Control Óptimo Predictivo de Redes de Alcantarillado

Manuel Pardavila Escalera

Universidad Politècnica de Catalunya

Escola Tècnica Superior d'Enginyeria Industrial de Barcelona

Institut de Robòtica i Informàtica Industrial

Proyecto codirigido por:

Vicenç Puig Cayuela, Bernat Joseph i Duran

ANEXOS

Anexo A Parámetros del modelo CORAL

- Variables de estado (volumen en tanques reales/virtuales)

Variable	Rango	Descripción
V_1	$0 \le V_1 \le 3546$	Volumen tanque virtual 1
V_2	$0 \le V_2 \le 25000$	Volumen tanque virtual 2
V_3	$0 \le V_3 \le 1000000$	Volumen tanque virtual 3
V_4	$0 \le V_4 \le 8626.08$	Volumen tanque virtual 4
V_6	$0 \le V_6 \le 4085$	Volumen tanque virtual 6
V_7	$0 \le V_7 \le 25500$	Volumen tanque virtual 7
V_8	$0 \le V_8 \le 6991$	Volumen tanque virtual 8
V_9	$0 \le V_9 \le 24000$	Volumen tanque virtual 9
V_{10}	$0 \le V_{10} \le 7688$	Volumen tanque virtual 10
V_{11}	$0 \le V_{11} \le 66688$	Volumen tanque virtual 11
V_{12}	$0 \le V_{12} \le 28897$	Volumen tanque virtual 12
V_{DZUN_C1}	$0 \le V_{DZUN\_C1} \le 64000$	Volumen tanque real Zona Universitaria
V_{DDDO}	$0 \le V_{DDDO} \le 46925$	Volumen tanque real Doctor Dolça
V_{DL}	$V_{DL} = 0$	Volumen retención en línea en alcantarillado

- Límites de caudal en los colectores

Variable	Rango	Descripción
C_1	$19.03 > C_1 > 0$	Flujo alcantarillado tanque 1
C_2	$15 > C_2 > 0$	Flujo alcantarillado tanque 2
C_3	$2.50 > C_3 > 0$	Flujo alcantarillado tanque 3
C_4	$16.7 > C_4 > 0$	Flujo alcantarillado tanque 4
C_6	$2.63 > C_6 > 0$	Flujo alcantarillado nodo 6 - R 3
C_7	$10 > C_7 > 0$	Flujo alcantarillado tanque 7
C_8	$20 > C_8 > 0$	Flujo alcantarillado nodo 7 - tanque 10
C_{10}	$20 > C_{10} > 0$	Flujo alcantarillado tanque 10 - tanque 11
C_{11}	$20 > C_{11} > 0$	Flujo alcantarillado tanque 11- CSO
C_{12}	$100 > C_{12} > 0$	Flujo alcantarillado CSO-tanque 12
C_{17}	$100 > C_{17} > 0$	Flujo alcantarillado tanque 12- R4
C_{45}	$13.36 > C_{45} > 0$	Flujo alcantarillado nodo 4 - R 11
C_{50}	$17 > C_{50} > 0$	Flujo alcantarillado tanque 15 - nodo 7
C_{76}	$40.906 > C_{76} > 0$	Flujo alcantarillado nodo 2 - nodo 1

C_{91}	$20.181 > C_{91} > 0$	Flujo alcantarillado nodo 9 - tanque 6
C_{93}	$10.7 > C_{93} > 0$	Flujo alcantarillado tanque 6 - tanque 9
C_{114}	$10.8 > C_{114} > 0$	Flujo alcantarillado R 11 - nodo 5
C_{124}	$2.63 > C_{124} > 0$	Flujo alcantarillado DDDO - nodo 5
C_{125}	$2.63 > C_{125} > 0$	Flujo alcantarillado nodo 5 - nodo 6
C_{134}	$2.63 > C_{134} > 0$	Flujo alcantarillado R 3 - nodo 7
C_{135}	$25.315 > C_{135} > 0$	Flujo alcantarillado tanque 8 - nodo 7
C_{RES}	$30 > C_{RES} > 0$	Flujo alcantarillado R 12 - nodo 9
C_{WWTP}	$2 > C_{WWTP} > 0$	Flujo alcantarillado a WWTP
Q_{14}	$12.125 > Q_{14} > 0$	Flujo alcantarillado R 11 - DDDO
Q_{21}	$46 > Q_{21} > 0$	Flujo alcantarillado nodo 1 - R 12
Q_{39}	$100 > Q_{39} > 0$	Flujo alcantarillado R 4 - Mar
Q_{45}	$29 > Q_{45} > 0$	Flujo alcantarillado nodo 16 - DZUN_C1
Q_{64}	$10 > Q_{64} > 0$	Flujo alcantarillado R 13 - Ronda del Mig
Q_{68}	$47 > Q_{68} > 0$	Flujo alcantarillado U 18 - nodo 2
Q_{72}	$29 > Q_{72} > 0$	Flujo alcantarillado R 12 - nodo 16
Q_{89}	$7.42 > Q_{89} > 0$	Flujo alcantarillado DZUN_C1 - nodo 9
Q_{103}	$15 > Q_{103} > 0$	Flujo alcantarillado U18 - nodo 4

- Variables de control

Variable	Rango	Descripción
CM_{15}	$0 \leq CM_{15} \leq 3.71$	Compuerta de flujo CM_{15}
CM_{19}	$0 \leq CM_{19} \leq 2.55$	Compuerta de flujo CM_{19}
CSO	$0 \leq CSO \leq 41.106$	Compuerta de flujo CSO

Anexo B Codificación GAMS

- **Ecuaciones**

```
* File: main.gms 21/01/2015 12:30:03

* Equation for Basin:V1 ,Id: B1

DEPV1(T) $(MP(T) ne 1).. XV1(T+1) =E= XV1(T) + DELTAT * (AUV1 * RGP3(T) -
QXV1(T) );
CAUDAUXRGV1(T).. QDAUXRGV1(T) =E= AUV1 * RGP3(T);
CAUDDV1(T).. QDV1(T) =E= MAX (0,XV1(T) + DELTAT * (QDAUXRGV1(T) - QXV1(T)
) - VOLMAXV1) / DELTAT;
CAUDSV1(T).. QXV1(T) =E= CVCV1 * XV1(T);
CAUDFC1(T).. QFC1(T) =E= QXV1(T);
PENALV1.. PXV1 =E= SUM(T$(MP(T) ne 1), 1 * QDV1(T) * QDV1(T));

* Equation for Basin:V2 ,Id: B2

DEPV2(T) $(MP(T) ne 1).. XV2(T+1) =E= XV2(T) + DELTAT * (AUV2 * RGP3(T) -
QXV2(T) );
CAUDAUXRGV2(T).. QDAUXRGV2(T) =E= AUV2 * RGP3(T);
CAUDDV2(T).. QDV2(T) =E= MAX (0,XV2(T) + DELTAT * (QDAUXRGV2(T) - QXV2(T)
) - VOLMAXV2) / DELTAT;
CAUDSV2(T).. QXV2(T) =E= CVCV2 * XV2(T);
CAUDFC2(T).. QFC2(T) =E= QXV2(T);
PENALV2.. PXV2 =E= SUM(T$(MP(T) ne 1), 1 * QDV2(T) * QDV2(T));

* Equation for Basin:V3 ,Id: B3

DEPV3(T) $(MP(T) ne 1).. XV3(T+1) =E= XV3(T) + DELTAT * (AUV3 * RGP19(T)
- QXV3(T) );
CAUDAUXRGV3(T).. QDAUXRGV3(T) =E= AUV3 * RGP19(T);
CAUDDV3(T).. QDV3(T) =E= MAX (0,XV3(T) + DELTAT * (QDAUXRGV3(T) - QXV3(T)
) - VOLMAXV3) / DELTAT;
CAUDSV3(T).. QXV3(T) =E= CVCV3 * XV3(T);
CAUDFC3(T).. QFC3(T) =E= QXV3(T);
PENALV3.. PXV3 =E= SUM(T$(MP(T) ne 1), 1 * QDV3(T));

* Equation for Basin:V7 ,Id: B38

DEPV7(T) $(MP(T) ne 1).. XV7(T+1) =E= XV7(T) + DELTAT * (AUV7 * RGP3(T) -
QXV7(T) );
CAUDAUXRGV7(T).. QDAUXRGV7(T) =E= AUV7 * RGP3(T);
CAUDDV7(T).. QDV7(T) =E= MAX (0,XV7(T) + DELTAT * (QDAUXRGV7(T) - QXV7(T)
) - VOLMAXV7) / DELTAT;
CAUDSV7(T).. QXV7(T) =E= CVCV7 * XV7(T);
CAUDFC7(T).. QFC7(T) =E= QXV7(T);
PENALV7.. PXV7 =E= SUM(T$(MP(T) ne 1), 1 * QDV7(T) * QDV7(T));

* Equation for Basin:V4 ,Id: B4

DEPV4(T) $(MP(T) ne 1).. XV4(T+1) =E= XV4(T) + DELTAT * (AUV4 * RGP19(T)
- QXV4(T) );
CAUDAUXRGV4(T).. QDAUXRGV4(T) =E= AUV4 * RGP19(T);
```

```
CAUDDV4(T).. QDV4(T) =E= MAX (0,XV4(T) + DELTAT * (QDAUXRGV4(T) - QXV4(T)
) - VOLMAXV4) / DELTAT;
CAUDSV4(T).. QXV4(T) =E= CVCV4 * XV4(T);
CAUDFC4(T).. QFC4(T) =E= QXV4(T);
PENALV4.. PXV4 =E= SUM(T$(MP(T) ne 1), 1 * QDV4(T) * QDV4(T));

* Equation for Basin:V6 ,Id: B40

DEPV6(T) $(MP(T) ne 1).. XV6(T+1) =E= XV6(T) + DELTAT * (AUV6 * RGP3(T) -
QXV6(T) +QC91(T));
CAUDAUXRGV6(T).. QDAUXRGV6(T) =E= AUV6 * RGP3(T);
CAUDDV6(T).. QDV6(T) =E= MAX (0,XV6(T) + DELTAT * (QDAUXRGV6(T) - QXV6(T)
+QC91(T)) - VOLMAXV6) / DELTAT;
CAUDSV6(T).. QXV6(T) =E= CVCV6 * XV6(T);
CAUDFC93(T).. QFC93(T) =E= QXV6(T);
PENALV6.. PXV6 =E= SUM(T$(MP(T) ne 1), 1 * QDV6(T) * QDV6(T));

* Equation for Basin:V9 ,Id: B41

DEPV9(T) $(MP(T) ne 1).. XV9(T+1) =E= XV9(T) + DELTAT * (AUV9 * RGP3(T) -
QXV9(T) +QC93(T));
CAUDAUXRGV9(T).. QDAUXRGV9(T) =E= AUV9 * RGP3(T);
CAUDDV9(T).. QDV9(T) =E= MAX (0,XV9(T) + DELTAT * (QDAUXRGV9(T) - QXV9(T)
+QC93(T)) - VOLMAXV9) / DELTAT;
CAUDSV9(T).. QXV9(T) =E= CVCV9 * XV9(T);
CAUDFC50(T).. QFC50(T) =E= QXV9(T);
PENALV9.. PXV9 =E= SUM(T$(MP(T) ne 1), 1 * QDV9(T) * QDV9(T));

* Equation for Basin:V8 ,Id: B44

DEPV8(T) $(MP(T) ne 1).. XV8(T+1) =E= XV8(T) + DELTAT * (AUV8 * RGP16(T)
- QXV8(T) );
CAUDAUXRGV8(T).. QDAUXRGV8(T) =E= AUV8 * RGP16(T);
CAUDDV8(T).. QDV8(T) =E= MAX (0,XV8(T) + DELTAT * (QDAUXRGV8(T) - QXV8(T)
) - VOLMAXV8) / DELTAT;
CAUDSV8(T).. QXV8(T) =E= CVCV8 * XV8(T);
CAUDFC135(T).. QFC135(T) =E= QXV8(T);
PENALV8.. PXV8 =E= SUM(T$(MP(T) ne 1), 1 * QDV8(T) * QDV8(T));

* Equation for Basin:V10 ,Id: B57

DEPV10(T) $(MP(T) ne 1).. XV10(T+1) =E= XV10(T) + DELTAT * (AUV10 *
RGP16(T) - QXV10(T) +QC8(T));
CAUDAUXRGV10(T).. QDAUXRGV10(T) =E= AUV10 * RGP16(T);
CAUDDV10(T).. QDV10(T) =E= MAX (0,XV10(T) + DELTAT * (QDAUXRGV10(T) -
QXV10(T) +QC8(T)) - VOLMAXV10) / DELTAT;
CAUDSV10(T).. QXV10(T) =E= CVCV10 * XV10(T);
CAUDFC10(T).. QFC10(T) =E= QXV10(T);
PENALV10.. PXV10 =E= SUM(T$(MP(T) ne 1), 1 * QDV10(T) * QDV10(T));

* Equation for Basin:V11 ,Id: B58

DEPV11(T) $(MP(T) ne 1).. XV11(T+1) =E= XV11(T) + DELTAT * (AUV11 *
RGP11(T) - QXV11(T) +QC10(T));
CAUDAUXRGV11(T).. QDAUXRGV11(T) =E= AUV11 * RGP11(T);
CAUDDV11(T).. QDV11(T) =E= MAX (0,XV11(T) + DELTAT * (QDAUXRGV11(T) -
QXV11(T) +QC10(T)) - VOLMAXV11) / DELTAT;
CAUDSV11(T).. QXV11(T) =E= CVCV11 * XV11(T);
CAUDFC11(T).. QFC11(T) =E= QXV11(T);
```

```
PENALV11.. PXV11 =E= SUM(T$(MP(T) ne 1), 1 * QDV11(T) * QDV11(T));

* Equation for Basin:V12 ,Id: B61

DEPV12(T) $(MP(T) ne 1).. XV12(T+1) =E= XV12(T) + DELTAT * (AUV12 *
RGP11(T) - QXV12(T) +QC12(T));
CAUDAUXRGV12(T).. QDAUXRGV12(T) =E= AUV12 * RGP11(T);
CAUDDV12(T).. QDV12(T) =E= MAX (0,XV12(T) + DELTAT * (QDAUXRGV12(T) -
QXV12(T) +QC12(T)) - VOLMAXV12) / DELTAT;
CAUDSV12(T).. QXV12(T) =E= CVCV12 * XV12(T);
CAUDFC17(T).. QFC17(T) =E= QXV12(T);
PENALV12.. PXV12 =E= SUM(T$(MP(T) ne 1), 1 * QDV12(T) * QDV12(T));

* Equation for Detention Gate:CM15 ,Id: DEG32
CAUDFQ89(T).. QFQ89(T) =L= QFCM15(T);

* Equation for Detention Gate:CM19 ,Id: DEG35
CAUDFC124(T).. QFC124(T) =L= QFCM19(T);

* Equation for Detention Gate:CSO ,Id: DEG64
CAUDFC12(T).. QFC12(T) =L= QFCSO(T);

* Equation for Diversion Gate:U18 ,Id: DIG8
CAUDFQ103(T).. QFQ103(T) =E= QC3(T) - QFQ68(T);
CAUDFAQ103(T).. QFQ103(T) =L= QC3(T) ;
CAUDFBQ103(T).. QFQ68(T) =L= QC3(T) ;

* Equation for Environment:MEDI3 ,Id: E55
TMEDI3(T).. WWPMEDI3(T) =E= QQ64(T);
FSUMMEDI3.. SUMMEDI3 =E= SUM(T$(MP(T) ne 1), WWPMEDI3(T));
FCSUMMEDI3.. PSUMMEDI3 =E= SUM(T$(MP(T) ne 1), 1 * WWPMEDI3(T) *
WWPMEDI3(T));

* Equation for Environment:MEDI2 ,Id: E69
TMEDI2(T).. WWPMEDI2(T) =E= QQ39(T);
FSUMMEDI2.. SUMMEDI2 =E= SUM(T$(MP(T) ne 1), WWPMEDI2(T));
FCSUMMEDI2.. PSUMMEDI2 =E= SUM(T$(MP(T) ne 1), 1 * WWPMEDI2(T));

* Equation for Environment:MEDI1 ,Id: E70
TMEDI1(T).. WWPMEDI1(T) =E= QCWWTP(T);
FSUMMEDI1.. SUMMEDI1 =E= SUM(T$(MP(T) ne 1), WWPMEDI1(T));
FCSUMMEDI1.. PSUMMEDI1 =E= SUM(T$(MP(T) ne 1), 1 * WWPMEDI1(T) *
WWPMEDI1(T));

* Elements for node:N16 ,Id: N22
CAUDFQ45(T).. QFQ45(T) =E= 1 * (QQ72(T));

* Elements for node:N9 ,Id: N23
CAUDFC91(T).. QFC91(T) =E= 1 * (QQ89(T)+QCRES(T));

* Elements for node:N5 ,Id: N24
CAUDFC125(T).. QFC125(T) =E= 1 * (QC124(T)+QC114(T));

* Elements for node:N6 ,Id: N45
CAUDFC6(T).. QFC6(T) =E= 1 * (QC7(T)+QC125(T));

* Elements for node:N7 ,Id: N48
CAUDFC8(T).. QFC8(T) =E= 1 * (QC134(T)+QC50(T)+QC135(T));
```

```
* Elements for node:N1 ,Id: N5
CAUDFQ21(T).. QFQ21(T) =E= 1 * (QC76(T)+QC1(T));

* Elements for node:N2 ,Id: N6
CAUDFC76(T).. QFC76(T) =E= 1 * (QC2(T)+QQ68(T));

* Elements for node:N4 ,Id: N7
CAUDFC45(T).. QFC45(T) =E= 1 * (QC4(T)+QQ103(T));

* Equation for Overflow by Volume:R12 ,Id: OF18
CAUDFCRES(T).. QFCRES(T) =E= QQ21(T) - QFQ72(T);
CAUDFQ72(T).. QFQ72(T) =E= MAX(0, QQ21(T) - LIMR12);


* Equation for Overflow by Volume:R11 ,Id: OF19
CAUDFC114(T).. QFC114(T) =E= QC45(T) - QFQ14(T);
CAUDFQ14(T).. QFQ14(T) =E= MAX(0, QC45(T) - LIMR11);

* Equation for Overflow by Volume:R3 ,Id: OF52
CAUDFC134(T).. QFC134(T) =E= QC6(T) - QFQ64(T);
CAUDFQ64(T).. QFQ64(T) =E= MAX(0, QC6(T) - LIMR3);

* Equation for Overflow by Volume:R4 ,Id: OF68
CAUDFCWWTP(T).. QFCWWTP(T) =E= QC17(T) - QFQ39(T);
CAUDFQ39(T).. QFQ39(T) =E= MAX(0, QC17(T) - LIMR4);


* Equation for Tank:DDDO ,Id: T25
DEPDDDO(T) $(MP(T) ne 1).. XDDDO(T+1) =E= XDDDO(T) + DELTAT * (QQ14(T) -
QC124(T));
CAUDFCM19(T).. QFCM19(T) =L= QLIMCM19;
CAUDDDDDO(T).. QDDDDO(T) =E= MAX (0,XDDDO(T) + DELTAT * (QQ14(T) -
QFC124(T)) - VOLMAXDDDO) / DELTAT;
PENALDDDO.. PXDDDO =E= SUM(T$(MP(T) ne 1), 1 * QDDDDO(T) * QDDDDO(T));

* Equation for Tank:DZUNC1 ,Id: T28
DEPDZUNC1(T) $(MP(T) ne 1).. XDZUNC1(T+1) =E= XDZUNC1(T) + DELTAT *
(QQ45(T) - QQ89(T));
CAUDFCM15(T).. QFCM15(T) =L= QLIMCM15;
CAUDDDZUNC1(T).. QDDZUNC1(T) =E= MAX (0,XDZUNC1(T) + DELTAT * (QQ45(T) -
QFQ89(T)) - VOLMAXDZUNC1) / DELTAT;
PENALDZUNC1.. PXDZUNC1 =E= SUM(T$(MP(T) ne 1), 1 * QDDZUNC1(T) *
QDDZUNC1(T));

* Equation for Tank:DL ,Id: T62
DEPDL(T) $(MP(T) ne 1).. XDL(T+1) =E= XDL(T) + DELTAT * (QC11(T) -
QC12(T));
CAUDFCSO(T).. QFCSO(T) =L= QLIMCSO;
CAUDDDL(T).. QDDL(T) =E= MAX (0,XDL(T) + DELTAT * (QC11(T) - QFC12(T)) -
VOLMAXDL) / DELTAT;
PENALDL.. PXDL =E= SUM(T$(MP(T) ne 1), 1 * QDDL(T) * QDDL(T));

* Elements for sewer:C134 ,Id: ES102
CAUDDC134(T).. QDC134(T) =E= MAX(0,QFC134(T) - LIMC134);
CAUDC134(T).. QC134(T) =E= QFC134(T) - QDC134(T);
SCARSC134(T).. SCC134(T) =E= MAX(0,QFC134(T) - DESC134);
PENALC134.. PQC134 =E= SUM(T$(MP(T) ne 1), 1 * SCC134(T) * SCC134(T));
```

```
* Elements for sewer:CWWTP ,Id: ES71
CAUDDCWWTP(T).. QDCWWTP(T) =E= MAX(0,QFCWWTP(T) - LIMCWWTP);
CAUDCWWTP(T).. QCWWTP(T) =E= QFCWWTP(T) - QDCWWTP(T);
SCARSCWWTP(T).. SCCWWTP(T) =E= MAX(0,QFCWWTP(T) - DESCWWTP);
PENALCWWTP.. PQCWWTP =E= SUM(T$(MP(T) ne 1), 1 * SCCWWTP(T) *
SCCWWTP(T));

* Elements for sewer:Q39 ,Id: ES72
CAUDDQ39(T).. QDQ39(T) =E= MAX(0,QFQ39(T) - LIMQ39);
CAUDQ39(T).. QQ39(T) =E= QFQ39(T) - QDQ39(T);
SCARSQ39(T).. SCQ39(T) =E= MAX(0,QFQ39(T) - DESQ39);
PENALQ39.. PQQ39 =E= SUM(T$(MP(T) ne 1), 1 * SCQ39(T) * SCQ39(T));

* Elements for sewer:C2 ,Id: S10
CAUDDC2(T).. QDC2(T) =E= MAX(0,QFC2(T) - LIMC2);
CAUDC2(T).. QC2(T) =E= QFC2(T) - QDC2(T);
SCARSC2(T).. SCC2(T) =E= MAX(0,QFC2(T) - DESC2);
PENALC2.. PQC2 =E= SUM(T$(MP(T) ne 1), 1 * SCC2(T) * SCC2(T));

* Elements for sewer:Q64 ,Id: S101
CAUDDQ64(T).. QDQ64(T) =E= MAX(0,QFQ64(T) - LIMQ64);
CAUDQ64(T).. QQ64(T) =E= QFQ64(T) - QDQ64(T);
SCARSQ64(T).. SCQ64(T) =E= MAX(0,QFQ64(T) - DESQ64);
PENALQ64.. PQQ64 =E= SUM(T$(MP(T) ne 1), 1 * SCQ64(T) * SCQ64(T));

* Elements for sewer:C3 ,Id: S11
CAUDDC3(T).. QDC3(T) =E= MAX(0,QFC3(T) - LIMC3);
CAUDC3(T).. QC3(T) =E= QFC3(T) - QDC3(T);
SCARSC3(T).. SCC3(T) =E= MAX(0,QFC3(T) - DESC3);
PENALC3.. PQC3 =E= SUM(T$(MP(T) ne 1), 1 * SCC3(T) * SCC3(T));

* Elements for sewer:C4 ,Id: S12
CAUDDC4(T).. QDC4(T) =E= MAX(0,QFC4(T) - LIMC4);
CAUDC4(T).. QC4(T) =E= QFC4(T) - QDC4(T);
SCARSC4(T).. SCC4(T) =E= MAX(0,QFC4(T) - DESC4);
PENALC4.. PQC4 =E= SUM(T$(MP(T) ne 1), 1 * SCC4(T) * SCC4(T));

* Elements for sewer:C76 ,Id: S13
CAUDDC76(T).. QDC76(T) =E= MAX(0,QFC76(T) - LIMC76);
CAUDC76(T).. QC76(T) =E= QFC76(T) - QDC76(T);
SCARSC76(T).. SCC76(T) =E= MAX(0,QFC76(T) - DESC76);
PENALC76.. PQC76 =E= SUM(T$(MP(T) ne 1), 1 * SCC76(T) * SCC76(T));

* Elements for sewer:Q68 ,Id: S14
CAUDDQ68(T).. QDQ68(T) =E= MAX(0,QFQ68(T) - LIMQ68);
CAUDQ68(T).. QQ68(T) =E= QFQ68(T) - QDQ68(T);
SCARSQ68(T).. SCQ68(T) =E= MAX(0,QFQ68(T) - DESQ68);
PENALQ68.. PQQ68 =E= SUM(T$(MP(T) ne 1), 1 * SCQ68(T) * SCQ68(T));

* Elements for sewer:Q103 ,Id: S15
CAUDDQ103(T).. QDQ103(T) =E= MAX(0,QFQ103(T) - LIMQ103);
CAUDQ103(T).. QQ103(T) =E= QFQ103(T) - QDQ103(T);
SCARSQ103(T).. SCQ103(T) =E= MAX(0,QFQ103(T) - DESQ103);
PENALQ103.. PQQ103 =E= SUM(T$(MP(T) ne 1), 1 * SCQ103(T) * SCQ103(T));

* Elements for sewer:C45 ,Id: S20
CAUDDC45(T).. QDC45(T) =E= MAX(0,QFC45(T) - LIMC45);
CAUDC45(T).. QC45(T) =E= QFC45(T) - QDC45(T);
SCARSC45(T).. SCC45(T) =E= MAX(0,QFC45(T) - DESC45);
PENALC45.. PQC45 =E= SUM(T$(MP(T) ne 1), 1 * SCC45(T) * SCC45(T));
```

```
* Elements for sewer:Q21 ,Id: S21
CAUDDQ21(T).. QDQ21(T) =E= MAX(0,QFQ21(T) - LIMQ21);
CAUDQ21(T).. QQ21(T) =E= QFQ21(T) - QDQ21(T);
SCARSQ21(T).. SCQ21(T) =E= MAX(0,QFQ21(T) - DESQ21);
PENALQ21.. PQQ21 =E= SUM(T$(MP(T) ne 1), 1 * SCQ21(T) * SCQ21(T));

* Elements for sewer:Q45 ,Id: S31
CAUDDQ45(T).. QDQ45(T) =E= MAX(0,QFQ45(T) - LIMQ45);
CAUDQ45(T).. QQ45(T) =E= QFQ45(T) - QDQ45(T);
SCARSQ45(T).. SCQ45(T) =E= MAX(0,QFQ45(T) - DESQ45);
PENALQ45.. PQQ45 =E= SUM(T$(MP(T) ne 1), 1 * SCQ45(T) * SCQ45(T));

* Elements for sewer:Q89 ,Id: S34
CAUDDQ89(T).. QDQ89(T) =E= MAX(0,QFQ89(T) - LIMQ89);
CAUDQ89(T).. QQ89(T) =E= QFQ89(T) - QDQ89(T);
SCARSQ89(T).. SCQ89(T) =E= MAX(0,QFQ89(T) - DESQ89);
PENALQ89.. PQQ89 =E= SUM(T$(MP(T) ne 1), 1 * SCQ89(T) * SCQ89(T));

* Elements for sewer:C124 ,Id: S37
CAUDDC124(T).. QDC124(T) =E= MAX(0,QFC124(T) - LIMC124);
CAUDC124(T).. QC124(T) =E= QFC124(T) - QDC124(T);
SCARSC124(T).. SCC124(T) =E= MAX(0,QFC124(T) - DESC124);
PENALC124.. PQC124 =E= SUM(T$(MP(T) ne 1), 1 * SCC124(T) * SCC124(T));

* Elements for sewer:C91 ,Id: S42
CAUDDC91(T).. QDC91(T) =E= MAX(0,QFC91(T) - LIMC91);
CAUDC91(T).. QC91(T) =E= QFC91(T) - QDC91(T);
SCARSC91(T).. SCC91(T) =E= MAX(0,QFC91(T) - DESC91);
PENALC91.. PQC91 =E= SUM(T$(MP(T) ne 1), 1 * SCC91(T) * SCC91(T));

* Elements for sewer:C93 ,Id: S43
CAUDDC93(T).. QDC93(T) =E= MAX(0,QFC93(T) - LIMC93);
CAUDC93(T).. QC93(T) =E= QFC93(T) - QDC93(T);
SCARSC93(T).. SCC93(T) =E= MAX(0,QFC93(T) - DESC93);
PENALC93.. PQC93 =E= SUM(T$(MP(T) ne 1), 1 * SCC93(T) * SCC93(T));

* Elements for sewer:C7 ,Id: S46
CAUDDC7(T).. QDC7(T) =E= MAX(0,QFC7(T) - LIMC7);
CAUDC7(T).. QC7(T) =E= QFC7(T) - QDC7(T);
SCARSC7(T).. SCC7(T) =E= MAX(0,QFC7(T) - DESC7);
PENALC7.. PQC7 =E= SUM(T$(MP(T) ne 1), 1 * SCC7(T) * SCC7(T));

* Elements for sewer:C125 ,Id: S47
CAUDDC125(T).. QDC125(T) =E= MAX(0,QFC125(T) - LIMC125);
CAUDC125(T).. QC125(T) =E= QFC125(T) - QDC125(T);
SCARSC125(T).. SCC125(T) =E= MAX(0,QFC125(T) - DESC125);
PENALC125.. PQC125 =E= SUM(T$(MP(T) ne 1), 1 * SCC125(T) * SCC125(T));

* Elements for sewer:C50 ,Id: S49
CAUDDC50(T).. QDC50(T) =E= MAX(0,QFC50(T) - LIMC50);
CAUDC50(T).. QC50(T) =E= QFC50(T) - QDC50(T);
SCARSC50(T).. SCC50(T) =E= MAX(0,QFC50(T) - DESC50);
PENALC50.. PQC50 =E= SUM(T$(MP(T) ne 1), 1 * SCC50(T) * SCC50(T));

* Elements for sewer:C135 ,Id: S50
CAUDDC135(T).. QDC135(T) =E= MAX(0,QFC135(T) - LIMC135);
CAUDC135(T).. QC135(T) =E= QFC135(T) - QDC135(T);
SCARSC135(T).. SCC135(T) =E= MAX(0,QFC135(T) - DESC135);
```

```
PENALC135.. PQC135 =E= SUM(T$(MP(T) ne 1), 1 * SCC135(T) * SCC135(T));

* Elements for sewer:C6 ,Id: S53
CAUDDC6(T).. QDC6(T) =E= MAX(0,QFC6(T) - LIMC6);
CAUDC6(T).. QC6(T) =E= QFC6(T) - QDC6(T);
SCARSC6(T).. SCC6(T) =E= MAX(0,QFC6(T) - DESC6);
PENALC6.. PQC6 =E= SUM(T$(MP(T) ne 1), 1 * SCC6(T) * SCC6(T));

* Elements for sewer:C8 ,Id: S59
CAUDDC8(T).. QDC8(T) =E= MAX(0,QFC8(T) - LIMC8);
CAUDC8(T).. QC8(T) =E= QFC8(T) - QDC8(T);
SCARSC8(T).. SCC8(T) =E= MAX(0,QFC8(T) - DESC8);
PENALC8.. PQC8 =E= SUM(T$(MP(T) ne 1), 1 * SCC8(T) * SCC8(T));


* Elements for sewer:C10 ,Id: S60
CAUDDC10(T).. QDC10(T) =E= MAX(0,QFC10(T) - LIMC10);
CAUDC10(T).. QC10(T) =E= QFC10(T) - QDC10(T);
SCARSC10(T).. SCC10(T) =E= MAX(0,QFC10(T) - DESC10);
PENALC10.. PQC10 =E= SUM(T$(MP(T) ne 1), 1 * SCC10(T) * SCC10(T));

* Elements for sewer:C11 ,Id: S63
CAUDDC11(T).. QDC11(T) =E= MAX(0,QFC11(T) - LIMC11);
CAUDC11(T).. QC11(T) =E= QFC11(T) - QDC11(T);
SCARSC11(T).. SCC11(T) =E= MAX(0,QFC11(T) - DESC11);
PENALC11.. PQC11 =E= SUM(T$(MP(T) ne 1), 1 * SCC11(T) * SCC11(T));

* Elements for sewer:C12 ,Id: S66
CAUDDC12(T).. QDC12(T) =E= MAX(0,QFC12(T) - LIMC12);
CAUDC12(T).. QC12(T) =E= QFC12(T) - QDC12(T);
SCARSC12(T).. SCC12(T) =E= MAX(0,QFC12(T) - DESC12);
PENALC12.. PQC12 =E= SUM(T$(MP(T) ne 1), 1 * SCC12(T) * SCC12(T));

* Elements for sewer:C17 ,Id: S73
CAUDDC17(T).. QDC17(T) =E= MAX(0,QFC17(T) - LIMC17);
CAUDC17(T).. QC17(T) =E= QFC17(T) - QDC17(T);
SCARSC17(T).. SCC17(T) =E= MAX(0,QFC17(T) - DESC17);
PENALC17.. PQC17 =E= SUM(T$(MP(T) ne 1), 1 * SCC17(T) * SCC17(T));

* Elements for sewer:C1 ,Id: S9
CAUDDC1(T).. QDC1(T) =E= MAX(0,QFC1(T) - LIMC1);
CAUDC1(T).. QC1(T) =E= QFC1(T) - QDC1(T);
SCARSC1(T).. SCC1(T) =E= MAX(0,QFC1(T) - DESC1);
PENALC1.. PQC1 =E= SUM(T$(MP(T) ne 1), 1 * SCC1(T) * SCC1(T));

* Elements for sewer:CRES ,Id: S95
CAUDDCRES(T).. QDCRES(T) =E= MAX(0,QFCRES(T) - LIMCRES);
CAUDCRES(T).. QCRES(T) =E= QFCRES(T) - QDCRES(T);
SCARSCRES(T).. SCCRES(T) =E= MAX(0,QFCRES(T) - DESCRES);
PENALCRES.. PQCRES =E= SUM(T$(MP(T) ne 1), 1 * SCCRES(T) * SCCRES(T));

* Elements for sewer:Q72 ,Id: S96
CAUDDQ72(T).. QDQ72(T) =E= MAX(0,QFQ72(T) - LIMQ72);
CAUDQ72(T).. QQ72(T) =E= QFQ72(T) - QDQ72(T);
SCARSQ72(T).. SCQ72(T) =E= MAX(0,QFQ72(T) - DESQ72);
PENALQ72.. PQQ72 =E= SUM(T$(MP(T) ne 1), 1 * SCQ72(T) * SCQ72(T));

* Elements for sewer:C114 ,Id: S97
CAUDDC114(T).. QDC114(T) =E= MAX(0,QFC114(T) - LIMC114);
```

```
CAUDC114(T).. QC114(T) =E= QFC114(T) - QDC114(T);
SCARSC114(T).. SCC114(T) =E= MAX(0,QFC114(T) - DESC114);
PENALC114.. PQC114 =E= SUM(T$(MP(T) ne 1), 1 * SCC114(T) * SCC114(T));

* Elements for sewer:Q14 ,Id: S98
CAUDDQ14(T).. QDQ14(T) =E= MAX(0,QFQ14(T) - LIMQ14);
CAUDQ14(T).. QQ14(T) =E= QFQ14(T) - QDQ14(T);
SCARSQ14(T).. SCQ14(T) =E= MAX(0,QFQ14(T) - DESQ14);
PENALQ14.. PQQ14 =E= SUM(T$(MP(T) ne 1), 1 * SCQ14(T) * SCQ14(T));

* Global equations:

TCALLE(T).. CALLE(T) =E= QDV1(T) + QDV2(T) + QDV3(T) + QDV7(T) + QDV4(T)
+ QDV6(T) + QDV9(T) + QDV8(T) + QDV10(T) + QDV11(T) + QDV12(T) +
QDC134(T) + QDCWWTP(T) + QDQ39(T) + QDC2(T) + QDQ64(T) + QDC3(T) +
QDC4(T) + QDC76(T) + QDQ68(T) + QDQ103(T) + QDC45(T) + QDQ21(T) +
QDQ45(T) + QDQ89(T) + QDC124(T) + QDC91(T) + QDC93(T) + QDC7(T) +
QDC125(T) + QDC50(T) + QDC135(T) + QDC6(T) + QDC8(T) + QDC10(T) +
QDC11(T) + QDC12(T) + QDC17(T) + QDC1(T) + QDCRES(T) + QDQ72(T) +
QDC114(T) + QDQ14(T);
FCSUMCALLE.. SUMCALLE =E= SUM(T$(MP(T) ne 1), CALLE(T));
*FCSUMPENAL.. SUMPENAL =E= 0;
FCSUMPENALMEDIO.. SUMPENALMEDIO =E= 1 * (0);
FCSUMPENALMEDIOSEWER.. SUMPENALMEDIOSEWER =E= 1 * (0);

FSafe.. SAFETY =E= PQC1 + PQC10 + PQC11 + PQC114 + PQC12 + PQC124 +
PQC125 + PQC134 + PQC135 + PQC17 + PQC2 + PQC3 + PQC4 + PQC45 + PQC50 +
PQC6 + PQC7 + PQC76 + PQC8 + PQC91 + PQC93 + PQCRES + PQQ103 + PQQ14 +
PQQ21 + PQQ45 + PQQ68 + PQQ72 + PQQ89 + PXV1 + PXV10 + PXV11 + PXV12 +
PXV2 + PXV3 + PXV4 + PXV6 + PXV7 + PXV8 + PXV9;

FMar..    FMM      =E= SUM(T$(MP(T) ne 1), 1 * QQ39(T) * QQ39(T));
FRondaMig..  FRM      =E= SUM(T$(MP(T) ne 1), 1 * QQ64(T) * QQ64(T));
WWTP..    FWWTP    =E= SUM(T$(MP(T) ne 1), 1 * WWPMEDI1(T) *
WWPMEDI1(T));


FCOSTE..    FC  =E= SAFETY - FWWTP + FMM + FRM;
```

- ***Main***

```
* File: main.gms 19/01/2015 12:17:16
$eolcom #
$if exist Parameters.gms $include Parameters.gms
$if exist lluvia.gms $include lluvia.gms
$if exist histcond.gms $include histcond.gms
$if exist Equations.gms $include equations.gms
$if exist Bounds.gms $include Bounds.gms
$if exist dep_ini.gms $include dep_ini.gms
$if exist mouse.gms $include mouse.gms
MODEL AM619 /ALL/;
OPTION DNLP = conopt3;
AM619.WORKSPACE = 10;
OPTION LIMROW = 25;
AM619.SCALEOPT = 1;
AM619.OPTFILE = 1;
OPTION RESLIM = 240;
OPTION ITERLIM = 100000;
SOLVE AM619 USING DNLP MINIMIZING FC;
```

```
$if exist res_mat.gms $include res_mat.gms
$if exist res_mat.gms $include res_gates.gms
$if exist res_mat.gms $include res_weirs.gms
$if exist res_obj.gms $include res_obj.gms
```

- ***Dep_Ini***

```
XV1.LO('0') = 3.500000;
XV1.UP('0') = 3.500000;

XV2.LO('0') = 22.277847;
XV2.UP('0') = 22.277847;

XV3.LO('0') = 121.608040;
XV3.UP('0') = 121.608040;

XV4.LO('0') = 4.071247;
XV4.UP('0') = 4.071247;

XV6.LO('0') = 35.839695;
XV6.UP('0') = 35.839695;

XV7.LO('0') = 28.974359;
XV7.UP('0') = 28.974359;

XV8.LO('0') = 16.266667;
XV8.UP('0') = 16.266667;

XV9.LO('0') = 53.230769;
XV9.UP('0') = 53.230769;

XV10.LO('0') = 80.366667;
XV10.UP('0') = 80.366667;

XV11.LO('0') = 375.848564;
XV11.UP('0') = 375.848564;

XV12.LO('0') = 166.701299;
XV12.UP('0') = 166.701299;

XDDDO.LO('0') = 12274.400000;
XDDDO.UP('0') = 12274.400000;

XDL.LO('0') = 1298.176188;
XDL.UP('0') = 1298.176188;

XDZUNC1.LO('0') = 46020.475000;
XDZUNC1.UP('0') = 46020.475000;
```

- ***Bounds***

```
* Fitxer:C:\Documents and
Settings\sac\Escritorio\EqRieraBlancaTestDDDO_2\Bounds.gms


* Limits Comporta Retencio CM15

        QFCM15.LO(T)    =       0;
        QFQ89.UP(T)     =       7.42;
* Limits Comporta Retencio CM19

        QFCM19.LO(T)    =       0;
        QFC124.UP(T)    =       2.63;
* Limits Comporta Retencio CSO

        QFCSO.LO(T)     =       0;
        QFC12.UP(T)     =       100.00;
* Limits del Diposit Real DDDO

        XDDDO.LO(T)     =       0;
        XDDDO.UP(T)     =       54918.00;
        XDDDO.LO('0')   =       0.00;
        XDDDO.UP('0')   =       0.00;
* Limits del Diposit Real DL

        XDL.LO(T)       =       0;
        XDL.UP(T)       =       27758;
        XDL.LO('0')     =       0.00;
        XDL.UP('0')     =       0.00;
* Limits del Diposit Real DZUN_C1

        XDZUNC1.LO(T)  =       0;
        XDZUNC1.UP(T)  =       102524.00;
        XDZUNC1.LO('0')        =       0.00;
        XDZUNC1.UP('0')        =       0.00;
* Limits del Diposit Virtual V1

        XV1.LO('0')     =       0.00;
        XV1.UP('0')     =       0.00;
* Limits del Diposit Virtual V10

        XV10.LO('0')    =       0.00;
        XV10.UP('0')    =       0.00;
* Limits del Diposit Virtual V11

        XV11.LO('0')    =       0.00;
        XV11.UP('0')    =       0.00;
* Limits del Diposit Virtual V12

        XV12.LO('0')    =       0.00;
        XV12.UP('0')    =       0.00;
* Limits del Diposit Virtual V2

        XV2.LO('0')     =       0.00;
        XV2.UP('0')     =       0.00;
* Limits del Diposit Virtual V3
```

```
        XV3.LO('0')     =       0.00;
        XV3.UP('0')     =       0.00;
* Limits del Diposit Virtual V4

        XV4.LO('0')     =       0.00;
        XV4.UP('0')     =       0.00;
* Limits del Diposit Virtual V6

        XV6.LO('0')     =       0.00;
        XV6.UP('0')     =       0.00;
* Limits del Diposit Virtual V7

        XV7.LO('0')     =       0.00;
        XV7.UP('0')     =       0.00;
* Limits del Diposit Virtual V8

        XV8.LO('0')     =       0.00;
        XV8.UP('0')     =       0.00;
* Limits del Diposit Virtual V9

        XV9.LO('0')     =       0.00;
        XV9.UP('0')     =       0.00;
```

Anexo C Comparativa CORAL-MATLAB-MOUSE

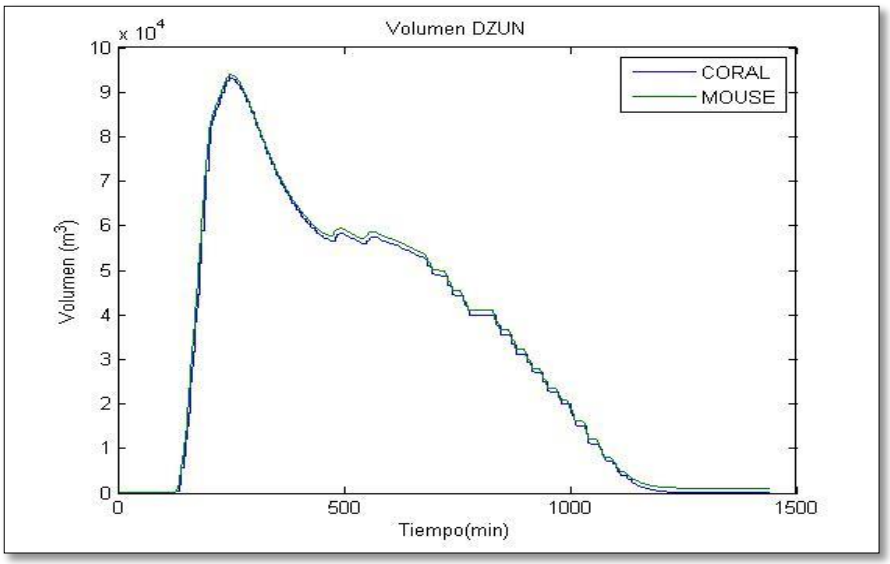
- **Código completo Matlab para realizar las representaciones**

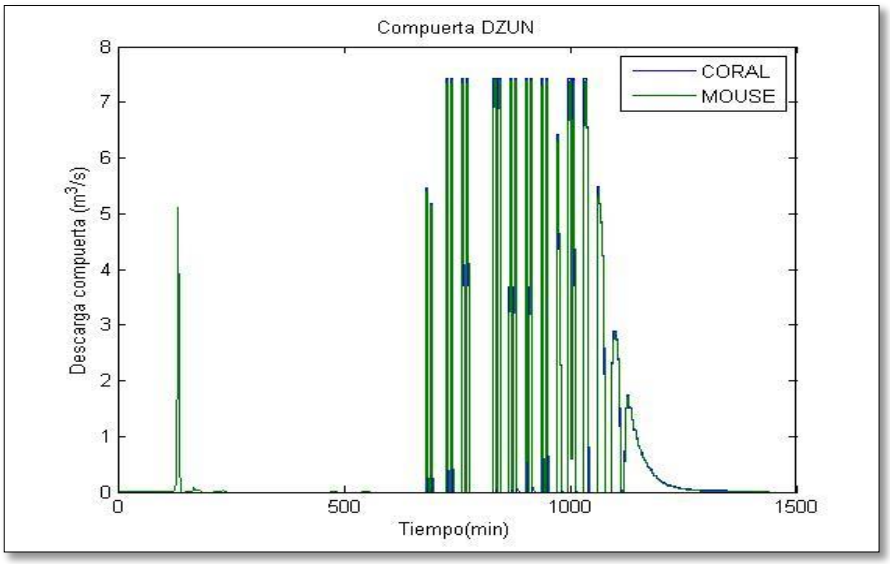
```
T(2) = 860;

I = sparse(5*T(ep),T(ep));

for i = 1:T(ep)
    I((i-1)*5+1:i*5,i) = ones(5,1);
end

return


%% Diposits

%% GDDDO
figure
plot([I*GDDDO(:,1) G(3,:)'+G(6,:)'])
legend('CORAL','MOUSE');
title('Compuerta DDDO')
xlabel('Tiempo(min)');
ylabel ('Descarga compuerta (m^3/s)')

%% GDZUN
figure
plot([I*GDZUN(:,1) G(4,:)'+G(5,:)'])
legend('CORAL','MOUSE');
title('Compuerta DZUN')
xlabel('Tiempo(min)');
ylabel ('Descarga compuerta (m^3/s)')

%% GCSO
figure
plot([I*GCSO(:,1) G(7,:)'])
legend('CORAL','MOUSE');
title('Compuerta CSO')
xlabel('Tiempo(min)');
ylabel ('Descarga compuerta (m^3/s)')

%% WWTP
figure
plot([2*ones(5*T(ep),1) G(10,:)'])
legend('CORAL','MOUSE');
title('WWTP')
xlabel('Tiempo(min)');
ylabel ('Caudal entra (m^3/s)')

%% Volum DZUN
figure
VDZUN = cumsum(G(8,:)-G(4,:)-G(5,:))*60;
plot([I*Res.XDZUN_C1(:,1) VDZUN']);
```

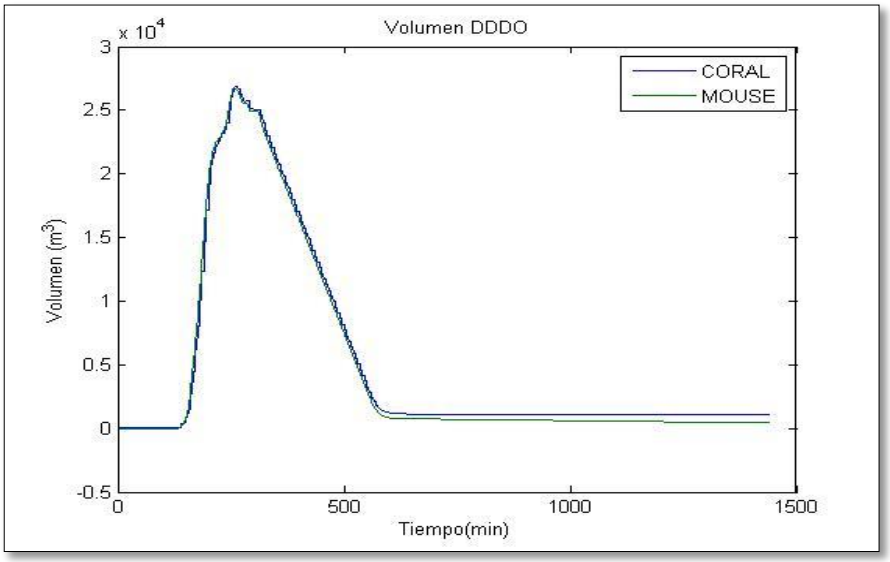
```
legend('CORAL','MOUSE');
title('Volumen DZUN')
xlabel('Tiempo(min)');
ylabel( 'Volumen (m^3)');

%% Volum DDDO
figure
%VDDDO = cumsum(G(9,:)-G(3,:)-G(6,:))*60;
VDDDO = cumsum(G(9,:)-Qin(89,:))*60;
plot([I*Res.XDDDO(:,1) VDDDO']);
legend('CORAL','MOUSE');
title('Volumen DDDO')
xlabel('Tiempo(min)');
ylabel( 'Volumen (m^3)');
```

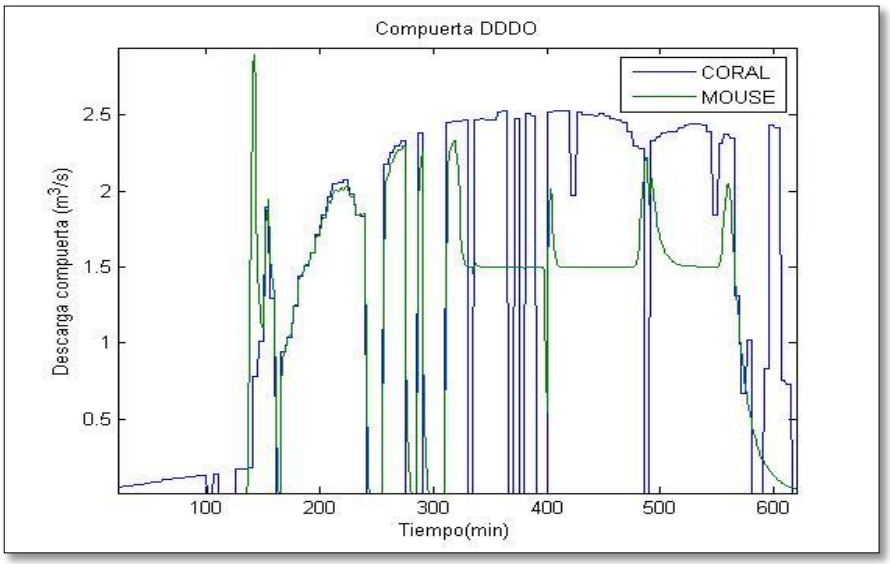
Es el código para representar los elementos más importantes de la red; tanto los depósitos como los puntos críticos de la planta de tratamiento y de los posibles vertidos al mar. A continuación se muestran algunos de los gráficos obtenidos con ese código para los eventos de estudio.

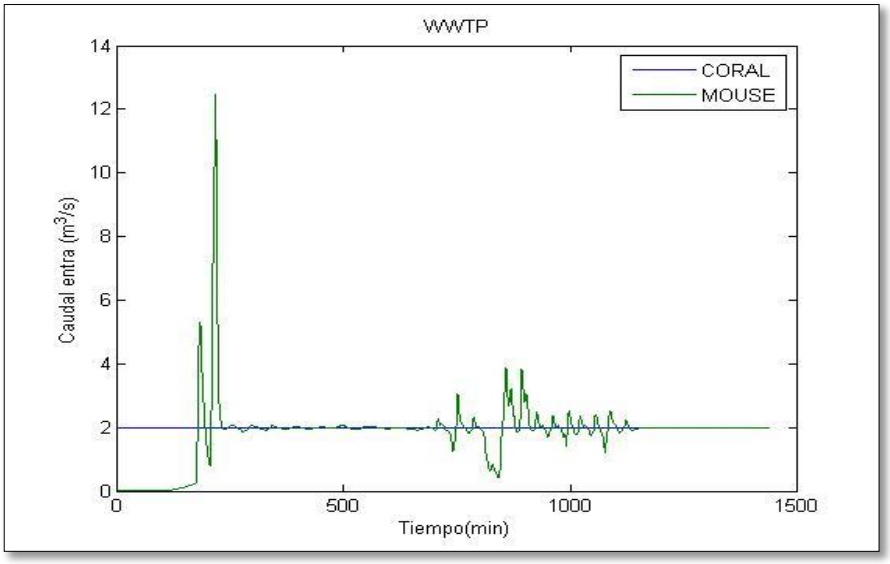
- **Gráficos**

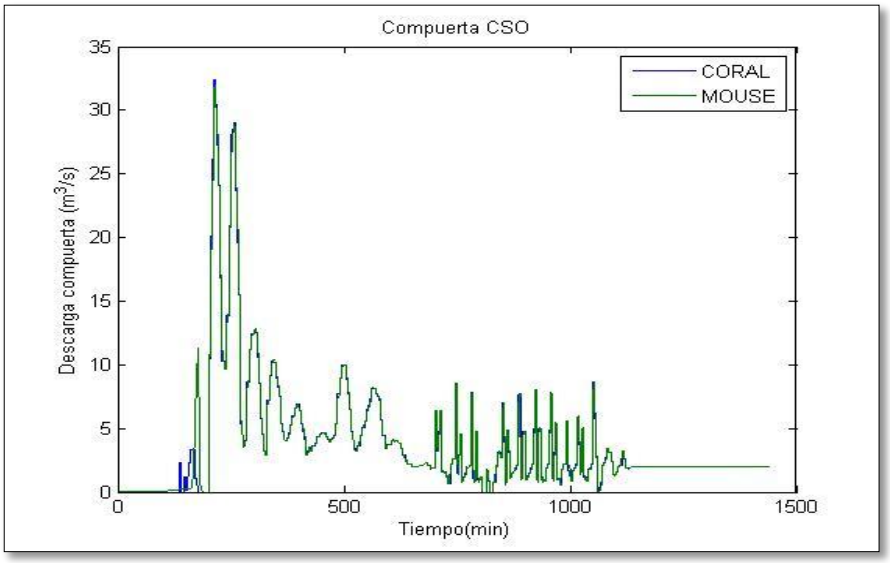


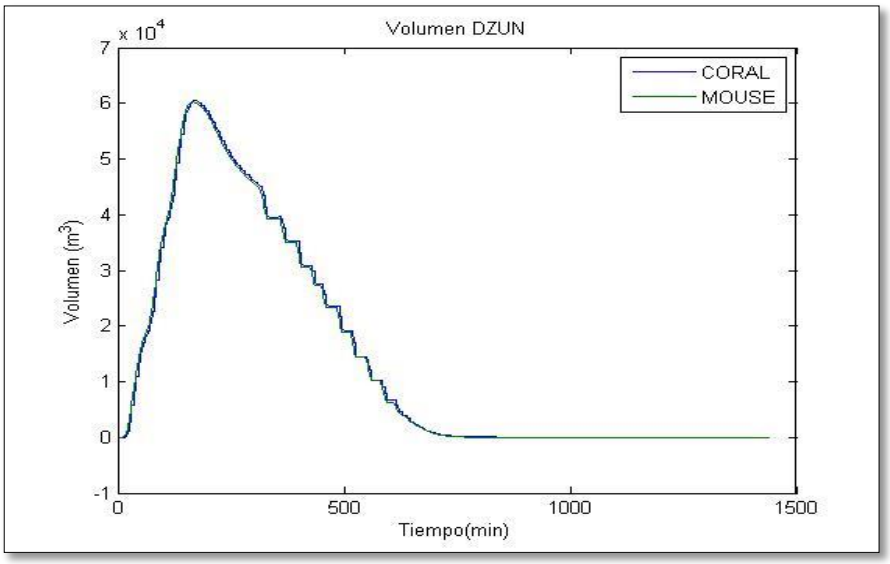

Compuerta DZUN
CORAL
MOUSE
Descarga compuerta (m3/s)
Tiempo(min)
0
1
2
3
4
5
6
7
8
0
500
1000
1500

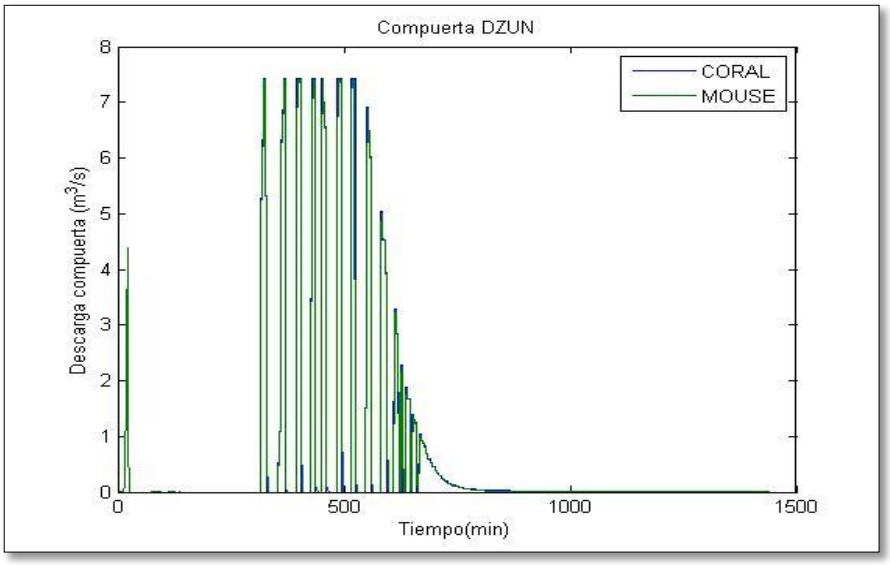

Volumen DDDO
x 10^4
CORAL
MOUSE
Volumen (m3)
Tiempo(min)
-0.5
0
0.5
1
1.5
2
2.5
3
0
500
1000
1500

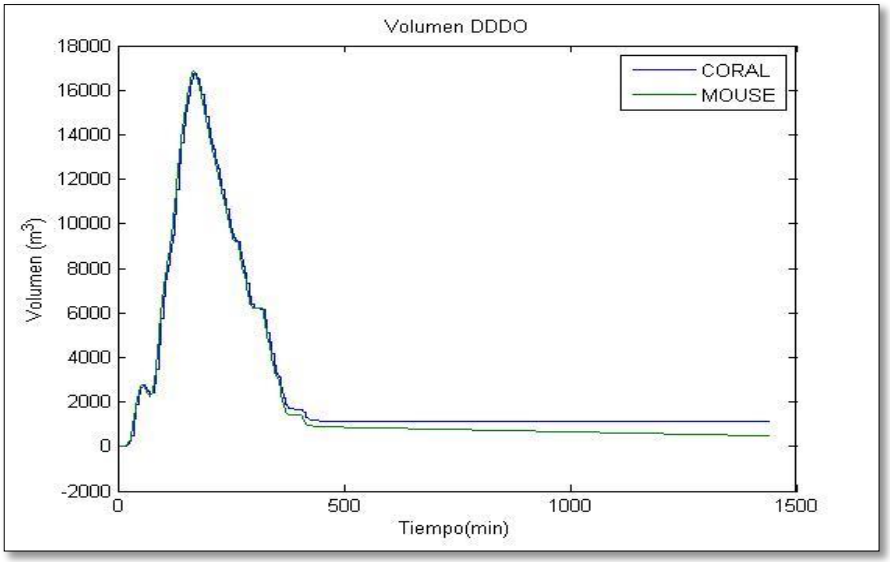

Compuerta DDDO
CORAL
MOUSE
Descarga compuerta (m3/s)
Tiempo(min)
0.5
1
1.5
2
2.5
100
200
300
400
500
600

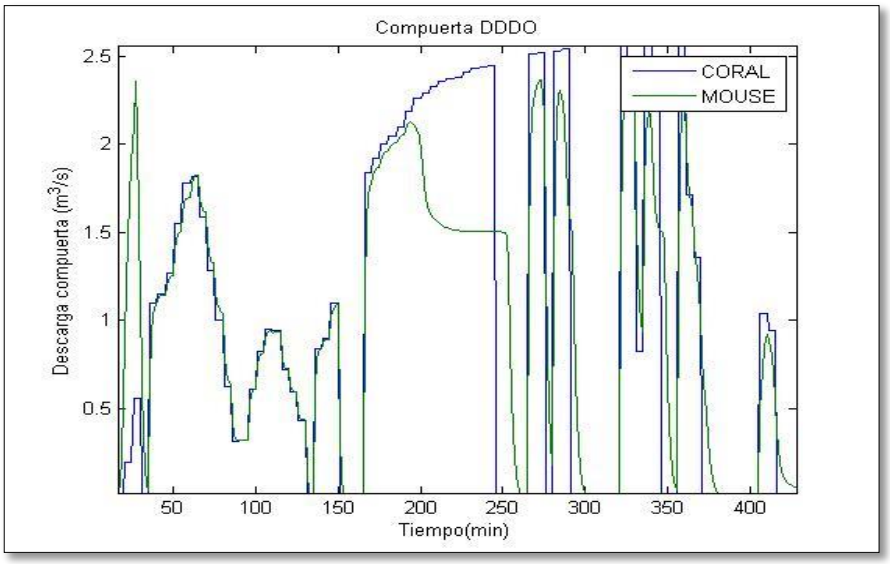

WWTP
CORAL
MOUSE
Caudal entra (m3/s)
Tiempo(min)
0
2
4
6
8
10
12
14
0
500
1000
1500

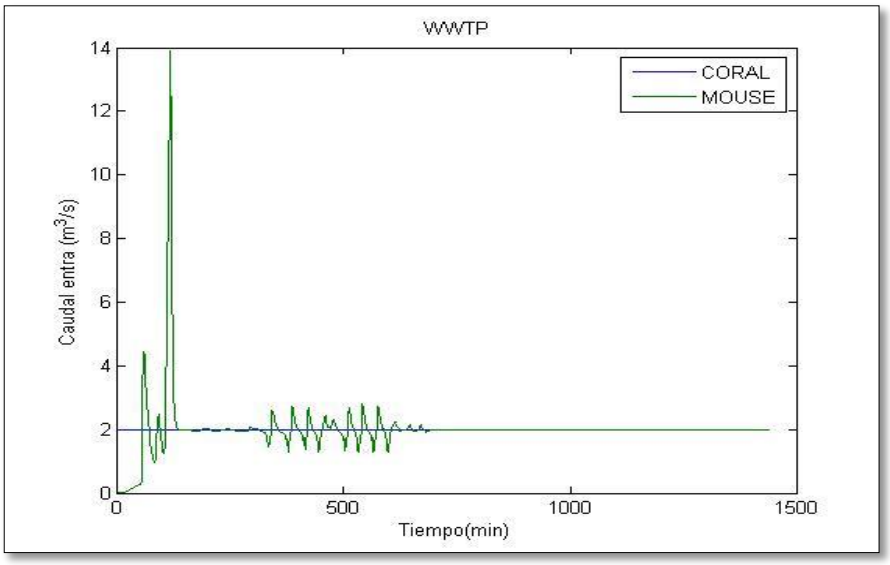

Compuerta CSO
CORAL
MOUSE
Descarga compuerta (m3/s)
Tiempo(min)
0
5
10
15
20
25
30
35
0
500
1000
1500

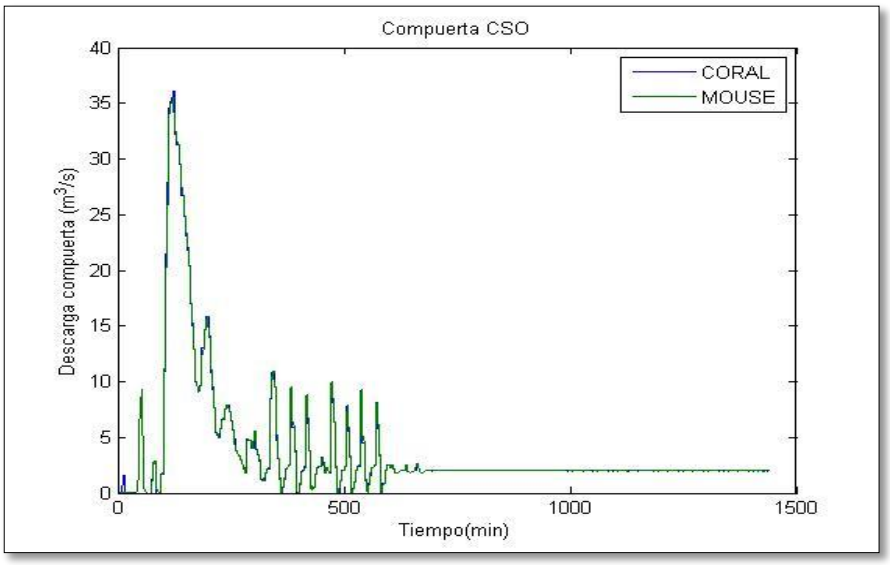

Volumen DZUN
x 10^4
CORAL
MOUSE
Volumen (m3)
Tiempo(min)
-1
0
1
2
3
4
5
6
7
0
500
1000
1500


Compuerta DZUN
CORAL
MOUSE
Descarga compuerta (m3/s)
Tiempo(min)
0
1
2
3
4
5
6
7
8
0
500
1000
1500


Volumen DDDO
CORAL
MOUSE
Volumen (m3)
Tiempo(min)
-2000
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
0
500
1000
1500


Compuerta DDDO
CORAL
MOUSE
Descarga compuerta (m3/s)
Tiempo(min)
0.5
1
1.5
2
2.5
50
100
150
200
250
300
350
400


WWTP
CORAL
MOUSE
Caudal entra (m3/s)
Tiempo(min)
0
2
4
6
8
10
12
14
0
500
1000
1500


Compuerta CSO
CORAL
MOUSE
Descarga compuerta (m3/s)
Tiempo(min)
0
5
10
15
20
25
30
35
40
0
500
1000
1500