Analyses of Canal Flows in NSP (Nagarjuna Sagar Project) Right Canal Using Flow Pro 2.1 Software

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ABSTRACT
Nagarjuna Sagar Right (Jowhar) Canal Command area spared 37 mandals in Guntur and 23 mandals in Prakasam districts. Hydraulic particulars of main and branch canal was collected from Water resources department, Lingamguntla circle and Ongole circle. The area irrigated under Nagarjuna Sagar Right Canal (Jawahar canal) is 4.75 lakh ha covering Guntur district with 2.84 lakh ha and Prakasam district with 1.91 lakh ha. The computed values at head, middle and tail section of the main canal were 3.05 m/s, 0.85 m/s and 0.719 m/s and as per the design 3.048 m/s, 0.85 m/s and 0.814 m/s respectively. The variation in values is also not more than 11%. The computed values at head, middle and tail sections of the Addanki branch canal was 0.807 m/s, 0.782 m/s and 0.73 m/s and as per design 0.889 m/s, 0.87 m/s and 0.805 m/s respectively. The maximum variation is even not more than 10%. Darsi branch canal were 0.832 m/s, 0.802 m/s and 0.155 m/s and as per the design 0.82 m/s, 0.753 m/s and 0.135 m/s respectively. The maximum variation is even not more than 14%. Hence, the simulated discharges of flowpro 2.1 software compared with designed discharges and velocities and there is no much variation in canal flow.

Keywords: NSPRCC, Hydraulic particulars, Flowpro, Water surface profile and Critical depth.

INTRODUCTION
Nagarjuna Sagar Project is built across river Krishna at Nandikonda village of Nalgonda District. The main objective of this Nagarjuna Sagar project is to bring the 9 lakhs hectare of land in to cultivation. The right canal was designed 11,000 cusecs carrying capacity. Rapid growth in industrialization and urbanization in the country resulted as decrease in the availability of water for domestic and irrigation purpose and it creates the high demand in those sectors.

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Guntur and Prakasam Districts of 4.75 lakhs ha area is irrigating by Nagarjuna Sagar Jawahar Canal (Anonymous, 1999). The Canal is divided into 9 branch canals spread across Guntur and Prakasam districts. The Right main canal having Guntur, Zulakallu, Bellarnkonda, Peddanandipadu, Addanki, Eddanapudi, Darsi, Pamidipadu and Ongole branch canals. The scope for resilience and adaptation of large surface irrigation systems is vital to the development of management strategies designed to mitigate the impact of river basin closure on food production and the livelihoods of farmers.

Study area

Nagarjuna Sagar Project Right Canal (Jawahar) Command

The command area lies between the latitudes of 15° 20' to 16° 41' 24" N and the longitudes of 79° 18'44" to 80° 25' 56" E, encompassing Guntur and Prakasam districts in the state of Andhra Pradesh. The geographical command area consists from block 1 to 22 (GA) as shown in Figure 1.

Figure 1. Location map of study area

Nagarjuna Sagar Right (Jowhar) Canal Command area spared 37 mandals in Guntur and 23 mandals in Prakasham districts.

| Milage   | Name of the Branch Canal/ Major         | Length | Designed discharge in C/S | Block No |
|----------|----------------------------------------|--------|---------------------------|----------|
| M-F-Ft   | Right Canal Head Regulator              |        | 11,000                    |          |
| 0-0-000  | Pasuvemula Major                        | 1-0-207| 5.24                      | 1        |
| 4-6-000  | Tallapalli Major – I                    | 0-4-365| 4.48                      | 2        |
| 7-4-000  | Tallapalli Major – II                   | 0-4-300| 10.13                     | 2        |
| 12-1-558 | Mallavaram Major                        | 7-7-572| 126.18                    | 3        |
| 13-6-000 | Khambampadu Major                       | 1-6-290| 18.53                     | 3        |
| 15-7-000 | Paluvai Major                           | 5-0-110| 64.09                     | 3        |
| 20-7-076 | Buggavagu O T Regulator                 |        | 11000                     |          |
|   | Description of Flow pro 2.1 |
|---|----------------------------|
|   | Flow Pro 2.1 Visually design waterways and channels with an intuitive interface. Effortlessly design open-channel waterways, culverts, irrigation channels, sluiceways, and flumes with Flow Pro. Looking for easy to use software to help you plot water surface profiles, or calculates critical depth and slope. Flow Pro saves you time and money by letting you compare more than one hydraulic design alternatives and exports the results to Word or Excel. Visualize depth, flow, and velocity with its built-in graphing software. The software having File, Channel type, Units, Tools and Help are appeared in the main menu bar. DUFLOW is a microcomputer software package for simulating one-

|   | Rentachintala Major | 9-5-655 | 42.64 | 4 |
|---|---------------------|---------|-------|---|
|   | Daida Major         | 12-6-360| 266.40| 4 |
|   | Charlagudipadu Major| 3-4-150 | 24.16 | 4 |
|   | Miryala Major       | 2-5-495 | 17.20 | 5 |
|   | Ramapuram Major     | 18-3-018| 253.80| 5 |
|   | Pedakodamagundla Major | 2-4-402 | 22.30 | 5 |
|   | Cross regulator cum surplus escape |         |       |   |
|   | Kesanupalli Major   | 6-6-613 | 68.80 | 6 |
|   | Zulakallu Branch Canal | 1-3-299 | 564.29| 6 |
|   | Janapadu Major      | 4-4-000 | 34.40 | 6 |
|   | Guttikonda Major    | 2-4-535 | 15.20 | 7 |
|   | Kotanemalipuri Major| 7-2-330 | 31.40 | 7 |
|   | Bellamkonda Branch Canal | 11-3-027 | 645 | 8&9 |
|   | Guntur Branch Canal | 32-1-000| 2920  | 10 |
|   | O.T. of 1 AR Kothapalli Major(shifted from GBC) | 8.64 |       | 10 |
|   | Addanki Brach Canal | 37-3-272| 2469  | 11 |
|   | Cross regulator     | 3947.00 |       |   |
|   | Inumella D.P        | 1.07 / 0.25 | 11A |
|   | Inumella Major      | 8-0-080 | 23.20 | 11A |
|   | Ipur D.P            | 1.80    |       | 12 |
|   | Angaluru Major      | 8-0-440 | 52.02 | 12 |
|   | Perumallapalli Major| 20-5-372| 192.60| 13 |
|   | Perurupadu Major    | 3-1-110 | 28.97 | 13 |
|   | Dondapadu Major     | 6-2-220 | 48.97 | 14 |
|   | Chekateegalapalem Major | 14-1-550 | 140.14| 14 |
|   | Palakuru Major      | 0-6-250 | 5.57  | 14 |
|   | Cross regulator cum escape | 3346 |       |   |
dimensional unsteady flow in open-channel systems by Clemmens et al. (1993). In Channel type there is option to select the sections like trapezoidal, circular, U shaped, elongated circular and channel type and name. In units icon select the either SI or English. According to Charles et al. (2018) requires calculated, remote manual adjustments to all the canal check structure gate positions in addition to two flow rate changes made at the head of the canal, followed by are turn to automated upstream control. In Tools icon critical depth and slope, depth, flow rate, slope and Roughness, Orifices, underflow gates, water surface profile and weirs.

Nagarjuna Sagar Right Canal Command area flows were analyzed using the Flow Pro 2.1 version software at three different sections like head section, middle and tail end of the main canal. The input data needed for the software as given in the Table 1 and computed water surface profiles as shown in Figure 1, 2 and 3.

Table 1: Data input of Nagarjuna Sagar Right canal Command area main canal needed for Flow pro 2.1

| S No | Particulars       | Head section | Middle | Tail end |
|------|-------------------|--------------|--------|---------|
| 1    | Start Station, m  | 0            | 92211+00.000 | 199616+00.000 |
| 2    | End station, m    | 3532+00.000  | 92593+00.000 | 202796+00.000 |
| 3    | Flow rate, m³/s   | 311.49       | 111.77  | 79.65   |
| 4    | Width, m          | 18.593       | 26.213  | 18.8976 |
| 5    | Manning’s         | 0.018        | 0.0255  | 0.0255  |
| 6    | Bottom slope      | 0.00034072   | 0.00008333 | 0.00008333 |
| 7    | Control depth, m  | 9.296        | 3.871   | 3.871   |
| 8    | Side slope        | 0.25:1       | 2:1     | 2:1     |

Fig. 1: Flow Pro computed water surface profile data and other parameters at head section of the NSRC command area
Fig. 2: Flow Pro computed water surface profile data and other parameters at middle section of the NSRC command area

Fig. 3: Flow Pro computed water surface profile data and other parameters at tail end of the NSRC command area

The computed parameters like profile type, flow type, critical depth, critical area, velocity, wetted perimeter and hydraulic radius as shown in the Table 2 and Figure 4.

Table 2: Flowpro2.1 computed values at three levels

| S No | Particulars          | Head section | Middle | Tail end |
|------|----------------------|--------------|--------|---------|
| 1    | Profile type         | Mild, M-1    | Mild, M-2 | Mild, M-2 |
| 2    | Flow type            | Subcritical  | Subcritical | Subcritical |
| 3    | Critical depth, m    | 3.017        | 1.190  | 1.168  |
| 4    | Critical slope       | 0.00295      | 0.00634 | 0.00846 |
| 5    | Critical area, m²    | 58.37        | 34.045 | 24.799 |
| 6    | Depth (normal), m    | 9.296        | 3.871  | 3.871  |
| 7    | Velocity, m/s        | 3.05         | 0.85   | 0.719  |
| 8    | Area, m²             | 194.44       | 131.44 | 103.12 |
| 9    | Wetted perimeter, m  | 37.757       | 43.525 | 36.209 |
| 10   | Hydraulic radius, m  | 5.150        | 3.020  | 2.848  |
Fig. 4: Comparison of flowpro2.1 computed values with designed values at different locations of NSRJC

The computed values at head, middle and tail section s of the main canal were 3.05 m/s, 0.85 m/s and 0.719 m/s and as per the design 3.048 m/s, 0.85 m/s and 0.814 m/s respectively. The variation in values is also not more than 11%. Similarly, Addanki branch canal of NSRJC input data were tabulated in the following Table 3.

Table 3: Data input for Addanki branch canal of NSRJC

| S No | Particulars         | Head section | Middle | Tail end         |
|------|---------------------|--------------|--------|------------------|
| 1    | Start Station, m    | 30700+00.000 | 43721+00.000 | 199616+00.000   |
| 2    | End station, m      | 38025+00.000 | 50006+00.000 | 202796+00.000   |
| 3    | Flow rate, m/s      | 51.578       | 41.680   | 79.65            |
| 4    | Width, m            | 22.555       | 18.288   | 18.8976          |
| 5    | Manning’s           | 0.025        | 0.025    | 0.025            |
| 6    | Bottom slope        | 0.0005152    | 0.0005152 | 0.0005152        |
| 7    | Control depth, m    | 2.438        | 2.438    | 2.286            |
| 8    | Side slope          | 1.5:1        | 1.5:1    | 1.5:1            |

The computed values at head, middle and tail sections of the Addanki branch canal was shown in following Table 4 and Figure 5 as 0.807 m/s, 0.782 m/s and 0.73 m/s and as per the design 0.889 m/s, 0.87 m/s and 0.805 m/s respectively. The maximum variation is even not more than 10%.

Table 4: Computed values at three levels of Addanki branch canal of NSRJC

| S No | Particulars         | Head section | Middle | Tail end |
|------|---------------------|--------------|--------|----------|
| 1    | Profile type        | Mild, M-1    | Mild, M-2 | Mild, M-1   |
| 2    | Flow type           | Subcritical  | Subcritical | Subcritical |
| 3    | Critical depth, m   | 0.796        | 0.791   | 0.731    |
| 4    | Critical slope      | 0.00691      | 0.00698 | 0.00718  |
| 5    | Critical area, m²   | 18.915       | 15.412  | 12.393   |
| 6    | Depth (normal), m   | 2.438        | 2.438   | 2.286    |
| 7    | Velocity, m/s       | 0.807        | 0.782   | 0.73     |
| 8    | Area, m²            | 63.905       | 53.297  | 44.072   |
| 9    | Wetted perimeter, m | 31.345       | 27.049  | 24.092   |
| 10   | Hydraulic radius, m | 2.039        | 1.97    | 1.829    |
Similarly, Darsi branch canal of NSRJC input data were tabulated in the following Table 5.

| S No | Particulars | Head section | Middle | Tail end |
|------|-------------|--------------|--------|---------|
| 1    | Start Station, m | 30700+00.000 | 43721+00.000 | 199616+00.000 |
| 2    | End station, m | 38025+00.000 | 50006+00.000 | 202796+00.000 |
| 3    | Flow rate, m/s | 51.578 | 41.680 | 79.65 |
| 4    | Width, m | 22.555 | 18.288 | 18.8976 |
| 5    | Manning’s | 0.025 | 0.025 | 0.025 |
| 6    | Bottom slope | 0.0005152 | 0.0005152 | 0.0005152 |
| 7    | Control depth, m | 2.438 | 2.438 | 2.286 |
| 8    | Side slope | 1.5:1 | 1.5:1 | 1.5:1 |

The computed values at head, middle and tail sections of the Darsi branch canal were shown in following Table 6 and Figure 6.

| S No | Particulars | Head section | Middle | Tail end |
|------|-------------|--------------|--------|---------|
| 1    | Profile type | Mild, M-1 | Mild, M-2 | Mild, M-1 |
| 2    | Flow type | Subcritical | Subcritical | Subcritical |
| 3    | Critical depth, m | 1.149 | 1.022 | 0.054 |
| 4    | Critical slope | 0.00516 | 0.00513 | 0.01349 |
| 5    | Critical area, m² | 39.396 | 33.224 | 0.619 |
| 6    | Depth (normal), m | 3.871 | 3.871 | 1.829 |
| 7    | Velocity, m/s | 0.832 | 0.802 | 0.155 |
| 8    | Area, m² | 153.84 | 127.149 | 2.908 |
| 9    | Wetted perimeter, m | 49.312 | 45.726 | 12.383 |
| 10   | Hydraulic radius, m | 3.12 | 2.781 | 0.235 |
Fig. 6: Comparison of computed values with designed values at different locations of Darsi branch canal of NSRJC

From the above data Darsi branch canal were 0.832 m/s, 0.802 m/s and 0.155 m/s and as per the design 0.82 m/s, 0.753 m/s and 0.135 m/s respectively. The maximum variation is even not more than 14%.

Hence, the simulated discharges of flow pro2.1 software compared with designed discharges and velocities and there is no much variation in flow. The maximum variation is occurred only 10%.

**CONCLUSIONS**

The computed values at head, middle and tail section s of the main canal were 3.05 m/s, 0.85 m/s and 0.719 m/s and as per the design 3.048 m/s, 0.85 m/s and 0.814 m/s respectively. Similarly, Addanki and Darsi branch canals were also computed using Flowpro2.1 software. Hence, flow pro2.1 software simulated discharges compared with designed discharges and velocities and there is no much variation in flow.

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