GEOG210A Assignment Week6

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Question1

```
E = kT.*(1./2).*(T.^2);
```

Question2

(a)

```
dt = 1/365;% over the course of one year
t = [0:dt:1];
kT = 0.1; % cm.* yr.^(-1).*C.^(-2)
Pmax = 100; % cm/yr
Tmax = 25; % C
Tmin = 10; % C
T = ((Tmax - Tmin)./2).*(sin(2*pi*t - pi*(1./2))+1)+Tmin;
% (a)
P = (Pmax./2).*(cos(2*pi*t)+1);
E = kT.*(1./2).*(T.^2);
figure(1);
plot(t,P);
hold on
plot(t,E);
legend('Precipitation','Evapotranspiration');
xlabel('time(year)');
ylabel('moisture flux (cm/yr)');
title('amount of water stored in the aquifer');
```

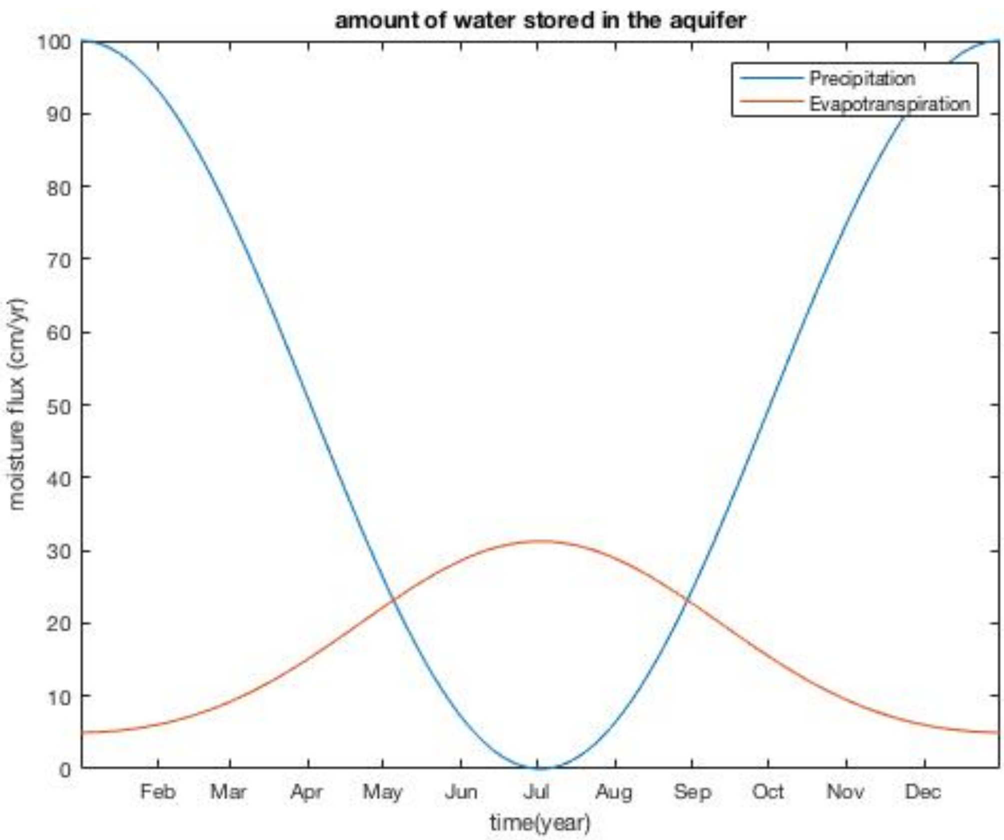

Figure1

(b)

```
% (b)
nt = length(t);
P_int = sum(P(2:nt).*dt); % P_int = 50
% (c)
% months labels
dd = [ 31 28 31 30 31 30 31 31 30 31 31];

% plot something
set(gca,'XTick',cumsum(dd)./365)
set(gca,'XTickLabel',{'Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Oct','Nov','Dec','Jan'})
```

The total rainfall is around 50m over the year.

(c)

From the plot, we could see that there is net evaporation during May, June, July, August, September.

Question3

(a)

```
%% 3
dt = 1/365;
t = [0:dt:1000];
qn = 0;
kb = 0.01; % /yr
ks = 10;
kT = 0.001; % m/yr
Ph = 1; % m/yr
A = 10.^6; % m.^2
Tmax = 25; % C
Tmin = 10; % C
T = ((Tmax - Tmin)./2).*(sin(2*pi*t - pi*(1./2))+1)+Tmin;
Pmax = 1; %m/yr
P = (Pmax./2).*(cos(2*pi*t)+1);
E = kT.*(1./2).*(T.^2);
qs = P/(1+ks*exp(-P/Ph));

figure(2)
plot(t, S, '-ob')
xlabel('time(year)');
ylabel('water storage (m.^3)');
title('Water Storage Over One Thousand Years');
```

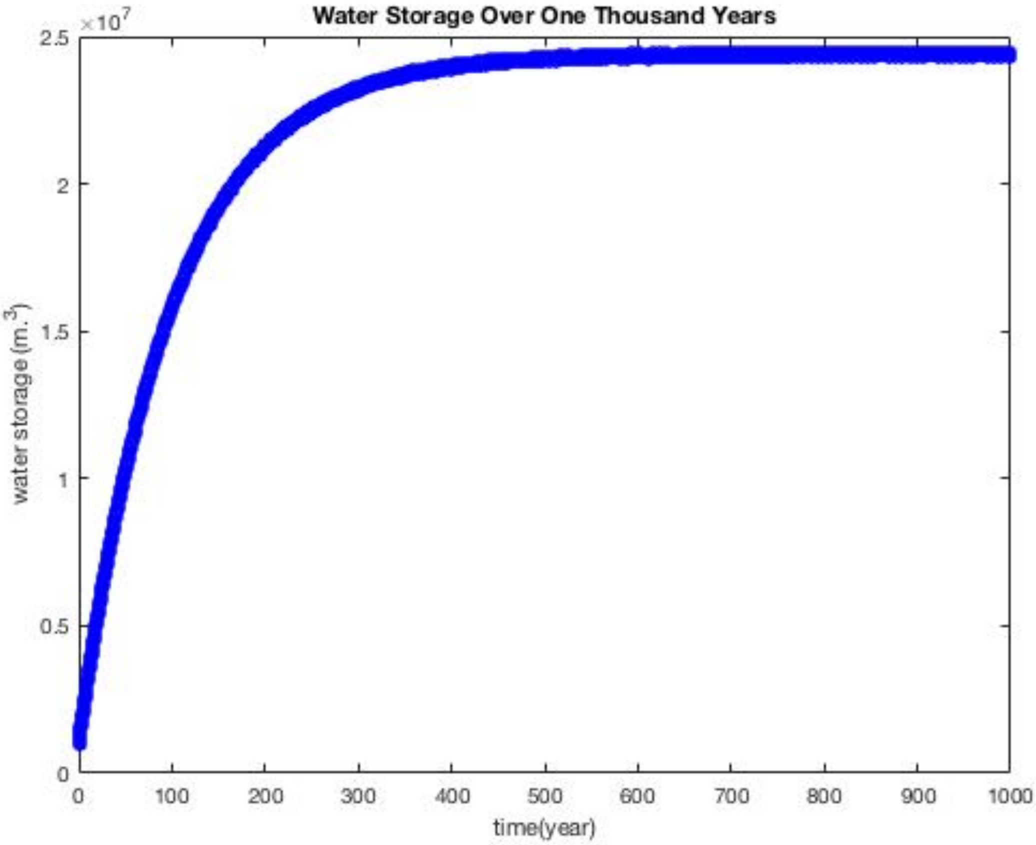

Figure2

From figure2, we could see that the system takes around 600 years to reach the steady-state.

(b)

```
figure(3);
plot(t((600/dt):(605/dt)),S((600/dt):(605/dt)))
xlabel('Time(year)');
ylabel('Water Storage (m.^3)');
title('Water Storage Over Five Years');

% c
% spring 2.434 - 2.443; summer 2.443 - 2.434; fall 2.426 - 2.434; winter
% 2.434 - 2.426
depth = 0.5*(S(605/dt)+S(600/dt))/A; % depth = 24.3445
```

From Figure3, we could tell that the storage is at a maximum during March.

(c)

From Figure3, we know that the range of water storage during spring is 90000 (= 2.443*10.^7 – 2.434*10.^7) m.^3; during summer is 90000 (= 2.443*10.^7 – 2.434*10.^7) m.^3; during fall is 80000 (= 2.434*10.^7 – 2.426*10.^7) m.^3; during winter is 80000 (= 2.434*10.^7 – 2.426*10.^7) m.^3. The mean depth is 24.3445m.

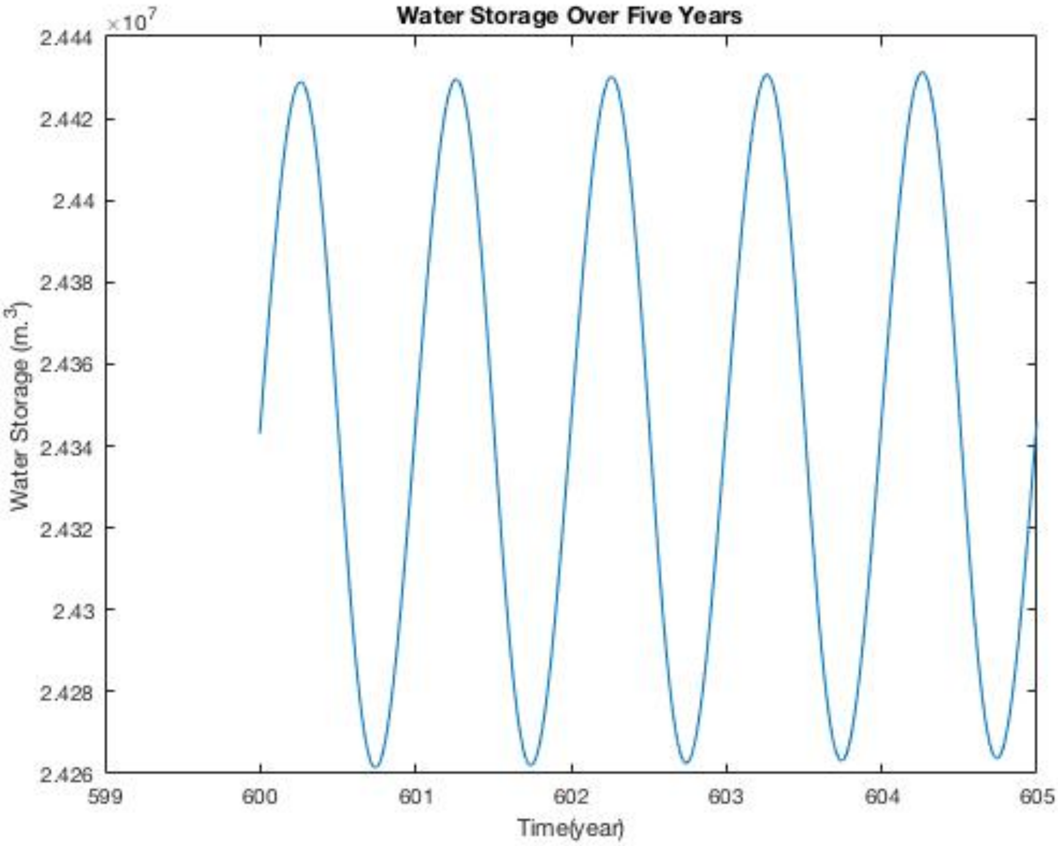

Figure3

Question4

(a)

```
dt = 1/365;
t1 = [0:dt:600];
t2 = [0:dt:650];

qn = 0;
kb = 0.01; % /yr
ks = 10;
kT = 0.001; % m/yr
Ph = 1; % m/yr
A = 10.^6; % m.^2
Tmax = 25; % C
Tmin = 10; % C
Pmax = 1; %m/yr

pr = 100000; % pump rate m.^3/yr

S = 0*t1;
S0 = 10.^6; % m.^3
S(1) = S0; %S = P - E - qs - qn - qb; % steady-state
for i = 2:length(t1)
    P(i-1) = (Pmax/2)*(cos(2*pi*t1(i-1))+1);
    T(i-1) = ((Tmax-Tmin)/2)*(sin(2*pi*t1(i-1)-pi/2)+1)+Tmin;
    E(i-1) = (1/2)*kT*T(i-1).^2;
    qs(i-1) = P(i-1)./(1+ks*exp(-P(i-1)/Ph));
    S(i) = S(i-1) + dt*(P(i-1)*A - E(i-1)*A - qs(i-1)*A - kb*S(i-1));
end


for i = 219001:length(t2)
    P(i-1) = (Pmax/2)*(cos(2*pi*t2(i-1))+1);
    T(i-1) = ((Tmax-Tmin)/2)*(sin(2*pi*t2(i-1)-pi/2)+1)+Tmin;
```

```
    E(i-1) = (1/2)*kT*T(i-1).^2;
    qs(i-1) = P(i-1)./(1+ks*exp(-P(i-1)/Ph));
    S(i) = S(i-1) + dt*(P(i-1)*A - E(i-1)*A - qs(i-1)*A - kb*S(i-1)-pr);
end

figure(4)
plot(t2((600/dt):(650/dt)),S((600/dt):(650/dt)));
xlabel('Time(year)');
ylabel('Water Storage (m.^3)');
title('Water Storage Over Fifty Years');
drop = (S(length(t2))-S(length(t1)))/A; % drop = -3.9118
```

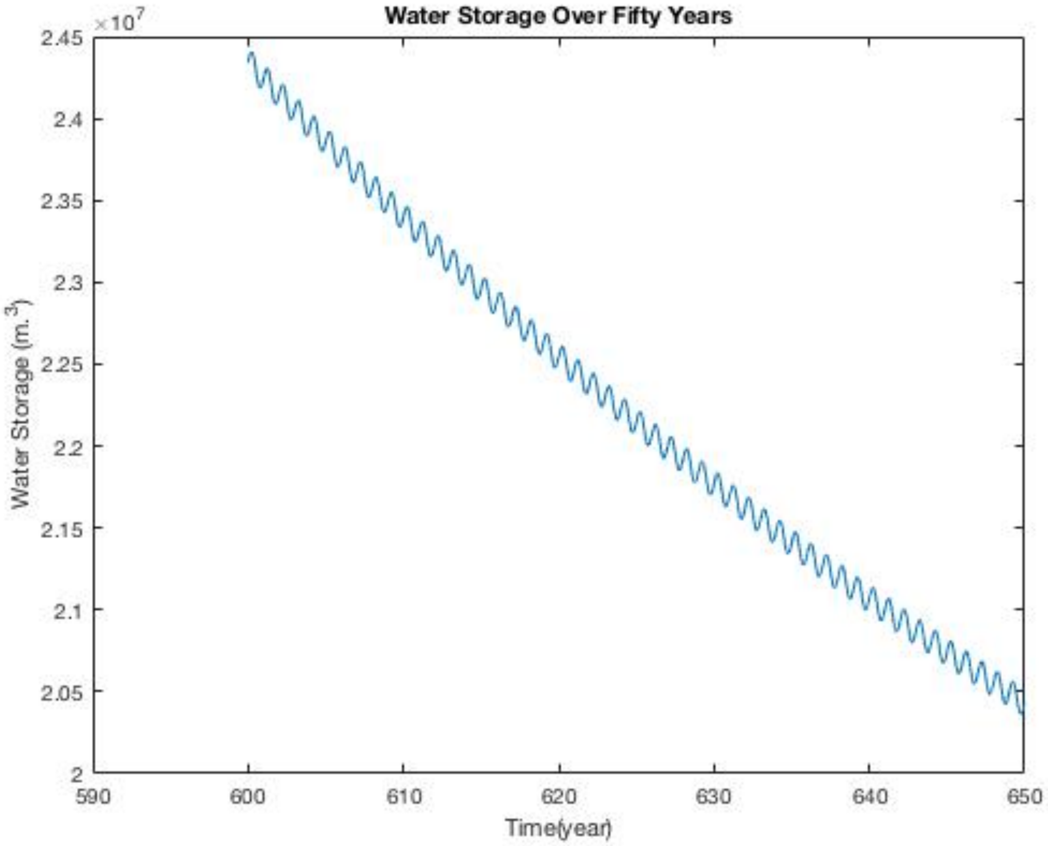

Figure4

After 50 years of this pumping, the water level has dropped 3.9118m.

(b) From figure4, I could tell that this is not a sustainable rate of pumping as the water storage is keep dropping over the years it will drain out eventually.

Question5

```
dt = 1/365;
t1 = [0:dt:600];
t2 = [0:dt:650];

qn = 0;
kb = 0.01; % /yr
ks = 10;
kT = 0.001; % m/yr
Ph = 1; % m/yr
A = 10.^6; % m.^2
Tmax = 25; % C
```

```
Tmin = 10; % C
Pmax = 1; %m/yr

kn = 10000;

S = 0*t1;
S0 = 10.^6; % m.^3
S(1) = S0; %S = P - E - qs - qn - qb; % steady-state
for i = 2:length(t1)
    P(i-1) = (Pmax/2)*(cos(2*pi*t1(i-1))+1);
    T(i-1) = ((Tmax-Tmin)/2)*(sin(2*pi*t1(i-1)-pi/2)+1)+Tmin;
    E(i-1) = (1/2)*kT*T(i-1).^2;
    qs(i-1) = P(i-1)./(1+ks*exp(-P(i-1)/Ph));
    S(i) = S(i-1) + dt*(P(i-1)*A - E(i-1)*A - qs(i-1)*A - kb*S(i-1));
end

for i = 219001:length(t2)
    for j = 2:length(t2)
        qn(j) = qn(j-1)+ kn*dt;
    end
    P(i-1) = (Pmax/2)*(cos(2*pi*t2(i-1))+1);
    T(i-1) = ((Tmax-Tmin)/2)*(sin(2*pi*t2(i-1)-pi/2)+1)+Tmin;
    E(i-1) = (1/2)*kT*T(i-1).^2;
    qs(i-1) = P(i-1)./(1+ks*exp(-P(i-1)/Ph));
    S(i) = S(i-1) + dt*(P(i-1)*A - E(i-1)*A - qs(i-1)*A - kb*S(i-1)-qn(i-1));
end
figure(5)
plot(t2((600/dt):(650/dt)),S((600/dt):(650/dt)));
xlabel('Time(year)');
ylabel('Water Storage (m.^3)');
title('Water Storage Over Fifty Years');
drop = (S(650/dt)-S(600/dt))/A; % drop = -246.7128
```

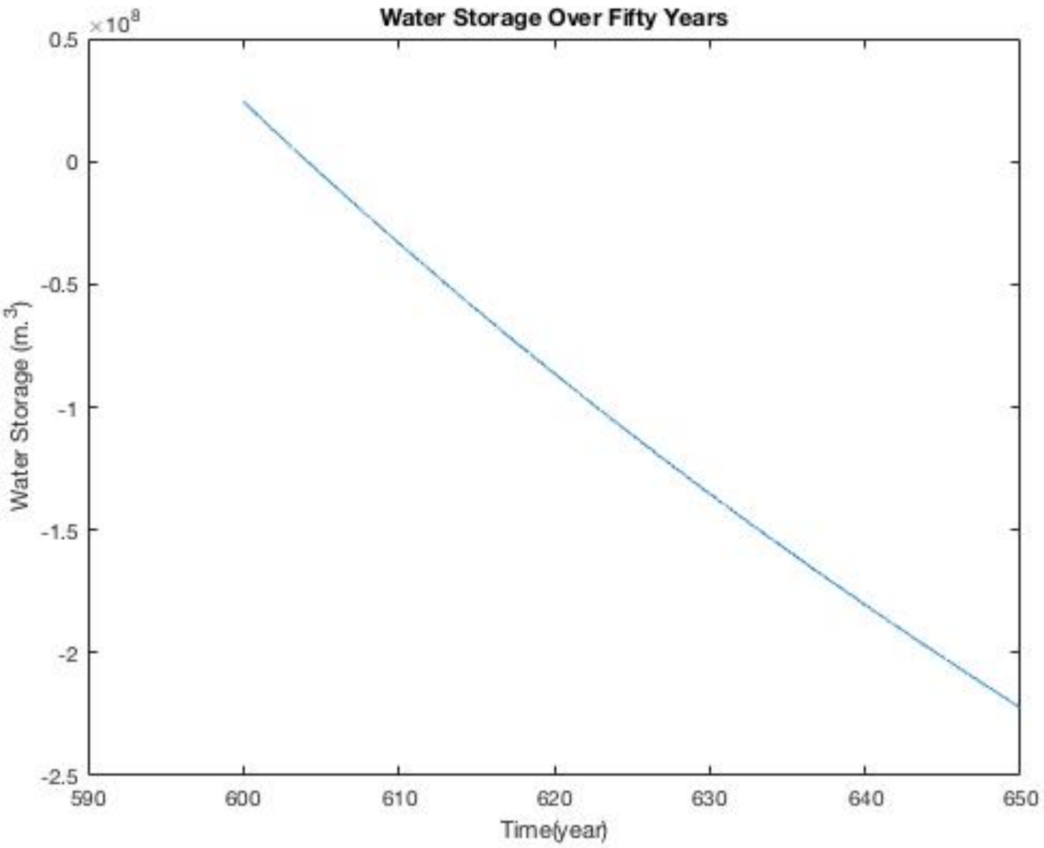

Figure5

The answer shows water level drops 247m over 50 years.

Question6

```
kn = (P(600/dt)*A - E(600/dt)*A - qs(600/dt)*A - kb*S(600/dt))/S(600/dt);
```

Kn = 0.0202 will maintain the aquifer at its current water level.

Question7

(a)

```
dt = 1/365;
t1 = [0:dt:600];
t2 = [0:dt:620];

qn = 0;
kb = 0.01; % /yr
ks = 10;
kT = 0.001; % m/yr
Ph = 1; % m/yr
A = 10.^6; % m.^2
Tmax = 25; % C
Tmaxd = 27;
Tmin = 10; % C
Tmind = 12;

Pmax = 1; %m/yr

S = 0*t1;
S0 = 10.^6; % m.^3
S(1) = S0; %S = P - E - qs - qn - qb; % steady-state
for i = 2:length(t1)
    P(i-1) = (Pmax/2)*(cos(2*pi*t1(i-1))+1);
    T(i-1) = ((Tmax-Tmin)/2)*(sin(2*pi*t1(i-1)-pi/2)+1)+Tmin;
    E(i-1) = (1/2)*kT*T(i-1).^2;
    qs(i-1) = P(i-1)./(1+ks*exp(-P(i-1)/Ph));
    S(i) = S(i-1) + dt*(P(i-1)*A - E(i-1)*A - qs(i-1)*A - kb*S(i-1));
end


for i = 219001:length(t2)
    P(i-1) = (Pmax/2)*(cos(2*pi*t2(i-1))+1);
    T(i-1) = ((Tmaxd-Tmind)/2)*(sin(2*pi*t2(i-1)-pi/2)+1)+Tmind;
    E(i-1) = (1/2)*kT*T(i-1).^2;
    qs(i-1) = P(i-1)./(1+ks*exp(-P(i-1)/Ph));
    S(i) = S(i-1) + dt*(P(i-1)*A - E(i-1)*A - qs(i-1)*A - kb*S(i-1));
end

figure(7)
plot(t2((600/dt):(620/dt)), S((600/dt):(620/dt))/A);
xlabel('Time(year)');
ylabel('Water Storage (m.^3)');
title('Water Storage Over Twenty Years');
```

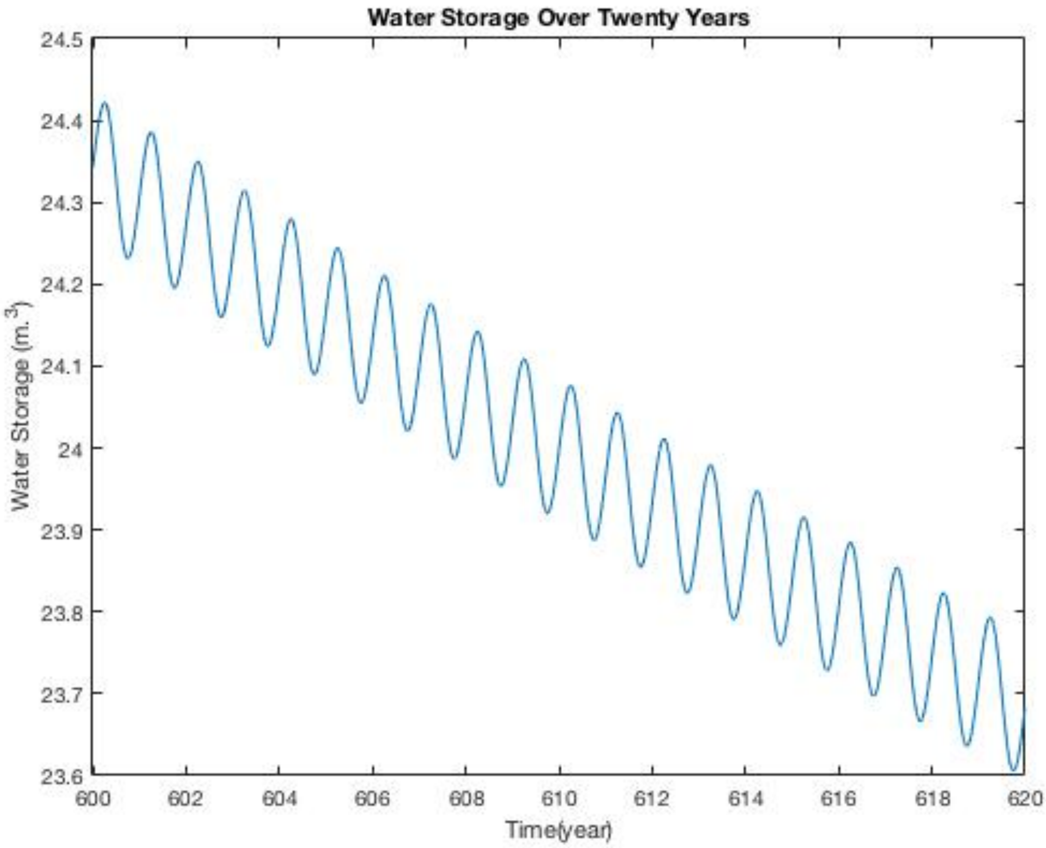

Figure6

The evapotranspiration rises, so the water level drops over twenty years.

(b)

```
change = (S(620/dt)-S(600/dt))/S(600/dt); % change = -0.0271
```

Assuming the population remains constant, per capita water consumption change 2.71% over twenty years.

Question8

```
dt = 1/365;
t1 = [0:dt:600];
t2 = [0:dt:605];

qn = 0;
kb = 0.01; % /yr
ks = 10;
kT = 0.001; % m/yr
Ph = 1; % m/yr
A = 10.^6; % m.^2
Tmax = 25; % C
Tmin = 10; % C

Pmax = 1; %m/yr
Pmaxd = 0.25;

S = 0*t1;
S0 = 10.^6; % m.^3
S(1) = S0; %S = P - E - qs - qn - qb; % steady-state
for i = 2:length(t1)
    P(i-1) = (Pmax/2)*(cos(2*pi*t1(i-1))+1);
    T(i-1) = ((Tmax-Tmin)/2)*(sin(2*pi*t1(i-1)-pi/2)+1)+Tmin;
```

```
    E(i-1) = (1/2)*kT*T(i-1).^2;
    qs(i-1) = P(i-1)./(1+ks*exp(-P(i-1)/Ph));
    S(i) = S(i-1) + dt*(P(i-1)*A - E(i-1)*A - qs(i-1)*A - kb*S(i-1));
end


for i = 219001:length(t2)
    P(i-1) = (Pmaxd/2)*(cos(2*pi*t2(i-1))+1);
    T(i-1) = ((Tmax-Tmin)/2)*(sin(2*pi*t2(i-1)-pi/2)+1)+Tmin;
    E(i-1) = (1/2)*kT*T(i-1).^2;
    qs(i-1) = P(i-1)./(1+ks*exp(-P(i-1)/Ph));
    S(i) = S(i-1) + dt*(P(i-1)*A - E(i-1)*A - qs(i-1)*A - kb*S(i-1));
end

figure(8)
plot(t2((600/dt):(605/dt)), S((600/dt):(605/dt))/A);
xlabel('Time(year)');
ylabel('Water Storage (m.^3)');
title('Water Storage Over Five Years');
drop = (S(605/dt)-S(600/dt))/A; % drop = -1.4587
```

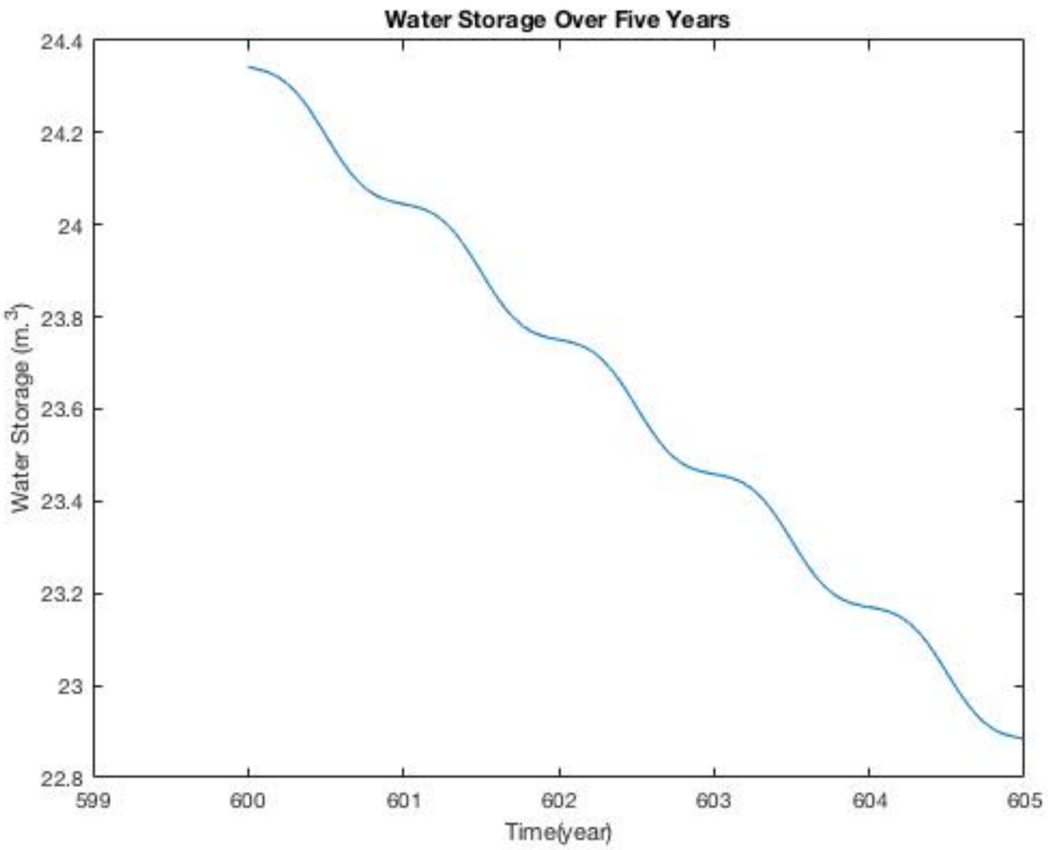

Figure7

The water level in the aquifer drop 1.4587m after 5 years of this drought and warming.

Question9

(1) Many conditions will contaminate water in aquifer and will be good to preclude before using this model. Conditions could be landfills, septic tanks and wells.

(2) Different soil types will have different permeability and porosity, which should be considered in this model.

(3) Continue with point (1), which could lead to artesian aquifer, the water level should be redefined.