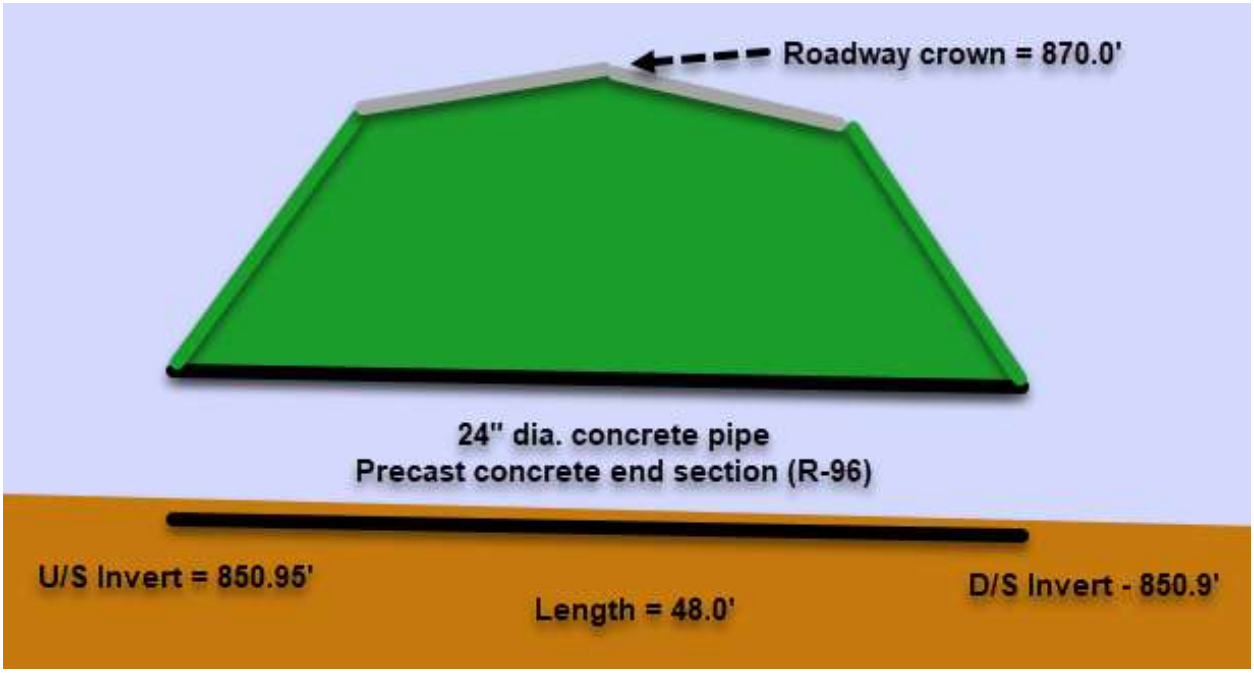
Existing Culvert

Determine headwater and outlet velocity for the existing culvert

- Q_{50} = 40 cfs
- Q_{100} = 50 cfs
- TW_{50} = 853.56’
- TW_{100} = 853.84’



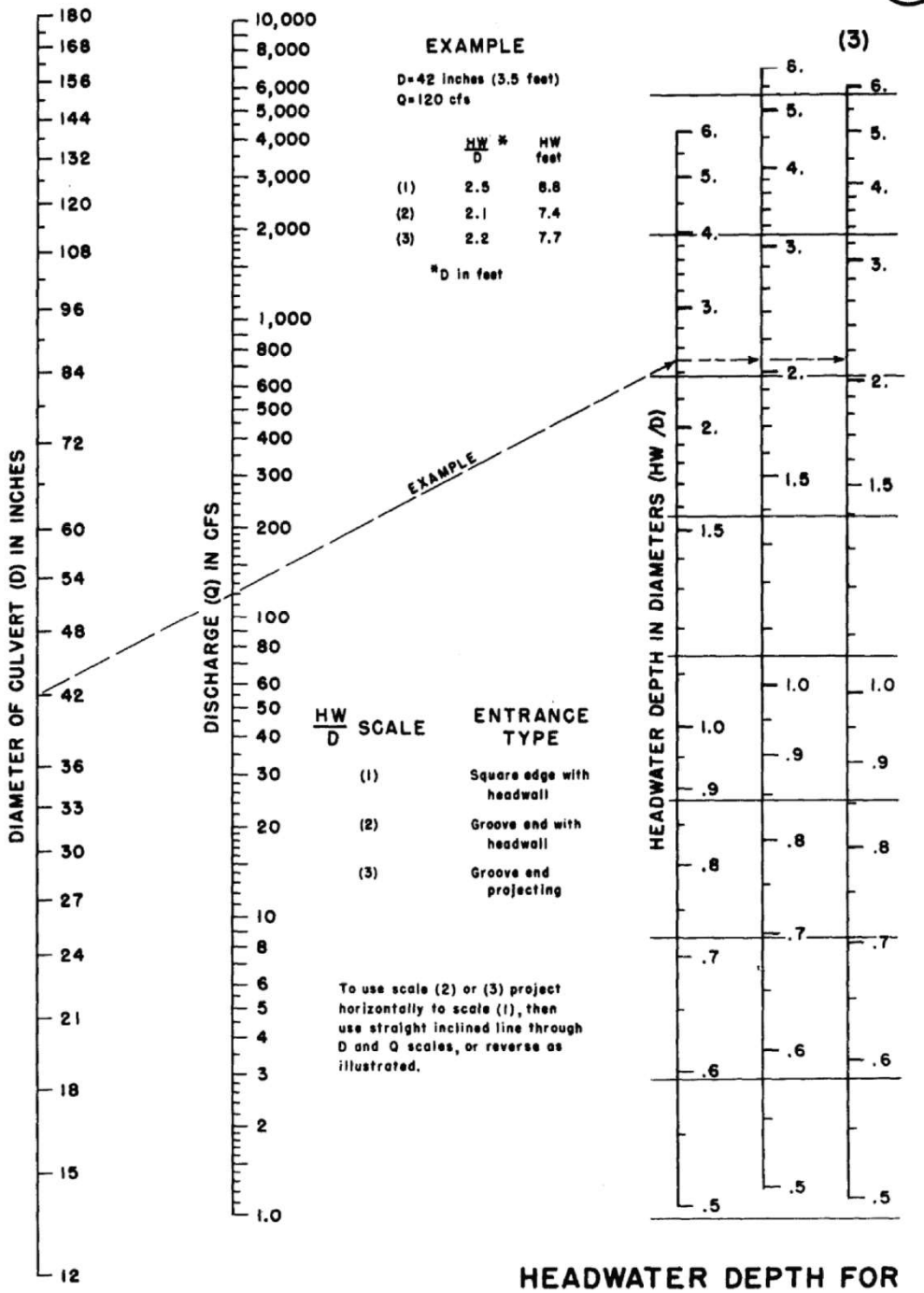
Existing Culvert

Determine inlet control headwater (Chart 1B):

- Q_{50}
  - HW / D = _____
  - HW = _____ * D = _____ * 2’ = _____’
  - $HW_{ic} = U/S_{invert} + HW$ = 850.95’ + _____’ = _____’

- Q_{100}
  - HW / D = _____
  - HW = _____ * D = _____ * 2’ = _____’
  - $HW_{ic} = U/S_{invert} + HW$ = 850.95’ + _____’ = _____’

CHART 1B



HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

Existing Culvert

Determine outlet control headwater:

- TW_{50} = 853.56'
- TW_{100} = 853.84'

- k_e = 0.5 (squared edge with headwall)
- n = 0.012 (concrete)

- Determine headloss:

$H_L = (1 + K_e + 29\ n^2\ L / R^{1.33}) * V^2 / 2g$

Full barrel area = $A_{full} = \pi\ D^2 / 4$

$= \pi\ (2\ ft.)^2 / 4 =$ _____ **sft**

Full barrel hydraulic radius = $R = A_{full} / P_{full} = (\pi\ D^2 / 4) / (\pi\ D)$

$= D / 4 = 2\ ft. / 4 =$ _____ **ft.**

Existing Culvert

Determine outlet control headwater (cont.):

- Determine headloss (cont.):
  - Is the downstream crown submerged?
  - Q_{50}:

$V_{full} = Q / A_{full}$ (Continuity Eq.)

= 40 cfs / _____ sft. = _____ ft/s

$H_L = (1 + K_e + 29\ n^2\ L / R^{1.33}) * V^2 / 2g$

= (1 + 0.5 + 29 * $(0.012)^2$ * 48' / (____$^{1.33}$) * (_____ ft/s)^2 / (2 * 32.2 ft/s^2)

= **_____ ft**.

Existing Culvert

Determine outlet control headwater (cont.):

- Determine headloss (cont.):
  - Is the downstream crown submerged?
  - Q_{100}:

$V_{full} = Q / A_{full}$ (Continuity Eq.)

= 40 cfs / _____ sft. = _____ ft/s

$H_L = (1 + K_e + 29\ n^2\ L / R^{1.33}) * V^2 / 2g$

= (1 + 0.5 + 29 * $(0.012)^2$ * 48' / (____$^{1.33}$) * (_____ ft/s)^2 / (2 * 32.2 ft/s^2)

= **_____ ft**.

Existing Culvert

Determine outlet control headwater (cont.):

- Determine outlet control headwater:
  - $HW_{oc} = TW + h_L$ (Assume $V_u \approx V_d$)
  - Q_{50}:

HW_{oc} = 853.56’ + _____’ = _____’

  - Q_{100}:

HW_{oc} = 853.84’ + _____’ = _____’

- Determine controlling headwater (HW_c) for existing culvert:
  - Q_{50}:

    HW_{ic} ____ HW_{oc} ??

    HW_c = _____’

  - Q_{100}:

    HW_{ic} ____HW_{oc} ??

    HW_c = _____’

Proposed Culvert

Determine size, headwater, and outlet velocity for the existing culvert

- Q_{50} = 40 cfs
- Q_{100} = 50 cfs
- TW_{50} = 853.56’
- TW_{100} = 853.84’

Proposed Culvert

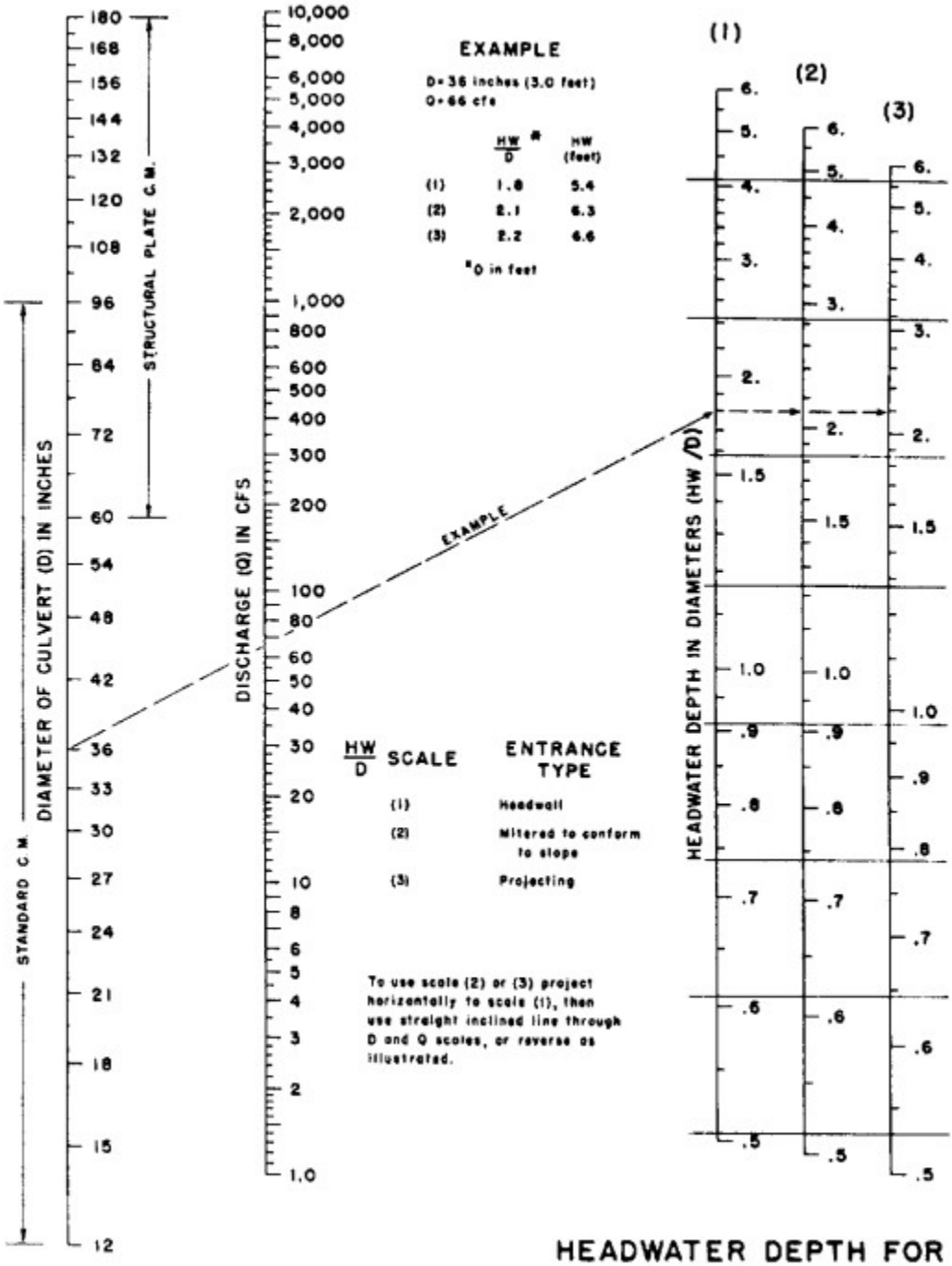
Determine inlet control headwater (Chart 2B):

- Q_{50}
  - HW / D = _____
  - HW = _____ * D = _____ * 2' = _____'
  - HW_{ic} = U/S_{invert} + HW = 850.35' + _____' = _____'

- Q_{100}
  - HW / D = _____
  - HW = _____ * D = _____ * 2' = _____'
  - HW_{ic} = U/S_{invert} + HW = 850.35' + _____' = _____'

Note: Proposed invert lowered 6 inches, per 5.3.4 in the Drainage Manual

CHART 2B



HEADWATER DEPTH FOR
C. M. PIPE CULVERTS
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Proposed Culvert

Determine outlet control headwater:

- TW_{50} = 853.56'
- TW_{100} = 853.84'

- k_e = 0.5 (squared edge with headwall)
- n = 0.024 (assume worst case, CMP)

- Determine headloss:

$H_L = (1 + K_e + 29\, n^2\, L / R^{1.33}) * V^2 / 2g$

Full barrel area = $A_{full} = \pi D^2 / 4$

$= \pi\, (2 \text{ ft.})^2 / 4 =$ _____**sft**

Full barrel hydraulic radius = $R = A_{full} / P_{full} = (\pi D^2 / 4) / (\pi D)$

$= D / 4 = 2 \text{ ft.} / 4 =$ _____**ft**

Proposed Culvert

Determine outlet control headwater (cont.):

- Determine headloss (cont.):
  - Use partial elements to determine V_{part} and R_{part}:
    - Q_{50}:

TW_{100} / D = (2.66 ft. + 0.5 ft.) / _____ ft. = _____

Based on partial elements:

A_{part} / A_{full} = _____

A_{part} = _____ * A_{full} = _____ * _____ sft. = _____ sft.

V_{part} = Q / A_{full} = 50 cfs / _____ sft. = **_____ft/s**

R_{part} / R_{full} = _____

R_{part} = _____ * R_{full} = _____ * _____ ft. = _____ ft.

Proposed Culvert

Determine outlet control headwater (cont.):

- Determine headloss (cont.):
  - Use partial elements to determine V_{part} and R_{part}:
    - Q_{100}:

TW_{100} / D = (2.94 ft. + 0.5 ft.) / _____ ft. = _____

Based on partial elements:

A_{part} / A_{full} = _____

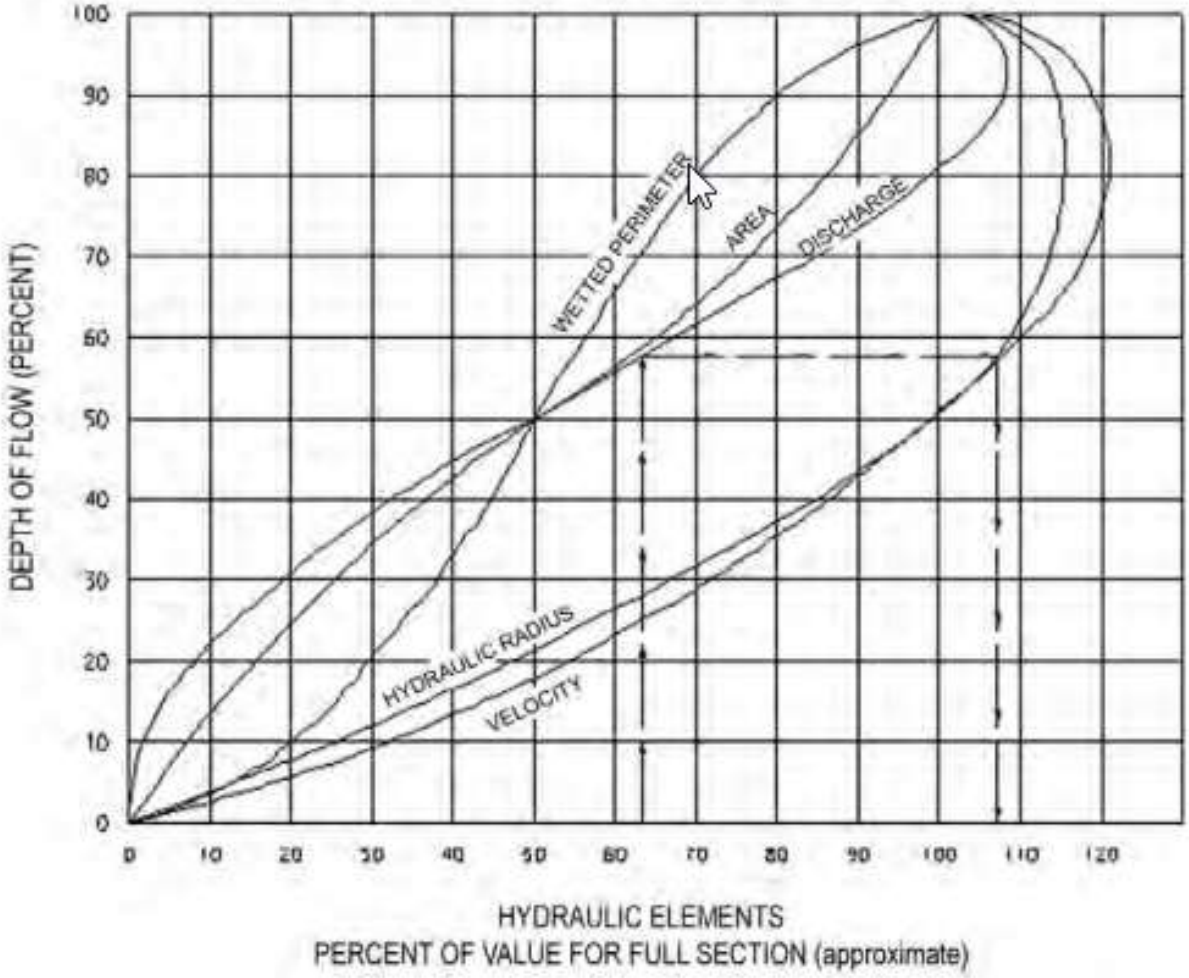
A_{part} = _____ * A_{full} = _____ * _____ sft. = _____ sft.

V_{part} = Q / A_{full} = 50 cfs / _____ sft. = **_____ft/s**

R_{part} / R_{full} = _____

R_{part} = _____ * R_{full} = _____ * _____ ft. = _____ ft.

HYDRAULIC ELEMENTS OF CHANNEL SECTIONS



Proposed Culvert

Determine outlet control headwater (cont.):

- Determine headloss (cont.):
  - Q_{50}:

$H_L = (1 + K_e + 29\ n^2\ L / R^{1.33}) * V^2 / 2g$

$= (1 + 0.5 + 29 * (0.024)^2 * 48' / (____^{1.33}) * (_____\ ft/s)^2 / (2 * 32.2\ ft/s^2)$

= **_____ ft**.

Proposed Culvert

Determine outlet control headwater (cont.):

- Determine headloss (cont.):
  - Q_{100}:

$H_L = (1 + K_e + 29\ n^2\ L / R^{1.33}) * V^2 / 2g$

$= (1 + 0.5 + 29 * (0.024)^2 * 48' / (____^{1.33}) * (_____\ ft/s)^2 / (2 * 32.2\ ft/s^2)$

= **_____ ft**.

Proposed Culvert

Determine outlet control headwater (cont.):

- Determine outlet control headwater:
  - $HW_{oc} = TW + h_L$ (Assume $V_u \approx V_d$)
  - Q_{50}:

HW_{oc} = 853.56’ + _____’ = _____’

  - Q_{100}:

HW_{oc} = 853.84’ + _____’ = _____’

- Determine controlling headwater (HW_c) for existing culvert:
  - Q_{50}:

    HW_{ic} ____ HW_{oc} ??

    HW_c = _____’

  - Q_{100}:

    HW_{ic} ____HW_{oc} ??

    HW_c = _____’