3.20	470.5	4.70	431.2	5/12/2010	1.01	783.9	4.40	939.4	5.60	831.6
11/12/2005	1.00	381.2	3.20	411.2	4.70	415.8	5/13/2010	1.01	759.2	4.40	855.5	5.60	693.0
11/13/2005	1.00	237.9	3.20	447.4	4.70	338.8	5/14/2010	1.01	800.8	4.40	775.4	5.50	766.2
11/14/2005	1.00	386.5	3.20	368.8	4.60	396.6	5/15/2010	1.01	856.2	4.30	787.7	5.50	723.8

11/15/2005	1.00	345.0	3.20	311.9	4.60	331.1	5/16/2010	1.01	894.7	4.30	939.4	5.50	893.2
11/16/2005	1.00	300.3	3.20	551.3	4.60	531.3	5/17/2010	1.01	916.3	4.30	839.3	5.50	669.9
11/17/2005	1.00	314.9	3.20	452.8	4.60	373.5	5/18/2010	1.01	967.9	4.30	851.6	5.50	723.8
11/18/2005	1.00	358.1	3.20	569.8	4.50	377.3	5/19/2010	1.01	786.2	4.30	820.1	5.50	943.3
11/19/2005	1.00	368.1	3.20	485.1	4.50	446.6	5/20/2010	1.01	770.8	4.30	982.5	5.50	943.3
11/20/2005	1.00	395.8	3.20	468.9	4.50	492.8	5/21/2010	1.01	821.6	4.30	861.6	5.50	881.7
11/21/2005	1.00	304.2	3.20	503.6	4.50	346.5	5/22/2010	1.01	733.0	4.30	887.8	5.50	800.8
11/22/2005	1.00	247.2	3.20	424.3	4.50	358.1	5/23/2010	1.01	924.0	4.30	887.0	5.40	635.3
11/23/2005	1.00	244.1	3.20	281.1	4.50	269.5	5/24/2010	1.00	993.3	4.30	833.1	5.40	839.3
11/24/2005	1.00	254.1	3.20	236.9	4.40	396.6	5/25/2010	1.00	854.7	4.30	999.5	5.40	816.2
11/25/2005	1.00	317.2	3.20	300.3	4.40	477.4	5/26/2010	1.00	869.3	4.30	1091.1	5.40	847.0
11/26/2005	1.00	358.1	3.20	215.6	4.40	246.4	5/27/2010	1.00	812.4	4.30	1044.1	5.40	797.0
11/27/2005	1.00	519.8	3.20	360.4	4.40	500.5	5/28/2010	1.00	885.5	4.30	939.4	5.40	723.8
11/28/2005	1.00	187.1	3.20	385.0	4.40	531.3	5/29/2010	1.00	967.1	4.30	910.1	5.40	754.6
11/29/2005	1.00	291.1	3.20	430.4	4.40	377.3	5/30/2010	1.00	821.6	4.30	885.5	5.40	727.7
11/30/2005	1.00	251.8	3.20	258.0	4.40	462.0	5/31/2010	1.00	733.0	4.30	852.4	5.40	527.5
12/1/2005	1.00	250.3	3.20	302.6	4.40	377.3	6/1/2010	1.00	893.2	4.30	821.6	5.40	908.6
12/2/2005	1.00	310.3	3.20	331.1	4.30	354.2	6/2/2010	1.00	831.6	4.30	830.1	5.40	716.1
12/3/2005	1.00	493.6	3.20	246.4	4.30	361.9	6/3/2010	1.00	813.1	4.30	939.4	5.40	669.9
12/4/2005	1.00	231.0	3.20	244.1	4.30	354.2	6/4/2010	1.00	1033.3	4.30	706.1	5.40	600.6
12/5/2005	1.00	308.8	3.20	447.4	4.30	369.6	6/5/2010	1.00	1001.8	4.30	797.7	5.30	689.2
12/6/2005	1.00	217.9	3.20	447.4	4.30	415.8	6/6/2010	1.00	1024.9	4.30	929.4	5.30	643.0
12/7/2005	1.00	260.3	3.20	251.8	4.30	184.8	6/7/2010	1.00	643.7	4.30	726.9	5.30	600.6
12/8/2005	1.00	303.4	3.20	298.0	4.30	508.2	6/8/2010	1.00	482.8	4.30	760.0	5.30	746.9
12/9/2005	1.00	221.0	3.20	251.0	4.30	392.7	6/9/2010	1.00	877.8	4.30	937.9	5.30	577.5
12/10/2005	1.00	276.4	3.20	177.1	4.30	284.9	6/10/2010	1.00	927.9	4.30	894.0	5.30	642.2

12/11/2005	1.00	157.9	3.20	300.3	4.30	508.2	6/11/2010	1.00	881.7	4.30	937.1	5.30	723.8
12/12/2005	1.00	256.4	3.20	256.4	4.30	331.1	6/12/2010	1.00	969.4	4.20	850.1	5.30	623.7
12/13/2005	1.00	83.9	3.40	24.6	4.30	231.0	6/13/2010	1.00	944.8	4.20	896.3	5.30	758.5
12/14/2005	1.00	133.2	5.10	418.1	4.30	284.9	6/14/2010	1.00	880.1	4.20	868.6	5.30	681.5
12/15/2005	1.00	182.5	7.50	346.5	4.40	250.3	6/15/2010	1.00	862.4	4.20	918.6	5.30	854.7
12/16/2005	1.00	101.6	8.20	392.7	4.60	165.6	6/16/2010	1.00	686.8	4.20	994.8	5.30	939.4
12/17/2005	1.00	217.9	7.10	354.2	4.80	165.6	6/17/2010	1.00	643.0	4.20	1167.3	5.30	800.8
12/18/2005	1.00	187.1	5.60	295.7	5.10	446.6	6/18/2010	1.00	760.0	4.20	859.3	5.30	916.3
12/19/2005	1.00	158.6	4.60	425.8	5.20	354.2	6/19/2010	1.00	815.4	4.20	850.9	5.30	839.3
12/20/2005	1.00	392.7	4.00	444.3	5.30	346.5	6/20/2010	1.00	808.5	4.20	1192.7	5.30	958.7
12/21/2005	1.00	292.6	3.80	410.4	5.30	415.8	6/21/2010	1.00	862.4	4.20	663.7	5.30	877.8
12/22/2005	1.00	328.8	3.60	369.6	5.20	354.2	6/22/2010	1.00	835.5	4.20	1040.3	5.30	951.0
12/23/2005	1.00	415.8	3.50	277.2	5.20	315.7	6/23/2010	1.00	997.2	4.20	1047.2	5.30	804.7
12/24/2005	1.00	164.8	3.40	377.3	5.20	381.2	6/24/2010	1.00	808.5	4.30	1034.1	5.30	770.0
12/25/2005	1.00	454.3	3.40	246.4	5.10	388.9	6/25/2010	1.00	850.9	4.90	1016.4	5.30	843.2
12/26/2005	1.00	251.8	3.30	225.6	5.10	408.1	6/26/2010	1.00	786.9	8.30	771.5	5.30	816.2
12/27/2005	1.00	477.4	3.30	272.6	5.00	423.5	6/27/2010	1.00	993.3	8.30	833.1	5.50	827.8
12/28/2005	1.00	194.8	3.30	280.3	5.00	412.0	6/28/2010	1.00	993.3	6.70	959.4	5.70	870.1
12/29/2005	1.00	297.2	3.30	254.9	4.90	385.0	6/29/2010	1.00	986.4	5.70	899.4	5.90	1047.2
12/30/2005	1.00	257.2	3.30	181.0	4.90	419.7	6/30/2010	1.00	706.9	5.20	970.2	6.00	862.4
12/31/2005	1.00	411.2	3.30	341.9	4.80	411.2	7/1/2010	1.00	778.5	4.90	773.9	6.00	939.4
1/1/2006	1.00	362.7	3.20	177.1	4.80	207.9	7/2/2010	1.00	704.6	4.70	59.3	6.00	781.6
1/2/2006	1.00	412.0	3.20	368.1	4.80	431.2	7/3/2010	1.00	726.1	4.50	576.7	6.00	644.5
1/3/2006	1.00	304.2	3.20	362.7	4.70	354.2	7/4/2010	1.00	862.4	4.50	954.8	6.00	673.8
1/4/2006	1.00	288.8	3.20	523.6	4.70	361.9	7/5/2010	1.00	924.0	4.40	731.5	6.00	696.9
1/5/2006	1.00	317.2	3.20	740.0	4.70	438.9	7/6/2010	1.01	948.6	4.40	901.7	5.90	770.0

1/6/2006	1.00	463.5	3.20	638.3	4.60	469.7	7/7/2010	1.03	893.2	4.30	935.6	5.90	723.8
1/7/2006	1.00	346.5	3.20	346.5	4.60	531.3	7/8/2010	1.08	827.8	4.30	914.0	5.80	920.2
1/8/2006	1.00	431.2	3.20	298.0	4.60	277.2	7/9/2010	2.70	754.6	18.50	612.9	6.00	1266.7
1/9/2006	1.00	427.4	3.20	347.3	4.60	477.4	7/10/2010	260.81	475.9	283.20	576.7	11.60	762.3
1/10/2006	1.00	175.6	3.20	511.3	4.50	246.4	7/11/2010	346.59	601.4	625.20	654.5	45.30	854.7
1/11/2006	1.00	336.5	3.20	278.0	4.50	366.5	7/12/2010	154.96	644.5	419.50	937.9	112.30	908.6
1/12/2006	1.00	277.2	3.20	271.0	4.50	331.1	7/13/2010	51.90	537.5	219.50	223.3	171.20	900.9
1/13/2006	1.00	320.3	3.20	346.5	4.50	100.1	7/14/2010	22.53	686.1	145.80	697.6	194.70	739.2
1/14/2006	1.00	262.6	3.20	277.2	4.50	400.4	7/15/2010	12.94	659.1	113.80	684.5	191.50	773.9
1/15/2006	1.00	455.1	3.20	485.1	4.50	577.5	7/16/2010	35.13	478.2	100.80	566.0	178.00	746.9
1/16/2006	1.00	220.2	3.20	220.2	4.40	169.4	7/17/2010	43.89	551.3	90.30	646.8	162.80	666.1
1/17/2006	1.00	191.0	3.20	438.9	4.40	546.7	7/18/2010	21.11	755.4	82.20	441.2	148.40	797.0
1/18/2006	1.00	312.6	3.20	362.7	4.40	308.0	7/19/2010	9.27	768.5	77.80	589.8	135.70	935.6
1/19/2006	1.00	526.7	3.20	338.8	4.40	238.7	7/20/2010	5.62	423.5	64.40	485.1	124.20	827.8
1/20/2006	1.00	172.5	3.20	408.1	4.40	300.3	7/21/2010	4.28	884.7	54.30	256.4	113.40	762.3
1/21/2006	1.00	227.2	3.20	249.5	4.40	400.4	7/22/2010	4.01	616.8	47.10	467.4	103.00	462.0
1/22/2006	1.00	258.7	3.20	300.3	4.40	577.5	7/23/2010	3.95	566.0	43.60	778.5	93.90	762.3
1/23/2006	1.00	302.6	3.20	362.7	4.40	377.3	7/24/2010	3.64	573.7	43.70	616.0	93.90	723.8
1/24/2006	1.00	229.5	3.20	333.4	4.30	354.2	7/25/2010	3.15	612.2	37.60	508.2	130.00	581.4
1/25/2006	1.00	230.2	3.20	321.1	4.30	442.8	7/26/2010	2.71	350.4	33.40	202.5	87.50	250.3
1/26/2006	1.00	340.3	3.20	419.7	4.30	515.9	7/27/2010	2.44	489.0	31.30	424.3	69.00	381.2
1/27/2006	1.00	348.8	3.20	223.3	4.30	38.5	7/28/2010	2.36	627.6	26.90	395.0	139.70	412.0
1/28/2006	1.00	357.3	3.20	169.4	4.30	585.2	7/29/2010	2.41	533.6	24.50	413.5	567.40	227.2
1/29/2006	1.00	223.3	3.20	280.3	4.30	200.2	7/30/2010	2.48	250.3	22.80	392.7	179.00	130.9
1/30/2006	1.00	374.2	3.20	439.7	4.30	292.6	7/31/2010	2.41	223.3	20.70	385.0	71.50	820.1
1/31/2006	1.00	459.7	3.20	367.3	4.30	377.3	8/1/2010	2.20	419.7	18.90	385.0	50.30	539.0

2/1/2006	1.00	249.5	3.20	299.5	4.30	365.8	8/2/2010	1.97	683.0	17.60	489.7	44.10	839.3
2/2/2006	1.00	405.0	3.20	325.7	4.30	427.4	8/3/2010	1.77	448.9	16.50	505.1	39.90	646.8
2/3/2006	1.00	390.4	3.20	361.9	4.30	546.7	8/4/2010	1.62	606.0	15.70	491.3	36.60	693.0
2/4/2006	1.00	386.5	3.20	446.6	4.30	261.8	8/5/2010	1.55	485.1	110.80	462.0	36.50	877.8
2/5/2006	1.00	373.5	3.20	361.9	4.30	315.7	8/6/2010	2.96	612.9	103.10	629.1	42.80	823.9
2/6/2006	1.00	435.8	3.20	602.1	4.30	515.9	8/7/2010	14.88	595.2	65.60	629.1	51.20	712.3
2/7/2006	1.00	398.9	3.20	606.8	4.30	392.7	8/8/2010	22.36	401.2	43.80	453.5	55.70	639.1
2/8/2006	1.00	288.8	3.20	555.2	4.30	377.3	8/9/2010	15.20	705.3	32.10	506.7	55.80	604.5
2/9/2006	1.00	261.8	3.20	391.9	4.30	288.8	8/10/2010	8.48	718.4	25.90	560.6	53.10	793.1
2/10/2006	1.00	277.2	3.20	346.5	4.30	250.3	8/11/2010	5.16	408.1	22.10	468.9	49.30	468.2
2/11/2006	1.00	252.6	3.20	415.8	4.20	515.9	8/12/2010	3.57	589.1	19.30	576.7	64.90	600.6
2/12/2006	1.00	308.0	3.20	617.5	4.20	323.4	8/13/2010	2.73	576.0	17.10	400.4	49.80	485.1
2/13/2006	1.00	501.3	3.20	555.2	4.20	677.6	8/14/2010	2.49	555.2	15.40	394.2	40.70	585.2
2/14/2006	1.00	487.4	3.20	387.3	4.20	454.3	8/15/2010	2.79	546.7	14.10	191.7	36.30	261.8
2/15/2006	1.00	546.7	3.20	532.8	4.20	231.0	8/16/2010	3.07	600.6	13.20	311.1	33.30	523.6
2/16/2006	1.00	560.6	3.20	398.1	4.20	331.1	8/17/2010	2.98	400.4	16.40	381.2	30.90	739.2
2/17/2006	1.00	348.0	3.20	304.2	4.20	323.4	8/18/2010	2.64	705.3	24.50	552.9	29.20	569.8
2/18/2006	1.00	244.1	3.20	331.1	4.20	377.3	8/19/2010	2.29	695.3	18.70	762.3	28.10	666.1
2/19/2006	1.00	283.4	3.20	318.8	4.20	589.1	8/20/2010	2.00	682.2	25.50	87.8	27.40	562.1
2/20/2006	1.00	384.2	3.20	446.6	4.20	288.8	8/21/2010	1.78	323.4	41.90	398.1	27.50	400.4
2/21/2006	1.00	362.7	3.20	312.6	4.20	231.0	8/22/2010	1.61	532.1	43.30	471.2	28.60	462.0
2/22/2006	1.00	394.2	3.20	206.4	4.20	523.6	8/23/2010	1.49	579.0	32.30	614.5	30.00	469.7
2/23/2006	1.00	147.1	3.20	284.9	4.20	246.4	8/24/2010	1.39	545.2	23.10	670.7	30.60	585.2
2/24/2006	1.00	399.6	3.20	446.6	4.20	523.6	8/25/2010	1.32	582.9	20.50	555.2	30.30	558.3
2/25/2006	1.00	378.1	3.20	454.3	4.20	408.1	8/26/2010	1.27	582.1	20.00	390.4	29.40	627.6
2/26/2006	1.00	405.8	3.20	564.4	4.20	623.7	8/27/2010	1.23	497.4	37.70	463.5	28.90	331.1

2/27/2006	1.00	547.5	3.20	614.5	4.20	793.1	8/28/2010	1.24	395.0	41.20	368.1	29.40	473.6
2/28/2006	1.00	347.3	3.20	628.3	4.20	500.5	8/29/2010	2.43	84.7	46.50	322.6	30.90	373.5
3/1/2006	1.00	483.6	3.20	723.8	4.20	400.4	8/30/2010	6.68	469.7	38.90	431.2	161.10	431.2
3/2/2006	1.00	538.2	3.20	654.5	4.20	800.8	8/31/2010	8.14	331.1	28.20	339.6	90.60	635.3
3/3/2006	1.00	488.2	3.20	546.7	4.20	623.7	9/1/2010	6.60	500.5	30.00	597.5	69.50	512.1
3/4/2006	1.00	555.9	3.20	469.7	4.20	438.9	9/2/2010	4.59	686.8	29.60	435.8	59.60	650.7
3/5/2006	1.00	479.7	3.20	531.3	4.20	685.3	9/3/2010	3.30	566.0	23.20	289.5	49.60	635.3
3/6/2006	1.00	541.3	3.20	580.6	4.20	666.1	9/4/2010	2.54	628.3	17.20	457.4	42.40	750.8
3/7/2006	1.00	408.9	3.20	433.5	4.20	500.5	9/5/2010	2.20	519.8	14.90	448.1	38.40	254.1
3/8/2006	1.00	612.2	3.20	378.1	4.20	585.2	9/6/2010	6.74	554.4	45.70	497.4	67.90	1166.6
3/9/2006	1.00	529.8	3.20	535.9	4.20	723.8	9/7/2010	17.59	535.2	259.60	378.1	217.50	385.0
3/10/2006	1.00	406.6	3.20	392.7	4.20	123.2	9/8/2010	14.93	469.7	298.30	288.0	143.40	592.9
3/11/2006	1.00	591.4	3.20	377.3	4.20	577.5	9/9/2010	8.82	537.5	189.10	274.9	109.10	331.1
3/12/2006	1.00	311.9	3.20	491.3	4.20	284.9	9/10/2010	5.32	501.3	84.60	346.5	115.00	481.3
3/13/2006	1.00	442.8	3.20	539.0	4.20	385.0	9/11/2010	3.61	539.8	37.20	401.9	114.30	408.1
3/14/2006	1.00	482.8	3.20	703.8	4.20	666.1	9/12/2010	2.71	348.0	21.30	442.8	103.90	385.0
3/15/2006	1.00	542.1	3.20	445.1	4.20	531.3	9/13/2010	2.19	552.9	15.70	349.6	90.80	723.8
3/16/2006	1.00	639.9	3.20	530.5	4.20	739.2	9/14/2010	1.86	366.5	13.00	446.6	78.50	489.0
3/17/2006	1.00	544.4	3.20	531.3	4.20	292.6	9/15/2010	1.65	452.0	11.60	415.0	68.00	0.0
3/18/2006	1.00	434.3	11.10	462.8	4.30	385.0	9/16/2010	1.50	468.2	11.10	347.3	59.30	546.7
3/19/2006	1.00	306.5	26.30	415.8	4.80	284.9	9/17/2010	1.39	619.1	10.60	435.8	52.20	573.7
3/20/2006	1.00	309.5	31.60	327.3	5.90	592.9	9/18/2010	1.32	749.2	9.80	425.0	46.30	465.9
3/21/2006	1.00	495.9	24.30	562.1	7.50	331.1	9/19/2010	1.26	711.5	9.10	634.5	41.30	531.3
3/22/2006	1.00	589.8	14.80	669.1	9.00	746.9	9/20/2010	1.23	469.7	8.50	417.3	37.10	816.2
3/23/2006	1.00	538.2	8.90	808.5	9.90	616.0	9/21/2010	1.73	242.6	8.70	113.2	101.10	0.0
3/24/2006	1.00	433.5	6.00	515.9	10.10	600.6	9/22/2010	4.82	167.9	18.80	110.1	93.40	92.4

3/25/2006	1.00	662.2	4.80	485.1	10.00	639.1	9/23/2010	7.96	625.2	26.80	325.7	51.90	435.1
3/26/2006	1.00	542.9	4.20	594.4	9.70	585.2	9/24/2010	7.38	515.9	17.20	330.3	36.90	385.0
3/27/2006	1.00	469.7	3.90	673.8	9.30	585.2	9/25/2010	5.44	500.5	12.30	323.4	31.90	612.2
3/28/2006	1.00	525.1	3.70	439.7	9.00	477.4	9/26/2010	3.88	620.6	10.50	388.1	28.90	186.3
3/29/2006	1.00	756.9	3.60	658.4	8.60	608.3	9/27/2010	2.92	609.8	9.40	123.2	26.60	269.5
3/30/2006	1.00	635.3	3.50	609.8	8.30	338.8	9/28/2010	2.33	577.5	8.80	359.6	24.60	400.4
3/31/2006	1.00	622.9	3.40	485.1	8.00	612.2	9/29/2010	1.95	614.5	8.40	409.6	22.90	315.7
							9/30/2010	1.71	614.5	3.20	409.6	0.20	315.7

APPENDIX B CROP PATTERN IN THE AGRICULTURAL YEARS 2001 TO 2010

These planted areas are in hectares:

Year	Maiz.	Whea.	Saffl.	Gar.	Veget.	Sorg.	Cot.	Alfal.	Fruits	Soy.	Ses.
01-02	16449	165573	2749	4274	11891	1057	1415	5003	1876	0	0
02-03	23697	150957	7753	334	10031	0	795	4753	1352	0	0
03-04	11915	4119	22174	2253	8043	258	7271	3172	2396	0	0
04-05	7703	66076	31926	11150	9900	1561	23491	4014	1794	13.48	0
05-06	16265	137508	10723	14002	10237	437	1499	6478	2121	0	0
06-07	11781	148183	16014	7492	9904	5254	2368	6063	3122	0	0
07-08	16781	157226	8500	6620	9750	5244	1403	5167	3673	0	0
08-09	11471	171995	6023	3805	11586	6729	1140	4463	3199	0	0
09-2010	17685	154639	9282	5488	11221	3854	2084	4797	4657	758	126

APPENDIX C MATLAB CODES

Matlab was used to plot graphs:

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% Calibration/Validation of HEC-HMS simulation for ground observations
% created by Adil Mounir (October 2017)

clear mem
clear all
clc

ANGOSTURACALIB=xlsread('StationsHMSfinal.xlsx','CalibrationAngostura');
ANGOSTURAVVALID=xlsread('StationsHMSfinal.xlsx','ValidationAngostura');
NOVILLOCALIB=xlsread('StationsHMSfinal.xlsx','CalibrationNovillo');
NOVILLOVALID=xlsread('StationsHMSfinal.xlsx','ValidationNovillo');
OVIACHICCALIB=xlsread('StationsHMSfinal.xlsx','CalibrationOviachic');
OVIACHICVALID=xlsread('StationsHMSfinal.xlsx','ValidationOviachic');

Rain1 = xlsread('StationsHMSfinal.xlsx','AngosturaRainCalibration');
Rain2 = xlsread('StationsHMSfinal.xlsx','AngosturaRainValidation');
Rain3 = xlsread('StationsHMSfinal.xlsx','NovilloRainCalibration');
Rain4 = xlsread('StationsHMSfinal.xlsx','NovilloRainValidation');
Rain5 = xlsread('StationsHMSfinal.xlsx','OviachicRainCalibration');
Rain6 = xlsread('StationsHMSfinal.xlsx','OviachicRainValidation');

time1 = [1:1:length(OVIACHICCALIB(:,1))];
time2 = [1:1:length(OVIACHICVALID(:,1))];

CalibrationObservedAngostura = ANGOSTURACALIB(:,2);
CalibrationSimulatedAngostura = ANGOSTURACALIB(:,1);
ValidationObservedAngostura = ANGOSTURAVVALID(:,2);
ValidationSimulatedAngostura = ANGOSTURAVVALID(:,1);

CalibrationObservedOviachic = OVIACHICCALIB(:,2);
CalibrationSimulatedOviachic = OVIACHICCALIB(:,1);
ValidationObservedOviachic = OVIACHICVALID(:,2);
ValidationSimulatedOviachic = OVIACHICVALID(:,1);

CalibrationObservedNovillo = NOVILLOCALIB(:,2);
CalibrationSimulatedNovillo = NOVILLOCALIB(:,1);
ValidationObservedNovillo = NOVILLOVALID(:,2);
ValidationSimulatedNovillo = NOVILLOVALID(:,1);

RainAngosturaCalibration = Rain1(:,1);
RainAngosturaValidation = Rain2(:,1);
RainNovilloCalibration = Rain3(:,1);
RainNovilloValidation = Rain4(:,1);
RainOviachicCalibration = Rain5(:,1);
RainOviachicValidation = Rain6(:,1);

fsize = 12;
%%
```

```

%Plotting calibration for Angostura
subplot(3,2,1)
t1=time1*((2006.2420558-2001.7461675)./length(time1))+2001.7461675;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
plot(t1,CalibrationObservedAngostura,'DisplayName','Observed','LineWidt
h',2.5,'Color','b');
hold on;
plot(t1,CalibrationSimulatedAngostura,'DisplayName','Simulated','LineWi
dth',1,'Color','r');
hold all;
grid off;
ylabel({'Runoff [m^3/s]'}, 'FontSize', fsize, 'FontName', 'Arial');
legend('Observed', 'Simulated', 'Position', [.75 .7433 0.06625 0.06632]);
xlim([min(t1) max(t1)]);
ylim([0 1200]);
set(gca, 'YTick', [0 100 200 300 400 500 600 700 800 900 1000 1100
1200]);
set(gca, 'XTick', [2001 2002 2003 2004 2005 2006]);

ax1 = gca;
set(ax1, 'XColor', 'k', 'YColor', 'k');
sec_ax1 =
axes('Position', get(ax1, 'Position'), 'XAxisLocation', 'top', 'YAxisLocatio
n', 'right', 'Color', 'none', 'XColor', 'k', 'YColor', 'k');
line(time1, RainAngosturaCalibration, 'DisplayName', 'Precipitation
(P)', 'LineWidth', 2, 'Color', 'k', 'Parent', sec_ax1);
hold all;
grid off;
ylabel({'P
[mm]'}, 'FontSize', fsize, 'FontName', 'Arial', 'VerticalAlignment', 'cap', 'R
otation', 270);
ylim([0 200]);
xlim([0 length(t1)]);
set(gca, 'YDir', 'reverse', 'FontSize', fsize, 'FontName', 'Arial', 'Xticklabe
l', ' ');
legend1 = legend(sec_ax1, 'show');
set(gca, 'YTick', [0 20 40]);
title('Calibration Angostura')
%%
%Plotting validation for Angostura
subplot(3,2,2)
t2=time2*((2010.7434278-2006.2447956)./length(time2))+2006.2447956;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
plot(t2, ValidationObservedAngostura, 'DisplayName', 'Observed', 'LineWidth
', 2.5, 'Color', 'b');
hold on;
plot(t2, ValidationSimulatedAngostura, 'DisplayName', 'Simulated', 'LineWid
th', 1, 'Color', 'r');
hold all;
grid off;
ylabel({'Runoff [m^3/s]'}, 'FontSize', fsize, 'FontName', 'Arial');
xlim([min(t2) max(t2)]);

```



```

ylim([0 1000]);
set(gca,'YTick',[0 100 200 300 400 500 600 700 800 900 1000]);
set(gca,'XTick',[2006 2007 2008 2009 2010]);

ax1 = gca;
set(ax1,'XColor','k','YColor','k');
sec_ax1 =
axes('Position',get(ax1,'Position'),'XAxisLocation','top','YAxisLocation','right','Color','none','XColor','k','YColor','k');
line(time2,RainAngosturaValidation,'DisplayName','Precipitation (P)','LineWidth',2,'Color','k','Parent',sec_ax1);
hold all;
grid off;
ylabel({'P [mm]'},'FontSize',fsize,'FontName','Arial','VerticalAlignment','cap','Rotation',270);
ylim([0 500]);
xlim([0 length(t2)]);
set(gca,'YDir','reverse','FontSize',fsize,'FontName','Arial','Xticklabel',' ');
set(gca,'YTick',[0 30 60]);
title('Validation Angostura')
%%
%Plotting calibration for Novillo
subplot(3,2,3)
t1=time1*((2006.2420558-2001.7461675)./length(time1))+2001.7461675;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
plot(t1,CalibrationObservedNovillo,'DisplayName','Observed','LineWidth',2.5,'Color','b');
hold on;
plot(t1,CalibrationSimulatedNovillo,'DisplayName','Simulated','LineWidth',1,'Color','r');
hold all;
grid off;
ylabel({'Runoff [m^3/s]'},'FontSize',fsize,'FontName','Arial');
xlim([min(t1) max(t1)]);
ylim([0 2000]);
set(gca,'YTick',[0 150 300 450 600 750 900 1050 1200 1350 1500 1650 1800 2000]);
set(gca,'XTick',[2001 2002 2003 2004 2005 2006]);

ax1 = gca;
set(ax1,'XColor','k','YColor','k');
sec_ax1 =
axes('Position',get(ax1,'Position'),'XAxisLocation','top','YAxisLocation','right','Color','none','XColor','k','YColor','k');
line(time1,RainNovilloCalibration,'DisplayName','Precipitation (P)','LineWidth',2,'Color','k','Parent',sec_ax1);
hold all;
grid off;
ylabel({'P [mm]'},'FontSize',fsize,'FontName','Arial','VerticalAlignment','cap','Rotation',270);

```

```

ylim([0 200]);
xlim([0 length(t1)]);
set(gca,'YDir','reverse','FontSize',fsize,'FontName','Arial','Xticklabel', ' ');
set(gca,'YTick',[0 20 40]);
title('Calibration Novillo')
%%
%Plotting validation for Novillo
subplot(3,2,4)
t2=time2*((2010.7434278-2006.2447956)./length(time2))+2006.2447956;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
plot(t2,ValidationObservedNovillo,'DisplayName','Observed','LineWidth',
2.5,'Color','b');
hold on;
plot(t2,ValidationSimulatedNovillo,'DisplayName','Simulated','LineWidth',
1,'Color','r');
hold all;
grid off;
ylabel({'Runoff [m^3/s]'},'FontSize',fsize,'FontName','Arial');
xlim([min(t2) max(t2)]);
ylim([0 2400]);
set(gca,'YTick',[0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200
2400]);
set(gca,'XTick',[2006 2007 2008 2009 2010]);

ax1 = gca;
set(ax1,'XColor','k','YColor','k');
sec_ax1 =
axes('Position',get(ax1,'Position'),'XAxisLocation','top','YAxisLocation',
'n','right','Color','none','XColor','k','YColor','k');
line(time2,RainNovilloValidation,'DisplayName','Precipitation
(P)','LineWidth',2,'Color','k','Parent',sec_ax1);
hold all;
grid off;
ylabel({'P
[mm]'},'FontSize',fsize,'FontName','Arial','VerticalAlignment','cap','R
otation',270);
ylim([0 500]);
xlim([0 length(t2)]);
set(gca,'YDir','reverse','FontSize',fsize,'FontName','Arial','Xticklabel', ' ');
set(gca,'YTick',[0 40 80]);
title('Validation Novillo')
%%
%Plotting calibration for Oviachic
subplot(3,2,5)
t1=time1*((2006.2420558-2001.7461675)./length(time1))+2001.7461675;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
plot(t1,CalibrationObservedOviachic,'DisplayName','Observed','LineWidth',
2.5,'Color','b');
hold on;

```

```

plot(t1,CalibrationSimulatedOviachic,'DisplayName','Simulated','LineWid
th',1,'Color','r');
hold all;
grid off;
ylabel({'Runoff [m^3/s]'},'FontSize',fsize,'FontName','Arial');
xlim([min(t1) max(t1)]);
ylim([0 1200]);
set(gca,'YTick',[0 100 200 300 400 500 600 700 800 900 1000 1100
1200]);
set(gca,'XTick',[2001 2002 2003 2004 2005 2006]);

ax1 = gca;
set(ax1,'XColor','k','YColor','k');
sec_ax1 =
axes('Position',get(ax1,'Position'),'XAxisLocation','top','YAxisLocatio
n','right','Color','none','XColor','k','YColor','k');
line(time1,RainOviachicCalibration,'DisplayName','Precipitation
(P)','LineWidth',2,'Color','k','Parent',sec_ax1);
hold all;
grid off;
ylabel({'P
[mm]'},'FontSize',fsize,'FontName','Arial','VerticalAlignment','cap','R
otation',270);
ylim([0 200]);
xlim([0 length(t1)]);
set(gca,'YDir','reverse','FontSize',fsize,'FontName','Arial','Xticklabe
l',' ');
set(gca,'YTick',[0 20 40 60]);
title('Calibration Oviachic')
%%
%Plotting validation for Oviachic
subplot(3,2,6)
t2=time2*((2010.7434278-2006.2447956)./length(time2))+2006.2447956;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
plot(t2,ValidationObservedOviachic,'DisplayName','Observed','LineWidth'
,2.5,'Color','b');
hold on;
plot(t2,ValidationSimulatedOviachic,'DisplayName','Simulated','LineWidt
h',1,'Color','r');
hold all;
grid off;
ylabel({'Runoff [m^3/s]'},'FontSize',fsize,'FontName','Arial');
xlim([min(t2) max(t2)]);
ylim([0 2400]);
set(gca,'YTick',[0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200
2400]);
set(gca,'XTick',[2006 2007 2008 2009 2010]);

ax1 = gca;
set(ax1,'XColor','k','YColor','k');
sec_ax1 =
axes('Position',get(ax1,'Position'),'XAxisLocation','top','YAxisLocatio
n','right','Color','none','XColor','k','YColor','k');

```

```

line(time2,RainOviachicValidation,'DisplayName','Precipitation
(P)','LineWidth',2,'Color','k','Parent',sec_ax1);
hold all;
grid off;
ylabel({'P
[mm]'},'FontSize',fsize,'FontName','Arial','VerticalAlignment','cap','R
otation',270);
ylim([0 400]);
xlim([0 length(t2)]);
set(gca,'YDir','reverse','FontSize',fsize,'FontName','Arial','Xticklabe
l',' ');
set(gca,'YTick',[0 30 60]);
title('Validation Oviachic')

```

APPENDIX D GAMS CODES

Angostura Optimization:

```

*****
* Yaqui River Basin Project (HEC-HMS and GAMS)
* Objective: 'Optimization of a reservoir operations'
* Mathematical Program Used: Nonlinear programming with discontinuous derivatives
  (DNLP)
* Reservoir to be Modeled: Angostura Reservoir
* Simulation Period: Daily from 10/1/2001 - 9/30/2010 (3287 time steps)
* Goals: 1) Minimize industrial releases deviations from target releases
*        2) Satisfy urban users needs
*        3) Obey operation constraints
* Model written by Adil Mounir (October 2017)
*****
*


---


SETS   T TIME INDEX /T1*T3288/
        I INPUT INDEX /I1*I4/;
* INDEX I1 = DAILY INFLOW TO THE RESERVOIR (M^3/day)
* I2 = DAILY EVAPORATION RATE IN 0.1 METERS PER DAY (evaporation in
  1000 m^3 = evaporation rate (0.1 m/d) * area(in hectares))
* I3 = DAILY WATER ASSIGNED TO PUEBLOS RIBERENOS IN M^3
* I4 = DAILY WATER ASSIGNED TO THE COPPER MINE IN M^3
*


---


SCALAR STU UPPER LIMIT OF RESERVOIR STORAGE IN M^3 /618400000/
        STL LOWER LIMIT OF RESERVOIR STORAGE IN M^3 /85000000/
        K INITIAL RESERVOIR STORAGE IN M^3 /263101029.3/
        RMAX MAXIMUM RELEASE RATE IN M^3 PER SECOND /40/
        RMIN MINIMUM RELEASE RATE IN M^3 PER SECOND /1.6/

Table Q(T,I) DAILY NEEDED DATA
$call =xls2gms r=A1:E3288 i=AngosturaGAMS.xlsx O=parP.inc
$include parP.inc
;
*


---


VARIABLES ST(T) STORAGE OF RESERVOIR AT TIME T (M^3)
           RWS(T) DAILY WATER SUPPLYING PUEBLOS RIBERENOS (M^3)
           RIN(T) DAILY INDUSTRIAL RELEASE TOWARDS THE COPPER MINE
           (M^3)
           RST(T) DAILY RELEASE TO THE STREAM NETWORK (M^3)
           SA(T) RESERVOIR SURFACE AREA (M^2)
           E(T) VOLUMETRIC DAILY EVAPORATION (M^3)

```

OBJ OBJECTIVE: DEFICIT = SUM (MINING ASSIGNED VOLUMES -
RELEASES TOWARDS MINING INDUSTRIES);

POSITIVE VARIABLE ST(T);
POSITIVE VARIABLE RWS(T);
POSITIVE VARIABLE RIN(T);
POSITIVE VARIABLE RST(T);
POSITIVE VARIABLE SA(T);
POSITIVE VARIABLE E(T);

*

EQUATIONS	MASSBAL(T)	MASS BALANCE FOR EACH PERIOD
	STOMAX(T)	UPPER LIMIT OF RESERVOIR STORAGE
	STOMIN(T)	LOWER LIMIT OF RESERVOIR STORAGE
	INISTO	INITIAL RESERVOIR STORAGE
	EVAPOR(T)	VOLUMETRIC DAILY EVAPORATION
	RELMAX(T)	RELEASE RATE UPPER CONSTRAINT
	RELMIN(T)	RELEASE RATE LOWER CONSTRAINT
	URBAN(T)	PUEBLOS RIBERENOS CONSTRAINT
	INDUST(T)	AVOID HAVING 0 RELEASES TO THE MINE
	STOSUR(T)	STORAGE-SURFACE AREA RELATIONSHIP
	OBJECTIVE	OBJECTIVE FUNCTION;

MASSBAL(T)..ST(T+1)=L=ST(T)+Q(T,'I1')-RWS(T)-RIN(T)-RST(T)-E(T);

*All variables are in M³ per day

STOMAX(T)..ST(T)=L=STU;

STOMIN(T)..ST(T)=G=STL;

INISTO..ST('I1')=E=K;

*STASTO(T)..ELE(T)=E=211+(0.0000000446039)*ST(T);

STOSUR(T)..SA(T)=E=1.8753*((ST(T)/1000)**0.56);

*ST(T)/1000 is in 1000 M³ and SA(T) is in Hectares

EVAPOR(T)..E(T)=E=(Q(T,'I2')*SA(T))*1000;

*E(T) is in M³

RELMAX(T)..RST(T)=L=RMAX*86400;

RELMIN(T)..RWS(T)=G=RMIN*86400;

*RMAX and RMIN are in M³/day

URBAN(T)..RWS(T)=G=Q(T,'I3');

INDUST(T)..RIN(T)=G=Q(T,'I4');

OBJECTIVE..OBJ=E=ABS((SUM(T,(Q(T,'I4')-RIN(T))**2)));

*

MODEL MINDEFICIT /ALL/;

SOLVE MINDEFICIT USING DNLP MINIMIZING OBJ;

*

FILE Storage /StorageAngostura.txt/

PUT Storage

```

*PUT 'Reservoir Storage (m^3)', PUT/
LOOP(T, PUT ST.I(T), PUT/)
*
FILE IndustrialRelease /IndustrialAngostura.txt/
PUT IndustrialRelease
*PUT 'Daily Release to Mining Industry (m^3/day)', PUT/
LOOP(T, PUT RIN.I(T), PUT/)
*
FILE UrbanRelease /UrbanAngostura.txt/
PUT UrbanRelease
*PUT 'Daily Release to Pueblos Riberenos(m^3/day)', PUT/
LOOP(T, PUT RWS.I(T), PUT/)
*
FILE InstreamRelease /InstreamAngostura.txt/
PUT InstreamRelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RST.I(T), PUT/)
*
FILE Evaporation /EvaporationAngostura.txt/
PUT Evaporation
*PUT 'Daily Evaporation (m^3)', PUT/
LOOP(T, PUT E.I(T), PUT/)
*
FILE SurfaceArea /SurfaceAreaAngostura.txt/
PUT SurfaceArea
*PUT 'Surface Area (ha)', PUT/
LOOP(T, PUT SA.I(T), PUT/)
*

```

Novillo Optimization:

- * Yaqui River Basin Project (HEC-HMS and GAMS)
- * Objective: 'Optimization of a reservoir operations'
- * Mathematical Program Used: Nonlinear Programming

- * Reservoir to be Modeled: Novillo Reservoir
- * Simulation Period: Daily from 10/1/2001 - 9/30/2010 (3287 time steps)
- * Goals: 1) Maximize the outflow towards Next reservoir
- * 2) Satisfy operation constraints
- * Model written by Adil Mounir (October 2017)

*

SETS T TIME INDEX /T1*T3288/

I INPUT INDEX /I1*I2/;

* INDEX I1 = DAILY INFLOW TO THE RESERVOIR (M³/day)

* I2 = DAILY EVAPORATION RATE (*area(in hectares)=evaporation in 1000 M³)

* I3 = DAILY PRECIPITATION (M/DAY)

*

SCALAR STU UPPER LIMIT OF RESERVOIR STORAGE IN M³ /2755000000/

STL LOWER LIMIT OF RESERVOIR STORAGE IN M³ /2650000000/

K INITIAL RESERVOIR STORAGE IN M³ /1462404323/

RMAX MAXIMUM RELEASE RATE IN M³ PER SECOND /155/

RMIN MINIMUM RELEASE RATE IN M³ PER SECOND /4/;

Table Q(T,I) DAILY INFLOW IN M³ PER DAY AND EVAPORATION RATE IN M⁻¹ PER DAY

\$call =xls2gms r=A1:C3288 i=NovilloGAMS.xlsx O=parP.inc

\$include parP.inc

;

*

VARIABLES ST(T) STORAGE OF RESERVOIR AT TIME T (M³)

R(T) DAILY EXCESS RELEASE (M³)

ELE(T) WATER SURFACE ELEVATION (M)

SA(T) RESERVOIR SURFACE AREA (M²)

E(T) VOLUMETRIC DAILY EVAPORATION (M³)

OBJ OBJECTIVE: SUM OF ALL RELEASES ;

POSITIVE VARIABLE ST(T);

POSITIVE VARIABLE R(T);

POSITIVE VARIABLE ELE(T);

POSITIVE VARIABLE SA(T);

POSITIVE VARIABLE E(T);

*

EQUATIONS	MASSBAL(T)	MASS BALANCE FOR EACH PERIOD
	STOMAX(T)	UPPER LIMIT OF RESERVOIR STORAGE
	STOMIN(T)	LOWER LIMIT OF RESERVOIR STORAGE
	INISTO	INITIAL RESERVOIR STORAGE
	EVAPOR(T)	VOLUMETRIC DAILY EVAPORATION
	RELMAX(T)	RELEASE RATE UPPER CONSTRAINT
	RELMIN(T)	RELEASE RATE LOWER CONSTRAINT
	STOSUR(T)	STORAGE-SURFACE AREA RELATIONSHIP
	OBJECTIVE	OBJECTIVE FUNCTION;

MASSBAL(T)..ST(T+1)=L=ST(T)+Q(T,'I1')-R(T)-E(T);

*All variables are in M³ per day

STOMAX(T)..ST(T)=L=STU;

STOMIN(T)..ST(T)=G=STL;

INISTO..ST('T1')=E=K;

STOSUR(T)..SA(T)=E=0.71*((ST(T)/1000)**0.642);

EVAPOR(T)..E(T)=E=(Q(T,'I2')*SA(T))*1000;

*E(T) is in M³

RELMAX(T)..R(T)=L=RMAX*86400;

RELMIN(T)..R(T)=G=RMIN*86400;

*RMAX and RMIN are in M³/day

OBJECTIVE..OBJ=E=SUM(T,R(T));

*

MODEL MAXRELEASE /ALL/;

SOLVE MAXRELEASE USING NLP MAXIMIZING OBJ;

*

FILE Storage /StorNovillo.txt/

PUT Storage

*PUT 'Reservoir Storage (m³)', PUT/

LOOP(T, PUT ST.I(T), PUT/)

*

FILE Release /RelNovillo.txt/

PUT Release

*PUT 'Daily Release (m³/day)', PUT/

LOOP(T, PUT R.I(T), PUT/)

*

FILE Evaporation /EvapNovillo.txt/

PUT Evaporation

*PUT 'Daily Evaporation (m³)', PUT/

LOOP(T, PUT E.I(T), PUT/)

*

FILE SurfaceArea /SurfaceNovillo.txt/

PUT SurfaceArea

```
*PUT 'Surface Area (ha)', PUT/  
LOOP(T, PUT SA.1(T), PUT/)  
*
```

Oviachic Optimization:

- * Yaqui River Basin Project (HEC-HMS and GAMS)
- * Objective: 'Optimization of a reservoir operations having an agricultural purpose'
- * Mathematical Program Used: Nonlinear programming with discontinuous derivatives (DNLP)
- * Reservoir to be Modeled: Oviachic Reservoir
- * Simulation Period: Daily from 10/1/2001 - 9/30/2010 (3287 time steps)
- * Goals: 1) Reproduce the authorized irrigation releases by the model
- * 2) Satisfy urban constraints
- * 3) Satisfy operation constraints
- * Model written by Adil Mounir (October 2017)

*

SETS T TIME INDEX /T1*T3288/

 I INPUT INDEX /I1*I16/;

* INDEX I1 = DAILY INFLOW TO THE RESERVOIR (M³/day)

* I2 = DAILY EVAPORATION RATE IN 0.1 METERS PER DAY (evaporation in 1000 m³ = evaporation rate (0.1 m/d) * area(in hectares))

* I3 = DAILY WATER ASSIGNED TO URBAN USE IN M³

* I4 = daily required volume for crop Maize in m³

* I5 = daily required volume for crop Wheat in m³

* I6 = daily required volume for crop Safflower in m³

* I7 = daily required volume for crop Garbanzo in m³

* I8 = daily required volume for crop Vegetables in m³

* I9 = daily required volume for crop Sorghum in m³

* I10 = daily required volume for crop Cotton in m³

* I11 = daily required volume for crop Alfalfa in m³

* I12 = daily required volume for crop Fruits in m³

* I13 = daily required volume for crop Soybeans in m³

* I14 = daily required volume for crop Sesame in m³

* I15 = daily water assigned to ID.018 in m³

* I16 = daily ground water extractions for irrigation purposes in m³

*

SCALAR STU UPPER LIMIT OF RESERVOIR STORAGE IN M³ /2439100000/

 STL LOWER LIMIT OF RESERVOIR STORAGE IN M³ /550000000/

 K INITIAL RESERVOIR STORAGE IN M³ /1036197764/

 RMAX MAXIMUM RELEASE RATE IN M³ PER SECOND /210/

 RMIN MINIMUM RELEASE RATE IN M³ PER SECOND /10/

 LAND TOTAL IRRIGABLE AREA IN HECTARES /227224/

 EFF CONVEYANCE EFFICIENCY /0.87/

 MINERR MAXIMUM ERROR ACCEPTABLE /0.01/;

Table Q(T,I) DAILY NEEDED DATA

\$call =xls2gms r=A1:Q3288 i=OviachicGAMS.xlsx O=parP.inc

\$include parP.inc

;
*

VARIABLES ST(T) STORAGE OF RESERVOIR AT TIME T (M³)
 RWS(T) DAILY WATER SUPPLYING THE CITY OF OBREGON AND
 NEIGHBORING TOWNS (M³)
 RMAIZE(T) DAILY MAIZE RELEASE (M³)
 RWHEAT(T) DAILY WHEAT RELEASE (M³)
 RSAFFLOWER(T) DAILY SAFFLOWER RELEASE (M³)
 RGARBANZO(T) DAILY GARBANZO RELEASE (M³)
 RVEGETABLES(T) DAILY VEGETABLES RELEASE (M³)
 RSORGHUM(T) DAILY SORGHUM RELEASE (M³)
 RCOTTON(T) DAILY COTTON RELEASE (M³)
 RALFALFA(T) DAILY ALFALFA RELEASE (M³)
 RFRUITS(T) DAILY FRUITS RELEASE (M³)
 RSOYBEANS(T) DAILY SOYBEANS RELEASE (M³)
 RSESAME(T) DAILY SESAME RELEASE (M³)
 RIRRIGA041(T) DAILY IRRIGATION DISTRICT 041 RELEASE (M³)
 RIRRIGA018(T) DAILY IRRIGATION DISTRICT 018 RELEASE (M³)
 GROUNDWATER(T) DAILY GROUNDWATER EXTRACTIONS IN (M³)
 RST(T) DAILY RELEASE TO THE STREAM NETWORK (M³)
 SA(T) RESERVOIR SURFACE AREA (M²)
 E(T) VOLUMETRIC DAILY EVAPORATION (M³)
 ERR(T) SUM |CROP REQUIRED VOLUME - VOLUME RELEASED FOR
 CROP|
 OBJ OBJECTIVE: MINIMIZE SUM (ERR(T));

POSITIVE VARIABLE	ST(T);
POSITIVE VARIABLE	RWS(T);
POSITIVE VARIABLE	RMAIZE(T);
POSITIVE VARIABLE	RWHEAT(T);
POSITIVE VARIABLE	RSAFFLOWER(T);
POSITIVE VARIABLE	RGARBANZO(T);
POSITIVE VARIABLE	RVEGETABLES(T);
POSITIVE VARIABLE	RSORGHUM(T);
POSITIVE VARIABLE	RCOTTON(T);
POSITIVE VARIABLE	RALFALFA(T);
POSITIVE VARIABLE	RFRUITS(T);
POSITIVE VARIABLE	RSOYBEANS(T);
POSITIVE VARIABLE	RSESAME(T);
POSITIVE VARIABLE	RIRRIGA041(T);
POSITIVE VARIABLE	RIRRIGA018(T);

POSITIVE VARIABLE GROUNDWATER(T);
 POSITIVE VARIABLE RST(T);
 POSITIVE VARIABLE SA(T);
 POSITIVE VARIABLE E(T);
 POSITIVE VARIABLE ERR(T);
 RWHEAT.I(T) = Q(T,'I5')/EFF;

*

EQUATIONS	MASSBAL(T)	MASS BALANCE FOR EACH PERIOD
	STOMAX(T)	UPPER LIMIT OF RESERVOIR STORAGE
	STOMIN(T)	LOWER LIMIT OF RESERVOIR STORAGE
	INISTO	INITIAL RESERVOIR STORAGE
	EVAPOR(T)	VOLUMETRIC DAILY EVAPORATION
	RELMAX(T)	RELEASE RATE UPPER CONSTRAINT
	RELMIN(T)	RELEASE RATE LOWER CONSTRAINT
	OUTFLOW(T)	AVOID NO OUTFLOW BACK TO THE STREAM

NETWORK

URBAN(T)	URBAN CONSTRAINT
URBANMAX(T)	MAX URBAN RELEASE
MAIZE(T)	CONSTRAINT FOR MAIZE
WHEAT(T)	CONSTRAINT FOR WHEAT
SAFFLOWER(T)	CONSTRAINT FOR SAFFLOWER
GARBANZO(T)	CONSTRAINT FOR GARBANZO
VEGETABLES(T)	CONSTRAINT FOR VEGETABLES
SORGHUM(T)	CONSTRAINT FOR SORGHUM
COTTON(T)	CONSTRAINT FOR COTTON
ALFALFA(T)	CONSTRAINT FOR ALFALFA
FRUITS(T)	CONSTRAINT FOR FRUITS
SOYBEANS(T)	CONSTRAINT FOR SOYBEANS
SESAME(T)	CONSTRAINT FOR SESAME
GROUND(T)	GROUNDWATER EXTRACTIONS
ID18(T)	IRRIGATION DISTRICT 018 RELEASES
ID41(T)	IRRIGATION DISTRICT 041 RELEASES
STOSUR(T)	STORAGE-SURFACE AREA RELATIONSHIP
ERROR(T)	URBAN RELEASE TARGET
ERRORMIN(T)	MAXIMUM ERROR ACCEPTABLE
OBJECTIVE	OBJECTIVE FUNCTION;

MASSBAL(T)..ST(T+1)=E=ST(T)+Q(T,'I1')-E(T)-RWS(T)-RST(T)-RIRRIGA018(T)-
 RIRRIGA041(T);

*All variables are in M³ per day

STOMAX(T)..ST(T)=L=STU;

STOMIN(T)..ST(T)=G=STL;

INISTO..ST('T1')=E=K;

```

STOSUR(T)..SA(T)=E=1.079*((ST(T)/1000)**0.6464);
*ST(T)/1000 is in 1000 M^3 and SA(T) is in Hectares
EVAPOR(T)..E(T)=E=(Q(T,'I2')*SA(T))*1000;
*E(T) is in M3
RELMIN(T)..RWS(T)=G=RMIN*86400;
*RMAX and RMIN are in M3/day
OUTFLOW(T)..RST(T)=G=RMIN*864000;
URBAN(T)..RWS(T)=G=Q(T,'I3');
URBANMAX(T)..RWS(T)=L=650000;
MAIZE(T)..EFF*RMAIZE(T)=E=Q(T,'I4');
WHEAT(T)..EFF*RWHEAT(T)=E=Q(T,'I5');
SAFFLOWER(T)..EFF*RSAFFLOWER(T)=E=Q(T,'I6');
GARBANZO(T)..EFF*RGARBANZO(T)=E=Q(T,'I7');
VEGETABLES(T)..EFF*RVEGETABLES(T)=E=Q(T,'I8');
SORGHUM(T)..EFF*RSORGHUM(T)=E=Q(T,'I9');
COTTON(T)..EFF*RCOTTON(T)=E=Q(T,'I10');
ALFALFA(T)..EFF*RALFALFA(T)=E=Q(T,'I11');
FRUITS(T)..EFF*RFRUITS(T)=E=Q(T,'I12');
SOYBEANS(T)..EFF*RSOYBEANS(T)=E=Q(T,'I13');
SESAME(T)..EFF*RSESAME(T)=E=Q(T,'I14');
GROUND(T)..GROUNDWATER(T)=E=Q(T,'I16');
ID18(T)..RIRRIGA018(T)=E=Q(T,'I15')/EFF;
ID41(T)..RIRRIGA041(T)=E=-
  GROUNDWATER(T)+(RMAIZE(T)+RWHEAT(T)+RSAFFLOWER(T)+RGARBANZ
    O(T)+RVEGETABLES(T)+RSORGHUM(T)+RCOTTON(T)+RALFALFA(T)+RFRUI
    TS(T)+RSOYBEANS(T)+RSESAME(T))/EFF;
RELMAX(T)..RIRRIGA041(T)+RWS(T)=L=RMAX*86400;
ERROR(T)..ERR(T)=E=(ABS(RWS(T)-Q(T,'I3'))**2);
ERRORMIN(T)..ERR(T)=L=MINERR;
OBJECTIVE..OBJ=E=SUM(T,ABS(ERR(T)));
*
MODEL OVIACHIC /ALL/;
SOLVE OVIACHIC USING DNLP MINIMIZING OBJ;
*
FILE Storage /StorageOviachic.txt/
PUT Storage
*PUT 'Reservoir Storage (m^3)', PUT/
LOOP(T, PUT ST.I(T), PUT/)
*
FILE UrbanRelease /UrbanOviachic.txt/
PUT UrbanRelease
*PUT 'Daily Release to CITY OF OBREGON AND NEIGHBORING
  TOWNS(m^3/day)', PUT/
LOOP(T, PUT RWS.I(T), PUT/)

```

```

*
FILE InstreamRelease /OutflowOviachic.txt/
PUT InstreamRelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RST.l(T), PUT/)
*
FILE MAIZERelease /MAIZEOviachic.txt/
PUT MAIZERelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RMAIZE.l(T), PUT/)
*
FILE WHEATRelease /WHEATOviachic.txt/
PUT WHEATRelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RWHEAT.l(T), PUT/)
*
FILE SAFFLOWERRelease /SAFFFLOWEROviachic.txt/
PUT SAFFLOWERRelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RSAFFLOWER.l(T), PUT/)
*
FILE GARBANZORelease /GARBANZOOviachic.txt/
PUT GARBANZORelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RGARBANZO.l(T), PUT/)
*
FILE VEGETABLESRelease /VEGETABLESOviachic.txt/
PUT VEGETABLESRelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RVEGETABLES.l(T), PUT/)
*
FILE SORGHUMRelease /SORGHUMOviachic.txt/
PUT SORGHUMRelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RSORGHUM.l(T), PUT/)
*
FILE COTTONRelease /COTTONOviachic.txt/
PUT COTTONRelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RCOTTON.l(T), PUT/)
*
FILE ALFALFARelease /ALFALFAOviachic.txt/
PUT ALFALFARelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/

```

```

LOOP(T, PUT RALFALFA.l(T), PUT/)
*
FILE FRUITRelease /FRUITSOviachic.txt/
PUT FRUITRelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RFRUIT.l(T), PUT/)
*
FILE SOYBEANSRelease /SOYBEANSOviachic.txt/
PUT SOYBEANSRelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RSOYBEANS.l(T), PUT/)
*
FILE SESAMERelease /SESAMEOviachic.txt/
PUT SESAMERelease
*PUT 'Daily Release to Stream (m^3/day)', PUT/
LOOP(T, PUT RSESAME.l(T), PUT/)
*
FILE Evaporation /EvaporationOviachic.txt/
PUT Evaporation
*PUT 'Daily Evaporation (m^3)', PUT/
LOOP(T, PUT E.l(T), PUT/)
*
FILE SurfaceArea /SurfaceAreaOviachic.txt/
PUT SurfaceArea
*PUT 'Surface Area (ha)', PUT/
LOOP(T, PUT SA.l(T), PUT/)
*
FILE Irrigation /Irrigation.txt/
PUT Irrigation
*PUT 'Surface Area (ha)', PUT/
LOOP(T, PUT RIRRIGA041.l(T), PUT/)
*
FILE ERRORS /ERRORS.txt/
PUT ERRORS
*PUT 'Err1 (m^6)', PUT/
LOOP(T, PUT ERR.l(T), PUT/)
*

```

APPENDIX E PYTHON CODES

NLDAS fields processing:

```
#####
# NLDAS_Time_Series.py
# Objective: Create NLDAS complete time-series for each grid
# Created: October 21st,2016
# Last modified: October 25,2016
# Written by: Daniel Che (che@ohio.edu)
#####
import os,datetime # Importing Python package
class NLDAS_Time_Series(object):
    def __init__(self,NLDAS_input_dir,NLDAS_output_dir,total_nodes):
        all_years = os.listdir(NLDAS_input_dir)
        # Loop each node number
        for i in range(0,total_nodes,1):
            # Define output file
            nldas_file_output = open(NLDAS_output_dir+"\Node_"+str(i)+".dat",'w')
            # An initial empty storage for daily forcing is created for each node loop
            self.complete_time_series = []
            # Loop each available year
            for year in all_years:
                # Change directory to particular year
                os.chdir(NLDAS_input_dir+"/"+year)
                # list all files in this directory (should be all forcing files for each cell in this
                particular year)
                self.cells = os.listdir(os.getcwd())
                # Loop each cell forcing file
                for cell in self.cells:
                    # Use conditional statement to seek a particular file name
                    if cell.startswith("Fake_Rain_"+year+"_FID_"+str(i)+"_") or
cell.startswith("Fake_AirTemp_"+year+"_FID_"+str(i)+"_") or
cell.startswith("Fake_Rn_"+year+"_FID_"+str(i)+"_"):
                        fp = open(cell, "r") # Open data file for current cell in this particular year
                        # Read and store information from this forcing file (this current cell in this
                        year)
                        self.lines = fp.readlines()
                        fp.close() # Finish reading - close file
                        # Loop each row in the forcing file
                        for line in self.lines:
                            # Append daily value into the complete time-series array
                            self.complete_time_series.append(line)
                # Loop the total time-series for this node
```

```

    for data in self.complete_time_series:
        # Write the total forcing time-series for this node
        nldas_file_output.write("%s" % data)
        nldas_file_output.close() # Finish writing the file
        print NLDAS_output_dir+"\Node_"+str(i)+".txt", "saved." # Print on screen about
which file is being saved
def main():
    print "-- Start process:" , datetime.datetime.now(), "\n"
    # Define NLDAS data directories
    NLDAS_rain_data = r'C:\Users\che\Desktop\Adil Mounir Research
Materials\NLDAS_Data\Daily_forcings_NLDAS_HEC_HMS_Yaqui\Daily_forcings_N
LDAS_HEC_HMS_Yaqui\FAKE_PIXELS_YAQUI\RAIN'
    NLDAS_Temperature_data = r'C:\Users\che\Desktop\Adil Mounir Research
Materials\NLDAS_Data\Daily_forcings_NLDAS_HEC_HMS_Yaqui\Daily_forcings_N
LDAS_HEC_HMS_Yaqui\FAKE_PIXELS_YAQUI\TEMPERATURE'
    NLDAS_NETRAD_data = r'C:\Users\che\Desktop\Adil Mounir Research
Materials\NLDAS_Data\New_Yaqui_Pixels_DAILY_RADIATION_AVG\Yaqui_Pixels
_DAILY_RADIATION_AVG'
    # Define output directories
    NLDAS_rain_out = r'C:\Users\che\Desktop\Adil Mounir Research
Materials\NLDAS_Data\Extracted_for_DAT\Rain'
    NLDAS_Temperature_out = r'C:\Users\che\Desktop\Adil Mounir Research
Materials\NLDAS_Data\Extracted_for_DAT\Temperature'
    NLDAS_NETRAD_out = r'C:\Users\che\Desktop\Adil Mounir Research
Materials\NLDAS_Data\Extracted_for_DAT\InSol'
    # Enter total number of nodes here
    total_nodes = 614
    # Execute NLDAS_Time_Series object class
    NLDAS_Time_Series(NLDAS_rain_data,NLDAS_rain_out,total_nodes) # NLDAS
Rain

NLDAS_Time_Series(NLDAS_Temperature_data,NLDAS_Temperature_out,total_node
s) # NLDAS Temperature
    NLDAS_Time_Series(NLDAS_NETRAD_data,NLDAS_NETRAD_out,total_nodes)
# NLDAS Net Radiation
    print "\n -- All done!!" , datetime.datetime.now()
if __name__ == '__main__':
    main()

```

NLDAS bias correction:

```

#-----
# Name:      BiasCorrection
# Purpose:   This script corrects NLDAS data based on daily averaged ratio of means
# Author:    adil mounir
# Created:   12/06/2017
# Copyright: (c) am332215 2017
#-----

import openpyxl #to manipulate excel sheets
from openpyxl.utils import coordinate_from_string #to get the highest row in a column
from openpyxl.utils import (get_column_letter) #to use numbers to refer to excel
columns()
import os
#open the RM(j) excel and get the dates and RM values
File = openpyxl.load_workbook(r'C:\Users\am332215\Desktop\BIAS\solar\RM(j).xlsx')
Sheet = File.get_sheet_by_name('Sheet1')
dates = []
RM = []
last_row = Sheet.max_row
for r in range(2,last_row+1):
    dates.append(Sheet['A'+str(r)].value)
    RM.append(Sheet['B'+str(r)].value)
File.save(r'C:\Users\am332215\Desktop\BIAS\solar\RM(j).xlsx')
#get paths to nldas excel sheets that needs corrected
path=[]
for          root,          dirs,          filenames          in
os.walk(r'C:\Users\am332215\Desktop\NLDAS_Basin_Weighted_Forcings_05302017\S
olar', topdown=True):
    for f in filenames:
        path.append(os.path.join(root, f))
#multiply nldas data by RM if RM is non null
for p in range(0,len(path)):
    print path[p]
    File = openpyxl.load_workbook(path[p])
    Sheet = File.get_sheet_by_name('Sheet1')
    for r in range(4019,last_row+4018):
        Sheet['D'+str(r)]=dates[r-4019]
        if RM[r-4019]==0:
            Sheet['E'+str(r)]=Sheet['A'+str(r)].value
            print 'RM ' + str(r+1-4019) + ' = 0'
        else:
            Sheet['E'+str(r)]=RM[r-4019]*Sheet['A'+str(r)].value
    File.save(path[p])

```

Filling HEC-DSSVue with NLDAS fields:

```

#-----
# Name:      NLDASfilling
# Purpose:   This is script 1/2 that Inputs NLDAS from Excel to HEC-DSSVue
#           It starts by filling a text file from Excel
#           It then fill the DSSVue from the textfile
# Author:    adil mounir
# Created:   12/06/2017
#-----

import openpyxl #to manipulate excel sheets
from openpyxl.utils import coordinate_from_string #to get the highest row in a column
from openpyxl.utils import (get_column_letter) #to use numbers to refer to excel
columns()
NLDAS = []
last_row = 8331
print 'opening the excel workbook..'
#open the NLDAS excel and get the values
File = openpyxl.load_workbook(r'C:\Users\am332215\Desktop\Adjusted NLDAS
Final\AdjustedNLDAS.xlsx')
Sheet = File.get_sheet_by_name('solar')
for c in range(2,55):
    for r in range(1,last_row+1):
        NLDAS.append(Sheet[get_column_letter(c)+str(r)].value)
    print 'column ' + get_column_letter(c) + ' is appended'
print 'saving the excel workbook..'
File.save(r'C:\Users\am332215\Desktop\Adjusted NLDAS Final\AdjustedNLDAS.xlsx')
print "Excel data appended"
print NLDAS
#write the information in Temperature in text file
print 'writing the information in the text file'
c=0
file = open(r'C:\Users\am332215\Desktop\NLDAS\NLDAS_Adjusted_solar.txt',"w")
length = int(len(NLDAS))
for i in range(0,length):
    file.write("%f\n" % NLDAS[i])
    c=c+1
file.close
print "c = " + str(c)
print "before before last value is " + str(NLDAS[c-3])
print "before last value is " + str(NLDAS[c-2])
print "last value is " + str(NLDAS[c-1])
print "Text file ready"

```

```
#####
# GAMS_to_HEC_HMS.py
# Objective: Import NLDAS from a text file into HEC-DSSVue (NLDASfilling 2/2)
# Last Modified: October 13th,2017
# Adil Mounir (am332215@ohio.edu)
#####
print "\n- Importing HEC Package "
from hec.script import *
from hec.heclib.dss import *
from hec.heclib.util import *
from hec.io import *
import java
#####
from hec.dataTable import *
from java import util
print "\n - Done importing HEC Package\n"
#Create an initial empty storage for flows
NLDAS =[]
#Append NLDAS with data from the textfile
fp = open(r'C:\Users\am332215\Desktop\NLDAS\NLDAS_Adjusted_solar.txt','r')
#open the NLDAS file
file1=fp.readlines()
for row in file1:
    NLDAS.append(float(row.strip()))
fp.close() #finish reading - close file
print "length of NLDAS " + str(len(NLDAS))
print "first value in NLDAS is " + str(NLDAS[0])
print "second value in NLDAS is " + str(NLDAS[1])
print "last value in NLDAS is " + str(len(NLDAS)-1)
subbasins = [
    "/W1000/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W1010/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W1020/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W1030/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W1040/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W1050/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W1060/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W540/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W550/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W560/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W570/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W580/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W590/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
    "/W600/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",

```

```

"/W610/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W620/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W630/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W640/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W650/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W660/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W670/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W680/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W690/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W700/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W710/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W720/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W730/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W740/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W750/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W760/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W770/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W780/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W790/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W800/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W810/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W820/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W830/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W840/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W850/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W860/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W870/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W880/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W890/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W900/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W910/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W920/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W930/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W940/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W950/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W960/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W970/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W980/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/",
"/W990/YRB/SOLAR RADIATION/01JAN1989/1DAY/OBS/"
]
print "DSS paths for each subbasins are ready"
try:
    try:
        # Define and open the HEC-DSS file

```

```

myDss =
HecDss.open(r"C:\Users\am332215\Desktop\HMS_NLDAS_Adjusted_final\YRB_NLDAS_Adjusted_3.5\YRB_NLDAS_Adjusted_3.5_TimeSeries.dss")
tsc = TimeSeriesContainer()
c=0
for p in subbasins:
    # Define the HEC-DSS file path (obtain the path from HEC-DSSVue)
    tsc.fullName = p
    # Define the starting time of the time-series
    start = HecTime("31DEC1989", "00:00")
    # Define the time interval
    tsc.interval = 1440
    # Create empty storage called "times"
    times = []
    # Create loops for array "flows"
    for values in NLDAS:
        # Append each element in the "flows" array into storage times
        times.append(start.value())
        start.add(tsc.interval)
        #print start,"", value
    c=c+1
    tsc.times = times
    tsc.values = NLDAS
    if len(NLDAS)>8331:
        tsc.numberValues = 8331
    else:
        tsc.numberValues = len(NLDAS)
    tsc.units = "WATT/M2"
    tsc.type = "PER-AVER"
    myDss.put(tsc)
    print "length of NLDAS is " + str(len(NLDAS))
    print "Subbasin number " + str(c) + " is ready"
    if c<53:
        del NLDAS[0:8331]
except Exception, e:
    MessageBox.showError(".join(e.args),"Python Error")
except java.lang.Exception, e:
    MessageBox.showError(e.getMessage(),"Error")
finally:
    myDss.close()
print "All done!"

```

Import GAMS output text files to an Excel workbook:

```

#-----
# Name:      text2excel
# Purpose:   Copy GAMS textfile outputs into a desired excel workbook (Angostura
reservoir)
# Author:    adil mounir
# Created:   21/10/2017
#-----

import os
import openpyxl #to manipulate excel sheets
from openpyxl.utils import coordinate_from_string #to get the highest row in a column
from openpyxl.utils import (get_column_letter) #to use numbers to refer to excel
columns()
last_row = last_row = 3288
print "appending results from text files"
Storage=[]
IndustRelease=[]
UrbanRelease=[]
Outflow=[]
Evaporation=[]
Area=[]
#Get storage
path = r'C:\Users\am332215\Documents\gamsdir\projdir\StorageAngostura.txt'
fp = open(path, "r") #open storage file
print "Storage file opened"
file1=fp.readlines()
for row in file1:
    Storage.append(row.strip())
fp.close() #finish reading - close file
#Get mining release
path = r'C:\Users\am332215\Documents\gamsdir\projdir\IndustrialAngostura.txt'
fp = open(path, "r") #open mining release file
print "mining release file opened"
file1=fp.readlines()
for row in file1:
    IndustRelease.append(float(row.strip()))
fp.close() #finish reading - close file
#Get Pueblos release
path = r'C:\Users\am332215\Documents\gamsdir\projdir\UrbanAngostura.txt'
fp = open(path, "r") #open Pueblos release
print "Pueblos release file opened"
file1=fp.readlines()
for row in file1:

```



```

    UrbanRelease.append(float(row.strip()))
fp.close() #finish reading - close file

#Get Outflow
path = r'C:\Users\am332215\Documents\gamsdir\projdir\InstreamAngostura.txt'
fp = open(path, "r") #open Outflow
print "Outflow file opened"
file1=fp.readlines()
for row in file1:
    Outflow.append(float(row.strip()))
fp.close() #finish reading - close file
#Get Evaporation
path = r'C:\Users\am332215\Documents\gamsdir\projdir\EvaporationAngostura.txt'
fp = open(path, "r") #open Evaporation
print "Evaporation file opened"
file1=fp.readlines()
for row in file1:
    Evaporation.append(float(row.strip()))
fp.close() #finish reading - close file
#Get Area
path = r'C:\Users\am332215\Documents\gamsdir\projdir\SurfaceAreaAngostura.txt'
fp = open(path, "r") #open Area
print "Area file opened"
file1=fp.readlines()
for row in file1:
    Area.append(float(row.strip()))
fp.close() #finish reading - close file
print "opening Excel workbook"
File = openpyxl.load_workbook(r'C:\Users\am332215\Desktop\ResultsAngostura.xlsx')
Sheet = File.get_sheet_by_name('Sheet1')
c=0 #Lists' index
for r in range(2,last_row+1):
    Sheet["B"+str(r)]=Storage[c]
    Sheet["C"+str(r)]=IndustRelease[c]
    Sheet["D"+str(r)]=UrbanRelease[c]
    Sheet["E"+str(r)]=Outflow[c]
    Sheet["F"+str(r)]=Evaporation[c]
    Sheet["G"+str(r)]=Area[c]
    c=c+1
print 'saving the excel workbook..'
File.save(r'C:\Users\am332215\Desktop\ResultsAngostura.xlsx')
print "Excel workbook ready"
print "All done!"

```

HEC-HMS and GAMS integration (the batch file in Appendix F explains the order of the scripts to run):

```
#-----
# Name:      DeleteDSS
# Purpose:   Delete existing stored data in DSSVue in order to start a new
#            simulation and store new information
# Author:    Adil Mounir (am332215)
# Created:   09/05/2017
#-----
import os
os.remove(r'C:\Users\am332215\Desktop\YRB1\YRB.dss')
os.remove(r'C:\Users\am332215\Desktop\YRB2\YRB.dss')
os.remove(r'C:\Users\am332215\Desktop\YRB3\YRB.dss')
#####
# DSS1.py
# Objective: Export HEC-DSS data in to an Excel workbook.
# Last Modified: February 5th,2017
# Adil Mounir (am332215@ohio.edu)
#####
print "\n- Importing HEC Package "
from hec.script import *
from hec.heclib.dss import *
from hec.dataTable import *
from java import util
print "\n - Done importing HEC Package"
try:
    print "\n- opening HEC-DSS file\n"
    # Open the DSS
    dssFile = HecDss.open(r"C:\Users\am332215\Desktop\YRB1\YRB.dss", "01JAN1980
2400, 31JAN1980 2400")
    # Access specific data in the DSS file
    # precip = dssFile.get("//SUBBASIN-1/PRECIP-INC/01JAN2000/1DAY/RUN:RUN
1/")
    outflow = dssFile.get("//OUTLET1/FLOW/01JAN1980/1DAY/RUN:TEST/")
except lang.Exception, e :
    # Take care of any missing data or errors
    MessageBox.showError(e.getMessage(), "Error reading data")
# Add Data to a Java vector
datasets = util.Vector()
#datasets.add(precip)
datasets.add(outflow)
# Create an empty storage "list"
list = []
```

```

# Fill the "list" with the DSS data obtained
list.append(datasets)
# Creating a new HEC table prior exporting to an Excel file
table = HecDataTableToExcel.newTable()
# Define the directory and the name of the Excel file
dir = "C:/Users/am332215/Documents/gamsdir/projdir/inflow1.xls"
# Export the Excel file to the desired directory
table.createExcelFile(list, dir)
print ""
print "\nExcel file saved in:", dir
#####
#Get the outflow from the source of the second reservoir to check it's only zero for now
#####
try:
    print "\n- opening HEC-DSS file\n"
    # Open the DSS
    dssFile = HecDss.open(r"C:\Users\am332215\Desktop\YRB2\YRB.dss", "01JAN1980
2400, 31JAN1980 2400")
    # Access specific data in the DSS file
    # precip = dssFile.get("//SUBBASIN-1/PRECIP-INC/01JAN2000/1DAY/RUN:RUN
1/")
    outflow = dssFile.get("//R110/FLOW/01JAN1980/1DAY/RUN:TEST/")
except lang.Exception, e :
    # Take care of any missing data or errors
    MessageBox.showError(e.getMessage(), "Error reading data")
# Add Data to a Java vector
datasets = util.Vector()
#datasets.add(precip)
datasets.add(outflow)
# Create an empty storage "list"
list = []
# Fill the "list" with the DSS data obtained
list.append(datasets)
# Creating a new HEC table prior exporting to an Excel file
table = HecDataTableToExcel.newTable()
# Define the directory and the name of the Excel file
dir = r'C:\Users\am332215\Desktop\Check\Initial\2.xls'
# Export the Excel file to the desired directory
table.createExcelFile(list, dir)
print ""
print "\nExcel file saved in:", dir
#####
#Get the outflow from the source of the third reservoir to check it's only zero for now
#####

```

```

try:
    print "\n- opening HEC-DSS file\n"
    # Open the DSS
    dssFile = HecDss.open(r"C:\Users\am332215\Desktop\YRB3\YRB.dss", "01JAN1980
2400, 31JAN1980 2400")
    # Access specific data in the DSS file
    # precip = dssFile.get("//SUBBASIN-1/PRECIP-INC/01JAN2000/1DAY/RUN:RUN
1/")
    outflow = dssFile.get("//R340/FLOW/01JAN1980/1DAY/RUN:TEST/")
except lang.Exception, e :
    # Take care of any missing data or errors
    MessageBox.showError(e.getMessage(), "Error reading data")
# Add Data to a Java vector
datasets = util.Vector()
#datasets.add(precip)
datasets.add(outflow)
# Create an empty storage "list"
list = []
# Fill the "list" with the DSS data obtained
list.append(datasets)
# Creating a new HEC table prior exporting to an Excel file
table = HecDataTableToExcel.newTable()
# Define the directory and the name of the Excel file
dir = r'C:\Users\am332215\Desktop\Check\Initial\3.xls'
# Export the Excel file to the desired directory
table.createExcelFile(list, dir)
print ""
print "\nExcel file saved in:", dir

#-----
# Name:      ExcelData
# Purpose:   Get a column from an excel sheet and store it in an empty storage
# Author:    adil mounir
# Created:   19/03/2017
#-----

import xlswriter #to create a new workbook
import openpyxl #to manipulate excel sheets
from openpyxl.utils import coordinate_from_string #to get the highest row in a column
import win32com.client as win32
#####
#we need to convert from xls to xlsx because openpyxl doesn't work with xls
def XlstoXlsx(fname): #enter fnam as r'path to the specific file'
    excel = win32.gencache.EnsureDispatch('Excel.Application')
    wb = excel.Workbooks.Open(fname)

```

```

wb.SaveAs(fname+"x", FileFormat = 51) #FileFormat = 51 is for .xlsx extension
wb.Close() #FileFormat = 56 is for .xls extension
excel.Application.Quit()
print "the path to the created excel is:"
print fname+"x"
XlstoXlsx(r'C:\Users\am332215\Documents\gamsdir\projdir\inflow1.xls')
#####
#Open source data file
sourceFile =
openpyxl.load_workbook(r'C:\Users\am332215\Documents\gamsdir\projdir\inflow1.xlsx'
)
sourceSheet = sourceFile.get_sheet_by_name('Sheet1')
#read data from source file and create lists of new data
newList = []
row_count = sourceSheet.max_row
print "number of rows in the excel sheet is: \t" + str(row_count)
for row in range(8, row_count+1):
    data = sourceSheet['C' + str(row)].value
    newList.append(data)
print newList
# Create a workbook and add a worksheet.
def XlstoXlsx(path):
    workbook = xlsxwriter.Workbook(path)
    worksheet = workbook.add_worksheet()
    workbook.close()
XlstoXlsx(r'C:\GAMS\win64\24.6\inGAMS1.xlsx')
#open destination workbook
NewFile = openpyxl.load_workbook(r'C:\GAMS\win64\24.6\inGAMS1.xlsx')
NewSheet = NewFile.get_sheet_by_name('Sheet1')
#fill out the new workbook
NewSheet['B1']="I1"
print 'I1 added'
for i in range(2, row_count-5):
    NewSheet['A'+str(i)]="T"+str(i-1)
print 'T column added'
for i in range(2, row_count-5):
    NewSheet['B'+str(i)]=newList[i-2]
print "inflow added"
NewFile.save(r'C:\GAMS\win64\24.6\inGAMS1.xlsx')
print "Excel file ready to be read by GAMS"

#####
# GAMS_to_HEC_HMS.py
# Objective: Import GAMS outflows into HEC-HMS

```

```

# Last Modified: March 13th,2017
# Adil Mounir (am332215@ohio.edu)
#####
print "\n- Importing HEC Package "
import os
from hec.script import *
from hec.heclib.dss import *
from hec.heclib.util import *
from hec.io import *
import java
#####
from hec.dataTable import *
from java import util
print "\n - Done importing HEC Package\n"
#Create an initial empty storage for flows
flows = []
#Change directory to the output files from GAMS
path = r'C:/GAMS/win64/24.6/Offl.dat'
fp = open(path, "r") #open the release file
print "\n - File opened\n"
file1=fp.readlines()
for row in file1:
    flows.append(float(row.strip()))
fp.close() #finish reading - close file

print flows
# Define and open the HEC-DSS file
myDss = HecDss.open(r"C:\Users\am332215\Desktop\YRB2\YRB.dss")
tsc = TimeSeriesContainer()
# Define the HEC-DSS file path (obtain the path from HEC-DSSVue)
tsc.fullName = "//SOURCE-1/FLOW/01JAN1980/1DAY/RUN:TEST/"
# Define the staring time of the time-series
start = HecTime("31DEC1979", "1330")
# Define the time interval
tsc.interval = 1440
# Create empty storage called "times"
times = []
# Create loops for array "flows"
print "\nimporting following time-series into HEC-DSS data storage file:\n "
print flows
for value in flows :
    # Append each element in the "flows" array into storage times
    times.append(start.value())
    start.add(tsc.interval)

```

```
        #print start,"", value
print "\n"
tsc.times = times
tsc.values = flows
tsc.numberValues = len(flows)
tsc.units = "CFS"
tsc.type = "PER-AVER"
myDss.put(tsc)
#print "\n", nldas,i, "\n"
myDss.close()
print "\n - All done for the 1st reservoir!"
```

APPENDIX F BATCH FILE

This is the only file to run:

```
python C:\Users\am332215\Desktop\1\deleteDSS.py %*
cd "C:\Program Files (x86)\HEC\HEC-HMS\3.5"
call HEC-HMS.cmd -s C:\Users\am332215\Desktop\1\HMS.script
timeout /t 1
cd C:\Program Files (x86)\HEC\HEC-DSSVue
call HEC-DSSVue.cmd C:\Users\am332215\Desktop\2\DSS1.py
timeout /t 1
python C:\Users\am332215\Desktop\3\ExcelData.py %*
timeout /t 1
cd "C:\GAMS\win64\24.6"
gams "C:\Users\am332215\Desktop\3\GAMS3.5.gms"
timeout /t 1
cd C:\Program Files (x86)\HEC\HEC-DSSVue
call HEC-DSSVue.cmd C:\Users\am332215\Desktop\4\GAMS_TO_DSS.py
timeout /t 1
cd "C:\Program Files (x86)\HEC\HEC-HMS\3.5"
call HEC-HMS.cmd -s C:\Users\am332215\Desktop\1\HMS2.script
timeout /t 1
cd C:\Program Files (x86)\HEC\HEC-DSSVue
call HEC-DSSVue.cmd C:\Users\am332215\Desktop\2\DSS2.py
timeout /t 1
python C:\Users\am332215\Desktop\3\ExcelData2.py %*
timeout /t 1
cd "C:\GAMS\win64\24.6"
gams "C:\Users\am332215\Desktop\3\GAMS3.5.2.gms"
timeout /t 1
cd C:\Program Files (x86)\HEC\HEC-DSSVue
call HEC-DSSVue.cmd C:\Users\am332215\Desktop\4\GAMS_TO_DSS2.py
timeout /t 1
cd C:\Program Files (x86)\HEC\HEC-DSSVue
call HEC-DSSVue.cmd C:\Users\am332215\Desktop\2\DSS3.py
timeout /t 1
cd "C:\Program Files (x86)\HEC\HEC-HMS\3.5"
call HEC-HMS.cmd -s C:\Users\am332215\Desktop\1\HMS3.script
timeout /t 1
python C:\Users\am332215\Desktop\3\ExcelData3.py %*
timeout /t 1
cd "C:\GAMS\win64\24.6"
gams "C:\Users\am332215\Desktop\3\GAMS3.5.3.gms"
timeout /t 1
```



```
python C:\Users\am332215\Desktop\4\CutNPaste_releases.py %*  
timeout /t 1
```

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